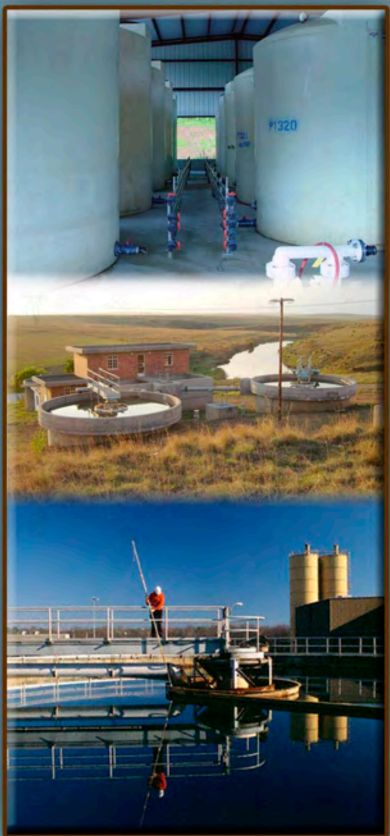
VOLUME 2: GUIDELINES

Guidelines for the Assessment of the Compliance of South African Potable Water Supply with Accepted Drinking Water Quality Standards and Management Norms

Maggy NB Momba
& Chris D Swartz



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WATER RESEARCH COMMISSION

GUIDELINES FOR THE ASSESSMENT OF THE COMPLIANCE OF SOUTH AFRICAN POTABLE WATER SUPPLY WITH ACCEPTED DRINKING WATER QUALITY STANDARDS AND MANAGEMENT NORMS

VOLUME 2: GUIDELINES

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Report to the
Water Research Commission

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Foreword

Volume 2 of the project report contains the guidelines and procedures that were developed for Water Services Providers (WSPs) and Water Supply Authorities (WSAs) to assist them with assessment of the compliance of their drinking water supply systems with accepted drinking water quality standards and management norms. These guidelines aim at providing South African potable water providers with the required water quality targets and a set of other operational and management norms, and a tool that could be used to identify the reasons for non-compliance and suggest solutions to any problems experienced which are preventing compliance to these guidelines and norms.

A *Diagnostic Tool* was developed to establish the reasons for non-compliance, and to provide remedial measures that can be used to achieve compliance. Compliance here not only relates to technical compliance, but also, and even more importantly in many instances, to compliance with non-technical (mostly human resources related) norms. A further important objective of the development of this *Diagnostic Tool* was that it can be used to establish not only symptomatic problems, but also the underlying causes. Addressing the underlying causes leads to more efficient and sustained solutions to the problems.

The *Diagnostic Tool* contains a set of criteria and norms to be used for the judgement of compliance of potable water providers. Differences existing across the country, such as different water types, geography and management structures were all taken into account.

The *Diagnostic Tool for Technical Compliance* is used to perform an assessment of technical treatment plant measurements, which includes design aspects, quality control, process control, plant monitoring, maintenance aspects and risk management. A main focus point is to measure the chemical and microbiological quality of the final water against the South African National Standard 241 specifications for drinking water.

The *Diagnostic Tool for Non-Technical Compliance* uses as a departure point an audit of all management and human resources issues involving the drinking water supply function within the WSP or WSA. It therefore also includes the human resources, financial and planning departments of the WSP. At water treatment plant level, it assesses the human resources issues involved in the plant management for process control and also support personnel functions. This includes the very important aspects of process controller classification, job conditions, motivational levels and inter-relationships (communication). Specific aspects that are investigated are the financial and budgeting systems used, the communication systems used, the safety, health and the environment, and the community involvement and awareness.

For every area of non-compliance, the causes and/or underlying problems are identified and flagged for further attention and action. Corrective and preventative measures are then proposed for each of these causes and problems and re-measurement of the total program undertaken to eliminate or manage these issues.

The diagnostic tool is intended for use by water care managers, engineers and supervisors to ensure compliance of their water treatment plants. The full assessments can be performed as often as is required, but would normally be conducted on a yearly basis. Re-measurements to obtain compliance should be performed on an on-going basis until compliance is achieved.

Executive Summary

In the research report of project 1668 (***Volume 1: Research Report*** *(WRC Report 1668/1/09*)), the identification of technical and non-technical problems and challenges experienced at water treatment plants led to the development of comprehensive diagnostic tools which spell out the step-by-step procedures and corrective actions needed to ensure the supply of safe water to non-metropolitan communities. These diagnostic tools for technical and non-technical compliance of water treatment plants were developed to perform an assessment of a water treatment plant and establish compliance with water quality standards and management norms.

Diagnostic tool for technical compliance **–** In this diagnostic tool, a detailed assessment of technical treatment plant measurements includes design aspects, quality control, process control, plant monitoring, maintenance aspects and risk management. The quality of the final water is measured against the specifications of South African National Standard (SANS) 241. For every area of non-compliance, the causes and/or underlying problems are identified and flagged for further attention and action. Corrective and preventative measures are then proposed for each of these causes and problems, and re-measurement of the total program is then undertaken to eliminate or manage these issues.

Diagnostic tool for non-technical compliance **–** This tool is used to perform an audit of the management components that play an important role in the sustainability of a water treatment plant. The assessment focuses on management issues and practices, human resources, the financial aspect, the communication systems in place, safety, health and environmental quality as well as community involvement and awareness. Problem areas that are identified during the assessment are then flagged and corrective measures proposed. A report is then sent to the authorities, and compliance re-assessed by performing a new re-measurement from the first step involving the human resources assessment. In this way, the problems resulting in non-compliance can be eliminated or addressed and preventative measures put in place, so as to ensure that these challenges can be managed effectively by the plant manager or supervisor.

The diagnostic tools were evaluated through on-site visits to 45 small water treatment plants in Eastern Cape, KwaZulu-Natal, Mpumalanga and Western Cape. The test mostly focused on quality control, process control and plant monitoring. This was due to the fact that most process controllers on duty during the visits were not able to provide the required information. However, most of the information regarding the non-technical aspects of the plants was obtained during workshops.

Step-wise procedures for performing a compliance assessment of water treatment plants

Compliance assessment using the technical diagnostic tool

The technical diagnostic tool developed during this study chronicles technical compliance assessments. It also shows corrective actions to be taken in cases of anomalies and can be used as a scoring guide. The essence of the technical diagnostic tool is to make information on the various aspects of the assessments widely available in order to canvass better understanding of the step-by-step procedures required for the eventual supply of safe water.

For the water treatment plant measurement, a detailed assessment of design, operational monitoring, compliance monitoring, plant monitoring, maintenance monitoring and risk management practices should be undertaken.

- *Assessment of design and operational monitoring practices* – The design should be assessed in terms of the availability and functioning of the mixing, flocculation, sedimentation, and filtration equipment. In each case, the mixing equipment should be checked for the duration and intensity of mixing, including accurate dosage of chemicals, whereas the flocculation equipment should be checked for the type and rapidity of floc formation, the condition of the dosing system, the calibration of the dosing rate including the availability of a backup dosing pump and the maintenance of flocculation equipment. The assessment of the sedimentation equipment should consider whether parameters such as short circuiting, retention time, settling velocity, maintenance work and sludge and backwash-water disposal are within acceptable standards. Filtration should be checked for the effectiveness of valves, filter nozzles, filtration rate, length of filter and the requirement of chlorine to prevent algae growth of lime and to increase pH and removal of metal, as well as whether turbidity of filtered water falls within the recommended limits.

- *Assessment of plant and final water monitoring practices* – Information on daily activities in water treatment plants should be obtained for the purpose of prompt identification of deviations or anomalies. Such information should include operating practices, measurement of flow rate, lime and alum doses, measurement and interpretation of turbidity, pH, temperature, chlorine dose and the state of the filters. Information may be obtained during a tour of the plant as well as interviews with process controllers and plant superintendants. In obtaining information, inspection of infrastructure and equipment noting unusual noises or smells is important. Process controllers are required to take notes of irregular observations in the plant logbook for eventual action by the plant manager or supervisor. Information on final water quality must also be obtained and recorded from various sampling points in terms of the concentration of free chlorine residual and the presence or absence of faecal indicator bacteria.

- *Assessment of maintenance practices* – Critical issues to be considered when assessing maintenance practices are the availability of spare-parts and back-up services, communication lines and facilities between the plant and management, suppliers and service providers, availability and ease of access to funds for maintenance, and accessibility to plant by motor vehicles (e.g. delivery trucks).

- *Assessment of risk management practices* – A Risk based approach for the identification of hazards from the catchment to the point of consumption including mitigation strategies must be established. All relevant measurements such as the quality of settled and filtered water and the quality of final water at the point of treatment and the point of use should comply with SANS 241.

- *Documenting and scoring of problem areas* – For all cases mentioned above, a listing and description of all the problem areas, including implications and consequences emanating from the problems, must be documented in order of priority. The scoring of the problem areas on the scale of one to five should be reflected as indicated below.

1	Insignificant Consequence
2	Minor Consequence
3	Moderate Consequence
4	Major Consequence
5	Catastrophic Consequence

- *Corrective and preventative measures for technical compliance* – Once the scoring is completed, corrective and preventative measures must be actioned and subsequent re-measurement performed by repeating the whole technical assessment, with emphasis on problem areas identified, and a continuation of the repeat process until full compliance is achieved. As guidance, a list of corrective and preventative measures for some of the most common problems experienced at water treatment plants is provided in this document.

Compliance assessment using the non-technical diagnostic tool

The non-technical compliance assessment should be predicated on management issues that are vital for the sustainability of water treatment plants. The assessment should therefore target such management issues and practices as human and financial resources, communication systems, community involvement and awareness, health, safety and environmental factors. The essence of the non-technical diagnostic tool is to make information on the various aspects of the assessments widely available in order to canvass better understanding of the management conditions required for the eventual supply of safe water.

- *Audit of management issues* – The management issues should emphasise plans for preventative strategies for drinking water management, recruitment of plant personnel, in-service training and job description as well as a comprehensive funding strategy. Tactical plans should emphasise strategies for maintenance and asset management, communication and general oversight of the plants during emergencies. The operational plan typifies the monitoring of attendance of process controllers including the use of a clock-in-system, an arrangement for substitute personnel when any of the operators is ill, absent or away on other official business. This plan should also specify the job requirements and responsibilities of supervisors and process controllers.

- *Audit of management practices* – Issues around management practices are: assessment of local and international management practices, assessment of personnel at the plant, qualification, training needs and career development including the assessment of working conditions of staff and classification of the plant. The understanding and implementation of local and international best practices are useful. Assessment of personnel should entail information on shift workers including guidelines/rules for their deployment. The relevant qualifications in relation to job fit and conditions of service including salaries and medical aid schemes are also critical issues for consideration. Other pertinent incentives should consist of the following: leave, retirement and pension benefits, strategies for in-service training and career advancement, conflict management as well as management and payment of overtime. Information on the type and category of classification of the plants must be readily available.

- *Audit of financial systems* – This includes assessment of financial, information sharing and procurement systems and should specify adequacy of funds for maintenance and overtime, communication channels between the financial and water care sections, meetings held and how decisions are taken and whether the minutes of meetings are freely available. The procurement system should be judged in terms of transparency, honesty and the involvement of the water section in the adjudication of tenders.

- *Audit of communication systems* – The audit of communication systems should encompass internal and external communication systems in terms of the effectiveness of communication channels between management and lower level process controllers, between management and municipalities or departments and consumers.

- *Audit of safety, health and environmental quality* – These parameters should be assessed in terms of strategies in place to ensure normal operations during incidents and emergencies including chlorine leaks, as well as the safety of process controllers on duty. Availability and accessibility of fire extinguishers must be guaranteed. Control measures that identify risks and mitigation strategies as well as plans to improve the quality of the working environment in order to enhance service delivery must be a source document.

- *Community involvement and awareness* are important factors in ensuring the supply of safe drinking water. Consequently, interface of water management staff and local communities is necessary to address community concerns in all their ramifications.

- *Documenting and scoring of problem areas* – For all cases mentioned above, a listing and description of all the problem areas including implications and consequences emanating from the problems must be documented in order of priority. The scoring of the problem areas on the scale of one to five should be reflected as indicated above.

- *Corrective and preventative measures for non-technical compliance* – The corrective measures and preventative measures are then initiated at the plant, and as soon as all these have been completed, re-measurement is conducted by repeating the whole technical compliance assessment, but this time concentrating on the problem areas that were identified during the first assessment, and establishing whether compliance has now been achieved/restored. This process is continued until all the problem areas have been eliminated and there is full compliance. A list of practical corrective and preventative measures for non-technical issues is highlighted in this document.

Scored and weighted system for technical and non-technical compliance

The overall compliance rating of a water treatment plant will be based on a scoring system according to the identified criteria and norms in this document. This is carried out separately for technical compliance and non-technical compliance to ensure rapid assessment of whether the main problems at the treatment plant (if applicable) lie within the technical or non-technical (management) area.

Because certain compliance criteria are more important than others, a weighting system is used whereby weight is given to each of the compliance sections. These weights should be determined by a panel of water treatment experts and regulation authorities, and should be revised on a regular basis and when necessary. The proposed weight systems for technical and non-technical compliance are provided in this document.

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CHAPTER 1

INTRODUCTION

Responsibility for the safety of drinking water supplied to consumers is shared by both the Water Services Authorities (WSAs) and the Water Services Providers (WSPs). If the goal is to provide safe drinking water, it is necessary to deal with both the management of technical and non-technical issues related to the compliance of water treatment plants with accepted drinking water quality norms.

The survey conducted on the compliance of 45 small water treatment plants located in Eastern Cape, KwaZulu-Natal, Mpumalanga and Western Cape provinces has revealed that most of the plants are facing challenges in terms of technical and non-technical compliances with the existing and generally accepted drinking water quality norms. This chapter addresses the above challenges by providing step-wise procedures and/or actions on how each of these technical and non-technical problems should be solved by non-metropolitan WSPs.

