An Operational Information Tool for the Efficient Operation and Maintenance of Small Water Treatment Plants

Report to the

Water Research Commission

by

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EXECUTIVE SUMMARY

Need for Sustainable Operation and Maintenance of Small Water Treatment Plants

The performance of small (and also some medium-sized) water treatment plants in terms of the provision of a potable standard of drinking water to the end consumer is suspect, mostly due to inadequate management aspects. Various studies and programmes in South Africa have shown, and continue to show, that in those non-metropolitan communities with adequate water supply services the drinking-water quality is often poor and even not fit for consumption at point of use. In particular, it is noted that effective water treatment is largely accepted as a necessity, but that the need for effective monitoring and management of water quality from raw water supply to point of use is less recognized and often very superficially performed. Studies have also shown that the overall management of water provision is not as effective as it should be. Although ensuring effective water treatment is already the focus of various provincial and national initiatives, further attention to this matter is urgently required in order to strengthen and support these efforts.

This situation is caused by a variety of reasons. One of these reasons is the lack of an adequate and efficient management information system. Water Services Providers (WSPs) either have their own system or do not use a system at all. A generic and user-friendly spreadsheet based system is required to assist plant owners and operators to manage their information flow in a logical and efficient manner and in a standardised way throughout the country. The performance of distribution systems in this regard should also be included to ensure that all factors up to the point of consumption are captured. The management system should include monitoring, operation, maintenance and asset management. The systems suggested should be piloted on a number of demonstration plants throughout the country in partnership with local government.

Aims of the Project

The aims of the project were as follows:

a. Investigate the existence and characteristics of operational information management systems, used by other countries, which could serve as a basis for a South African system.

b. Develop an operational information tool for South African small and medium sized water treatment plants (non-metro) under the jurisdiction of a water services authority.

c. Develop training aids for the application of this information management tool.

d. Pilot and apply the operational information tool on a test basis, using at least five representative Water Services Providers.

e. Compile a pamphlet on this operational information tool. Arrange at least five information transfer workshops throughout the country, where this operational information tool will be presented to relevant treatment plant and other Water Services Authority representatives, demonstrating its value as a management and regulatory system.

Development of the Operational Information Tool (OIT)

The objective was to develop a simple and user-friendly system of a set of standardised, active sheets (analogous to log-sheets) to be filled in by operations and management staff. The sheets will be both in electronic format, but also available in hard copies for plants without adequate computer facilities. It will be possible to enter all categories of information that require immediate action or storage for later manipulation and use, such as flows, levels, qualities, chemicals, assets, human resources, finances, stock, maintenance schedules, etc. The operational information tool also links up with the manual and training aids that were developed for sustainable operation and maintenance of small water treatment plant (WRC Project K5/1599).

The tool was developed and designed to fit into present municipal systems, and the information tool was also developed to be integrated with the information systems that have been developed by the Department of Water and Environmental Affairs (DWEA), such as the Drinking Water Quality Framework and Management Tool. The information tool was furthermore integrated with the Electronic Water Quality Management System, eWQMS (functionality development) (www.emanti.co.za/ewqms/).

Training aids were also developed for application of the operational information tool. The training aids consist of interactive media and wall-posters indicating step-by-step processes for using the tool. Both the Operational Information Tool and the training aids are available on CD as well as on the Technical Assistance Centre (TAC) website (www.watersupport.co.za).

During the second project workshop it was decided that as many water treatment plants as possible will be targeted for piloting of the operational spreadsheets so as to obtain inputs across a wide spectrum in the water treatment sector. Whilst the original project proposal made provision for piloting at five WSPs, it was decided that 12 treatment plants would be provided with the spreadsheets and shown how the different monitoring and record-keeping spreadsheets should be customized by the managers or supervisors, and filled in by the process controllers on a daily basis.

Technology Transfer Workshops for the OIT were combined with workshops for the Guidelines for Operation and Maintenance of Small Water Treatment Plants. Five workshops were given to introduce the operational spreadsheets to the municipal water treatment sector: in KwaZulu-Natal, Free State, Eastern Cape, Western Cape and North West provinces.

Conclusions

The tool is a simple and user-friendly system, using standardised active log-sheets (developed as spreadsheets), that can be filled in easily by operations and management staff. It captures all information that requires immediate action or storage for later, *viz*. personnel attendance, plant in- and outflows, chemical dosages (including coagulants, oxidants and disinfection agents), chemical usage, water qualities, unit process operational control (including alert levels), water quality monitoring in the distribution network, daily sheets of tasks, events and incidents, and monthly summaries of costs and water qualities.

The OIT spreadsheets will also link up with operational support products developed in other WRC projects, such as the "*Manual and Training Aids for Small Water Treatment Plants*" and the "*Compliance Diagnostic Tool*".

Benefits of the OIT are that it will assist WSAs and government departments (*e.g.* DWEA) with support and regulation of water treatment works, while he WSAs will be made aware of issues of concern, required remedial measures and current best practice techniques.

The WSAs will also have a useful tool to assess and optimise the performance of their water treatment works. This will ensure more cost-efficient operation and maintenance, and ultimately cost savings.

On a national level, the OIT will contribute toward a country-wide improvement in quality of drinking water to consumers.

Of particular advantage also to the water sector, is the integration of the OIT within the existing eWQMS. It is anticipated that with increased use of the OIT, user requests for additional features/functions requiring ongoing eWQMS modifications will result. The provision of resources to ensure ongoing user requirements are being met will be a key need for all stakeholders in the water sector in South Africa.

Recommendations

It is recommended that application of the OIT, as information management tool in the municipal water treatment sector, be actively promoted, and that the **Technical Assistance Centre for Small Water and Wastewater Treatment Plants (TAC)** play a leading role in ensuring dissemination of these and other tools to the small water market sector.

On-site training should be provided by Centre personnel during installation and implementation of the OIT, with managers receiving intensive training in this regard, as they will be doing the further in-house training to their supervisors and process controllers at their various water treatment plants on an ongoing basis (*i.e.* training and re-training).

During the implementation, the OIT posters that are supplied electronically on disk with this report, should be printed out in full-colour and posted on the walls of the process control room, office or plant laboratory.

The OIT should form an integral part of the "Tool Box for Small Water Treatment Plants" that is being distributed to all water treatment plants in the country.

The OIT and its training material should form part of training programmes for process controllers at water treatment plants.

The eWQMS team members should also be encouraged to train WSAs in the use of the OIT during their routine interactions and site visits. This will ensure rapid/maximum deployment of the OIT.

