Drinking Water Quality Management Guide for Water Services Authorities

Manage your drinking water quality effectively
for the health of your people

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water & forestry

PREFACE

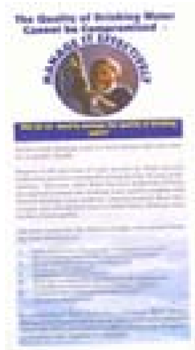
This Guide forms part of a series which is intended to provide the water sector with the information needed to monitor, manage, communicate and regulate drinking water quality in order to protect public health.

The **Drinking Water Quality Management Guide for Water Services Authorities** is intended to assist Water Services Authorities and Water Services Providers to manage their drinking water supply systems holistically and effectively.

The following documents form the series:

A Drinking Water Quality Framework for South Africa

Drinking Water Quality Management Guide for Water Services Authorities	Drinking Water Quality Regulation Strategy	Water Services Authority Awareness Pamphlet	Consumer Awareness Booklet



For further information on Drinking Water Quality Management, or copies of the documents in the series, please contact:

- The Department of Water Affairs and Forestry: Water Services Regulation on (012) 3366600, or the website: http://www.dwaf.gov.za.

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1. WHY DO WE NEED TO MANAGE THE QUALITY OF DRINKING WATER?

Access to safe drinking water is a basic human right and essential to people's health. Safe drinking water that complies with the South African National Standard (SANS) 241 Drinking Water Specification does not pose a significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages (babies and infants, the immuno-compromised and the elderly). Improving access to safe drinking water can thus result in tangible benefits to public health and every effort should be made to achieve a drinking water quality that complies with national safety standards.

Progress in the provision of water services by Water Services Institutions has been considerable during the first 10 years of democracy. However, while Water Services Authorities (WSAs) are required to ensure that drinking water quality complies with national drinking water standards, ongoing research shows that, in many non-metropolitan areas in South Africa, drinking water is often of poor quality.

The main reasons for this failure to comply with national drinking water standards are:

- WSAs are not aware of the necessary requirements to set up an effective Drinking Water Quality Management programme;
- Management and monitoring of drinking water services are often inadequate;
- Infrastructure is poorly maintained;
- WSAs may be hindered by institutional capacity problems such as insufficient or untrained staff, and budgetary constraints, and
- Appropriate interventions are not in place to address poor quality drinking water.

In recognition of these challenges, a Drinking Water Quality Framework for South Africa has been developed to ensure that WSAs are supported and enabled to effectively manage the quality of drinking water supplied to consumers.

2. WHO IS RESPONSIBILITIES FOR DRINKING WATER QUALITY MANAGEMENT?

2.1 WATER SERVICES AUTHORITIES

The primary responsibility for ensuring the provision of safe drinking water rests with WSAs. WSAs have a legal responsibility to:

- Monitor the quality of drinking water provided to consumers;
- Compare the results to national drinking water standards, and
- Communicate any health risks to consumers and appropriate authorities.

as described in the regulations to the Water Services Act (No. 108 of 1997) *Compulsory National Standards for the Quality of Potable Water*.

WSAs also have a responsibility to regulate the quality of water supplied by Water Services Providers (WSPs).

2.1 OTHER KEY INSTITUTIONAL ROLES AND RESPONSIBILITIES

2.2.1 THE DEPARTMENT OF WATER AFFAIRS AND FORESTRY

The Department of Water Affairs and Forestry (DWAF) supports and regulates the role of WSAs with regards to Drinking Water Quality by:

- Developing and maintaining a national Drinking Water Quality Framework;
- Managing information, including a sector database and information sharing system covering key aspects such as tracking WSA monitoring systems and drinking water quality data;
- Undertaking periodic regulatory audits of the Drinking Water Quality data and management systems of WSAs;
- Developing appropriate, practical and sustainable technical support documents and tools, and
- Assisting WSAs by reviewing Water Services Development Plans, to ensure that drinking water quality monitoring is included.

Future Catchment Management Agencies (CMAs) will be responsible for water resource planning and management at the catchment level, including licensing of water use and discharges, monitoring abstractions and discharges, and overseeing land-use activities. The CMAs will also be responsible for the implementation of the National Monitoring Programmes which monitor resource quality at the catchment level.

2.2.2 THE DEPARTMENT OF HEALTH

The Department of Health (DoH) supports the Drinking Water Quality Management function by:

- Collecting information on the incidence of waterborne diseases (for example, diarrhoea) and the use of this information to facilitate interventions, and
- Being the lead 'early warning' authority and execution agents for medical intervention under emergency drinking water quality conditions.

At District Municipality and Metropolitan level, the Environmental Health Officers support the Drinking Water Quality Management function by assuming the primary responsibility for health and hygiene education related to water and sanitation services, and undertaking drinking water quality monitoring as a routine audit function at point-of-use. DoH drinking water quality monitoring will focus on health-risk related constituents, particularly indicators of faecal contamination.

2.2.3 THE DEPARTMENT OF PROVINCIAL AND LOCAL GOVERNMENT

The Department of Provincial and Local Government (DPLG) supports the Drinking Water Quality Management function by the allocation of Municipal Infrastructure Grant, Capacity Building Grant and Equitable Share to address areas of need impacting on effective Drinking Water Quality Management.

2.2.4 CIVIL SOCIETY

Government is committed to promoting the active involvement of civil society in the provision of sustainable and affordable water services, including Drinking Water Quality Management. The Strategic Framework for Water Services (2003) notes that '*the most important and effective monitoring strategy for the sector is strengthening the voice of the consumer*'.

3. HOW DO WATER SERVICES AUTHORITIES MANAGE THE QUALITY OF THEIR DRINKING WATER SUPPLIES EFFECTIVELY?

A Drinking Water Quality Framework has been prepared to enable effective management of drinking water quality in South Africa to protect public health. The Framework is based on a preventative risk management approach, which is comprehensive from catchment to consumer. This approach promotes an understanding of the entire water supply system, the events that can compromise drinking water quality and the operational control necessary for optimising drinking water quality and protecting public health.

In recognition of the challenges facing WSAs in South Africa, a continual improvement approach is also advocated, with emphasis on fulfillment of minimum legislated requirements and achievement of interim goals and milestones as set by the WSAs to improve drinking water quality.