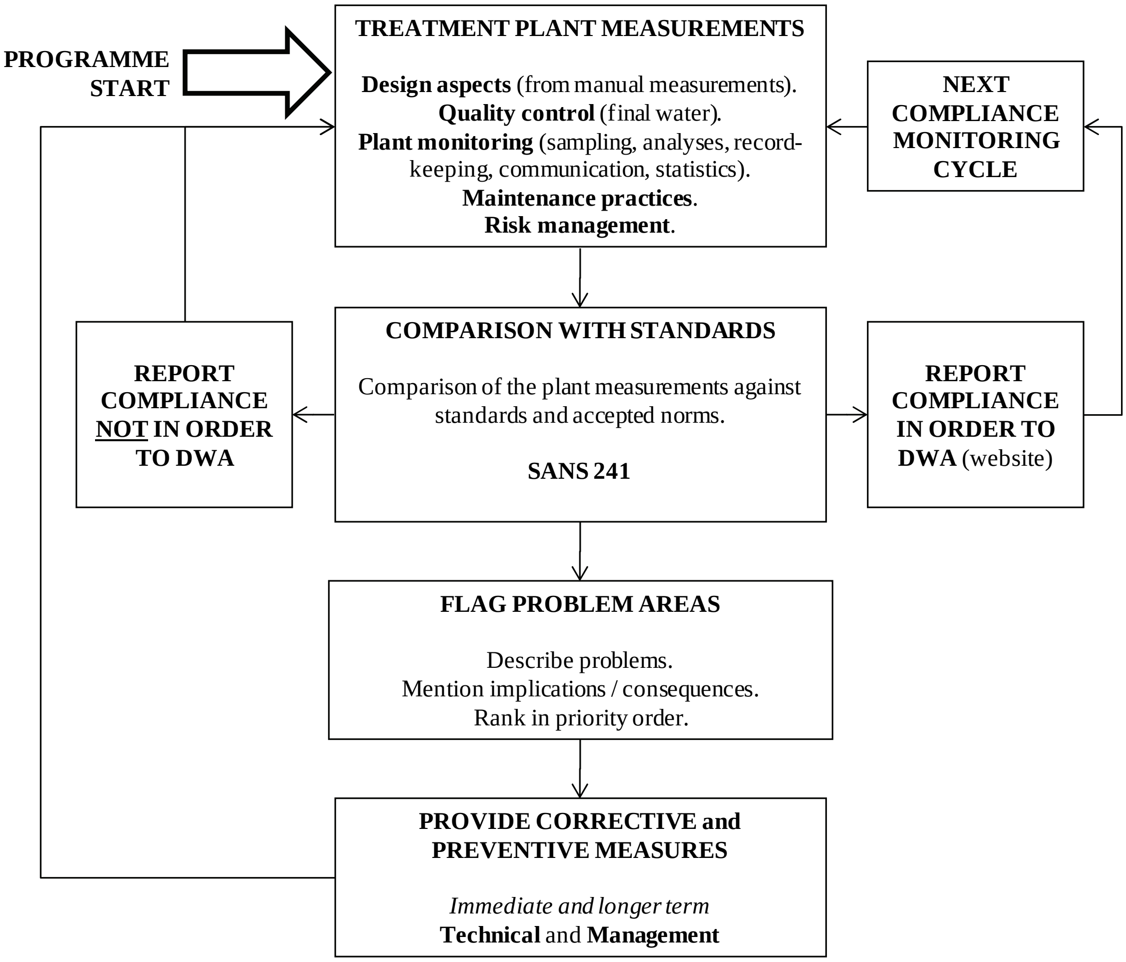
The practical procedures for the management of technical and non-technical issues presented in this document should be read in conjunction with other important documents and guidelines published by the Department of Water Affairs (DWA), formerly the Department of Water Affairs and Forestry (DWAF), the South African National Standard (SANS 241) and the Water Research Commission (WRC) (see Appendix A of ***Volume 1: Research Report*** (WRC Report No. 1668/1/09) for a list of most important documents).

CHAPTER 2

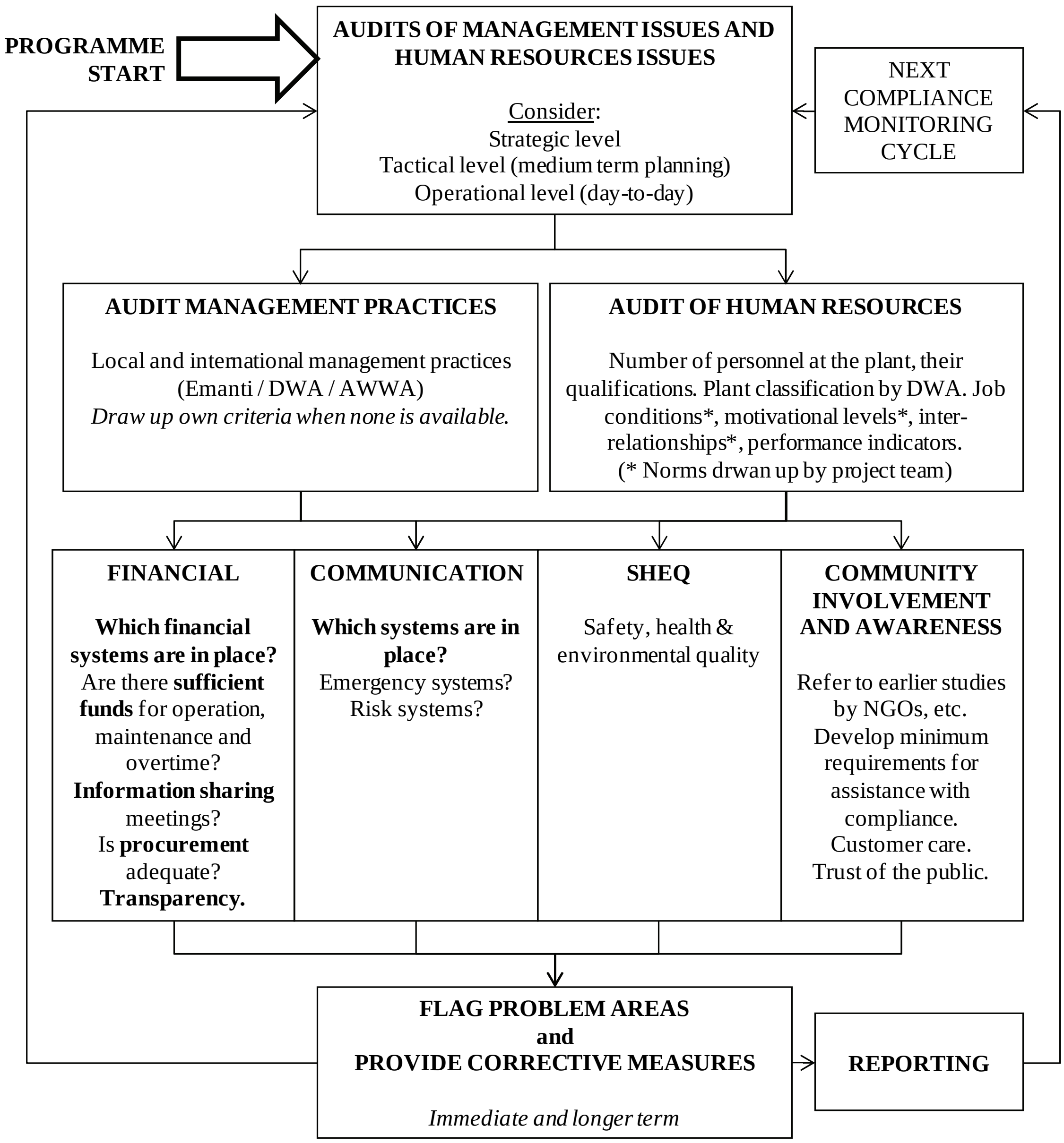
A DIAGNOSTIC TOOL FOR TECHNICAL AND NON-TECHNICAL COMPLIANCE OF WATER TREATMENT PLANTS

2.1 Procedure for Performing a Compliance Assessment of a Water Treatment Plant Using the Diagnostic Tools

When performing an assessment of a water treatment plant to establish compliance, the two diagnostic tools developed in this project, the technical diagnostic tool and non-technical diagnostic tool, should be used. The sequences of processes to be followed when using the two tools are shown in as flow charts below.



FRAMEWORK FOR THE DIAGNOSTIC TOOL FOR TECHNICAL COMPLIANCE



FRAMEWORK FOR THE DIAGNOSTIC TOOL FOR NON-TECHNICAL COMPLIANCE

The tools provide the flow diagram of observations and measurements to be performed and actions to be taken during the compliance assessment of the plant. These observations, measurements and actions to be taken are described below in a sequential order, according to the flow paths recommended in the tools.

2.2 Technical Compliance Assessment

2.2.1 STEP 1: Treatment plant assessment

Perform a detailed assessment of the water treatment plants and unit treatment processes consisting of design aspects, operational monitoring, compliance monitoring, plant monitoring, monitoring of maintenance practices, and monitoring of risk management practices. The following guidelines for performing this assessment are also reported in (Swartz, 2000).

2.2.1.1 Step 1A: Assessment of design aspects

a. Mixing equipment

Is the mixing intensity sufficient? Is the duration of rapid mixing sufficient/not too long? Can rapid mixing be improved by minor modifications? Are chemicals dosed at the correct point?

b. Flocculation equipment

- *Effectiveness* – Is good floc formation and floc growth observed? Does the floc settle effectively in a beaker? Is there any break-up of floc? How rapid is the floc formation? Is any polyelectrolyte or weighting agent required to improve the settleability or strength of the flocs?
- *Dosage* – Is the dosing system in good working order? Can the dosing rate be adjusted? Is the make-up solution mixed thoroughly? Can the dosing rate be calibrated? Are there spare dosing pumps for back-up? Are the plant personnel capable of operating and performing basic maintenance on dosing pumps?
- *Energy consumption* – Can mechanical flocculation be replaced by hydraulic flocculation?
- *Amount of maintenance work* – How much effort/time is needed to clean flocculation channels? How frequently must this be done? What service facilities are available for the maintenance of mechanical flocculation equipment?

c. Sedimentation equipment

- *Effectiveness* – Can any floc carry-over from the settling tank be observed? What is the overflow turbidity or concentration of suspended solids? Are there any current effects? Is there any short-circuiting in the sedimentation tank? Is the retention time in the tank sufficient? Are settling velocities adequate? Are overflow velocities within the design range? Do wind and sun have an effect? Does growth of algae pose a problem? Are the inlet arrangements designed to prevent floc break-up or currents?
- *Amount of maintenance work, including the renovation of the equipment and parts* – Can the tank (or one of the tanks) be taken out of commission for cleaning or maintenance?
- *Sludge and backwash-water disposal* – Are the sludge draw-off facilities adequate? Is the sludge disposed of in an environmentally acceptable manner?

d. Filtration equipment

- *Effectiveness* – Are the following factors effective? Operation of valves; robustness of filter nozzles; backwash pump and blower; correct medium in use; protection against corrosion; distribution system (under-drainage).
- *Requirements of pre-treatment* – Are any flocculants required? Is chlorine required to prevent algae growth or to oxidise metals such as iron? Are lime or soda-ash required to increase pH for removal of metals?
- *Construction cost* – What is the cost of civil structures? What is the cost of mechanical/ electrical equipment?
- *Filtration rate* – Calculate the filtration rate under normal loading and under peak loadings – does it fall within the design range? Are the filter(s) overloaded? Can any modifications be made to allow higher filtration rates?
- *Effectiveness of the filtration system* – Is the turbidity of filtered water within the recommended limits?
- *Length of filter runs* – How long can a filter run be maintained under varying loadings from the flocculated or settled water? Can longer filter runs be obtained by addition of a polyelectrolyte? Is backwashing performed on a routine basis or when a certain head loss is reached?

- *Amount of water used for backwashing* – What percentage of the water treated by the plant is required for backwashing? Will the additional use of air reduce this volume of backwash water? Is the backwash water recycled (after settling)? Is the backwashing procedure optimised? Has the process controller been shown how (and why) to backwash?
- *Amount of maintenance work* – How much effort and time is required to replace media, to clean and replace nozzles and to clean distribution laterals and slow sand filters? Are there standby filtration or backwash pumps?

e. Other important aspects

- *Temperature and other weather conditions* – Is sufficient protection provided against corrosion, floods, freezing temperatures, rain, and gale force winds?
- *Conditions of material supply* – Are the materials tested? Is the quality checked?
- *Land occupied and location* – Is there space for extension or upgrading of the plant? Are the access routes and communication routes adequate? What is the long term land use?
- *Technical strength and managing ability* – Are management and operation sufficient to ensure long-term sustainability of the present plant and any planned extensions/upgrades? Are attempts made to improve the management, operation and maintenance of the plant?

2.2.1.2 Step 1B: Assessment of operation monitoring practices

a. Coagulation and flocculation

Do the process controllers know how much they are dosing (even qualitatively)?
Can required dosages be calculated by the process controllers? Can the process controllers adjust the dosage rates and monitor how much is dosed? Are they familiar with the basics of coagulation and flocculation for water clarification? Do they have a programme for monitoring floc formation?

b. Sedimentation

Is the floc blanket observed and dislodging practices based thereon? Is the overflow weir kept clean? Is the flow of more than one sedimentation tank distributed evenly?

c. Filtration

Is backwashing performed properly (at the right time and according to the correct procedure)? Is the quality of the filtrate monitored on a regular basis? Are excessive head loss development or turbidity breakthrough monitored?

d. Disinfection

Is the chlorine dosed according to previously determined chlorine demand and/or by maintaining acceptable chlorine residual in the final water? Is the chlorine residual measured correctly and at the suggested frequency?

e. Stabilisation

Is the stability of the final water determined? Is the process controller familiar with the reason for stabilisation and how it can be affected and controlled?