Consideration should be given to further enhance the OIT to include wastewater treatment facilities. The WRC wastewater treatment based OIT could then also be incorporated into the eWQMS. As wastewater challenges in South Africa are significant, a tool such as this will be of significant benefit.

Further Work

A follow-up project is proposed to roll-out the OIT to all the WSAs and WSPs in South Africa, which could be facilitated by the Technical Assistance Centre. This roll-out should ideally be combined with the roll-out of the diagnostic tool for water treatment plant that was compiled in WRC Project K5/1668.

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The Reference Group responsible for this project consisted of the following persons:

Dr G Offringa/Dr JE Burgess	Water Research Commission (Chairpersons)
Ms ND Basson	Sedibeng Water
Mr NJ Bromley	Jeffares and Green
Prof MNB Momba	Tshwane University of Technology
Mr CS Crawford	Department of Water Affairs and Forestry

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Project Team:

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Mr Philip de Souza, Emanti Management
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Mr Peter Thompson, Umgeni Water
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OPERATIONAL INFORMATION TOOL FOR THE EFFICIENT OPERATION AND MAINTENANCE OF SMALL WATER TREATMENT PLANTS

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CHAPTER 1

INTRODUCTION

1.1 Need for Sustainable Operation and Maintenance of Small Water Treatment Plants

The performance of small (and also some medium-sized) water treatment plants in terms of the provision of a potable standard of drinking water (complying with SANS 241) to the end consumer is suspect, mostly due to inadequate management aspects. Various studies and programmes in South Africa have shown, and continue to show, that in those non-metropolitan communities with adequate water supply services the drinking-water quality is often poor and even not fit for consumption at point of use. In particular, it is noted that effective water treatment is largely accepted as a necessity, but that the need for effective monitoring and management of water quality from raw water supply to point of use is less recognized and often very superficially performed. Studies have also shown that the overall management of water provision is not as effective as it should be. Although ensuring effective water treatment is already the focus of various provincial and national initiatives, further attention to this matter is urgently required in order to strengthen and support these efforts.

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e. Compile a pamphlet on this operational information tool. Arrange at least five information transfer workshops throughout the country, where this operational information tool will be presented to relevant treatment plant and other Water Services Authority representatives, demonstrating its value as a management and regulatory system.

1.3 Approach to Development of the Operational Information Tool (OIT)

The objective was to develop a simple and user-friendly system of a set of standardised, active sheets (analogous to log-sheets) to be filled in by operations and management staff. The sheets will be available both in electronic format and in hard copies for plants without adequate computer facilities. It will be possible to enter all categories of information that require immediate action or storage for later manipulation and use, such as flows, levels, qualities, chemicals, assets, human resources, finances, stock, maintenance schedules, etc. The OIT also links up with the manual and training aids that were developed for sustainable operation and maintenance of small water treatment plant (WRC Project K5/1599: Project Leader: CD Swartz).

The tool was developed and designed to fit into present municipal systems, and the information tool was also developed to be integrated with the information systems that have been developed by the Department of Water and Environmental Affairs (DWEA) such as the Drinking Water Quality Framework and Management Tool. The information tool was furthermore integrated with the eWQMS (functionality development).

Training aids were also developed for application of the OIT. The training aids consist of interactive media and wall-posters indicating step-by-step processes for using the OIT. Both the OIT and the training aids are available on CD as well as on the Technical Assistance Centre (TAC) website.

CHAPTER 2

SURVEY OF INTERNATIONAL OPERATIONAL INFORMATION SYSTEMS

The survey comprised detailed searches on the internet as to what water treatment plant operational information is already in use on a world-wide basis. The emphasis was on small or rural water treatment plants, but also included larger water treatment plants, due to relatively scarce information being available on this topic.

Information that was obtained by the project leader during an earlier visit to the United States of America (USA) to study the operation, maintenance and management of small water treatment systems also provided valuable sources of related process control sheets and log sheets.

In South Africa, DWAF (now DWEA) had also developed plant monitoring log sheets that were piloted in the Limpopo province, and these are also reported on. Insights into other systems and sheets used locally were also obtained, notably that of Umgeni Water, Sedibeng Water and Stellenbosch Municipality.

2.1 United States of America

2.1.1 Process Control Sheets

The American Water Works Association (AWWA) Guidance Manual on "Self-Assessment for Treatment Plant Optimisation" (AWWA, 2001) points out that for a water treatment system to accomplish the goal of consistent, high-quality treated water, it is necessary that each unit treatment process perform properly. This is important because a breakdown in any one unit process places a greater burden on the remaining processes and increases the chance of viable pathogenic organisms reaching the distribution system and consumers' taps. When each unit process performs properly, the benefits of providing multiple barriers prior to distribution to the consumers are achieved.

The AWWA Manual emphasises that to achieve these levels of performance for each unit process, information focusing on raw water quality and on the performance of the various unit processes in the plant should be routinely obtained and recorded. Based on this information, appropriate controls must be exercised to maintain consistent treated water quality. The terms *routinely* and *consistent* are stressed in the Manual, because it is necessary to have the plant adequately staffed, monitored, and controlled at all times when it is in operation to allow information to be gathered.

It is recommended in the AWWA Manual that the first step in the development of a process control programme is to set performance goals for each treatment process and to develop procedures or protocols to achieve this. An example of process control targets at a medium sized water treatment plant is shown in Table 1 (taken from the AWWA Manual). The operating staff should then identify the controls available within the plant (a "control" is defined as "an adjustment that the plant staff has available to implement a change that will impact the unit process performance"). A number of examples of controls that typically exist in conventional treatment plant include are listed in the AWWA Manual, and are summarised below:

- Change the plant flow rate (e.g. reduce loading on treatment processes)
- Temporarily shut down the plant if treated water storage is available
- Change the raw water source, if available
    - Mixing, flocculation, sedimentation
    - Mixing intensity
    - Coagulation control
    - Type of chemical and chemical feed rate
    - Flocculation mixing energy input and taper between units in series
    - Sludge removal

Table 1: Example plant operations guidelines outlining unit process performance goals (AWWA, 2001)