The preventative Drinking Water Quality Framework for South Africa addresses four key areas, (which are described in more detail in the following section):

- Commitment to Drinking Water Quality Management and Multi-stakeholder Involvement;
- System Analysis and Management;
- Supporting Programmes, and
- Review & Audit.

3.1 COMMITMENT TO DRINKING WATER QUALITY MANAGEMENT

Effective Drinking Water Quality Management requires an integrated approach with all relevant stakeholders committed to working together. This commitment should be based on an awareness and understanding of the importance of Drinking Water Quality Management and how it affects public health.

3.2 SYSTEM ANALYSIS AND MANAGEMENT

3.2.1 ASSESSMENT OF THE DRINKING WATER SUPPLY SYSTEM

Effective Drinking Water Quality Management requires a clear understanding of the entire drinking water supply system, the hazards and events that can compromise drinking water quality, and the corrective and preventative measures and operational controls necessary to ensure a safe and reliable drinking water supply (NHMRC/ARMCANZ Co-ordinating Group, 2001).

In this context, the drinking water supply system is defined as including everything from the point of abstraction of water to the consumer:

- catchments including groundwater systems;
- riverine source waters;
- storage dams and abstractions;
- drinking water treatment systems;
- treated water reservoirs and distribution systems, and
- point-of-use consumers.

<u>Water Supply System Analysis</u>

An analysis should be performed to characterise each element of the water supply system with respect to drinking water quality and the factors that affect it. This promotes understanding of the water supply system, and assists with identification of hazards and assessment of risks to water quality. The analysis should be documented in the form of a flow diagram of the entire drinking water system from catchment to consumer. The purpose of this step is to develop a broad overview and understanding of the supply system.

A review of historical water quality data for the entire drinking water supply system will assist in understanding source water characteristics and system performance both over time and following specific events (for example heavy rainfall). This can aid the identification of hazards and the aspects of the drinking water system which may require improvement. All water quality data should be assessed, including data from routine and investigative monitoring.

Water quality constituents that can provide useful information include:

- chemical quality, including
  - total organic carbon;
  - pH;
  - disinfectant residuals;
  - disinfectant by-products.
- algal counts
- microbiological quality, including
  - Total coiliforms;
  - *E. coli.*
- physical quality, including
  - turbidity;
  - colour;
  - taste & odour.

If no historical water quality data exists, it is recommended that a screening process is undertaken where samples are collected and analysed for a wide variety of water quality constituents. This screening process can be used to group constituents of concern as opposed to those which pose no risk and thus require monitoring at lower frequencies.

Hazard Identification and Risk Assessment

Adoption of a risk-based approach of identifying hazards and assessing their contribution to water quality risks, is an effective means of consistently ensuring the safety of a drinking water supply. All hazards from catchment to consumer (and beyond the tap) need to be considered; some communities in South Africa rely on a tap located a distance away from the household.

Hazards and Risks:

- A **hazard** is an agent with the potential for causing harm (for example Cryptosporidium is a water quality hazard, a potential danger to public health), and
- **Risk** is the likelihood of identified hazards causing harm, including the magnitude of that harm and its consequences (for example the likelihood that Cryptosporidium cysts will breach the water management system barriers with sufficient numbers to cause illness in consumers).

(NHMRC/ARMCANZ Co-ordinating Group, 2001)

A structured approach to identify areas of greatest risk is important to ensure that significant issues are not overlooked. Steps involved in the process should include:

Hazard Identification

- Identify and document all potential hazards from catchment to consumer;
- Identify and document hazardous events, causes and scenarios that might affect the drinking water quality (what can happen and how).

All hazards are required to be identified and the level of risk estimated

Risk Assessment

- Estimate the level of risk for each hazard/scenario (a function of both likelihood and severity of the consequences);
- Establish and document priorities for risk management action based on assessment of risk.

3.2.2 PREVENTATIVE STRATEGIES FOR DRINKING WATER QUALITY MANAGEMENT

Prevention is an essential feature of effective Drinking Water Quality Management. When a situation that could to give rise to a significant hazard has been identified, preventative strategies can be identified to prevent or control the hazard, thereby minimising its risk.

Preventative strategies are those actions and activities that are required to eliminate hazards or reduce the likelihood or level of their impact to acceptable levels.

Multiple Protection Barriers

Securing the safety of drinking water supplies is based on the use of multiple barriers, from catchment to consumer, to prevent the contamination of drinking water or to reduce contamination to levels that will not harm people. The strength of the multiple barrier approach is that a failure of one barrier may be compensated for by effective operation of the remaining barriers, thus minimising the likelihood of contaminants passing through the entire treatment system and being present in sufficient amounts to cause harm to consumers.

Barriers to contamination include:

- catchment management and source water protection;
- abstraction management;
- coagulation, flocculation, sedimentation and filtration;
- disinfection ensuring an adequate disinfectant residual, and
- protection and maintenance of the distribution system.

3.2.3 OPERATIONAL PROCEDURES AND PROCESS CONTROL

The proper maintenance and operation of water supply, treatment and distribution systems are essential elements of any effort to ensure the production and delivery of the highest quality drinking water possible.

Water works should be operated and supervised by adequate numbers of suitably qualified and experienced staff. Staff requirements (competencies and numbers) will depend on a number of factors, such as the volume of water treated and population served, the complexity of the water treatment process and the variability of the raw water.

Documented operational procedures are essential for effective Drinking Water Quality Management

An Operator's Manual specific to the Water Treatment Works is essential and should contain the following information:

- Routine Operating Procedures;
- Process Control Techniques that apply to the water treatment works, for example jar tests, cascade tests, analysis of pH, chlorine and turbidity at appropriate control points;
- Procedures for incident or failure conditions when a loss of process control occurs, and
- Internal operating targets for key water quality determinands such as turbidity and free chlorine.

The Operator's Manual should be simply presented, easy to understand and written in a language that the operator can understand.

<u>Operational monitoring</u>

Water quality data from operational monitoring can be used as a trigger for immediate short-term corrective action to operational procedures, thereby improving drinking water quality. A key element is the identification of parameters that control performance so that their status can be used to predict final water quality and provide adequate lead-time for corrective action. Wherever possible, online and continuous monitoring of key parameters should be undertaken.