2.2.1.3 Step 1C: Assessment of plant monitoring practices

Obtain information on the practical activities undertaken on a daily basis in the water treatment plants. These include:

- Tour of the plant and identification of the various unit processes.
- Interview the process controllers and plant superintendent about operating practices.
- Flow rate measurement using the V-notch weir if the plant does not have a flow meter.
- Measurement of lime and alum doses.
- Jar tests to determine the optimum aluminium sulphate and lime doses.
- Cascade test to investigate the effect of velocity gradients and retention times for flocculation on clarifier performance.
- Measurement and interpretation of turbidity, pH and temperature at each step in the treatment process.
- Measurement of chlorine dose, and free and total chlorine in the clearwells.
- Investigation of the formation of flocs between the hydraulic flocculator and the clarifiers.
- Open and inspect the filters.

Establish which plant monitoring practices are carried out on a regular basis. This relates to inspection of infrastructure and equipment, and requires observation using all the senses, i.e. listening for unusual noises (e.g. faulty pumps), smells (e.g. burning cables), touch (equipment exhibiting raised temperatures), visual observation of infrastructure condition and safety and security aspects, etc.

The process controller should be alert to all of these possible eventualities, and should note any irregular observations in the plant logbook, for action by the plant manager or supervisor.

2.2.1.4 Step 1D: Assessment of final water compliance monitoring practices

- Obtain information on the quality of the final water that is produced by the plant. This can be done by accessing plant records or by scrutinising reports by consultants or authorities monitoring the plant. If no or very little information is available from these sources, then a sampling and analysis programme must be implemented to monitor the final water quality over a period of time, i.e. for at least one month.
- Should the water demand be seasonal (in holiday areas) then water quality data must be obtained for both the low and high seasons.
- In piped distribution systems, select various sampling points and determine the concentration of free chlorine residual, the presence or absence of faecal indicator bacteria: faecal coliform and thermotolerant coliform organisms – especially *Escherichia coli*.
- A statistical analysis should be performed on the data to determine the percentage of time that the treated water quality does not comply with the recommended limits set in South African Guidelines (SANS 241).

2.2.1.5 Step 1E: Assessment of maintenance practices

a. Sophistication of equipment

Is the equipment too sophisticated for the application? Is back-up service available? Is there opportunity for training of the plant personnel in using the sophisticated equipment?

b. Availability of spare-parts

Are spare-parts readily available? How long does it take to replace parts? What is the cost of replacing parts (including labour)?

c. Availability of back-up service

Is back-up service readily available? Does it take long to get this service? Is the service reliable? Are there ways that the community can perform some aspects of the service themselves, or that alternative suppliers can be found?

d. Communication facilities

Are there adequate communication facilities between the plant and management, between the plant and service providers, suppliers and consultants? Can this be readily improved?

e. Ability to perform own maintenance

Can the plant personnel or persons in the community perform their own maintenance (or parts thereof)? Can they be trained and are the necessary training facilities available?

f. Access to plant

Is there good access to the plant for motor vehicles (e.g. delivery trucks)? Are there alternative routes? Can the existing access routes be improved with existing funds?

g. Availability of funds for maintenance

Are funds available? Is there a possibility of finding alternative sources of funding for maintenance?

2.2.1.6 Step 1F: Assessment of risk management practices

Is there a comprehensive risk-based approach enabling the identification of hazards from the catchment to the point of consumption? Is there a thorough understanding and implementation of measures to identify and mitigate risks associated with the contamination and deterioration of the quality of sources and treated water?

2.2.2 STEP 2: Comparing the measurements with available standards

2.2.2.1 Step 2A: Compare unit process results with pre-determined alert levels (operational monitoring)

Assess whether the quality of settled water and filtered water complies with the recommended limits. The newly developed operational information tools currently being rolled out to WSPs and WSAs should be consulted for a listing of all operational monitoring (process control) alert levels.

2.2.2.2 Step 2B: Compare final water quality with SANS 241 (compliance monitoring)

Assess whether the quality of final water at the point of treatment, piped distribution systems and at the point of use complies with SANS 241.

2.2.3 STEP 3: Flag problem areas that were identified during the plant assessment

2.2.3.1 Step 3A: List and describe all the problem areas

During performance of the technical compliance assessment in Steps 1 and 2 above, a list should be drawn up of all practices, quality results, infrastructure or equipment not complying with the standards, alert levels or norms that are available for water treatment plants. The list should then give a description of each of the non-complying aspects, indicating the extent of the variation and where possible the direct and/or underlying causes of the problems

2.2.3.2 Step 3B: Mention implications and consequences resulting from these problems

Describe in details the implications and consequences resulting from these problems. In the same Table that was drawn up of problem areas in step 3A above, a further column should be provided in which the implications and consequences of the non-complying condition/events should be noted. This information will form the basis for prioritising the non-compliance issues (problem-areas).

Problem Area	Description	Implications / Consequences

2.2.3.3 Step 3C: Rank the problem areas in priority order

Each of the problem areas then receives a scoring point from 1 to 5 according to the following scoring system:

1	Insignificant Consequence
2	Minor Consequence
3	Moderate Consequence
4	Major Consequence
5	Catastrophic Consequence

The problem areas in the table should then re-listed with red flags in the top of the table, and proceeding down to the bottom rows of the table.

2.2.4 STEP 4: Provide corrective and preventative measures

For each of the problem areas listed in the table, a corrective measure(s) and preventative measure(s) should be provided (in two separate columns). As a guide, a list of corrective and preventative measures for some of the most common problems experienced at water treatment plants is provided in Tables 4.4 and 4.5.

2.2.5 STEP 5: Re-measure and report to authorities

The corrective measures and preventative measures are then applied to the plant, and as soon as all these have been completed, re-measurement performed by repeating the whole technical compliance assessment, but this time concentrating on the problem areas that were identified during the first assessment, and establishing whether compliance has now been achieved or restored. This process is continued until all the problem areas have been eliminated and there is full compliance (the first campaign may take some time to achieve this, but after this the process will be more rapid because most of the problem areas will have been rectified on a permanent or near-permanent basis). The summary assessment table is shown on page 10.

2.3 Non-Technical Compliance Assessment

Perform a detailed assessment of the management components that play an important role in the sustainability of water treatment plants to comply with accepted guidelines and norms. This assessment should focus on the management issues and practices, the human resources, the financial aspect, the communication system in place, the safety, health and environmental quality (SHEQ), and community involvement and awareness.

The following guide documents should also be considered when performing a non-technical compliance assessment:

- *Drinking Water Quality Guide for Water Service Authorities* (DWAF, 2005).
- *Guidelines for Ensuring Sustainable Effective Disinfection in Small Water Supply Systems* (Momba and Brouckaert, 2005).
- *Guidelines for the Improved Disinfection of Small Water Treatments Plants* (Momba *et al*., 2008a).

2.3.1 STEP 1: Audit of management issues

2.3.1.1 Step 1A: Assessment of strategic plans

- Does a strategic plan for the assessment of drinking water supply systems exist?
- Are there preventative strategic plans for drinking water quality management?
- Is there a strategic plan for the recruitment of personnel per water treatment plant available?
- Is there a strategic plan for operational monitoring and verification of drinking water system?
- Is there a strategic plan for the sharing and clarifying of roles and responsibilities among all personnel involved in the production of safe drinking quality water?
- Does a strategic plan exist for training and development of water plant personnel, and for community involvement and awareness?
- Is there any strategic funding plan for the implementation of drinking water quality management programmes?

2.3.1.2 Step 1B: Assessment of tactical plans

- Does a tactical plan exist for handling emergencies, including communication of such emergencies to communities?
- Is the overall periodic overseeing of water care function performed?
- Are there maintenance and asset management plans?

2.3.1.3 Step 1C: Assessment of operational plan (day to day)

- Is the attendance of process controllers (and in particular shift workers) at the treatment plant monitored? Is there a clock-in-system for attendance?
- Is the superintendent available to operators on a day-to-day basis?
- Is there a substitute system plan put in place when one of the operators is ill or away attending a course?
- Are the supervisors and process controllers aware of their job requirements?
- Are job descriptions available?

TECHNICAL or NON-TECHNICAL COMPLIANCE ASSESSMENT: No. ____________________________ DATE: ______________________________

Problem Area	Description	Direct Causes	Underlying Causes	Implications/ Consequences	Score (1-5)	Corrective Measures	Date Implemented	Compliance	Re-measurement		
								Date			

2.3.2 STEP 2: Audit of management practices

Assessment of local and international management practices

- Do the WSPs use existing local (Emanti / DWA) or international management practices? Are they implementing them in their water treatment plants?
- Are the WSPs able to understand the existing local or international practices and to implement them correctly?
- When local or international practices are not available, are the WSPs able to draw their own criteria?

2.3.3 STEP 3: Audit of humans resources

2.3.3.1 Step 3A: Assessment of personnel at the plants

a. Numbers of personnel per plant, shift workers and deployment

- Is the number of personnel related to the size of the plant?
- Are the needs of process controllers/supervisors and shift workers at each plant adequately met?
- Are there specific guidelines/rules for shift workers and their deployment?
- How many process controllers are there in total? How many shift workers?

a. Qualification of personnel

- How many process controllers have qualifications in the DWA categories?
- Are personnel being correctly deployed according to their qualifications?
- Are there guidelines or formal rules for upgrading of qualifications?

b. Training needs and career path development

- Are there in-service training programmes and policies? What is the in-service training policy of the WSA?
- Do process controllers/supervisors/managers know what training opportunities and courses are available?
- Are they sent on courses regularly?
- Are there specific criteria or formal rules that determine eligibility for training?
- Are there specific promotion requirement protocols in place?
- Are there career advancement opportunities?
- How many operators are there with the following number of years of experience: 1-3, 4-6, 7-10, >11?

2.3.3.2 Step 3B: Assessment of plant classification by DWA

- Is the plant classified by DWA?
- In which DWA class does the plant fall?

2.3.3.3 Step 3C: Assessment of working conditions

- Are the responsibilities of process controllers, supervisors and plant managers in line with their salary?
- What system is used for overtime management and payment?
- What is the WSA policy on conflict management (internal and external)?
- Is any medical assistance available for on the job injuries?

- Can all workers participate in medical schemes?
- Are retirement/pension-aid benefits, housing and travel allowance benefits available?
- Are leave benefits (vacation/study/sick), and bonus schemes available?
- Are there any other incentives?
- Are plant personnel satisfied with their working environment?
- Are the relationships between supervisors and their subordinates good or poor?
- Are there any performance indicators?

2.3.4 STEP 4: Audit of financial systems

2.3.4.1 Step 4A: Assessment of financial systems in place

- Which financial systems are in place?
- Are there sufficient funds for operation, maintenance and overtime?
- Do the size of the plants (small versus large) influence the allocation of funds?
- Does the WSA's budgeting system work in relation to emergency funds, scheduled upgrading/ extensions, unscheduled rehabilitation/upgrading?

2.3.4.2 Step 4B: Assessment of information sharing in place

- Are there communication channels and transparency between the financial section and the water care section?
- Are regular meetings held? Who attends/chairs these meetings?
- Are decisions taken by consensus/majority?
- Are reports freely available?

2.3.4.3 Step 4C: Assessment of procurement system

- Is the procurement system transparent?
- Is the procurement system open to all?
- Is the water sector involved in the adjudication of tenders?

2.3.5 STEP 5: Audit of communication systems

2.3.5.1 Step 5A: Assessment of internal communication systems

- Are there sufficient internal communication channels in place, including the provisions and shortcomings?
- Are these communication channels effective?
- Is the communication between supervisors and process controllers good or poor?
- Is there any interaction between the maintenance team and the rest of the personnel in the water treatment plant?
- Is the communication between management and lower level process controllers good or poor?

2.3.5.2 Step 5B: Assessment of external communication systems

- Are there sufficient communication channels with other municipalities and/or departments?
- Are there sufficient communication channels with consumers?
- Are these external communication channels effective, good or poor?

2.3.6 STEP 6: Audit of safety, health and environmental quality

2.3.6.1 Step 6A: Assessment of safety matters

- Are there water and safety management procedures for normal operation, incidents and emergency situations?
- Is there any safety plan at water treatment plants including the safety of process controllers on duties?
- Are there emergency plans in place for chlorine leaks?
- Are there hazardous chemicals and ablution facilities, appropriate location of fire extinguishers?
- Are safety meetings held regularly and who attends such meetings?

2.3.6.2 Step 6B: Assessment of health aspects

- Are there representatives for health and safety of consumers? If yes, are they effective?
- Are there control measures that identify risks and ensure that health based targets are met in terms of providing safe drinking water to all consumers?
- Are there emergency measures in place for water quality health impact?

2.3.6.3 Step 6 C: Assessment of environmental quality

- Are process controllers satisfied with their working environment?
- Is the working environment appropriate for improving or accelerating service delivery?
- Is there any strategic plan to improve the quality of the working environment?

2.3.7 STEP 7: Community involvement and awareness

2.3.7.1 Step 7A: Assessment of community involvement practices

- Are there protocols involving communities in decision-making?
- Is there an effective reporting system for communities to assist in a more rapid response to any water quality incident?
- Is there a consumer service to which non-compliance can be reported?

2.3.7.2 Step 7B: Assessment of community awareness practices

- Is there a mechanism system to receive and actively address community complaints in a timely fashion?
- Are there procedures for promptly advising of any significant incidents within the drinking water supply system, including notification of the public health authority?
- Is there any water quality information system available to consumers through annual reports and in the internet?

2.3.8 STEP 8: Flag problem areas that were identified during the plant assessment

2.3.8.1 Step 8A: List and describe all the problem areas

During performance of the technical compliance assessment in Steps 1 and 2 above, a list should be drawn up of all practices, quality results, infrastructure or equipment not complying with the standards, alert levels or norms that are available for water treatment plants. The list should then give a description of each of the non-complying aspects, indicating the extent of the variation and where possible the direct and/or underlying causes of the problems.