Sampling Location/Unit Process	Quality Parameter	Target Value
Raw water	Turbidity pH Alkalinity Iron Manganese Dissolved oxygen (DO)	< 5.0 NTU 7–9 80–120 mg/L < 0.3 mg/L < 0.05 mg/L > 4.0 mg/L
Rapid mix	pH	< 7,5
Settled water	Turbidity pH Alkalinity	< 0.5 NTU < 7.6 80–100 mg/L
Filter effluent	Turbidity	< 0.2 NTU Max < 0.1 NTU Ave
Finished water	pH Total chlorine Free chlorine Turbidity Fluoride Ammonia Alkalinity	> 8.4 mg/L > 2.2 mg/L < 0.2 mg/L < 0.1 NTU 1.0 mg/L < 0.5 mg/L 90-100 mg/L

- Filtration
    - Filtration hydraulic loading rate (start-up, normal operation, backwash)
    - Stability of filtration rates (rate control during backwash, increasing plant flow rate, etc)
    - Filter aid and primary coagulant chemical feed rate
    - Backwash frequency, duration, and rate
    - Filter to waste (rewash) duration and rate
    - Surface wash, if applicable
    - Number of filters in service, if applicable
    - Air scour, if applicable
    - Filter ripening time
- Disinfection
    - Disinfectant concentration
    - Disinfectant application point
    - Clearwell or disinfection contact basin water levels
    - Disinfectant type
    - pH adjustment

The Manual (AWWA, 2001) proposes that sampling locations should be chosen in accordance with the information that the operating or management personnel requires. The frequency of sampling will be dictated by how important each specific parameter is on dictating process performance and the rate at which the parameter can change. For critical parameters such as turbidity and disinfectant residuals, continuous measurements are considered necessary. It is also considered ideal to monitor turbidities from individual filters. Grab samples may be used for quality parameters that are not that critical or that do not change that quickly, *e.g.* raw and settled water turbidities (when conditions are stable). During rapidly changing conditions, increased sampling frequency is required, for instance when rainfall events impacts on raw water quality. It has been stated that, as a general rule of thumb, a supply can be considered unstable when a critical parameter (such as turbidity) increases by 1 log (ten-fold) in a 24-hour period. These conditions require more frequent sampling.

a. Monitoring forms ("operational information sheets")

The AWWA Manual recommends that detailed recording of monitoring data should be performed. For data that is collected continuously on chart recorders or computers, the peaks for every four-hour period should be noted. Trend charts are very useful and helps with the interpretation of the data. Example trend charts include the depiction of raw, settled, and final water turbidities. This aids in visualising the variability of these parameters. More or less level lines for settled and filtered water turbidities would indicate stable conditions, despite variable raw water quality. The data needs to be interpreted and the necessary controls adjusted to continuously maintain each unit process at desired performance goals.

b. Understanding the process control programme

The AWWA Manual points out that it is critical that all of the operating personnel within the water treatment plant should understand the importance of the process control programme to achieve the plant's performance goals, and that they should be committed to use and support the process control programme. Development of the performance goals by the plant's management, without input from the operational personnel, could lead to non-acceptance and that the process control programme is not used properly or consistently. On the other hand, if the process controllers develop a process control programme without inputs from management, there may be administrative decisions made that are in conflict with the process control programme.

All of the operational personnel should be involved in the development of the process control programme. This helps to ensure that all aspects related to the plant monitoring and process control are included, that everyone understands the programme, and that everyone will be committed to use it. Management should make time available for the operational personnel to attend such planning sessions for drawing up proper process control programmes.

It is critical that the process control programme is well documented, and should be incorporated in the Operations Guidelines for the plant. These guidelines should ideally be written and tested by the operational personnel, which would contribute toward ownership and commitment. It should be kept in ring binders and be readily accessible to the entire plant staff. It is important to create an environment where these guidelines are seen as "living" documents, and for this reason it needs to be updated and modified on a regular basis.

An example of a process control and sampling schedule for a conventional plant is shown in Table 2.

c. Checklist of Process Control Sheets Development

The Manual provides a useful checklist for drawing up a process control programme to ensure optimal unit treatment process performance and produce a high-quality final water. The following items should be considered (AWWA, 2001):

Have performance goals been established for each treatment process in the plant?

- Performance goals should be established for the unit treatment processes (which could also be the alert levels), and used by the plant process controllers to ensure efficient treatment. Any deviation of unit process performance from its established targets (or exceeding the alert levels) should result in rapid response to achieve and maintain the desired performance levels.

- High-priority performance goals are a stable settled water turbidity of less than 1 NTU, individual filter effluent turbidities of less than 0.1 NTU, and disinfection that meets the required *CT*s (CT is the product of the disinfectant concentration C and the contact time T).

Table 2: Example of a process control sampling and testing schedule for a conventional plant (adapted from AWWA, 2001)

Sample	Sample Location	Tests	Frequency	Sample by (*)
Plant influent	Tap by raw water turbidimeter	Turbidity pH Alkalinity Flow Total organic carbon (TOC) and/or dissolved organic carbon (DOC) Jar test Temperature	Continuous 1 /shift Daily Continuous Daily As needed Daily	Meter Operator Operator Meter Lab Operator Operator
Sedimentation basin	Effluent trough	Turbidity Sludge depth	2 / shift 1 /shift	Operator Operator
Filter effluent	Turbidimeter	Turbidity	Continuous	Meter
Clearwell	Laboratory tap	pH Turbidity Cl_2 Residual Fluoride	1 /shift Every 4 hours Continuous 2 /shift	Operator Operator Meter Operator

(*) *Note: Operator referred to as Process Controller in South Africa*

- A raw water quality target may be necessary in certain instances, *e.g.* for a plant that consistently has problems meeting performance goals for unit processes and compliance with final water quality, when periods of high-turbidity raw water is encountered. For example, when the raw water turbidity is greater than 400 NTU, operating personnel may shut down a plant and operate on storage (if this is available) until the raw water quality improves. This type of target is site-specific and depends on raw water quality variations, plant capabilities, and distribution system or raw water storage capacity.

Has a process control sampling and analysis schedule been developed and implemented?

- A sampling and analysis schedule should be used that provides information that is essential to monitoring and adjusting plant controls.
- Minimum measurements, frequency, and locations as it is proposed in the AWWA Manual are:

"Turbidity

- Raw water: Continuous or every 2 to 6 hours (site-specific)
- Settled water: Continuous or every 2 to 6 hours (site-specific)
- Individual filters: Continuous or based on an appropriated strategy for accurately assessing integrity on a daily basis (e.g. continuous on banks of filters)
- Finished water leaving plant: Continuous

Flow

- Raw water: Continuous
- Filter flow rate
- Backwash flow rate
- Return flow rate from backwash or sludge facilities
- Finished water flow rate to system

CT parameters

- Disinfectant residual: Continuous of finished water and as required following other unit processes to calculate *CT*

- Water flow out of contact basin
- *CT* calculation

Raw water chemical characteristics (source dependent):

- Alkalinity
- pH
- Temperature
- TOC and/or DOC (affects coagulation and disinfection by-product formation if present at levels > 4 mg/L)
- Iron
- Manganese

Frequency of sampling/testing source water:

- Base on the stability of the source water.
- Unstable source water (e.g. 1 log change in 24 hours) should be sampled on a frequent enough basis to allow response to changing conditions***".***

Have monitoring forms been developed and implemented that allow data to be accumulated and interpreted?