When setting up an **Operational Monitoring Programme**, the following should be considered:

- **Determinands** monitored should include critical process control variables such as pH, chlorine and turbidity. Microbiological analyses (including coliforms and *E. coli*) should also be undertaken as a minimum requirement when operational monitoring indicates a loss of process control or in response to consumer complaints.

- **Sampling points** need to include the raw water source, the water works final water, distribution reservoirs and strategic sites within the reticulation network. Special consideration should be given to network dead-ends, high occupancy buildings, hospitals and schools.

- The **frequency of sampling** will depend on the population served, the volume of water treated, the variability of the raw water and the frequency with which drinking water quality failures are experienced. Sampling should, however, be frequent enough to detect a loss of process control and enable the implementation of corrective action before a significant drinking water failure occurs. Daily monitoring is recommended for operational monitoring at a water works, including the raw water intake, with a minimum of monthly monitoring occurring within the distribution network.

A knowledge of Drinking Water Quality Monitoring sampling procedures is important as incorrect sampling procedures and methods can affect the accuracy and reliability of analytical results and lead to misleading conclusions on the quality of the water supply.

The following sampling equipment is needed for operational monitoring:

- A sample tap, or alternately dip sampling equipment which must be sterilised;
- Gas burner/alcohol for flaming/disinfecting the tap before sampling;
- Sample bottles and preservatives suited to the determinands to be analysed;
- Cooler boxes and ice packs for transporting microbiological samples;
- Sample labels for recording the sample point number, the date and time of sampling and the sampler's name;
- pH meter, or pH indicator strips and buffer solutions;
- Turbidity meter and standards for calibration;
- Equipment for measuring free and total chlorine concentrations, and
- Jar and cascade test equipment.

The decision of whether to disinfect the sample tap before sampling is dependant on the objective of the monitoring:

- If the objective of monitoring is to assess the quality of the water supplied by the WSA, the tap should be flamed prior to sampling;
- If the objective of monitoring is to assess the fitness of the water for consumption and the impact on public health, the tap (or the community container) should not be disinfected before sampling.

Access to an efficient Laboratory, preferably one that is SANAS accredited, is also necessary.

Data or log sheets, a Laboratory/Field Analysis Results book or a simple Excel spreadsheet need to be set up to record operational monitoring results. Electronic data sheets are recommended to be printed regularly to ensure that a paper record is kept.

Operational Preventative and Corrective Action

Planning should be undertaken to establish appropriate procedures for preventative and corrective action required to re-establish process control when operational monitoring indicates that target limits have not been met.

Adoption of internal operating guidelines that are stricter than the South African National Standard (SANS) Drinking Water Specification limits acceptable for lifetime consumption, and acting when

these guidelines have been exceeded, will reduce the chances of exceeding SANS 241 limits in the water works final waters.

The **SANS 241 Drinking Water Specification** is the definitive reference on acceptable limits for drinking water quality parameters in South Africa and provides guideline levels for a range of water quality characteristics. The SANS 241 Drinking-Water Specification effectively summarises the suitability of water for drinking water purposes by specifying two classes of water: Class I (Acceptable for lifetime consumption) and Class II (Maximum Allowable). In essence, drinking water quality should pose no health risk, and should satisfy SANS 241 limits for specified time frames.

Operating procedures should be documented and include instructions on required adjustments and process control changes. Operational roles and responsibilities, including communication and notification requirements should be clearly defined.

Examples of **preventative and corrective actions** for which operational procedures should be documented include:

- selection of alternate raw water source if available;
- altering plant flow rate (for example, reducing the loading on the works);
- jar testing for coagulant control and optimisation;
- altering mixing intensity;
- changing treatment chemicals;
- adjusting pH;
- varying chemical feed rates and feed points;
- adjusting the frequency of backwashing cycles of the filters;
- increasing disinfectant dose;
- secondary/booster disinfection, and
- mains flushing, cleaning and localised disinfection.

3.2.4 VERIFICATION OF DRINKING WATER QUALITY - COMPLIANCE MONITORING

Drinking Water Quality compliance monitoring is the final check in the process to ensure that the preventative Drinking Water Quality Management measures implemented to protect public health, are working effectively. Compliance monitoring is usually a comprehensive assessment of drinking water quality to assess compliance with regulatory requirements. It is recommended that, as a minimum for Drinking Water Treatment Works treating both surface and groundwater, all health-related determinands specified in the SANS 241 Drinking Water Specification should be monitored

at least once, prior to commissioning of the water works, and then every three to five years thereafter.

Compliance Monitoring is the final check that the barriers and preventative measures implemented to protect public health are working effectively

Drinking water quality compliance monitoring differs from operational monitoring not only in purpose but also in terms of the water quality characteristics to be measured, sampling locations and frequency of sampling:

- Key constituents for compliance monitoring include:
  - Microbiological indicator organisms (*E. coli*);
  - Concentrations of chemicals used in treatment processes, disinfectant residuals, and any disinfection by-products;
  - Any health-related constituent that can be reasonably expected to exceed the guideline value, even if occasionally; and
  - Any other potential constituents of concern identified in the System Analysis screening process and Hazard Identification.
- The recommended minimum sampling frequencies specified in the SANS 241 Drinking Water Specification should be adhered to for critical constituents, as these frequencies are based on population served and volume of water treated (see Table A.1 in Annexure 1). However, constituents which have results significantly below the SANS 241 Drinking Water Specification limits (or detection limits) can be monitored at less frequent intervals to minimise monitoring costs;
- Location of sampling depends on the water quality constituent being examined as well as the characteristics of the distribution system being managed.

The WSA's Drinking Water Quality Monitoring Programme as well as the drinking water quality monitoring data should be captured onto a Drinking Water Quality Management database and made available *via* a national internet based system to facilitate the provision of information on the status of drinking water quality management to a wide range of stakeholders.

Additional information on drinking water quality sampling, analysis, assessment, treatment and management can be found in the Department of Water Affairs and Forestry, Department of Health and Water Research Commission guides on the **Quality of Domestic Water Supplies**:

- Volume I: Assessment Guide;
- Volume II: Sampling Guide;
- Volume III: Analysis Guide;
- Volume IV: Treatment Guide, and

- Volume V: Management Guide.