2.3.8.2 Step 8B: Mention implications and consequences resulting from these problems

Describe in details the implications and consequences resulting from these problems. In the same Table that was drawn up of problem areas in step 8A above, a further column should be provided in which the implications and consequences of the non-complying condition/events should be noted. This information will form the basis for prioritising the non-compliance issues (problem areas).

Problem Area	Description	Implications / Consequences

2.3.8.3 Step 8C: Rank the problem areas in priority order

Each of the problem areas then receives a scoring point from 1 to 5 according to the following scoring system:

1	Insignificant Consequence
2	Minor Consequence
3	Moderate Consequence
4	Major Consequence
5	Catastrophic Consequence

The problem areas in the table should then be re-listed with highest consequence problems at the top of the table, and lowest at the bottom of the table.

2.3.9 STEP 9: Provide corrective measures and preventative measures

For each of the problem areas listed in the table, a corrective measure(s) and preventative measure(s) should be provided (in two separate columns).

2.3.10 STEP 10: Re-measure and report to authorities

The corrective measures and preventative measures are then applied to the plant, and as soon as all these have been completed, re-measurement performed by repeating the whole technical compliance assessment, but this time concentrating on the problem areas that were identified during the first assessment, and establishing whether compliance has now been achieved/restored.

This process is continued until all the problem areas have been eliminated and there is full compliance (the first campaign may take some time to achieve this, but after this the process will be more rapid because most of the problem areas will have been rectified on a permanent or near-permanent basis).

The summary assessment table is shown on page 10.

CHAPTER 3

CORRECTIVE ACTIONS FOR TECHNICAL COMPLIANCE

This chapter shows which corrective actions can be taken to remedy the problems or shortcomings that are identified during use of the technical diagnostic tool, and which result in non-compliance. These corrective actions are based on best practices in the design, operation, and maintenance and monitoring of water treatment plants.

3.1 Water Treatment Plant Measurements

3.1.1 Design aspects

The design of the water treatment plant should be based on internationally accepted design guidelines as contained in various local and international hand books and guideline documents. The following are examples of these books and documents:

- *Water Purification Works Design* (van Duuren, 1997).
- *Guidelines for planning and design of small water treatment plants for rural communities, with specific emphasis on sustainability and community involvement and participation* (Swartz and Ralo, 2004).

The design of a specific treatment plant should be based on the results of a detailed characterisation of the raw water sources. Design of unit treatment processes should allow for easy cleaning and maintenance of the structures and equipment.

The technology applied should be appropriate to the capacity of the community to manage and operate the plant. Complicated treatment schemes should be avoided in rural areas. Every drinking water treatment plant should be provided with a comprehensive set of operating instructions contained in a well written operation manual, which should be supplied by the design engineers during commissioning of the plants.

Design engineers should provide (or facilitate) full training for the designated process controllers. If it is found that non-compliance is ascribed to design shortcomings or inadequacies, this should be pointed out to the municipal engineer so that it can lead to the upgrading or extension of the treatment plants.

Plant managers should not compromise final water quality by taking shortcuts (e.g. excluding unit processes that provide bottleneck) to compensate for design shortcomings.

3.1.2 Operational monitoring

In every small water treatment plant, the following operational practices should be implemented on a routine basis:

- All small water treatment plants should have basic functioning raw and final water flow meters installed.

- Accurate records of flow into and out of the plant should be recorded on a daily basis or whenever a change in flow rate is made.
- Jar tests should be conducted at least once per week, or when the raw water quality changes, in order to determine the optimum dose of coagulants. Both overdosing and under-dosing coagulants/flocculants result in treatment problems. The general procedure for the jar test is described on page 23 of '*Quality of Domestic Water Supplies Volume 4: Treatment Guide*' (DWAF *et al*., 2002). However, each plant should have to work out what doses they need to test and how to apply them.
- Process controllers should monitor pH at various points in the plant for coagulation control.
- The turbidity of the settled and filtered water should be monitored and be below 5 NTU and 1 NTU, respectively.
- The chlorine dose should be applied proportionally to the plant flow rate. To ensure effective disinfection, measurement of the chlorine demand of water is highly recommended. Important steps regarding the measurement of the chlorine demand are described in '*Guidelines for ensuring sustainable effective disinfection in small water supply systems.*' (Momba and Brouckaert, 2005) and in '*Guidelines for the improved disinfection of small water treatment plants.*' (Momba *et al*., 2008a).

Recommended water quality parameters and frequency of analysis are summarised in Table 3.1 (next page).

Swartz *et al*. (2009) developed a set of operational spreadsheets to allow more effective communication of operational information from process controllers to management and vice versa. The information is also captured on the eWQMS for monitoring purposes. This operational information tool is currently being made available to all WSAs and WSPs in the country.

Practical activities (e.g. flow measurement and dose calculations, determination of the optimum coagulant dose, setting the correct dose at the plant, estimating contact time from the raw water flow rate contact) in conventional water treatment plants, and equipment required for operational monitoring, are described in '*On-site mobile training of operators in small rural water supplies*' (Momba *et al*., 2008b).

In order to implement an adequate operational monitoring programme, each water treatment needs to have the right equipment and instruments. Table 3.2 (page 19) provides a list of recommended equipment.

TABLE 3.1: RECOMMENDED WATER QUALITY MONITORING PROGRAMME FOR SMALL WATER TREATMENT PLANTS		
Measurement	**Sample**	**Frequency**
pH	**Coagulated water** **Final water**	**Hourly, but preferably chart** **Hourly or chart**
Colour (true) or UV absorbance	Raw water Settled water Filtered water Final water	Monthly Monthly Monthly Daily
Turbidity	Raw water Settled water Filtered water Final water	Weekly Daily Daily 8-hourly or chart
Alkalinity	Final water	Monthly
Ca, Mg hardness Total hardness	Filtered water Final water	Monthly Monthly
Conductivity	Raw water	Monthly
Free chlorine residual	Final water	4-hourly
Faecal coliforms (*Escherichia coli*)	Final water	The frequency is prescribed by DWA and depends on the population served (refer to SANS 241)

3.1.3 Compliance monitoring of final water

Measures of drinking water quality have always been considered under three main categories – microbiological, chemical and physical – to reflect the primary characteristics of each measure.

Routine analysis for the full range of contaminants as specified by SANS 241 will be expensive, especially for small municipalities. For a starting point, Table 3.3 illustrates minimum monitoring parameters, relevant to infectious disease outbreaks, that are recommended to each water treatment plant. Sampling points need to include the raw water source, the waterworks final water, the distribution reservoirs and the strategic sites within the reticulation network.

For regulatory purposes, DWA requires all WSAs and WSPs to submit results of final water quality analysis on a monthly basis. The turbidity of the final water should be monitored and fall within Class 1. This can only be achieved if the process controllers target a filtrate turbidity of < 1 NTU.

Water Services Providers should monitor the chlorine residual at the point of treatment as well as at various points in the distribution system, including the closest and farthest points from treatment, in order to ensure that the residual remains in an acceptable range throughout the systems.

TABLE 3.2: LIST OF EQUIPMENT REQUIRED FOR OPERATIONAL AND COMPLIANCE MONITORING AND SUPPLIERS
° Turbidity meter ° pH meter ° Chlorine meter or chlorine comparator ° Flow meters ° Standard jar test apparatus ° Stop watch ° Measuring cylinders or dosing tanks with calibrated sight glasses to measure dosing rates for dosing pumps ° Kitchen scales to measure dry chemical dose rates if dry feeders are used ° Chlorine gas flow meter if chlorine gas is used ° Clip board ° Log sheets ° Documented process control procedures

- Free chlorine residual is the primary indicator of microbial safety used in process control. Monitoring and maintenance of chlorine residual in the distribution system is important to prevent, or at least to substantially limit, fatal waterborne outbreaks.

For a monitoring programme to be effective, each small water treatment plant should be equipped with a turbidity meter, pH meter and a chlorine meter.

TABLE 3.3: MINIMUM MONITORING PARAMETERS RECOMMENDED TO EACH WATER TREATMENT PLANT		
Physical Parameters	**Chemical Parameters**	**Microbiological Parameters**
Turbidity Electrical conductivity	pH Residuals chemical (e.g. Fe, Al) Residual chlorine	Faecal coliforms/*Escherichia coli*

3.1.4 Plant monitoring

The plant inlet should be checked during every shift to ensure that the full volume of raw water is entering the plant, the inflow meter is working and for any visible change in the raw water quality.

Chemical dosing should be checked to ensure that the coagulant and pH adjustment chemicals are being dosed to the raw water. If not, the reason should be investigated. This may include dosing pump malfunction, blocked dosing pump, empty make-up tank, etc.

Floc formation should be checked at least one every four hours by collecting of a sample flocculated water in a glass beaker, slowly stirring and setting it up against a white background. If no flocs or very small flocs are observed, doses should be checked and a jar test performed if necessary.

The process controllers should check whether the flow into the settled water launders is evenly distributed along their length and that the weirs are kept clear of debris and floc deposits. Settling tanks should be desludged frequently, especially when the raw water turbidity increases, to prevent floc carryover to the sand filter. Filters should be backwashed as soon as, or before, any of the following occur:

- The filter reaches its maximum headloss (maximum pressure or degree of clogging. If the filter is not backwashed, the filtration rate will start to decrease).
- The filtered water turbidity starts to increase, even though coagulation, flocculation and sedimentation seem to be working well.

Process controllers should try to ensure that the filtered water turbidity remains less than 1 NTU. Backwash should be continued until the backwash water becomes clear.

Process controllers should check chlorination equipment at least once per shift to make sure that sufficient chlorine is available in chlorine cylinders, there are no blockages in the dosing pipe and that the injector is functioning properly. They should also ensure that the booster pump is in good working order, where applicable.

3.1.5 Maintenance practices

The importance of properly maintaining water treatment plants cannot be emphasised enough. Water treatment plants cannot be expected to function properly and comply with prescribed and generally accepted standards if they are not maintained effectively and on a scheduled basis.

It is highly recommended that a scheduled maintenance system be employed by all WSPs (municipalities), which should consist of a preventative maintenance programme and well-designed record-keeping system.

Preventative maintenance – For each piece of equipment on a water treatment works, there are regular checking procedures, adjustments and services that should be performed. If these procedures are carried out, the chances of breakdown are reduced drastically. To implement such a system, tasks for each process controller or technician should be carefully planned. Some items should be checked daily, but others less frequently, based on calendar days and actual number of hours that the equipment has worked. Each person must know which points they must check during their shift. For items requiring less frequent checking, it is better to draw up a timetable. The timetable should be posted on a notice board and the tasks should be spaced to provide an even workload.

Mechanical maintenance is of primary importance, because equipment should be kept in a good operating condition so that the plant can always be operated at optimal operating conditions. For a successful maintenance program, the process controller and his supervisor must understand the need for equipment that must be operated on a continuous basis.

Maintenance records – Preventative maintenance programmes help operating personnel to keep equipment in a satisfactory operating condition. The only way a process controller can control their maintenance program is through good record keeping.

An equipment service chart (master chart) should be completed for each piece of equipment in the plant, for example:

- name and type of equipment
- name and address of agent

- type of lubricants and frequency of application
- sizes of bearings

A second chart should be kept on record (service record chart) and must contain the date of service and spares used. It should also indicate, where possible, the repair cost.

Infrastructure maintenance – Building maintenance is also a program that should be undertaken on a regular basis. The maintenance program depends on the age of the buildings. Attention should be given to a variety of items in the treatment plant buildings, amongst which are electrical systems, plumbing, ventilation, floors, windows, roofs and drainage around the buildings. At each building the stairs, ladders, walkways and free-boards should be checked on a regular basis. Protection should be provided to all moving parts.

3.1.6 Risk management

Importance of risk management at water treatment plants – Risk is a measurement of the likeliness and consequences of an undesirable event taking place. In the drinking water sector this includes all potential hazards from source to tap (catchment to consumer). For water treatment plants, it is important to be aware of all the risks or potential risks that may have an effect on the operation, and ultimately the compliance and sustainability, of the plants. Poor operation of water treatment plants may lead to one or more of the following: unsafe drinking water; high treatment costs; need for specialist and time-consuming intervention to rectify problems; breakthrough of viruses and pathogens in the drinking water and resulting water borne diseases; compromising the wellbeing of consumers, especially babies, the aged, and those with poor immune systems; legal action against the service provider. It is therefore recommended that a risk assessment and risk evaluation be performed for any water treatment plant producing drinking water for human consumption.

Risk evaluation – Risk evaluation guidelines are used to provide a clear and nationally consistent method of evaluating the risk of a water or wastewater system (in first nation communities). Risk levels are then used as part of the priority ranking framework for capital and operation maintenance projects and in the development of action plans and long term capital plans for the purpose of correcting the systems at risk.

A WRC project on risk evaluation and risk management in small water treatment plants has recently been completed, and the user of the present document is referred to the guidelines document that has emanated from this risk management project (Thompson and Majam, 2009).

When performing a compliance audit or assessment of a treatment plant using the diagnostic tool, it should be established whether the WSP has performed a risk assessment and risk evaluation for the specific treatment plant, and if not, whether this could, through lack of taking remedial measures, have contributed to any non-compliance that may be identified.

3.2 Comparison with Standards

The SANS 241 document specifies a total of 36 physical, chemical and organoleptic contaminants and eight microbial contaminants. Some of these water quality parameters are recommended to be analysed in laboratories. South African National Standard 241 specifies three classes of water in terms of physical, microbial and chemical quality. Many critical measurements such as pH, turbidity and chlorine residual should be carried out on a daily basis in the plants by process controllers. Compulsory national standards for water quality of the water provided to consumers are defined in SANS 241.

Water Services Providers should compare their results with SANS 241: Specifications for drinking water, or the South African Water Quality Guidelines published by DWA. The turbidity of tap water should fall within the following target ranges:

- Ideal: <0.1 NTU
- Good: <1 NTU
- Acceptable: <10 NTU

Water Services Providers should target the turbidity ranges of <0.1 NTU and <1 NTU for tap water. The turbidity of tap water samples is often higher than that of filtered and finished water. This is not necessarily a problem, but a sudden and excess increase in turbidity in tap water samples not related to the performance of water treatment plant should be investigated further.