- Monitoring forms should allow recording of data that can be used as a basis for process control decisions.
- Data should be trend-charted to allow quick review with other daily parameters (e.g. raw, settled, filtered turbidity; chemical dose; plant flow).
- Forms may be developed for daily or monthly data and may be electronically produced using computers.

Has a coagulant control strategy been developed, documented, and implemented?

- Operating personnel should be capable of using one or more of the following coagulant control test methods unless they have developed another rational approach that meets the objectives of these tests:
  - Jar tests
  - Use of a streaming current monitor
  - Zeta potential measurement
  - Use of pilot filters

  (In South Africa, jar tests are most widely used).

- Coagulant control testing needs to be conducted when raw water quality changes occur that may require adjustment to coagulant dose. The process controllers need to determine what water quality change will trigger coagulant testing (i.e. they should set up a protocol for changes in raw water quality that will require jar testing, for instance if raw water turbidity changes by more than a certain percentage).

Has emergency response procedures been developed for loss of chemical feeds or unacceptable final water quality?

Has a documented dosage control strategy been developed and implemented for other plant chemicals (e.g. alkalinity adjustments, fluoride, iron and manganese control etc.)?

- For example, if chemical is added for pH adjustment, a pH target should be set, results documented, and guidelines for achieving the target developed.

Has *CT* control strategy been developed, documented, and implemented?

- Required *CT* targets should be established according to the USA state guidelines or the Surface Water Treatment Rule (SWTR) guidance manual. Guidelines for achieving the target *CT* should be developed and an emergency response procedure implemented in the event of loss of disinfectant. Guidelines should include
  - Minimum operating level of contact basin
  - Basin effluent flow rate
  - Disinfectant residual concentration in *CT* basin
  - pH, if controllable

Have all of the plant staff been involved in the development of the process control programme, and have they developed Operational Guidelines, including emergency response guidelines?

2.1.2 Plant Records and Operational Data

In a Field Study Training Program of the Californian Department of Health Services on "*Small Water System Operation and Maintenance*" (CDHS, 2003), it is pointed out that "*plant operations logs can be as different as the treatment plant whose information they record.*" The differences in amount, nature, and format of data are so significant that any attempt to prepare a "typical" log sheet would be very difficult. This point confirms the departure point of this WRC project that an operational information tool for South African small water treatment plants need to be developed for local conditions, and that a set of generic sheets will not suffice: the sheets will have to be designed in such a way that it can be customized easily by the users to meet the needs of all the types of water treatment plants that are found across the country.

The Californian Field Study Training Program also emphasises the importance of good plant maintenance record keeping. These records can be used to:

- Record important equipment data such as make, model, serial number, and date purchased
- Record maintenance and repair work performed to date
- Anticipate preventative maintenance needs
- Schedule future maintenance work.

2.1.3 Cell Phone Technology

The City of Pearland, a large, fast-growing suburb of Houston, Texas, has been using cell phone-based services to replace handwritten documents since 2005. According to the city's water production and wastewater treatment supervisor, they were "drowning in paperwork, trying to read and decipher handwritten log sheets and to compile that data into various weekly, monthly and annual reports" (Anthony, 2006).

The utility is responsible for delivering around 30 ML/d of water to more than 56 000 residential, commercial and industrial consumers. They have four supervisors and 22 operators who monitor and maintain 11 water treatment plants, four wastewater treatment plants, 75 pump stations and more than 20 000 connections. With additional water and wastewater treatment plants coming on-line in the near future, they were facing a substantial data collection and management burden. Their initial concern was to simplify the data gathering by their field personnel and hopefully improve data quality.

According to the article (Anthony, 2006), operators used to collect plant data via handwritten log sheets. Every week these log sheets would be collected and transcribed into a spreadsheet. Supervisors spent hours inputting data to generate operational and managerial reports as well as reports for other entities such as Pearland city officials, the Texas Commission on Environmental Quality and the Texas Clean Rivers Program. This was a time-consuming and inefficient process.

After reviewing different options, the utility decided to use the services of a private company that provides a wireless data collection service through the use of a cell phone. Their services were designed to provide the water industry an economic solution to accurately and efficiently capture data one time at the source. The service saves time for workers and managers and eliminates errors caused by redundant data entry. The service also allows managers to take advantage of readily available data to generate operational or compliance reports, or to "feed" other back office systems such as asset management.

The City of Pearland has already utilised the automatic report generation feature to better manage water conservation compliance. The report is also web-based, and therefore it is easy to share information with other users through the assignment of a secure password or ID.

Reports formerly took many hours to compile and submit. Currently, it is generated with the push of a button, and shared with other users by assigning a password to view and download individual reports.

2.2 Australia

In April 2000, Goulburn Valley Water (GVW) in Victoria, Australia undertook an operations review with the aim of identifying the key issues facing its Operations Group (Whittaker, 2004). The operations review identified several factors that could impact on GVW's ability to continually deliver high quality water services to customers. One of the main factors identified was the lack of concise operations and maintenance (O&M) documentation.

Manuals were to be developed for all water treatment and wastewater treatment plants, pumping facilities, and collection and distribution systems. A number of alternatives to deliver a concise and comprehensive library of manuals were considered.

The project proposed using the O&M template developed by an external consultant to produce complete web-based operations and maintenance manuals for three of GVW's facilities. The initial facilities were the Seymour and Numurkah Water Treatment Plants (WTPs) and associated systems and the Tatura WMF and associated systems. The consultant began to collect the operating information from one facility initially and in the process continued to establish the standard template for all future manuals. After the construction of the standard template and the first manual, the next two facilities were documented.

According to the review report (Whittaker, 2004), a facility's operation is able to be broken into two specific lines of information.

- The *Operations Section* incorporating such elements as Safety, Maintenance, Monitoring, Normal Operation, Emergency etc. and;
- The *Process Element Section* such as Raw Water, Alum Dosing, Filtration, Treated Water etc.