(Available from http://www.dwaf.gov.za/iwqs/report.htm)

Consumer Satisfaction

WSAs are required to have a Consumer Service (Regulation 16 of Section 9 of the Water Services Act (No. 108 of 1997)) which can be used to monitor drinking water quality consumer comments and complaints, thereby providing valuable information on potential problems that may have gone unidentified.

While the costs of setting up an operational and compliance Drinking Water Quality Monitoring Programme may appear high to a WSA, significant efficiencies can accrue as a result of these programmes, including:

- Operational efficiencies (reduction in treatment costs *via* improved efficiency of stabilisation, optimisation of chemical addition during treatment (e.g. coagulant, chlorine) and reduction in pipe maintenance due to effective network monitoring and pre-emptive maintenance);
- Personnel efficiencies (reduced manpower requirements via improved efficiency of network management and water treatment processes).

Value Impact Assessment Case Studies indicate that, at the least Drinking Water Quality Monitoring Programmes pay for themselves, but in all likelihood will result in efficiencies and cost savings for WSAs (Mackintosh, de Souza, Wensley and Delport, 2004).

3.2.5 INCIDENT AND EMERGENCY RESPONSE

Notwithstanding the best possible raw water sources, adequate treatment infrastructure and optimal treatment processes, unexpected incidents can disrupt water supplies. Natural disasters such as floods, and man-made incidents, for example catchment chemical spills and bacteriological contamination, can significantly disrupt and impact on the quality of water services thus posing a significant health risk to consumers.

The Water Services Act (No. 108 of 1997) Section 5(4), states that in emergency situations, a WSA must take reasonable steps to provide basic water supply to any person within its area of jurisdiction and must do so at the cost of the authority. This can be achieved by having emergency protocols and communication plans in place.

Emergency protocols and communication plans ensure that during drinking water failures:

- Key stakeholders are kept fully informed;

- Roles and responsibilities of individuals and organisations are clearly outlined to avoid miscommunication and duplication of effort;
- Timeous interventions are taken to rectify the situation; and
- Affected communities are properly informed and have alternative safe drinking water for the duration of the problem.

Definition of a Drinking Water Quality Failure

The Water Services Act (No. 108 of 1997) states that drinking water quality should comply with prescribed National Drinking Water Standards (SANS 241 Drinking Water Specification. The ideal situation is where drinking water quality satisfies the SANS 241 Class I limits, suitable for lifetime consumptions. Where a water fails Class I limits, but is within the Class II limits, efforts are required to ensure that water quality is improved to within Class I limits. Importantly, when a constituent does not comply with SANS 241 Class II limits, this can be regarded as a failure and would pose a threat to consumers. Clear Maximum Allowable limits (Class II limits) are provided in Table 2 of SANS 241 for physical, organoleptic and chemical constituents.

Microbiological constituents (such as total coliforms, *E. coli*, and the protozoan parasites *Cryptosporidium* and *Giardia*) can cause the water to fail the Drinking Water Specification if they exceed the allowable compliance contribution specified in Table 1 of SANS 241. Furthermore, where a single microbiological test result exceeds the value given in SANS 241 column 5 of Table 1 (for example, *E. coli* > 1 count per 100 mL, or faecal coliform > 10 counts per 100 mL), and is confirmed as such by a further test, this is regarded as a drinking water quality failure and the required remedial actions and drinking water quality failure response shall follow.

Table 1 and 2 of the SANS 241: 2001 Drinking Water Specification are shown in Annexure 1 for reference.

Drinking water quality failures can be considered acute or chronic, depending on associated risks and/or concentrations of the constituents, and therefore require different management approaches.

Acute Drinking Water Quality Failure Response

Acute water quality failures are of a short duration, can do harm even with short exposure, and usually result from treatment process inefficiency, water works breakdown or outbreak of bacteriological and protozoan parasite contamination. Acute failures require immediate interventions and if properly managed, can avoid a significant threat to consumers. Examples of acute failures are outbreaks of *Cryptosporidium* and *Giardia*, and equipment breakdown resulting in overdosing treatment chemicals.

Regulation 5 of Section 9 of the Water Services Act (No. 108 of 1997), the Compulsory National Standards for the Quality of Potable Water, states:

Should the comparison of the results as contemplated in sub regulation (3) indicate that the water poses a health risk, the water services institution must inform the Director-General of the Department of Water Affairs and Forestry and the head of the Provincial Department of Health, and it must take steps to inform its consumers-

(a) that the quality of the water that it supplies poses a health risk;
(b) of the reasons for the heath risk;
(c) of any precautions to be taken by the consumers; and
(d) of the time frame, if any, within which it may be expected that water of a safe quality will be provided.

Three Alert Levels are recommended to respond to acute drinking water quality failures :

- Alert Level I (no significant risk to health): Routine problems including minor disruptions to the water system and single sample non-compliances (Internal WSA response only).
- Alert Level II (potential minor risk to health): Minor emergencies, requiring additional sampling, process optimisation and reporting/communication of the problem (Internal WSA response only).
- Alert Level III (potential major risk to health): Major emergencies requiring significant interventions to minimise public health risk (Engagement of an designated Emergency Management Team).

The recommended Drinking Water Failure response actions for Acute Failures are depicted in Figures 1a and b of Annexure 2.

<u>Chronic Drinking Water Quality Failure Response</u>

Chronic drinking water quality failures have cumulative effects, and usually cause harm due to prolonged exposure to a certain constituent. Chronic failures are a result of poor source water quality, inadequate treatment processes and poor distribution system infrastructure. Examples of chronic failures are continuous low-level failure of microbiological constituents, or total trihalomethane concentrations exceeding SANS 241 Class II limits which is related to high organic loadings in the raw water source.

Chronic raw water quality responses require a more co-operative governance approach, with a range of key stakeholders required for interventions. This could involve stakeholders such as Department of Water Affairs and Forestry, Catchment Management Agencies and Fora, Department of Environmental Affairs and Tourism, industrial bodies and local government.