The optimum pH of the finished water falls in the range of 6.5 to 8.0, depending on the characteristics of water and the piping materials used in the distribution system.

The chlorine residual at the point of the delivery should be at least 0.2 mg/L under normal circumstances and 0.5 mg/L during periods of high risks of microbial concentration. Lower concentrations will not provide adequate protection against microbial contamination.

3.3 Provision of Corrective Measures and Preventative Measures

The sustainability and effectiveness in the provision of safe drinking water which comply with SANS 241 requires a holistic and pro-active approach to the entire water treatment and distribution process. The WSPs should therefore investigate the reason of the failure of the water quality from the sources of abstraction to the point of delivery and describe the problems. Thereafter, they should provide corrective measures and preventative measures.

3.3.1 Turbidity

Turbidity is generally used to assess the efficiency of the coagulation, flocculation, sedimentation and filtration processes and also the quality of water at the point of consumption. Table 3.4 provides a list of possible causes of water quality failure at each stage of the treatment process and corrective actions that should be taken by the WSPs.

TABLE 3.4: PROBABLE CAUSES OF TURBIDITY FAILURE AT EACH STAGE OF THE TREATMENT PROCESS AND CORRECTIVE ACTIONS

Stage	Possible Cause	Corrective Action
Raw	Heavy rains	For river abstraction, stop abstraction for short periods during storms and floods to avoid the worst quality raw water
	Very high raw water turbidity	When significant changes in raw water turbidity are observed, the WSPs should be prepared to make appropriate adjustments to chemical doses
Settled	The most likely cause is incorrect coagulant dose	The jar test should be used to find the correct dose
	Plant flow rate is too high	Adjust down if possible and extend hours of operation if necessary. The settling tanks may be operating above their design capacity and may require upgrading.
	Settling tank requires desludging	Desludge
	Excessive mixing in settling tanks due to wind or thermal currents	Design modifications may be required. Increase filter backwash frequency and chlorine dose while problem persists.
	Sludge blanket has been lost due to excessive desludging or other reasons	Dose bentonite if facilities available. Increase filter backwashing and chlorine dose until new sludge blanket develops.
Filtered	Post-precipitation. This can occur when alum, lime or ferric chloride is overdosed	Conduct the jar test to determine the optimum dose
	A filter has been taken off-line for backwashing or has just returned to service after backwashing	Keep monitoring filtered water turbidity and temporarily increase chlorine dose until turbidity improves. Check whether backwashing is being stopped too quickly. The turbidity of the dirty backwash water should drop to 10 NTU before backwash is stopped.
	Mudballing and filter cracking	Replace or chemically clean filter media as soon as possible. Investigate whether filter backwash is too weak. In the mean time increase the chlorine dose until the problem is fixed.
	A slow sand filter has been returned to service after being scraped	Raise the chlorine dose in the filtered water until the turbidity is within an acceptable limit
Finished water or off-site storage reservoir	Scouring of sludge accumulated in storage/contact tank	Drain and scour reservoir to remove sludge
	Dirty water leaking in from an external source	Repair leak. Clean and disinfect tank/reservoir.

Source: Momba and Brouckaert, 2005

3.3.2 Free chlorine residual

Free chlorine residual is the primary indicator of microbial safety used in process control. Ensuring adequate free chlorine in the finished water is the most important step in drinking water treatment. Consequently, the supervisor should ensure a daily routine of monitoring chlorine residual at all sampling points in the distribution system. In case of inadequate free chlorine residual, any necessary adjustments to operation should be made within minutes. Table 3.5 provides a list of possible causes of chlorine residual failure in finished water and corrective actions that should be taken by the WSPs.

TABLE 3.5: PROBABLE CAUSES OF CHLORINE RESIDUAL FAILURE AND CORRECTIVE ACTIONS

Sample	Possible Cause	Corrective action
Finished water	Chlorine dose inadequate	Increase dose
	Filtered water turbidity too high	Keep monitoring filtered water turbidity and temporarily increase chlorine dose until turbidity improves (ref. Table 3.4)
	Accumulated sediment in finished water reservoir consumes chlorine. (Another clue would be a drop in turbidity between the filtered and finished water).	Clean reservoir. Improve turbidity removal.
Point of delivery	Chlorine dose at plant inadequate	Check plant chlorine dose. Note that it takes several hours or days for water to travel from the treatment works to point of delivery in certain areas of the distribution system. There may have been a dosing disruption a few days earlier although the current dose is correct. Check the plant operating records and keep monitoring the situation.
	High turbidity in the filtered and finished water results in rapid disappearance of the chlorine residual	Refer to Table 3.4
	Sediment deposited in storage reservoirs exerts a high chlorine demand. (Another clue would be a decrease in turbidity after the reservoir).	Clean reservoir. Ensure reservoir properly covered and secured to prevent small animals, leaves, debris and rubbish getting in. Improve turbidity removal at plant (ref. Table 3.4).
Source: Momba and Brouckaert, 2005		

TABLE 3.5 (CONT.): PROBABLE CAUSES OF CHLORINE RESIDUAL PROBLEMS AND CORRECTIVE ACTIONS		
Sample	**Possible cause**	**Corrective action**
Point of delivery	The growth of biofilms in pipes and slimes in reservoirs. This may be accompanied by taste and odour problems at the point of delivery. This is usually the result of inadequate chlorine dosing, corrosion and ageing of the pipes.	Maintain effective chlorine dosing. Implement corrosion control. Some sections of pipe may need to be replaced in severe cases. Once biofilms are established, shock dosing with chlorine or chloramines, high pressure flushing or mechanical cleaning should be considered.
	Consumption of chlorine by corrosion products. This may be accompanied by other evidence of corrosion such as rusty water at the point of delivery.	Implement corrosion control. Some sections of pipe may need to be replaced in severe cases. High pressure flushing or mechanical cleaning can be considered.
	Contamination of the piped water due to leaks or cross-connections with sewage and wastewater lines	Repair all leaks promptly (water or wastewater). Be particularly careful with water lines passing through flooded areas. Keep up to date maps of all water and sewer lines and records of all repairs to lines. Implement a cross-connection prevention programme. Removal all illegal connections and educate public about the danger of cross-connections.
	Contamination of the storage reservoirs due to leaks or small animals, birds or rubbish getting into them.	Cover and secure all reservoirs to prevent any foreign materials entering them. All access hatches should be sealed and locked.
	Stagnant areas within the distribution system, especially storage reservoirs with much more capacity than required	Possible solutions include operating reservoirs at lower levels (no more than one week average retention time). Booster chlorination may be considered.
Source: Momba and Brouckaert, 2005		

3.3.3 Monitoring, recording and adjustment of operating parameters

To ensure the compliance of non-metropolitan potable water supplies with accepted drinking water guidelines and norms, several operating parameters listed in Table 3.6 should be monitored, recorded and adjusted when required.

TABLE 3.6: OTHER OPERATIONAL MONITORING PARAMETERS		
Operating Parameter	**Frequency**	**Preventative Actions**
Flow rate (raw, filtered, finished, recycled)	At least once per shift and every time the flow rate is changed.	Flows should be changed gradually rather than abruptly. Both the instantaneous flow and daily average flow must be recorded. The instantaneous flow is used to calculate required dose rates. The average daily flows are used to calculate water losses and balancing requirements.
Hours of operation	Daily	If the plant or any part of it does not operate continuously, then the hours of operation must be recorded. If the plant is shut down and started up manually, then the operator must record the **shutdown** and **start up times**. If shutdown and start up are automatic, the operator should record the number of hours on the **pump hour meters**.
Reservoir levels	Daily and whenever the flow rate is changed manually	Reservoir levels are required to calculate the chlorine contact time and flow balancing requirements
Desludging of settling tanks	Depends on plant design and raw water characteristics	If settling tanks are desludged manually then the operator must record **which tank is desludged, the time and date, the number of minutes the sludge valve is open and any comments about the quality and appearance of the sludge**. This information can be used to determine whether the desludging procedure needs to be adjusted.
Filter run time (rapid filters) and filter backwash	At least once a day if no auxiliary backwash (air), otherwise at least once every 48 hours. These time limits apply whether the plant operates continuously or not.	Filters should be backwashed if turbidity breakthrough occurs, the maximum pressure drop/headloss is achieved or if the maximum run time is reached. The **time of each backwash for each filter** should be recorded. This is to assist in the interpretation of filtered water turbidity data. The **duration of backwash** (number of minutes) should also be recorded along with any comments about the appearance of the wash water. If possible the operator should take a sample of the wash water **at the end of backwash** and check that the turbidity has dropped to about 10 NTU. If the turbidity is much higher the length of backwash should be increased. If the turbidity is lower than 10 NTU, the length of backwash may be decreased.
Jar test	Once a day or when the raw water turbidity changes	Records of all jar test results should be kept along with the **time** and **date** of each test. This will assist in the analysis of trends in coagulant demand and consumption.
Chemical dose rates	Once per shift and whenever adjusted	The **times** and **dates** of all dose rates adjustments must be recorded. All **calibration checks** should also be recorded.
Calcium carbonate precipitation potential (CCPP)	Monthly	The calculation of CCPP is required to determine the optimum pH range for stabilisation. Since the raw water characteristics change over time, the stabilisation requirements must be continuously reviewed.
Off-site storage reservoir levels and pumping hours.	Weekly	These should be recorded weekly by the supervisor or the plumbing department in order to monitor reservoir retention times.
Source: Momba and Brouckaert, 2005		

3.4 Scored and Weighted System for Technical Compliance

The overall compliance rating of a water treatment plant will be based on a scoring system according to the identified criteria and norms discussed above. This is conducted separately for technical compliance and non-technical compliance to ensure rapid assessment of whether the main problems at the treatment plant (if applicable) lie within the technical or non-technical (management) area.

Because certain compliance criteria are more important than others, a weighting system is used whereby weights are given to each of the compliance sections. These weights should be determined by a panel of water treatment experts and regulation authorities, and should be revised on a regular basis and when necessary. The proposed weight systems for technical compliance are below.

TABLE 3.7: TECHNICAL COMPLIANCE SCORING

Criterion		**Weight**
1.	**TREATMENT PLANT MEASUREMENTS**	
1A:	Design Aspects	0.1
1B:	Operation Monitoring Practices	0.2
1C:	Compliance (Final Water Quality) Monitoring Practices	0.3
1D:	Plant Monitoring Practices	0.1
1E:	Maintenance Practices	0.2
1F:	Risk Management Practices	0.1
TOTAL		1.0

TECHNICAL COMPLIANCE SCORING: Table 1			
Criterion		Yes =1	No = 0
1. **TREATMENT PLANT MEASUREMENTS**			
1A: Design Aspects			
Rapid Mixing	Is the mixing intensity sufficient?		
	Is the mixing time sufficient?		
	Are chemicals dosed at the correct points?		
Floccul-ation	Is flocculation intensity at correct levels (not too high; not too low)?		
	Is flocculation time sufficient (at least 15 minutes)?		
	Can the flocculation channels or tanks be cleaned easily?		
Sediment-ation	Is floc break-up prevented in the inlet to the sedimentation tank?		
	Is the upflow velocity in the sedimentation tank sufficiently low?		
	Is the weir overflow rate sufficiently low?		
	Can the sedimentation tank(s) be desludged easily and effectively?		
Filtration	Is filtration rate sufficiently low to ensure efficient filtration?		
	Is the filtration depth and filter media suitable for the type of raw water?		
	Is the underdrain system acceptable to ensure sustainable filtration?		
	Is the backwashing system suitable to ensure effective cleaning of sand filters?		
Disinfection	Can chlorine (or other disinfectant) be dosed at sufficient levels for the whole range of inflow rates and chlorine demands of the raw water (i.e. are dosing pumps sized correctly)?		
	Are monitoring systems in place to ensure timeous changing of chlorine cylinders or to replenish disinfectant make-up solutions?		
Dosing systems	Have dosage systems (coagulation; pH adjustment; oxidation; disinfection; stabilisation) been installed to ensure easy maintenance and trouble-free operation?		
Maximum possible score for *Design Aspects*		17	
Total score attained for *Design Aspects*			
Weight for *Design Aspects*		0.1	
Total weighted score for *Design Aspects*			

TECHNICAL COMPLIANCE SCORING: Table 2			
Criterion		Yes =1	No = 0
1. TREATMENT PLANT MEASUREMENTS			
1B: Operation Monitoring Practices			
Coagulation and Flocculation	Do the process controllers know how much they are dosing (even qualitatively)?		
	Can the process controllers adjust the dosage rates and monitor how much is dosed?		
	Do they have a programme for monitoring floc formation?		
Sediment-ation	Is the floc blanket observed and dislodging practices based thereon?		
	Is the overflow weir kept clean?		
	Is the flow of more than one sedimentation tank distributed evenly?		
Filtration	Is backwashing performed properly (at the right time and according to the correct procedure)?		
	Is the quality of the filtrate monitored on a regular basis?		
	Is excessive head loss development or turbidity breakthrough monitored?		
Disinfect-ion	Is the chlorine dosed according to previously determined chlorine demand and/or by maintaining acceptable chlorine residual in the final water?		
	Is the chlorine residual measured correctly and at the suggested frequency?		
Stabilis-ation	Is the stability of the final water determined?		
	Is the process controller familiar with the reason for stabilisation and how it can be affected and controlled?		
Maximum possible score for *Operation Monitoring Practices*		13	
Total score attained for *Operation Monitoring Practices*			
Weight for *Operation Monitoring Practices*		0.2	
Total weighted score for *Operation Monitoring Practices*			