To access information from a facility in the method desired, the consultant developed the behind the scenes file structure and HTML (programming code) that would allow the user to access information from more than one path.

The user would be able to access information relating to a plant across an entire process element (e.g. Raw Water – Safety, Maintenance, Monitoring, Normal Operation, Emergency etc.) or operation section (*e.g.* Monitoring – Raw Water, Alum Dosing, Filtration, Treated Water etc.).

The matrix (Table 3) depicts the structure of a facility's operation information. The matrix shows how a user is able to access the information vertically as a particular process element, or horizontally as an operation section across the process elements.

Table 3: Matrix of elements used in the development of the on-line O&M manuals

Operations Section \ Process Elements	General, Raw Water Supply, Alum Dosing, Clarification, Filters, pH Correction, Chlorination, Clear Water Storage	Generic or Attached Items	Other Business Areas
Purpose & Targets	KPI's, objective settings of elements, general description of process elements	EPA License & WQ requirements	EMS & Customer Contract
Safety	OH&S issues, 'Hazard Rating', training and protective equipment requirements	MSDS and Dangerous Goods OH&S SOP	Safety Plans
Management	Levels of authority and notification, required training to operate	GVW authority hierarchy	
Design Criteria & Components	Size, capacity and design assumptions, component description	Equipment list & supplier data including scanned supplier information and electronic information such as CDs of pump manufacturers' specifications	Asset Management, Supplier Register
Maintenance	Table of frequency (less frequently then monthly), type and location.	Suppliers Register and contacts, standard work order forms, spare parts list	Asset Management
Monitoring	Table of frequency (monthly or more frequently), type and location	Testing SOP, EMS requirements	EMS, Techbase
Normal Operation	Start up, operation and shut down procedures, chemical purchasing procedures, PLC / Citec / SCADA controls	Quality Management System Operation SOPs and log sheets, chemical suppliers	
Manual Operation	Manual start up, operation and shut down procedures	Operation SOP	
Process Control	Available process adjustments and likely impact, adjustment steps		
Trouble Shooting	Potential problems such as failure of PLC, possible cause and remedial action		
Emergency	Potential system failure and emergency responses	Emergency Response Procedures, Notification of Key Customers	Emergency Response Plans, Priority Customer List, AquaRate (database of all customers)
Other	Supply quality requirements, irrigator conditions, major customers	Service Suppliers list	
Drawings	Plant Drawings	Electronic Plan room	

2.3 Canada

2.3.1 Saskatoon

SaskWater, a water utility in Saskatoon, Canada has provided two styles of record sheets as examples of log sheets to be used for record-keeping at water treatment plants (SaskWater, Saskatoon). These example log sheets are provided to assist the plant manager or supervisor to develop record-keeping methods and documentation for his/her water treatment plants (*Section 42 of the local "**Water Regulations 2002**"* stipulates that the permit holder is ultimately responsible for developing and maintaining records according to the requirements of this section).

Two types of log sheets are provided as examples: the one for a groundwater based plant, and one for a surface water based plant. These log sheets may be adapted or expanded as necessary to fit the particular requirements of a waterworks. Additional information may also be recorded on a separate dedicated sheet.

SaskWater suggests that permit holders and operators should also pay attention to the manner in which information in operational records or logs are to be recorded or maintained. A number of points are emphasised (SaskWater, Saskatoon):

- "*operational records or logs must be made in chronological order, with the dates, times and testing locations clearly indicated;*
- *entries in an operational record or log must only be made by the permittee;*

- *any person making an entry in an operational record or log must do so in a manner that allows the person to be clearly identified as the maker of the entry;*
- *operational records or logs must be maintained for at least five years; any anomalies or instances of missing entries in an operational record or log must be accompanied by explanatory notes;*
- *operational records or logs must only contain data or information that is actually observed or produced;*
- *operational records or logs must not contain default values generated manually or by automated means; and*
- *operational records or logs maintained must be made available promptly on request of the Minister*".

2.3.2 Saskatchewan

Following a *Cryptosporidium* outbreak in 2001 in the City of North Battleford, Saskatchewan, a Commission of Inquiry was appointed to investigate the event. In a report of the Commission of Inquiry (North Battleford, 2002) on record keeping at the water treatment plant, it was indicated that the treatment plant maintained two principal records at the water treatment plant, namely (SaskWater, Saskatoon):

- A manual written log completed by the operator on each shift. The operators were expected, each hour, to record the raw water turbidity, the pH, the temperature, launder turbidity, launder free chlorine reading, percentage settling, and free and total chlorine residuals in the treated water.
- A computer record of much the same material that is entered by operators from the handwritten log when they have time to do so.

In evaluating the efficiency of the record keeping system, the report provided the following findings:

- The record keeping at the surface water treatment plant was primitive, and in many cases, incomplete. The computer record was often too inconsistent with the manual record to be relied upon.
- The record keeping system did not easily lend itself to third party review.
- There was no policy in place for internal or external review of the record keeping at the surface water treatment plant.

The following recommendation was made (North Battleford, 2002):

"That each permit to operate a surface water treatment plant specify as a condition for operation, the record system that shall be maintained within the plant, and also specify a monthly internal review process to ensure that operating parameters within the permit are consistently being met".

2.4 South Africa

2.4.1 DWAF/DoH/WRC Treatment Guide

According to **Quality of Domestic Water Supplies series, Volume 4: Treatment Guide** (DWAF et al, 2002) "*control is an essential management function to ensure that plans are carried out and that objectives are met. The control of a water scheme includes control of all activities on a plant and supporting services to ensure that water of the required quality is produced on a sustainable basis".*

The Guide continues to say that there are many items and aspects that have to be controlled in a water treatment plant. These include:

- measuring operating conditions, activities and programmes, and the quality of treated water

- compilation of reports that give a record of the measured items, whether it is the quality of treated water or the maintenance programmes carried out
- measuring or evaluation of the records against standards for that particular item
- identification of reasons for discrepancies
- taking of corrective action.

It is pointed out that log sheets play an important role in monitoring and controlling the performance of a treatment plant. The log sheets should make provision for the important operating parameters, including flow into and out of the works, turbidity and pH of the raw and final purified water. The residual chlorine in the final water is a very important parameter to ensure safety of the water. It should also make provision for the washing programme of filters, desludging of settling tanks and a water balance of the works, giving water production losses. Records should also be kept of electricity consumption (ammeter, kWh and hour meter readings).