3.2.6 DRINKING WATER QUALITY MANAGEMENT IN COMMUNITIES NOT YET SERVED WITH POTABLE WATER

In South Africa, approximately 5 million (11 %) of population do not have access to safe drinking water, the greatest proportion of which live in rural areas (Strategic Framework for Water Services, 2003). Whilst the government is making progress towards reducing water backlogs in the country, in the interim, the unserved population rely on rivers, streams, dams, springs, wetlands, boreholes and other raw water sources for drinking water and other domestic purposes. In most cases, the quality of these water resources is unsatisfactory or has not yet been determined.

Preventative Drinking Water Quality Management for the unserved communities focuses on protection of the catchment and raw water resource used by unserved communities, and measures that can be implemented to reduce incidents associated with unsafe water consumption in unserved communities.

Water Resource Assessments

Most communities rely on water sources for which the quality of that source is unknown. Determining the quality and quantity of water sources is an underlying requirement in identifying and addressing health risks resulting from consuming water from poor water quality sources. This can be achieved by implementing monitoring programmes and assessing water quality of water sources. Information gathered will be used to inform interventions to improve the situation including education awareness, boiling of water, chlorination, and alternative water supplies such as mobile water tanks.

The DWAF National Microbial Monitoring Programme monitors the microbial status of water resources in high health risk areas

DWAF (and future Catchment Management Agencies), as the custodian of the water resource, is responsible for regular catchment monitoring.

Community Health and Hygiene Training and Awareness

Health and hygiene education has been singled out as the most effective mechanism in preventing water-related illnesses. Health and hygiene education and awareness is aimed at changing/improving health and hygiene habits, thus serving as a barrier to water related diseases. It addresses several issues such as:

- Safe collection, transportation and storage of water;
- Eliminating bacteriological contaminants by training on low-technology point of use treatment methods, including boiling, use of household bleach or HTH granules and exposure to sunlight;
- Safe disposal of waste and faecal matter to prevent contamination of water resource.

Health and hygiene education is effective in preventing water-related illnesses

Drinking Water Quality Failures: Investigation of alternative supplies/methods

In cases of acute or chronic drinking water quality failures in unserved communities, alternative supplies and methods need to be investigated to reduce health risks associated with unsafe water use.

A number of alternative supplies and methods can be explored, including:

- **Point-of-use treatment methods**: In communities where no clean water sources are available, and contaminated water is routinely consumed, low-technology point of use treatment methods are recommended, including boiling, use of household bleach or HTH granules, or exposure to sunlight in suitable containers.

- **Preferential use of groundwater as a water source**: Where available, groundwater (boreholes/springs) may be used, because when sources are properly protected, bacteriological contamination is minimised.

- **Mobile water supplies**: Where water quality has deteriorated to such an extent that conventional methods such as boiling and adding disinfectants are inadequate, mobile water supplies/tanks should be provided, while interventions are undertaken to improve the situation.

3.3 SUPPORTING PROGRAMMES FOR THE DRINKING WATER QUALITY FRAMEWORK

Many actions are important in ensuring drinking water safety, but do not directly affect drinking water quality. These are termed Supporting Programmes and include basic elements of good practice to ensure that the system is sustainable and has the capacity to operate optimally and adapt to meet challenges.

3.3.1 AWARENESS AND TRAINING

The knowledge, skills, motivation and commitment of staff involved in Drinking Water Quality Management ultimately determine the ability of WSAs or WSPs to successfully operate a water supply system. It is thus important to ensure that the level of awareness, understanding and commitment to optimising and continually improving drinking water quality is developed and maintained.

Water Services Authority Employee Training

The training of employees in issues relating to drinking water quality is essential to the provision of a safe and reliable drinking water supply. Water treatment employees must be appropriately skilled

and trained in the management and operation of water supply systems as their actions can have a major impact on drinking water quality.

Employees should have a sound knowledge base from which to make informed operational decisions. This includes training in the methods and skills required to perform their tasks in an efficient and competent manner as well as the knowledge and understanding of the impact their activities can have on water quality.

Ideally, Drinking Water Quality Management training should be comprehensive, but at a minimum it should include:

- An understanding of preventative Drinking Water Quality Management from catchment to consumer;
- Knowledge of the treatment processes required to produce safe drinking water;
- Routine operating procedures and procedures for operating under drinking water quality failure conditions;
- Sampling procedures and the use of monitoring equipment to enable staff to collect representative samples, and
- Interpretation of drinking water quality results against standards.

WSA staff are required to be trained on all aspects of drinking water supply systems

Accredited training programmes and certification of operators are desirable. WSAs should utilise the services of the LGWSETA (Local Government & Water SETA) to build the capacity of their treatment works operators.

3.3.2 COMMUNITY INVOLVEMENT AND AWARENESS

Community consultation, involvement and awareness can have a major impact on public confidence in the water supply and the WSAs reputation. A communication programme including both consultation and education should be designed to provide active, two-way exchange of information to ensure that the consumers' needs and expectations are understood and are being satisfied.

Management of communication is particularly important in the event of an incident or emergency.

3.3.3 RESEARCH AND DEVELOPMENT

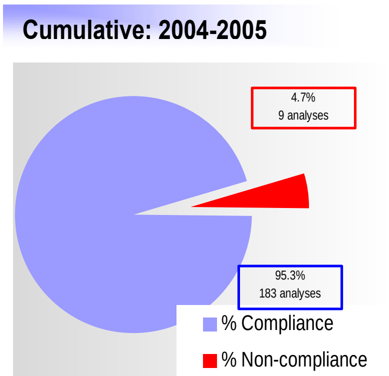
A commitment to conduct and participate in research aimed at improving knowledge of drinking water quality issues is important to ensure continual improvement. The Water Research Commission is involved in promoting and funding research into Drinking Water Quality Management in South Africa.

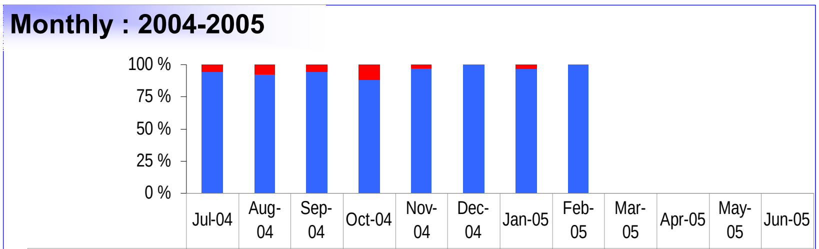
Ongoing research at WSA level is also necessary to increase understanding of the specific characteristics of individual water supply systems. Such research could include, for example, detailed analysis of temporal and spatial variations in source water quality.