TECHNICAL COMPLIANCE SCORING: Table 3			
Criterion		Yes =1	No = 0
1. TREATMENT PLANT MEASUREMENTS			
1C: Compliance Monitoring Practices			
Final water quality	Is the free chlorine residual sufficient?		
	Is the turbidity less than 1.0 NTU?		
	Is the pH between 6.0 and 9.0?		
	Is the colour less than 10 mg/L as Pt?		
	Is the final water free of any coliform indicator organisms?		
	Is the electrical conductivity less than 70 mS/m?		
	Is the iron level less than 0.2 mg/L as Fe?		
	Is the aluminium level less than 0.2 mg/L as Al?		
Maximum possible score for *Compliance Monitoring Practices*		8	
Total score attained for *Compliance Monitoring Practices*			
Weight for *Compliance Monitoring Practices*		0.3	
Total weighted score for *Compliance Monitoring Practices*			

TECHNICAL COMPLIANCE SCORING: Table 4			
Criterion		Yes =1	No = 0
1. TREATMENT PLANT MEASUREMENTS			
1D: Plant Monitoring Practices			
Plant Infrastructure & Equipment	Are all the pumps in working order?		
	Can all the valves open and close properly?		
	Are all leaks repaired?		
	Are all blockages in pipes cleared?		
	Are all unit treatment processes and equipment accessible?		
Maximum possible score for *Plant Monitoring Practices*		5	
Total score attained for *Plant Monitoring Practices*			
Weight for *Plant Monitoring Practices*		0.1	
Total weighted score for *Plant Monitoring Practices*			

TECHNICAL COMPLIANCE SCORING: Table 5			
Criterion		Yes =1	No = 0
1. TREATMENT PLANT MEASUREMENTS			
1E: Maintenance Practices			
Overall Treatment Plant	Is back-up service at all available?		
	Is there opportunity for training of the plant personnel in using the sophisticated equipment?		
	Are spare-parts readily available?		
	Can spare parts be replaced quickly?		
	Are spare parts affordable by the municipality?		
	Is back-up service readily / locally available?		
	Can service providers be on site at short notice?		
	Is this service reliable?		
	Can the community perform certain parts of the maintenance themselves?		
	Are there adequate communication facilities between the plant and management, authorities, service providers, suppliers and consultants?		
	Can this be readily improved?		
	Can the plant personnel perform their own maintenance (or parts thereof)?		
	Can they be trained and are such training facilities available?		
	Is there good access to the plant by motor vehicles and delivery trucks?		
	Can the existing access routes be improved with existing funds?		
	Are funds available?		
	Is there possibility of alternative sources of funding for maintenance?		
Maximum possible score for *Maintenance Practices*		18	
Total score attained for *Maintenance Practices*			
Weight for *Maintenance Practices*		0.2	
Total weighted score for *Maintenance Practices*			

TECHNICAL COMPLIANCE SCORING: Table 6			
Criterion		Yes =1	No = 0
1. TREATMENT PLANT MEASUREMENTS			
1F: Risk Management Practices			
Source to Tap	Is there a risk management system in place?		
	Are risk reduction options drawn up and implemented based on the risk assessment?		
	Are the risk assessments carried out on a regular basis?		
Maximum possible score for *Risk Management Practices*		3	
Total score attained for *Risk Management Practices*			
Weight for *Risk Management Practices*		0.1	
Total weighted score for *Risk Management Practices*			

TABLE 3.8: TECHNICAL COMPLIANCE SCORING Total Weighted Scoring for ________________________		
Compliance Criterion		**Weighted Score**
1.	**TREATMENT PLANT MEASUREMENTS**	
1A:	Design Aspects	
1B:	Operation Monitoring Practices	
1C:	Compliance (Final Water Quality) Monitoring Practices	
1D:	Plant Monitoring Practices	
1E:	Maintenance Practices	
1F:	Risk Management Practices	
TOTAL WEIGHTED SCORE		1.0

3.5 Technical Compliance Rating of Small Water Treatment Plants

Based on the Technical Compliance Scoring system used above and the final total weighted score calculated for the specific water treatment plant, the plant can then be rated according to the following Technical Compliance Rating:

TABLE 3.9: TECHNICAL COMPLIANCE RATING	
Total Weighted Score	**Rating Description**
0-50	*Class 3 Compliance:* Total non-compliance; serious and immediate intervention required (TAC)
50-90	*Class 2 Compliance:* Serious challenges requiring attention and improvement
90-100	*Class 1 Compliance:* Acceptable compliance

The following chapter focuses on the corrective actions for non-technical compliance that can be recorded in a drinking water supply.

CHAPTER 4

CORRECTIVE ACTIONS FOR NON-TECHNICAL COMPLIANCE

In this chapter, corrective actions that may be taken to remedy the problems or shortcomings that are identified during use of the non-technical diagnostic tool, and which results in non-compliance, are listed. These corrective actions are based on best practices and industry-accepted norms in the supervision and management of water treatment plants.

4.1 Strategic Planning

The focus of drinking water quality improvement will depend on the types of problems identified. The causes of poor drinking water quality need to be determined and appropriate strategic plans for promoting improvement should be recognised and implemented.

Water Services Authorities and WSPs should establish clear policies, objectives and processes necessary to deliver results or implement the policies already existing on:

- Assessment of drinking water supply system, which includes water supply system analysis, assessment of water quality data, hazard identification and risk assessment.
- Operational procedure and process control.
- Maintenance, auditing of WSPs and upgrading to assess whether these are in compliance.
- Management of incidents and emergencies.
- Sharing and clarification of roles and responsibilities among all personnel involved in the production of safe drinking water.
- Training and development of plant personnel.
- Community involvement, awareness and appropriate communication channels.
- Adequate budgeting, financial systems in place, internal and external auditing, purchasing and restocking plans.
- Documentation and reporting.

4.2 Tactical Planning

4.2.1 Management of incidents and emergencies

Drinking water safety is one of the most important public health issues in most of emergency situations. Emergency situations that are appropriately managed tend to stabilise after a matter of days or weeks. However those that develop into long-term situations can last for several years before a permanent solution is found. In this case, drinking water quality parameters that pose long-term risks to public health may become more important.

Water Services Authorities and WSPs should define appropriate medium and long term tactical plans for handling emergency situations in order to promote drinking water quality improvement.

4.2.1.1 Practical considerations

Such considerations should include:

Defining potential incident and emergency situations and developing emergency response plans.
Water Services Authorities and WSPs should develop emergency preparedness plans and relevant emergency response plans for foreseeable events such as major ruptures of pipelines, damage of pumps, failure of major equipment (e.g. chlorination system), human actions (e.g. strikes and sabotage) and natural disasters (e.g. flood). These emergency situations affect the quality of drinking water directly and require immediate intervention.

Water Service Institutions should consider the following factors when investigating the incident or emergency:

- The initiating cause of the problem.
- The most critical action required.
- The way to communicate the problem and how to address it.
- The immediate and long-term consequences.

Defining roles and responsibilities during emergency situations
For effective handling of the emergency situations, WSPs should develop a clear framework clarifying roles and responsibilities of staff involved in the programme and provide necessary training.

Establishing reporting and communication plans
Any emergency situation that affects the quality of drinking water should be reported to relevant WSAs and steps should be taken immediately to inform the consumers. An active two-way communication programme should be developed to inform consumers and promote awareness of drinking water quality issues during the incident and emergency. The report should include the **descriptions of failures** together with apparent **reasons** and the **actions to be taken.**

4.2.1.2 Procedures for disseminating information

To promote awareness of drinking water quality during the incident or emergency, procedures for disseminating information should be established. There are a number of communication systems that should be used to quickly alert the public:

- Supervisory Control and Data Acquisition (SCADA) system
- The use of flyers
- Radio announcement
- Call centre
- Bulk sms messages
- Relay of information by wards and municipal councillors and other community representatives
- In remote areas, WSPs should work hand in hand with community leaders

Providing to consumers practical guidelines ensuring safe drinking water during emergencies
In emergencies, available sources of safe drinking water are very limited. Unprotected rivers, ponds and springs are mainly used for drinking and other domestic purposes without any prior treatment. The risk of disease outbreaks is high, particularly with immuno-suppressed people such as children,

the elderly and individuals with HIV/AIDS. Moreover, providing a sufficient quantity of water for domestic purpose to the entire affected area may sometimes become difficult.

A boil water alert for drinking water should be issued immediately by the WSPs whenever there is an existing or potential risk of microbiological contamination of a community or non-community water supply which poses a threat to public health.

Environmental Health Officers should conduct a risk assessment to indicate whether the microbial quality of drinking water poses a threat to public health. Examples of situations which may present such threat include but are not limited to:

- Loss of pressure due to equipment or pipe failure.
- Persistent (one month) and/or severe violation of SANS 241 for bacteria.
- Evidence that an epidemiological incident may be water supply related.

Practical guidelines should be provided to consumers to ensuring the microbiological safety of boiled drinking water

4.2.2 Overseeing of water care function

In non-metropolitan potable water supplies there is a lack of tactical planning for the overall periodic overseeing of the water care function, which is one of the imperative aspects promoting the improvement of drinking water quality. The results of the survey conducted in the Eastern Cape, KwaZulu-Natal, Mpumalanga and Western Cape provinces have indicated that in certain municipalities, the process controllers on-site or the superintendents are responsible for the overseeing of the water care function, while in others, this task is undertaken by the Water Board or the managers or the Director of Technical Services (Town Engineers) and too much is left to the discretion of the process controllers.

For water treatment plants to function effectively and efficiently, WSAs and WSPs should develop a clear framework or policies ensuring the overall periodic overseeing of the water care function. The focus should be on the following aspects:

- Clarifying and defining the operational procedures as opposed to ad hoc operations.
- Defining who is responsible for ensuring the overall periodic overseeing of water care function.
- Implementing weekly or monthly meetings to look at problems affecting the water care function of the plants.
- Identifying the cause of the problems and providing corrective measures.
- Keeping records of the meeting reports and corrective measures.

4.2.3 Maintenance and asset management plants

Maintenance of all parts of the water treatment and distribution system is a critical part of providing effective, efficient and sustainable water services. A lack of maintenance plans in most of South African non-metropolitan drinking water supplies results in the production of drinking water not complying with the existing water quality guidelines and norms.

4.2.3.1 Practical considerations

When regarding maintenance and asset management at treatment plants, practical considerations should include the following:

- Water Services Institutions should submit details of their maintenance plans as part of their water development plans.
- They should make sure that adequate funds are allocated to maintenance during the budgeting process.
- There should be a five or ten year plan for upgrades, implementation of regular servicing and preventative maintenance as well as for the development and training of the maintenance personnel.
- There should be management plans in place with warehouse and stock control in the loop.
- In addition to drawing up and implementing routine programmes, WSPs should streamline the procedures for getting faulty equipment replaced or repaired.
- Water Services Providers should develop proper mechanisms that allow process controllers to report immediately any failure of the equipment to the supervisors or engineering service managers as soon as possible.
- Procedures for keeping records of all maintenance activities should be defined as this will assist in planning and scheduling routine maintenance and budgeting for both routine and non-routine maintenance.

Water Services Providers should realise that scheduling routine maintenance and addressing equipment problems as soon as they arise is cheaper in the long run than neglecting maintenance.

4.3 Operational Management (Day to Day)

4.3.1 Attendance of process controllers

Process controllers should fill in attendance registers, which should include time coming on-duty, time going off-duty and overtime worked (if any). The attendance times should be verified by the process controllers by providing signatures on the attendance register. The attendance register forms part of the Operational Information Tool developed in a different WRC project.

4.3.2 Availability of superintendent to operators

Superintendents should be available (on phone and in person within a reasonable time) to discuss any needs, problems or challenges with the plant personnel. There should be an open-door policy (within limits).

4.3.3 Job requirements

Each position in the water care function should have clear job descriptions which should encompass the job requirements of the post. Plant personnel should be aware of what is required of them, and should perform their duties within the framework of these job requirements.

4.4 Existing Management Practices

4.4.1 International management practices

Drinking water management practices have been developed in many countries. The following are some examples of the international documents that can be used to ensure the compliance of WSPs with management guidelines and norms:

- *Canadian Guidance for Managing Drinking Water Systems*, (Canadian Water and Wastewater Association, 2005).
- *National Water Quality Management Strategy, Australian Drinking Water Guidelines* (NHMRC, 2001)
- *World Health Organization Guidelines for Drinking Water Quality* (WHO, 2008).

In general, the drinking water quality management system in all of the above countries can be summarised into four practical steps:

PLAN	• Establish the policy, objectives and process necessary to deliver results
DO	• Implement the process
CHECK	• Monitor and measure process and report the results
IMPROVE	• Take action to continually improve performance

4.4.2 Local management practices

In South Africa, a basic drinking water quality management system developed by Emanti Management, and made available broadly by the Institutions of Municipal Engineers of South Africa (IMESA) is summarised below:

i. *Initial data collection on a water scheme* – This includes relevant information on water sources, vulnerability of sources, water treatment requirements and existing treatment procedures, the drinking-water distribution network, drinking-water quality records and present drinking-water quality management procedures.
ii. *Collection of additional water quality data to fill in gaps in existing data* – Special attention is given to sampling raw water sources, post-water treatment works, network dead-ends, high occupancy buildings, hospitals and schools, areas perceived to be problematic and any regions using untreated water.
iii. *Defining roles and responsibilities for operators, managers and community members* – Emphasis is placed on skills training, capacity building, technical support, planning, facilitation of project implementation and increasing community participation.

iv. *Design and implementation of a monthly drinking water quality monitoring programme* based on the findings of steps one and two, and considering the outcome of step three. This includes training operators and local community members to collect the required samples according to standard techniques, the review and dissemination of water quality data to all stakeholders and taking appropriate action when the water quality fails to comply with required standards. This includes issuing "boil order" alerts to the community if the water quality is determined to pose a significant health risk.

4.5 Human Resources Management

The knowledge, skills, motivation, commitment and working conditions of personnel determine the ability of a potable water supplier to comply with accepted drinking water quality and management guidelines and norms.

Coordinated mechanisms should be put in place to maximise the human resource capacity available in non-metropolitan areas. Such mechanisms should include:

- Personnel education and training programs.
- Personnel participation and involvement in decision making.
- Open and positive communication.