On the important matter of who should assume responsibility for water treatment plant management functions, of which management of operational data (*i.e.* process control and quality control) forms the basis of performance and compliance, the Guide shows that on a large treatment plant there is normally a plant manager on site who assumes overall management responsibility. There may also be lower level managers who are responsible for specific sections of the plant or for specific functions. However, on small and rural treatment plants, there may only be operators on the plant with people in management positions located somewhere else. In these cases the plant operators have to assume some management responsibilities. Even on small or rural treatment plants management functions have to be performed. This means that the operator on such a plant must assume responsibility for these functions, including management of operational data.

2.4.2 Handbook for the Operation of Water Treatment Works

In the chapter on "*Water Treatment Plant Control*" in this Handbook (Schutte, 2006), Attie Goosen also reiterates the importance of effective control measures to prevent problems from developing or to detect potential problems as early as possible in order to take corrective action.

Schutte (2006) provides a comprehensive overview of the process control philosophy that should be followed at water treatment plants, addressing critical control points, the various dependent and independent variables on a water treatment plant and in which way each of these have an effect on treatment plant process control, the importance of coagulation and disinfection control, corrective actions that could be taken when set targets are not met, record keeping and reporting, quality parameters that should be used for efficient process control, and type and frequency of sampling to be performed to ensure effective process and quality control.

The following sections are excerpts from Schutte (2006) and provide a summary of the most important issues related to the above aspects, with specific reference to the use thereof as basis for the development of the operational informational tool for small water treatment plants in this project.

a. Critical Aspects

Critical control points can be defined as those parameters that can affect further processes in the treatment train or those that can lead to process failure. Examples of such parameters are:

- Inadequate coagulation can adversely affect flocculation, sedimentation, filtration and disinfection. This can then be shown to have an indirect health impact due to inadequacies that may occur in the disinfection process.
- Sub-optimum flocculation can result in poor sedimentation; impaired filtration resulting in increased filtered water turbidity or lower filter production runs and again inadequacies in disinfection.
- Certain filter plant failures can result in reduced filtration efficiencies being experienced. In sand-filters this can be due to loss of filtration medium (sand), mud ball formation due to inadequate backwashing, mal-operation like putting a filter in operation when it is drained

without first filling it or failure of the support structure or collection system. All such failures will impact adversely on the disinfection of the water.

- A critical aspect in ensuring adherence to health requirements of potable water is efficient disinfection. Apart from the abovementioned factors adversely impacting on disinfection, other factors can also have a pronounced effect on disinfection efficiency. In this regard the disinfectant dose, contact time and disinfectant species are important.

b. Dependent and Independent Variables

Certain variables on a plant are considered to be independent and not under the control of process controllers, while other variables are dependent on the functioning of preceding processes and therefore dependent variables. Turbidity of the raw water can be considered to be an independent variable. This aspect is not controllable by the treatment plant personnel unless different raw water sources can be selected whereby a less turbid water source can be used as influent to the plant when increased (high) turbidity is detected in the normal influent.

Water supplied from a run of the river source is especially prone to variations in raw water turbidity. Raw water obtained from a dam is generally more stable regarding turbidity, although the intake position at the dam can result in large turbidity variations being experienced. Such variations are to be expected during flood conditions and even when rainfall results in the inflow of highly turbid water from tributaries into a river used as the water abstraction point, or when such rivers feed into a dam close to the abstraction point.

The raw water quality largely determines the water treatment regime used. In this regard the raw water turbidity is an important parameter. The coagulant used may be dependent on the turbidity but the dosage of the chemical is determined by the raw water turbidity. Changes in raw water turbidity will invariably require adjustment of the coagulant dose rate being used to obtain optimum coagulation and flocculation. Coagulant dose rate is thus a dependent variable, but is controllable by the operating personnel. Local operating instructions should be prepared to address this aspect if variations in raw water turbidity are expected to occur.

Ineffective coagulation and flocculation can have an adverse impact on downstream processes. Inefficiencies during the coagulation process will result in non-optimal flocculation that will result in poor sedimentation because of stable colloidal particles that remain in the water. This in turn will result in ineffective filtration due to the colloidal particles not being removed in the process. The presence of these turbidity particles in the filtered water will not only impact on the turbidity of the filtered water but can also result in inefficient disinfection resulting in adverse health effects being experienced.

Mixing intensities during the dosing of coagulants and the flocculation process play a major part in process efficiencies. Flash mixing (rapid mixing) is important regarding the coagulation process. High intensity mixing over a relatively short time span is required in this process to ensure complete mixing of the coagulant and raw water. Micro-flocs are formed during the operation but these can be broken, due to the high shear rate, when high intensity mixing is sustained for a long time. During flocculation, less intense mixing is applied and the micro-flocs aggregate into larger particles that settle more readily.

The settling takes place in a quiescent basin where the allowed up-flow velocity is determined by the settling velocity of the particles. Should the up-flow velocity be higher than the settling velocity, floc carry-over will occur and the filtration equipment will be affected.

Filtration efficiency will not be adversely affected by carry-over of well-formed floc, but the filter run length will be compromised and lower filtrate volumes will be experienced through the plant. This will reduce the finished water throughput through the plant due to a higher percentage of the water being used for filter backwash.

Inefficient backwash of filters can result in reduced filter production runs and the formation of mud-balls in the filter bed. Mud-ball formation generally results from too short backwash periods or too low backwash flow. Excessive backwash flow is not effective in removing filtered material from the bed and also results in excessive water usage.

c. Coagulation

Coagulant dosage is dependent on raw water quality and type of coagulant. Limits regarding this must be set at the plant.

The size and shape of the floc particles can be a rough guide to establishing probable problems that are being experienced. When a lack of flocculation is noticed in the flocculation chamber, the first action to be taken is to see that the coagulant dosing equipment is delivering the chemicals at the required rate. Normally a reduction in coagulant dose rate is experienced, but other factors can also play a role:

- The wrong chemicals could have been used to make the batch.
- Too little chemicals could have been added to the batch.
- Too much coagulant could have been used to make the batch. In this case pin floc may result due to re-stabilisation of the colloidal particles.

d. Disinfection

The disinfection process is the single most important process used to ensure that the product water does not pose a health risk to the consumers. Failure of this process can lead to serious waterborne disease outbreaks and such outbreaks have led to litigation in the Canada (see example cited earlier in this literature survey, page 18).