3.3.4 DOCUMENTATION AND REPORTING

A system of regular reporting, both internal and external, is important to ensure that the relevant people receive information needed to make informed decisions about the management or regulation of drinking water quality. Reporting publicly on drinking water quality performance thus ensures a high level of transparency and public accountability. The following Drinking Water Quality Management reports are recommended for WSAs:

- *Monthly report (Operational monitoring report)* – This is usually a summary report of the compliance of the drinking water quality during the month. It is useful in assessing system's performance, treatment process efficiency and infrastructure problems. Monthly reports are also useful for benchmarking purposes.





	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04	Jan-05	Feb-05	Mar-05	Apr-05	May-05	Jun-05
Volume (Ml/d)	0.38	0.47	0.6	0.59	0.71	0.73	0.9	0.69				
Analyses	18	41	18	17	32	18	27	21				
% Non-compliance	5.6 %	7.3 %	5.6 %	11.8 %	3.1 %	0.0 %	3.7 %	0.0 %				
% Compliance	94.4 %	92.7 %	94.4 %	88.2 %	96.9 %	100.0	96.3 %	100.0				

Example of monthly Operational monitoring report

- *Quarterly report (Consultative audit report)* – This report is proposed to be used by Consultative Audit teams to assess compliance of each WSA with the *Compulsory National Standards for the Quality of Potable Water*. These audits can be used to determine required regulatory intervention, assess progress with achieving drinking water quality compliance, and recommend Municipal Infrastructure Grant (MIG) and Capacity Building Grant (CBG) funding where capacity is lacking.

- *Annual Report (Stakeholder information report)* – Annual reports should be produced and made available to consumers, regulatory authorities and stakeholders which summarise drinking water quality performance over the preceding year against numerical guideline values and regulatory requirements. The report should include targets for water services quality, performance against targets, and interventions undertaken to improve water services during the annual period.

A **Drinking Water Quality Management Information system** will be set up such that it includes facilities for the:

- Submission of drinking water quality monitoring programme details and water quality data. Water quality data submission must include manual capture as well as electronic importing options;
- Assessment and interpretation of drinking water quality data, including comparison of results against SANS 241 Drinking Water Specification;
- Tabular, graphical and spatial summary presentations of drinking water quality data. The system will use maps to allow users to locate their areas of interest, commencing with the national map to the level of towns. Tables, graphs/pie charts as well as the actual data can be easily linked to the monitored point to ensure a variety of data presentation options to meet the user's needs.

It is important that the Drinking Water Quality Management Information system will allow access by consumers and will thus have a user-friendly interface with on-line support.

A variety of customisable options will be available to present users with drinking water quality information at the correct level, for example a manager may only want to view summary information, or an exceedance report, while technical WSA staff may need the be able to view the raw data.

The Drinking Water Quality Management Information system will be aligned with existing DWAF data management systems, in particular the National Regulatory Information System.

3.3.5 FUNDING FOR DRINKING WATER QUALITY MANAGEMENT

In acknowledgement of institutional capacity problems hindering WSAs, a number of possible funding mechanisms are available to WSAs for implementation of Drinking Water Quality Management programmes.

Table 1: Funding mechanisms for Drinking Water Quality Management

Funding mechanism	Source of funds	Notes
WSA internal funding	WSA	Funds obtained from within the WSA exchequer from either commercial sources or from within the WSA budget.
Municipal infrastructure grant (MIG)	DPLG	Funding for basic service infrastructure investment. The funding requirement must be contained within the Integrated Development Plan (IDP) and Water Services Development Plan (WSDP) and requires a registration process as well as a feasibility study.
Special municipal infrastructure fund (SMIF)	DPLG	Special funding for innovative infrastructure investment (approximately 3% from MIG budget available). Access to funding is *via* a business plan.
Masibambane	DWAF	Donor and DWAF funding for both infrastructure development, and capacity and support to WSAs. Requires the compilation a business plan to access the funding.
Capacity building grant (CBG)	DPLG	Funding of WSA capacity support requirements. Requires the compilation a business plan to access the funding.
Equitable share	State Treasury	Unconditional grant made to WSA based on number of indigent population, which is used for the provision of services.
Donor funding	Direct from donors	Direct funding from donor countries and organisations for specific programmes.

3.4 REVIEW & AUDIT

3.4.1 DATA EVALUATION

Long-term Evaluation of Drinking Water Quality Data

The systematic review of monitoring results over an extended period enables assessment of overall performance against standards, regulatory requirements and service levels, identifies emerging problems and trends, and assists in determining priorities for improving drinking water quality.

3.4.2 DRINKING WATER QUALITY AUDITS

Provincial Consultative Audits

Since some WSAs are not yet adhering to the *Compulsory National Standards for the Quality of Potable Water*, a process needs to be initiated by Provincial or National Government to rectify this situation. Consultative audits, similar to those practised monthly in the Free State, need to be initiated in each province. These co-operative governance-oriented drinking water quality audits will not replace the required drinking water quality monitoring and self-regulation to be undertaken by WSAs, but are seen as an interim supportive measure to be undertaken until capacity is built at the local level and WSAs can undertake their mandated requirements of drinking water quality monitoring, management and communication.

Information arising from the Consultative Audits will be:

- Communicated to Provincial Drinking Water Quality Management Fora, where the problem areas identified through the above process are discussed and prioritised (ranked).
- Used to determine required regulatory intervention, assess progress with achieving drinking water quality compliance, and recommend Municipal Infrastructure Grant (MIG) and Capacity Building Grant (CBG) funding where capacity is lacking.

Regulatory Audits

DWAF, as the sector regulator, will undertake Drinking Water Quality Regulatory Audits (scheduled or random), where a comprehensive assessment of Drinking Water Quality Management in a specific WSA is proposed to be undertaken.

Where there is lack of adherence to the monitoring requirements specified in the Water Services Act (No. 108 of 1997), or there is evidence of drinking water quality problems of an acute or chronic nature, DWAF will intervene in a supportive and developmental manner as far as possible. When capacity problems are identified that may prevent a Water Services Authority from being compliant with regulations, avenues of support will be explored until such time that the WSA is capable of being compliant. In cases of reluctance or negligence by the WSA management to rectify identified non-compliant activities relating to Drinking Water Quality Management, while being capable of doing so, punitive actions will be considered.