It is vital to create a participatory culture and to establish the commitment necessary for the continuous improvement of drinking water quality. Personnel should therefore be encouraged to discuss issues and actions with management.

The following sub-sections should be read in conjunction with:

- *Water Services Act (Act 108 of 1997)* that is currently under review in terms of regulation for the registration of waterworks and registration and licensing of process controllers.
- *National Water Act (Act 36 of 1998).*
- *Guidelines for ensuring sustainable effective disinfection in small water supply systems* (Momba and Brouckaert, 2005).

4.5.1 Skills requirement/training and qualification of personnel

Water Services Authorities and WSPs should:

- Ensure that all personnel involved in drinking water supply, including contractors, maintain the appropriate education, qualification and experience as stipulated in the Water Services Act.
- Identify training needs and ensure resources are available to support training programs.
- Establish mechanisms for evaluating the effectiveness of training.
- Make an effort to hire and retain competent and motivated staff.

A structure should be put in place to inform personnel of training courses which are available and of the times when they are presented. There should be a better communication system between the human resource offices, the supervisors and the process controllers and other workers in terms of training needs. Personnel training should be based on the following:

- Methods and skills required to perform their tasks efficiently and competently.
- Knowledge and understanding of the impact of their tasks on the compliance with accepted drinking water quality and management guidelines and norms.

For example in the case of process controllers, specific training should focus on the optimisation of the plant performance which includes:

- Coagulant control testing.
- Flow rate measurement.
- Proper filtration operation including regulating of filter pressure.
- Disinfection system operation.
- Reticulation management.
- Monitoring of parameters (such as temperature, pH, turbidity, chlorine residuals) and microbial contaminants (coliform bacteria, especially *Escherichia coli*).
- Operation and maintenance of equipment.

Process controllers should also be trained in other aspects of drinking water management such as: incident and emergency response, documentation, record keeping and reporting, preparations of solutions for membrane cleaning and safety measures during handling of chemicals.

Commonly used training techniques and methods include formal training courses accredited by the national training body, on-site training, on-the-job experience, mentor programs, workshops, demonstrations, seminars, courses and conferences.

Coordinated effort for training and capacity building of personnel could be achieved through strategic partnerships with relevant support agencies. Such agencies could include academic institutions, research bodies, community social networks, community based organisations, non-government organisations and relevant government departments. Partnership with research and academic institutions also offers opportunities for technical assistance and manpower through internship programmes where suitable prepared students and research fellows can take part in water supply activities (Momba and Brouckaert, 2005).

Training is an ongoing process and requirements should be regularly reviewed to ensure that personnel maintain the appropriate experience and qualifications. Regulation 17 of the Water Services Act highlights the importance of the training of process controllers. It is stipulated that no person shall operate a drinking water supply system or waterworks unless the person holds a valid process controller licence issued in accordance with this regulation. In other words, to qualify for a process controller's licence, a person must meet the requirements related to qualification and experience. The Water Services Institutions must ensure that every process controller employed must complete the required hours of training every year, over the five years between licence renewals. For various activities that have a significant impact on compliance with accepted drinking water quality management and norms, periodic verification of the capability of process controllers is highly recommended. Table 4.1 indicates the minimum annual training requirements according to Regulation 17 of the Water Services Act (1998).

TABLE 4.1: MINIMUM ANNUAL TRAINING REQUIREMENT		
Class of Process Controllers	Unit Standard Credit	
In Training	30	Continued Education
Class I	30	
Class II	30	
Class III	30	
Class IV	30	
Class V	10*	Continued Education/ Refresher Training
Class VI	10*	
Professional Credit: From Class V, process controllers must apply for Professional Process Controller Registration		

4.5.2 Treatment plant classification and number of process controllers at the plant

Regulation 2834 under the National Water Act defines five classes of water treatment plants and also specifies the level of process controller per class of works. Table 4.2 indicates the minimum class of process controller required per shift, supervision, operations and maintenance support.

TABLE 4.2: MINIMUM CLASS OF PROCESS CONTROLLER REQUIRED PER SHIFT, SUPERVISION, OPERATIONS & MAINTENANCE SUPPORT			
Waterworks Class	Class of Process Controllers per Shift	Class of Process Controller for Supervision*	Operations and Maintenance Support Services Requirements*
E	Class I	Class V*	These personnel must be available at all times but may be in-house or outsourced: Electrician Filter Instrumentation Technician
D	Class II	Class V*	
C	Class III	Class V*	
B	Class IV	Class V	
A	Class IV	Class V	
*Does not have to be at the works at all times, but must be available at all times.			

4.5.3 Job conditions

The capacity of any water treatment plant to provide acceptable drinking water also depends on the working conditions of personnel. Water Services Institutions should develop appropriate policies that aim at improving the standard of living of process controllers in non-metropolitan areas. Coordinated mechanisms should be put in place to ensure the availability and the implementation of these policies in all non-metropolitan water treatment plants nationwide. Important steps should be taken in terms of:

- **Salaries –** The responsibilities of process controllers, supervisors, plant manager and other plant workers should be in line with their qualifications and their salaries. Salaries should be in keeping with economic growth and the inflation rate.
- **Overtime management and payment –** Overtime and shift allowances should be managed and applicable according to the principles of labour law.
- **Conflict management –** Water Services Authorities should develop a clear policy on internal and external conflict management that should be applied not only to disciplinary issues, but also to performance management and training.

- **Medical assistance and medical schemes –** In each waterworks, there should be proper procedures for medical assistance (i.e. first aid boxes and trained first aid employees), evacuation procedures and other emergency strategies.
- **Retirement/pension-aid benefits, housing and travel allowance benefits –** All employees should be aware of policies related to retirement/pension-aid benefit, housing and travel allowance benefits. Housing and travel allowance benefits should be available to all employees irrespective of their work levels and responsibilities.
- **Leave benefits (vacation/study/sick), bonus schemes and other incentives –** Clear procedures for leave benefits should be available and implemented in all waterworks. As well as the 13th cheque, there should be other types of incentives that aim at motivating staff and attracting young people who are interested to contribute in the water sector in non-metropolitan areas. These should include for example: performance incentives, long service incentives, achievement award, etc.
- **Inter-relationships –** Increasing a good relationship between supervisors and their subordinates is vital for ensuring compliance with accepted drinking water quality and management guidelines and norms. All employees, including managers and supervisors, should understand what the roles and the responsibilities of the people working above and below them are. This will reduce the blaming syndrome that is rife in most water treatment plants for any deviations around acceptable norms.
- **Performance indicators –** The purpose of a water supply system is to deliver to each consumer safe drinking water that is adequate in quantity and in quality. The overall performance indicators in a water treatment plant should focus on the quality of the final water. This is possible only if WSPs aim to improve their operating and management practices. Ongoing professional development programmes for both process controllers and managers should be an essential part of meeting the required standards in terms of drinking water quality.

4.6 Financial Management

Proper financial planning and financial management and control are integral in ensuring effective and sustainable operation and maintenance of small water treatment plants. The following legislation contains important information on financial management of municipal water treatment plants, including, in this case, the small water treatment plants.

- Water Services Act (1997).
- Municipal Finance Management Act (1998; Amendment Act 2002).

4.6.1 Levels of financial management

There are two levels of financial management in the municipal water care sector:

a. Manager (Head of Water Care)

- Guidelines for planning.
- Procurement processes.
- Guidelines for budgeting for water treatment.

Cost control (budgeting) (budget control)

- On-plant exposure for these managers.

- Water treatment terminology as related to financial management.
- Importance of balancing income and expenditure (do not try to save costs on essential aspects such as chlorine, but do not overdose either).
- Income (cost recovery, etc.) (free basic water).
- Cost spreadsheets.

b. Plant personnel (operating personnel – supervisors and process controllers)

The essential expenditure on small treatment systems include:

Human resources

- Superintendent.
- Permanent.
- Operator.
- Security.
- Temporary staff.

Planned equipment maintenance and breakdown maintenance

- Annual maintenance contract.
- Critical spares.
- Emergency/breakdown.

Maintenance of infrastructure

- Grass-cutting.
- General cleaning.
- Sand filter cleaning.

Chemicals

- Coagulants/flocculants.
- pH correction (lime).
- Disinfectant.

Transport

Safety

- Personnel protective equipment.
- Overalls.
- Safety boots.
- Goggles, protective gloves.
- Ear muffs.
- Rain coats.

Training

- Safety.
- Adult Basic Education and Training (ABET).
- Process controller training.

4.6.2 Communication of financial information and transparency

Communication of financial information in the water sector should be transparent. This will ensure that proper budget control may be affected by plant managers and senior process controllers, so that purchase of, for example, chemicals not be compromised, or allocated funds reallocated for other departments to the disadvantage of the water supply function in certain instances.

There should be complete transparency in all communications within the municipal system, both upwards, downwards and lateral. This will ensure trust between the various levels in the management, operation and maintenance disciplines within the water care function of the municipality, and more effective water treatment performance.

4.6.3 Supply chain management

Local and district authorities should have very clear supply chain management rules, requiring specific procedures for ranges of tender amounts, and also requirements for database registration by suppliers.

4.7 Communication and Risk Systems

4.7.1 Communication systems

Operational information sheets (also referred to as log sheets) are very important to ensure not only optimal functioning and performance of the water treatment plant, but also financial management, and should be completed and managed meticulously by the process controllers and plant supervisory and management personnel. Log sheets for this purpose have been developed specifically for South African conditions in a WRC project entitled 'Operational Information Tool for the Effective Operation and Maintenance of Small Water Treatment Plants' (Swartz *et al*., 2009).

4.7.2 Risk systems

a. Importance of risk management at water treatment plants

It is essential that water treated at a treatment plant should comply with the required standards as set out in the SANS 241 document. This can only be achieved by ensuring that the plant is capable of producing a good quality end product and that the operating staff are sufficiently trained. It is also essential for test equipment to be available to perform basic tests to ensure good quality water.

Two of the main reasons for poor quality water are high turbidity and poor disinfection. High turbidity in drinking water has an adverse effect on the disinfection process of the water as it tends to screen the bacteria. It is also aesthetically unacceptable. Poor disinfection in water will result in the spread of water borne diseases such as cholera, diarrhoea, dysentery, gastroenteritis and typhoid. This can rapidly spread in a community resulting in an epidemic as was the case in the Eastern Cape in 2002/3 and at a small town in the Mpumalanga Province (Delmas) in 2008, when numerous people contracted cholera.

Treatment of patients suffering from the effects of poor quality water negatively impacts on clinics, hospitals, doctors, nurses and the country as a whole. Apart from the health issues, poor quality water (unstable water) also impacts on plant structures and reticulation systems. Aggressive water attacks concrete structures such as plant structures, reservoirs and reticulation systems resulting in damage in the long term. Water which is scale-forming adversely affects reticulation systems, especially hot water systems and equipment.

b. Impact of poor operation

- Unsafe drinking water.
- High treatment costs.
- Need for specialist and time-consuming intervention to fix problems.
- Breakthrough of viruses and pathogens in the drinking water – water borne diseases.
- Compromise wellbeing of consumers, especially babies, the aged and those with poor immune systems.
- Legal action against service provider.

c. Risk evaluation

Important information related to this subsection is discussed in section 4.3.1.

4.8 Safety, Health and Environmental Quality

The ultimate responsibility and accountability for SHEQ compliance as per the Act rests with the municipal manager, who then delegates responsibilities down the line. For SHEQ to be taken seriously, a senior manager should be the SHEQ driver. Depending on the number and distribution of the waterworks, a number of SHEQ coordinators oversee the implementation, monitoring and constant improvement of the SHEQ system. The SHEQ coordinator sets up an incident/accident reporting system as part of an integrated SHEQ system. There are standard incident/accident reporting books that are filled in as soon as an incident or accident has occurred. A preliminary incident/accident report is completed and distributed to the line manager and SHEQ coordinator within 24 hours. The system is such that reporting is encouraged and is followed by an investigation.

The incident/accident investigator is trained in the process of investigation. An investigation report in the form of a comprehensive questionnaire is completed by the investigator with the help of the person that reported the incident or accident. The main purpose of the investigation is to identify the cause of the incident/accident and then make recommendations to remove or reduce the risk to acceptable levels. The final report is sent to senior management for implementation of the recommendations. In the case of an accident resulting in a disabling injury or death, departure of manpower and the Workman’s Compensation department have to be informed, who will then conduct the accident investigation at a higher level. The employer may be prosecuted if the investigation shows that the employer was negligent by not mitigating an unsafe situation.

4.9 Community Involvement and Awareness

Operation, maintenance and construction (if feasible) should be within the competence of local technical staff or the users. Prior to construction or upgrading an assessment should be made of available skills in the community and the authority. The choice of treatment system, as well as its implementation and management, must take into consideration the aspirations and preferences of the community itself.

Community participation has the following dimensions:

- Involvement of all those affected in decision making about what should be done and how.
- Mass contribution to the development effort, i.e. to the implementation of the decisions.
- Sharing in the benefits of the programmes.
- Research has indicated that there is an on-going need for training in the following areas for communities:

  Constituting and running of water committees.

  Bookkeeping, accounting and recording of minutes.

  Training of plumbers for constructing and maintaining unsophisticated water distribution systems.

  Training of borehole pump maintenance personnel.

  Training of water storage tank builders.

  Training of community health educators.

  Training of primary school teachers in the fundamentals of domestic water supply, management, public health awareness and personal hygiene.

4.10 Scored and Weighted System for Non-Technical Compliance

Systematic evaluation of the overall performance of potable water supplies against numerical guideline and norm values is required to determine the level of compliance or the problems that result in non-compliance of the water treatment plants. Tables below illustrate the scoring and weighted systems that can be used for the evaluation of non-technical compliance.