Effective disinfection can only be ensured when a disinfectant residual is present after the disinfection process. It must be stressed that the presence of a residual disinfectant concentration on its own does not necessarily imply that the water is of an acceptable bacteriological quality. This can only be confirmed by regular microbiological testing of the water.

e. Corrective Actions

<u>Coagulant dosing</u>. Areas that need to be addressed are associated with the efficiency of dosing. Blockages in the dosing lines can go unnoticed but hourly records of the dosing tank levels can give an indication of reduced dosage. Blockages of the suction strainer and both the suction and discharge lines can result in reduced dosage rates. These causes are apart from the obvious failures such as broken pipes, inoperative pumps and power failures. All such failures must be addressed to rectify the problem.

When polyelectrolyte is used as a coagulant, or flocculant aid, foam collection at the flocculating chamber is a sign of possible over-dosing of the chemical. Reducing the dosing rate of the polyelectrolyte can rectify this. Confirmation of overdosing of polyelectrolyte can be done by an empirical test where a small mass of bentonite powder is added to the filtered water and the sample is then subjected to a normal jar test as used for coagulation-flocculation studies. Floc formation during this test is indicative of excess polyelectrolyte being present in the filtered water.

<u>Dosing regimes</u>. When a change in raw water turbidity is experienced the first step should be to adjust the coagulant dosage to allow effective coagulation and flocculation to proceed despite the change raw water quality. It may even require that the coagulant type be changed under certain circumstances.

<u>Flow changes</u>. Flow changes to the plant are normally required after transient conditions have been experienced. This may only be temporary to allow steady state conditions to be achieved, but other interventions like increased blow down of sludge will be required for the duration of the period when higher turbidity is being experienced. The nature of the floc that is formed may however result in increased floc carry-over and this will adversely affect the throughput through the filtration plant. This

in turn will result in a higher filter backwashing frequency and should this adversely affect the water production the flow reduction may have to be maintained during the period of high raw water turbidity.

f. Record Keeping and Reporting

Records are to be kept to allow proper plant management and control. Performance records are required for trouble shooting, to identify changes in operating conditions, to identify reasons for process failure or water quality reduction, for process optimisation, to record changes in influent quality and process conditions, etc. A further important aspect of recordkeeping is the availability of data and information for research and design of future expansion to the facility or erection of new facilities using the same raw water resource.

Process flow charts, operating and maintenance manuals and the plant design philosophy should be accommodated in the documentation system. These documents should be available to the relevant personnel and specific requirements must be included in the operating philosophy. Any modifications to the plant must be recorded, and the engineering drawings and process flow charts must be updated accordingly.

The mere recording of data without a systematic associated retrieval system is a wasted effort. The data must be stored in a system from where it can be readily retrieved and where it is securely stored. Control of the documentation is of the utmost importance. It must be impossible to change the data, and when changes are required, it must only be possible under the supervision and direction of an appointed responsible person. Any changes must be highlighted and the original value as well as the reason for changing it must be recorded. When an electronic database is used the file must either be in a PDF format or it must only be available in a "read only" format while access for change must be password protected.

The time that data is stored is a critical part of the management of the record keeping system. This should be based on the purpose that the data is to be put to while legislative requirements must be considered as well. Cognisance must be taken of the requirements of the water use permit or licence regarding data availability and requirements by the authorities before deciding on the time that historical data is to be kept.

g. Quality Parameters for Plant or Process Control

Quality parameters for plant process control depend on the size, design and type of treatment plant.

Schutte (2006) proposes the following quality parameters to be used as target values that should be readily attained in a well-operated plant.

- <u>Coagulation:</u> coagulant dosing should be as specified by the plant manager or senior process controller for that specific day; influent rate should be within specified limits; sufficient flash mixing should take place.

- <u>Flocculation:</u> sufficient floc formation should take place.

- <u>Sedimentation:</u> settled water turbidity should be < 4 NTU; flow rate should not be excessive.

- <u>Sludge removal:</u> removal rates should be checked for efficiency; removal systems should be checked for correct operation.

- <u>Filtration:</u> Filtrate turbidity should be < 0.2 NTU; differential pressure should be within set limits.

- <u>pH adjustment:</u> pH value should be maintained as required, and pH adjustment dose rate should be as specified by the plant manager or senior process controller for that specific day.

- <u>Fluoridation:</u> Dose rate should be checked frequently to prevent overdosing of water.

- Disinfection: Required residual levels should be controlled frequently (chlorine > 0.5 mg/L); injection equipment should be operational; leak detection equipment should also be operational; personal protective equipment should be serviceable.

- Chemical dosing: Chemical tank levels should be sufficient; all dosing pumps should be operating effectively.

- Bulk chemicals: Sufficient stock should be available to allow continuous plant operation; possible spillages should to be rectified.

- Pumps: Delivery and suction pressures of pumps must be recorded; oil temperature of lubrication systems should be recorded; oil levels of pumps and gearboxes should be checked; starting sequences and starting of pumps should be carried out according to operating instructions; instances of water hammer should be recorded and investigated.

- Reservoirs: Reservoir levels should be checked routinely; sedimentation in storage reservoirs should be monitored; when the level of potable water reservoirs is allowed to drop very low entrainment of sediment may occur resulting in poor quality water supplied to consumers; where raw water reservoirs are installed the levels must be checked to ensure that adequate supply of raw water is available.

h. Sampling and Analysis

Sample locations should be chosen so as to ensure that all the unit processes are controlled effectively. For example, when a chemical is dosed where a rapid mixing system is not supplied, the sample should be taken at least ten pipe diameters from the point of chemical addition. Where this is not possible, there should be a sufficiently long distance between the dosing and sampling points.

According to Schutte (2006), the frequency of analysis depends on the raw water variability and the impact that various treatment chemicals may have on the consumers and plant performance. The health impact of fluoride and the adverse impact of too little disinfectant on consumer health are good examples. Similarly, the adverse impact of under- and overdosing of coagulant on turbidity removal can be used as illustration of the effect of plant performance.

Different unit processes require different quality parameters to be monitored. It has already been pointed out earlier (page 13) that the required frequency of analysis differs from one unit process to the other. For this reason, different parameters are recommended to be analyzed in order to ensure effective process control. This would require different sampling and analysis frequencies.

Sample points are to be established, installed (where practical) and marked appropriately. This will ensure that samples are taken at the same place and will not be dependent on human factors. This is a very important aspect, as communication regarding this aspect is often found to be lacking at local water treatment plants. Sample containers are to be marked properly (refer to Quality of Domestic Water Supplies series, Volume 3: Sampling Guide (DWAF et al, 2002) for specific guidelines on sampling methods).