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ANNEXURE 1: SANS 241: 2005 DRINKING WATER SPECIFICATION

Table 1 — Microbiological Safety Requirements

1	2	3	4	5
Determinand	**Unit**	**Allowable compliance contribution**[a]		
		95% of samples, min.	**4% of samples, max.**	**1% of samples, max.**
		Upper limits		
E. coli[b] or	count/100 mL	Not detected	Not detected	1
Thermotolerant (faecal) coliform bacteria[c]	count/100 mL	Not detected	1	10

[a] The allowable compliance contribution shall be at least 95 % to the limits indicated in column 3, with a maximum of 4 % and 1 %, respectively, to the limits indicated in column 4 and column 5. The objective of disinfection should, nevertheless, be to attain 100 % compliance to the limits indicated in column 3.

[b] Definitive, preferred indicator of faecal pollution.

[c] Indicator of unacceptable microbial water quality, could be tested instead of *E. coli* but is not the preferred indicator of faecal pollution. Also provides information on treatment efficiency and aftergrowth in distribution networks.

Table 2 — Physical, Organoleptic and Chemical Requirements

1	2	3	4	5
Determinand	**Unit**	**Class I (recommended operational limit)**	**Class II (max. allowable for limited duration)**	**Class II water consumption period,**[a] **max.**
Physical and organoleptic requirements				
Colour (aesthetic)	mg/L Pt	< 20	20 – 50	No limit[b]
Conductivity at 25 °C (aesthetic)	mS/m	< 150	150 – 370	7 years
Dissolved solids (aesthetic)	mg/L	< 1 000	1 000 – 2 400	7 years
Odour (aesthetic)	TON	< 5	5 – 10	No limit[b]
pH value at 25 °C (aesthetic/ operational)	pH units	5,0 – 9,5	4,0 – 10,0	No limit[c]
Taste (aesthetic)	FTN	< 5	5 – 10	No limit
Turbidity (aesthetic/operational/ indirect health)	NTU	< 1	1 – 5	No limit[d]
Chemical requirements — macro-determinand				
Ammonia as N (operational)	mg/L	< 1,0	1,0 – 2,0	No limit[d]
Calcium as Ca (aesthetic/operational)	mg/L	< 150	150 – 300	7 years
Chloride as Cl^- (aesthetic)	mg/L	< 200	200 – 600	7 years
Fluoride as F^- (health)	mg/L	< 1,0	1,0 – 1,5	1 year

Table 2 — Physical, Organoleptic and Chemical Requirements (continued)

1	2	3	4	5
Determinand	**Unit**	**Class I (recommended operational limit)**	**Class II (max. allowable for limited duration)**	**Class II water consumption period,[a] max.**
Magnesium as Mg (aesthetic/ health)	mg/L	< 70	70 – 100	7 years
(Nitrate and nitrite) as N (health)	mg/L	< 10	10 – 20	7 years
Potassium as K (operational/health)	mg/L	< 50	50 – 100	7 years
Sodium as Na (aesthetic/health)	mg/L	< 200	200 – 400	7 years
Sulfate as $SO_4^{=}$ (health)	mg/L	< 400	400 – 600	7 years
Zinc as Zn (aesthetic/health)	mg/L	< 5,0	5,0 – 10	1 year
Chemical requirements — micro-determinand				
Aluminium as Al (health)	µg/L	< 300	300 – 500	1 year
Antimony as Sb (health)	µg/L	< 10	10 – 50	1 year
Arsenic as As (health)	µg/L	< 10	10 – 50	1 year
Cadmium as Cd (health)	µg/L	< 5	5 – 10	6 months
Total Chromium as Cr (health)	µg/L	< 100	100 – 500	3 months
Cobalt as Co (health)	µg/L	< 500	500 – 1 000	1 year
Copper as Cu (health)	µg/L	< 1 000	1 000 – 2 000	1 year
Cyanide (recoverable) as CN^- (health)	µg/L	< 50	50 – 70	1 week
Iron as Fe (aesthetic/ operational)	µg/L	< 200	200 – 2 000	7 years[b]
Lead as Pb (health)	µg/L	< 20	20 – 50	3 months
Manganese as Mn (aesthetic)	µg/L	< 100	100 – 1 000	7 years
Mercury as Hg (health)	µg/L	< 1	1 – 5	3 months
Nickel as Ni (health)	µg/L	< 150	150 – 350	1 year
Selenium as Se (health)	µg/L	< 20	20 – 50	1 year
Vanadium as V (health)	µg/L	< 200	200 – 500	1 year
Chemical requirements — organic determinand				
Dissolved organic carbon as C (aesthetic/health)	mg/L	< 10	10 – 20	3 months[e]
Total trihalomethanes (health)	µg/L	< 200	200 – 300	10 years[f]
Phenols (aesthetic/health)	µg/L	< 10	10 – 70	No limit[b]

[a] The limits for the consumption of class II water are based on the consumption of 2 L of water per day by a person of mass 70 kg over a period of 70 years. Columns 4 and 5 shall be applied together.
[b] The limits given are based on aesthetic aspects.
[c] No primary health effect – low pH values can result in structural problems in the distribution system.
[d] These values can indicate process efficiency and risks associated with pathogens.
[e] When dissolved organic carbon is deemed of natural origin, the consumption period can be extended.
[f] This is a suggested value because trihalomethanes have not been proven to have any effect on human health.

Table A.1 — Suggested minimum frequency of sampling (Water Works Final sample)

1	2
Population served	**Frequency[a]** min.
More than 100 000	10 every month per 100 000 of population served
25 001 – 100 000	10 every month
10 001 – 25 000	3 every month
2 500 – 10 000	2 every month
Less than 2 500	1 every month

[a] During the rainy season, sampling should be carried out more frequently.

SANS 241: 2005: *Drinking Water*, Edition 6.

ANNEXURE 2: DRINKING WATER FAILURE RESPONSE MODEL

Figure 1a: Acute Drinking Water Quality Failure Model - Response actions

ALERT LEVEL I - ROUTINE PROBLEMS

These incidents are minor disruptions to the water system, associated with process inefficiency or sample contamination. Anticipated to be solved within 24 hrs or less.