TABLE 4.3: NON-TECHNICAL (MANAGEMENT) COMPLIANCE SCORING

Criterion		Weight
2.	NON-TECHNICAL ASSESSMENT	
2A:	Management Issues	0.1
2B:	Management Practices	0.2
2C:	Human Resources	0.2
2D:	Financial Systems	0.1
2E:	Communication Systems	0.2
2F:	Safety, Health and Environmental Quality	0.15
2G:	Community Involvement and Awareness	0.05
TOTAL		**1.0**

NON-TECHNICAL COMPLIANCE (MANAGEMENT) SCORING: Table 1			
2. NON-TECHNICAL ASSESSMENT			
2A: Management Issues			
	Criterion	**Yes =1**	**No = 0**
Assessment of strategic plans	Does a strategic plan for the assessment of drinking water supply systems exist?		
	Are there preventative strategic plans for drinking water quality management?		
	Is there a strategic plan for recruitment of personnel per water treatment plant available?		
	Is there a strategic plan for operational monitoring and verification of drinking water system?		
	Is there a strategic plan for sharing and clarifying roles and responsibilities among all personnel involved in the production of safe drinking quality water?		
	Does a strategic plan for training and development of water plant personnel, and for community involvement and awareness exist?		
	Is there any strategic funding plan for implementation of drinking water quality management programmes?		
Assesment of tactical plans	Does a tactical plan for handling emergencies including communication of such emergencies to communities exist?		
	Is the overall periodic overseeing of the water care function performed?		
	Are there maintenance and asset management plans?		
Assessment of operational plans	Is the attendance of process controllers (and in particular shift workers) at the treatment plant monitored? Is there a clock-in system for attendance?		
	Is the superintendent available to operators on a day-to-day basis?		
	Is there a substitute system plan put in place when one of the operators is ill or away attending a course?		
	Are the supervisors and process controllers aware of their job requirements? Are job descriptions available?		
Maximum possible score for *Management Issues*		14	
Total score attained for *Management Issues*			
Weight for *Management Issues*		0.1	
Total weighted score for *Management Issues*			

NON-TECHNICAL COMPLIANCE (MANAGEMENT) SCORING: Table 2		
Criterion	**Yes =1**	**No = 0**
2. NON-TECHNICAL ASSESSMENT		
2B: Management Practices		
Do the WSPs use existing local (Emanti/DWA) or international management practices? Are they implementing them in their water treatment plants?		
Are the WPSs able to understand the existing local or international practices and implement them correctly?		
When local or international practices are not available, are the WSPs able to draw their own criteria?		
Maximum possible score for *Management Practices*	3	
Total score attained for *Management Practices*		
Weight for *Management Practices*	0.2	
Total weighted score for *Management Practices*		

NON-TECHNICAL COMPLIANCE (MANAGEMENT) SCORING: Table 3			
Criterion		**Yes =1**	**No = 0**
2. NON-TECHNICAL ASSESSMENT			
2C: Human Resources			
Personnel at the plant	Is the number of personnel related to the size of the plant?		
	Are the numbers of process controllers/supervisors and shift workers adequate?		
	Are there specific guidelines/rules for shift workers and their deployment?		
	Are there sufficeint operators in total? How many shift workers?		
Personnel Quali-fications	Do all / most of the total operators present have qualifications in the DWA categories?		
	Are personnel being correctly applied according to their qualifications?		
	Are there guidelines or formal rules for upgrading of qualifications?		
Training Need:	Are there in-service training programmes and policies? What is the in-service training policy of the WSA?		
	Do process controllers/supervisors/managers know what training opportunities and courses are available?		
	Are they sent on courses regularly?		
	Are there specific criteria or formal rules to qualify for training?		
	Are there specific promotion requirement protocols in place?		
	Are there career advancement opportunities?		
Plant class	Is the plant classified by DWA?		
	Has classification been performed according to the new system?		
Working Conditions	Are the responsibilities of process controllers, supervisors and plant managers in line with their salary?		
	Is a system used for overtime management and payment?		
	Is there a WSA policy on conflict management (internal and external)?		
	Is any medical assistance available for on the job injuries?		
	Can all workers participate in medical schemes?		
	Are retirement/pension-aid benefits, housing and travel allowance benefits available?		
	Are leave benefits (vacation /study/ sick), and bonus schemes available?		
	Are there any other incentives?		
	Are plant personnel satisfied with their working environment?		
	Are the relationships between supervisors and their subordinates good or poor?		
	Is there any performance indicators?		
Maximum possible score for *Human Resources*		27	
Total score attained for *Human Resources*			
Weight for *Human Resources*		0.2	
Total weighted score for *Human Resources*			

NON-TECHNICAL COMPLIANCE (MANAGEMENT) SCORING: Table 4			
Criterion		**Yes =1**	**No = 0**
2. NON-TECHNICAL ASSESSMENT			
2D: Financial Systems			
Financial Systems Sharing in Place	Are financial systems in place?		
	Are there sufficient funds for operation, maintenance and overtime?		
	Do the size of the plants (small versus large) influence the allocation of funds?		
	Does the WSA's budgeting system work in relation to emergency funds, scheduled upgrading/extensions, unscheduled rehabilitation/upgrading?		
Information Sharing in Place	Are there communication channels and transparency between the financial section and the water care section?		
	Are regular meetings held? Who attends/chairs these meetings?		
	Are decisions taken at consensus/majority?		
	Are reports freely available?		
Procure-ment System	Is the procurement system transparent?		
	Is the procurement system open to all?		
	Is the water sector involved in the adjudication of tenders?		
Maximum possible score for *Financial Systems*		11	
Total score attained for *Financial Systems*			
Weight for *Financial Systems*		0.1	
Total weighted score for *Financial Systems*			

NON-TECHNICAL COMPLIANCE (MANAGEMENT) SCORING: Table 5			
Criterion		**Yes =1**	**No = 0**
2. NON-TECHNICAL ASSESSMENT			
2E: Communication Systems			
Internal	Are there sufficient internal communication channels in place?		
	Are these communication channels effective?		
	Is the communication between supervisors and process controllers good?		
	Is there any interaction between the maintenance team and the rest of the personnel in the water treatment plant?		
	Is the communication between management and lower level process controllers good?		
External	Are there sufficient communication channels with other municipalities and/or departments?		
	Are there sufficient communication channels with consumers?		
	Are these external communication channels good and effective?		
Maximum possible score for *Communication Systems*		8	
Total score attained for *Communication Systems*			
Weight for *Communication Systems*		0.2	
Total weighted score for *Communication Systems*			

NON-TECHNICAL COMPLIANCE (MANAGEMENT) SCORING: Table 6			
Criterion		**Yes =1**	**No = 0**
2. NON-TECHNICAL ASSESSMENT			
2F: Audit of safety, health and environmental quality			
Safety Matters	Are there water and safety management procedures for normal operation, incidents and emergency situations?		
	Is there any safety plan at water treatment plants including the safety of process controllers on duties?		
	Are there emergency plans in place for chlorine leaks?		
	Are there hazardous chemical and ablution facilities, and appropriately located fire extinguishers?		
	Are safety meetings held regularly and who attends such meetings?		
Health Aspects	Are there representatives for the health and safety of consumers? If yes, are they effective?		
	Are there control measures that identify risks and ensure that health-based targets are met in terms of providing safe drinking water to all consumers?		
	Are there emergency measures in place for water quality health impact?		
Environ-mental Quality	Are process controllers satisfied with their working environment?		
	Is the working environment appropriate for improving or accelerating the service delivery?		
	Is there any strategic plan to improve the quality of the working environment?		
Maximum possible score for *SHEQ*		11	
Total score attained for *SHEQ*			
Weight for *SHEQ*		0.15	
Total weighted score for *SHEQ*			

NON-TECHNICAL COMPLIANCE (MANAGEMENT) SCORING: Table 7			
Criterion		**Yes =1**	**No = 0**
2. NON-TECHNICAL ASSESSMENT			
2G: Community involvement and awareness			
Community Involvement	Are there protocols involving communities in decision-making?		
	Is there an effective reporting system for communities to assist in more rapid response to any water quality incident?		
	Is there a consumer service to which non-compliance can be reported?		
Community Awareness	Is there a mechanism system to receive and actively address community complaints in a timely fashion?		
	Are there procedures for promptly advising of any significant incidents within the drinking water supply including notification of the public health authority?		
	Is there any water quality information system available to consumers through annual reports and on the internet?		
Maximum possible score for *Community Involvement*		6	
Total score attained for *Community Involvement*			
Weight for *Community Involvement*		0.05	
Total weighted score for *Community Involvement*			

TABLE 4.4: NON-TECHNICAL (MANAGEMENT) COMPLIANCE SCORING Total Weighted Scoring for ______________________		
Compliance Criterion		Weighted Score
2.	NON-TECHNICAL ASSESSMENT	
2A:	Management Issues	
2B:	Management Practices	
2C:	Human Resources	
2D:	Financial Systems	
2E:	Communication Systems	
2F:	Safety, Health and Environmental Quality	
2G:	Community Involvement and Awareness	
TOTAL WEIGHTED SCORE		

4.11 Non-Technical Compliance Rating of Small Water Treatment Plants

TABLE 4.5: NON-TECHNICAL (MANAGEMENT) COMPLIANCE RATING	
Total Weighted Score	Rating Description
0-50	*Class 3 Compliance*: Total non-compliance; serious and immediate intervention required (TAC)
50-90	*Class 2 Compliance:* Serious challenges requiring attention and improvement
90-100	*Class 1 Compliance:* Acceptable compliance

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Supply of drinking water by non-metropolitan water treatment plants is still fraught with several shortcomings such as limited literacy level of process controllers, lack of emergency preparedness, inadequate budgeting and absence of a consistent and sustainable maintenance culture. These shortcomings have led to a lack of safe drinking water in several rural and peri-urban communities across the country.

Unsafe water supply will impact negatively on the health of the affected population, with a ripple effect on socio-economic development. Waterborne diseases such as cholera and other diarrhoeal diseases account for great debility, morbidity and mortality in some parts of South Africa, leading to substantial losses in working hours.

Lack of adherence to and compliance with the accepted drinking water quality guidelines and norms may be inimical to the health of the communities, and therefore implementation of the present diagnostic tools must be cost effective and sustainable.

Education and in-service training for process controllers and water managers are indispensable for effective skills acquisitions so as to enhance technical performance for the provision of safe drinking water.

To ensure effective and efficient health care delivery, WSAs and WSPs should be mandated to use the present diagnostic tools in a consistent and sustainable manner.

REFERENCES

CANADIAN WATER AND WATER ASSOCIATION (2005) *Canadian Association of Quality Annual Report.* http://www.cawq.ca/en/CAWQ2005AnnualReport.pdf . (accessed 20th April 2009).

DWAF (2002) *Quality of Domestic Water Supplies Volume 4: Treatment Guide.* Research report no. TT 181/02. Water Research Commission, Pretoria.

DWAF (2005) *Drinking Water Quality Guide for the Water Services Authorities.* Department of Water Affairs and Forestry, Pretoria.

MOMBA MNB and BROUCKAERT BM (2005) *Guidelines for ensuring sustainable effective disinfection in small water supply systems.* Research report no. TT 249/05. Water Research Commission, Pretoria.

MOMBA MNB, MAKALA N and DUNGENI M (2008b) On-site mobile training of operators in small rural water supplies. Research report no. TT 348/08. Water Research Commission, Pretoria.

MOMBA MNB, OBI CL and THOMPSON P (2008a) *Improving disinfection efficiency in small drinking water treatment plants.* Research report no. TT355/08. Water Research Commission, Pretoria.

MOMBA MNB, SWARTZ CD and OBI CL (2009) Guidelines for the assessment of the compliance of south african potable water supply with accepted drinking water quality standards and management norms. Volume 1: research report. Research report no. 1668/1/09. Water Research Commission, Pretoria.

MUNICIPAL FINANCIAL MANAGEMENT ACT (2004) Local Government: Municipal Financial Management Act [No. 56 of 2003], Government Gazette 26019, 13 February 2004. Available at http://www.info.gov.za/gazette/acts/2003/a56-03.pdf (accessed 9th October 2006).

NATIONAL WATER ACT (1998) National Water Act, [No. 36 of 1998], Government Gazette 19182, 26 August 1998. Available at http://www.info.gov.za/view/DownloadFileAction?id=70693 (accessed 22nd August 2006).

NATIONAL WATER QUALITY MANAGEMENT (2004) Australian Drinking Water Guidelines.

NHMRC/ARMCANZ COORDINATING GROUP (2001) Framework for management of drinking water quality, Public Consultation Department.

SANS 241 (2005) Drinking water specification. South African National Standards, 6th edition.

SWARTZ CD (2000) *Guidelines for the upgrading of existing small water treatment plants.* Research report no.730/1/00. Water Research Commission, Pretoria. WRC Report 738/1/00

SWARTZ CD and RALO T (2004) *Guidelines for Planning and Design of Small Water Treatment plants for Rural Communities, with specific Emphasis on Sustainability and Community Involvement and Participation.* Research report no. 1185/1/04. Water Research Commission, Pretoria.

SWARTZ CD, MWIINGA G, MARLER M, MEYER V, HLOPHE M, RAJAGOPAUL R and CHARLES K (2009) Guidelines and training aids for the sustainable operation and maintenance of small water treatment plants. Research report no. TT408/09. Water Research Commission, Pretoria.

THOMPSON P and MAJAM S (2009) The development of a generic water safety plan for small community water supply. Research report no. TT415/09. Water Research Commission, Pretoria.

VAN DUUREN FA (1997) Water purification works design. Research Report No. TT 92/97. Water Research Commission, Pretoria.

WATER SERVICES ACT (1997) Water Services Act, [No. 108 of 1997], Government Gazette 18522, 19 December 1997. Available at http://www.info.gov.za/view/DownloadFileAction?id=70766 (Accessed 9th October 2006).

WHO (2004) The World Health Report 2004 – Changing History. Available at http://www.who.int/whr/2004/en/. (Accessed 27th July 2009).

WHO (2008) Guidelines for drinking-water quality (3rd Ed). World Health Organization, Geneva, Switzerland. Available online at http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html (accessed 16 October 2009).