Internal Reporting and Communication required

STEP 1: ROUTINE MONITORING FAILURE (NON COMPLIANCE WITH SANS 241:2001 CLASS II)

Operations to:

- Flag the result and inform Water Services Manager within 24 hrs of the release of the result.
- Undertake a resample to confirm the result.
- Operations to investigate treatment process efficiency and optimise the treatment process.

STEP 2: RESAMPLE RESULT CLEAR

Resample result complies with Specification.

Operations to:

- Inform Water Services Manager within 24 hrs of the result.
- Ensure continuous optimisation of treatment process.

No further action required.

RESAMPLE DOES NOT COMPLY

ALERT LEVEL II - MINOR EMERGENCIES

More significant problems anticipated to be solved within 72 hours or less. For example, low levels of total and faecal coliform bacteria or failure of chemical feeder system.

Internal Reporting and Communication required.

STEP 3: RESAMPLE RESULT FAILS

Operations to:

- Inform the Water Services Manager within 24 hrs of data release.
- Further assess treatment process including process specialist input.
- Optimise the treatment process.

The Water Services Manager to:

- Request further monitoring including distribution system to establish the extent of the problem.

STEP 4: ADDITIONAL SAMPLE RESULTS CLEAR

Additional sample result complies with Specification.

Operations to:

- Inform Water Services Manager within 24 hrs of the result.
- Confirm whether the problem was due to treatment process inefficiency or sample contamination.
- Ensure continuous optimisation of treatment process.
- Phase out additional monitoring.

ADDITIONAL RESAMPLE DOES NOT COMPLY

ALERT LEVEL III - MAJOR EMERGENCY

These incidents are significant disruptions to the drinking water system and are anticipated to require more than 72 hours to be resolved. Major emergencies may require interventions to be immediately implemented to minimise health risks such as boiling water before use, or the implementation of alternative water supplies.
For example, failure of treatment works, widespread bacteriological contamination.

Requires continuous monitoring, reporting and communication and active Emergency Management Team.

Figure 1b: Acute Drinking Water Quality Failure Model - Response actions (continued)

ALERT LEVEL III - MAJOR EMERGENCY

These incidents are significant disruptions to the drinking water system and are anticipated to require more than 72 hours to be resolved. Major emergencies may require interventions to be immediately implemented to minimise health risks such as boiling water before use, or implementation of alternative water supplies.
For example failure of treatment works, widespread bacteriological contamination outbreak.

Requires continuous monitoring, reporting and communication and active Emergency Management Team.

STEP 5: ADDITIONAL SAMPLE RESULTS FAIL (INCLUDING DISTRIBUTION)

Operations to:
- Inform the Water Services Manager within 24 hrs of data release.
- Continue monitoring the system including raw water to identify source.

The Water Services Manager to:
- Request the District Disaster Management Unit to assemble the Emergency Management Team within 24 hrs of the data release.
- Liaise with the Technical Director and the Municipal Manager as required.
- Inform Director General of the Department of Water Affairs and Forestry and head of the Provincial Department of Health of the problem.

→

STEP 6: ENGAGEMENT OF THE EMERGENCY TEAM

The Emergency Team to:
- Meet on daily basis to discuss the progress.
- Investigate source of the problem thoroughly.
- Investigate the magnitude of the problem and associated impacts.
- Identify areas/communities at risks.
- Decide on the fitness for use of water by the community
- Investigate alternative water supply.
- Investigate best possible way to inform the community.
- Engage with process specialists to resolve the problem.

↓

STEP 6: ENGAGEMENT OF THE EMERGENCY TEAM (CONT.)

The Water Services Manager to:
- inform the Technical Director and the Municipal Manager of the progress of the interventions and time frame.
- inform the community of the problem as required by the *Compulsory National Standards for the Quality of Potable Water*.

The Municipal Manager to:
- inform Director General of the Department of Water Affairs and Forestry and head of the Provincial Department of Health of progress that has been made so far, interventions and time frame.

→

STEP 7: EMERGENCY RESOLVED - RESULTS COMPLY WITH SANS 241:2001 SPECIFICATION

Operations to:
- Phase out additional drinking water emergency monitoring.

The Emergency Team to:
- Prepare notifications advising the end of emergency, the cause of the incident and actions taken to minimise future occurences.
- Finalise the investigation report, stating the cause of the problem and preventive measures to be taken to prevent the same problem.

The Water Services Manager to:
- Inform the Technical Director, Municipal Manager, community, Director-General of DWAF and Head of Provincial DoH of the end of emergency.

↓

STEP 8: REVIEW EMERGENCY PROTOCOLS

The Emergency Team to:
- Revisit the process.
- Prepare documentation and reporting of the emergency.
-

The Water Services Manager to:
- Identify amendments to the existing protocols.
- Retrain staff in updated emergency protocols.

ANNEXURE 3: LIST OF ABBREVIATIONS

CBG	Capacity Building Grant
CBO	Community Based Organisation
CMA	Catchment Management Agency
CMF	Catchment Management Forum
DoH	Department of Health
DLG	Department of Local Government
DPLG	Department of Provincial and Local Government
DWAF	Department of Water Affairs and Forestry
DWQ	Drinking water quality
DWQM	Drinking Water Quality Management
LGWSETA	Local Government & Water SETA
MIG	Municipal Infrastructure Grant
NDMC	National Disaster Management Centre
NGO	Non-Governmental Organisation
NWA	National Water Act
NWRS	National Water Resources Strategy
PHAST	Participatory Hygiene and Sanitation Transformation
SAAWU	South African Association of Water Utilities
SALGA	South African Local Government Association
SANS	South African National Standard
SMIF	Special Municipal Infrastructure Fund
SWOT	Strengths, Weaknesses, Opportunities and Threats
WRC	Water Research Commission
WSA	Water Services Authority
WSDP	Water Services Development Plan
WSP	Water Services Provider

ANNEXURE 4: MEMBERS OF THE DWQM TASK AND DRAFTING TEAMS

The participation of the Drinking Water Quality Management Drafting and Task Teams in the drafting and review of the Drinking Water Quality Framework is gratefully acknowledged.

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