When metal salts are used as coagulants, a reduction in alkalinity is experienced. The difference in alkalinity between the raw water and the filtered coagulated water alkalinity can be used to determine the coagulant concentration dosed. The pH of the coagulated water may also be reduced but this will be dependent on the buffer capacity of the raw water and is not as good an indicator as the differential alkalinity.

Flocculation efficiency can be established by visual inspection where floc formation is observed. When the flow-rate through the sedimentation basin is within design parameters the turbidity of the basin overflow will give a good indication of the flocculation efficiency achieved.

Filtration is aimed at the removal of solid particles from the water. When the water is flocculated effectively, the filtration plant should remove any flocculated material carried over from the sedimentation section. Extensive carry-over of floc will result in shortened filtration run lengths and early breakthrough will result. The turbidity of the individual filters must be established to prevent the masking of a breakthrough on an individual filter by a number of filters producing acceptable water quality.

The purpose of disinfection is to render a product water that conforms to microbiological quality criteria for potable water. Sufficient disinfectant must be added to achieve this aim. When chlorine is used a residual free or available chlorine concentration of 1 mg/L should be detected in the water after 10 minutes retention time.

Stabilisation of water is done to render the water non-corrosive and to reduce the scaling potential of the water. Adjusting the pH of the finished water normally achieves this and when soft raw water is used the addition of calcium can also be used. The scaling potential of the finished water should normally be maintained at about 4 mg $CaCO_3$/L. In order to calculate this, the pH, conductivity, calcium hardness, total hardness, sodium, sulphate and chloride are required as input to the Stasoft program that can be used to calculate the calcium carbonate precipitation potential. Less eloquent indicators of stabilisation of water are the Langelier or Ryznar indices that yield results expressed as a number. The inputs required are pH, conductivity, calcium hardness and alkalinity.

Table 4 gives an indication of sampling and analysis recommended.

Table 4: Sampling and analyses required for effective process control on a water treatment plant (Schutte, 2006)

Process	Sample point	Parameter	Frequency	Recommended maxima
Coagulation	After rapid mixing	pH Alkalinity	Daily Daily	Site specific Site specific
Flocculation	After sedimentation	Turbidity Visual observation of floc formation	Shift Every shift	< 2 NTU
Sedimentation	Basin discharge	Turbidity	Shift	< 2 NTU
Filtration	Individual outlet	Turbidity	Shift	< 0.2 NTU
Disinfection	After contact zone	Disinfectant residual	Shift	Dependant on disinfectant
Stabilisation	After pH adjustment	pH Conductivity Alkalinity Calcium Total hardness	3 times per week	$CaCO_3$ precipitation potential 3 to 4 mg $CaCO_3$ /L
Fluoridation	After chemical addition and mixing	Fluoride	Daily	Site specific
Sludge treatment and disposal	Sludge discharge stream	Settlable solids	Weekly	Site specific

2.4.3 Manual for the Operation and Maintenance of Small Water Treatment Plants (Swartz et al, 2008)

In this Manual that was developed with the main objective to improve the performance and sustainability of small water treatment plants, Swartz and co-workers have included a section on process control and quality control. In this section, a table is provided with a recommended water quality monitoring programme for small water treatment plants (Table 5).

Table 5: Recommended monitoring programme for small water treatment plants (< 2.5 ML/d)

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 Final water	Monthly Monthly
Iron	Final water	Monthly
Aluminium	Final water	Monthly
Free chlorine residual	Final water	4-hourly
Total plate count	Final water	The frequency is prescribed by DWAF and depends on the population served (SANS, 2006)
Total coliforms	Final water	
Faecal coliforms (*E. coli*)	Final water	

CHAPTER 3

DEVELOPMENT OF THE OPERATIONAL INFORMATION TOOL

3.1 Requirements for an operational information tool

The need for an operational information tool to ensure effective communication and information transfer from the treatment plant personnel to the WSA and WSP management and to the regulating authority (DWAF) was identified during planning sessions for the development of a national drinking water quality management system. This information tool at plant operational level should therefore be developed in close coordination with the strategic plans of DWAF for drinking water quality regulation and management (*e.g.* eWQMS). As such, during the onset of this WRC project, a DWAF DWQM Workshop was attended by the Project Leader to obtain first-hand information on the requirements of DWAF for such an operational information tool, and how the tool should be integrated into the existing DWQM systems and strategic plans.

A project workshop was held to commence development of the OIT based on the deliberations at the DWAF workshop. This was followed by a first presentation of the OIT and its development at a DWAF Drinking Water Quality Conference held at Sun City. At the conference, the Project Leader did a presentation on the rationale for development of the tool, requirements and proposed structure, and a first draft of the spreadsheets that will constitute the information tool at treatment plant level. The tool was further developed during subsequent workshops, and was piloted at a number of small treatment plants, to solicit inputs from WSA and WSP water care personnel on the use and fine-tuning of the OIT.

3.2 Need for an Operational Monitoring System for Small Water Treatment Works in South Africa

The need for an OIT was described in Chapter 1, giving the main reason as a lack of an adequate and efficient management information system for water treatment plants. As water services sector leader, DWAF is deploying various supportive initiatives, and, in particular, has developed a DWQM Framework to guide WSAs to comply with the promulgated Regulation 5 under Section 9(1) of the Water Services Act 108 of 1997. Addition of the Information Management Tool for Small Water Treatment Works onto the DWAF/Institute of Municipal Engineers (IMESA) WQMS will further enhance the present WQMS and allow the tool to be used by all WSAs within South Africa.

Initial needs for an operational information tool were therefore summarized as follows:

- performance of small water treatment plants to produce potable standard water is suspect
- water quality is often poor and sometimes not even fit for consumption
- effective water treatment is largely accepted as necessity, but need effective monitoring and management is often very superficially performed, if at all
- overall management of water provision is not effective; lack of an adequate and efficient management information system
- there is a need for a generic and user friendly spreadsheet based system
- should include performance of distribution systems
- system should include
  - monitoring
  - operation
  - maintenance
  - asset management
- systems should be piloted at a number of demonstration plants

3.3 Department of Water and Environmental Affairs Requirements for an Operational Information Tool for Small Water Treatment Plants

At the DWAF workshop and during subsequent discussions with DWAF personnel, the following requirements and intended positioning of the OIT in the national Drinking Water Quality Management System was noted.

The position within the national DWQM where the operational information tool will be applied is shown in the Figure 1.

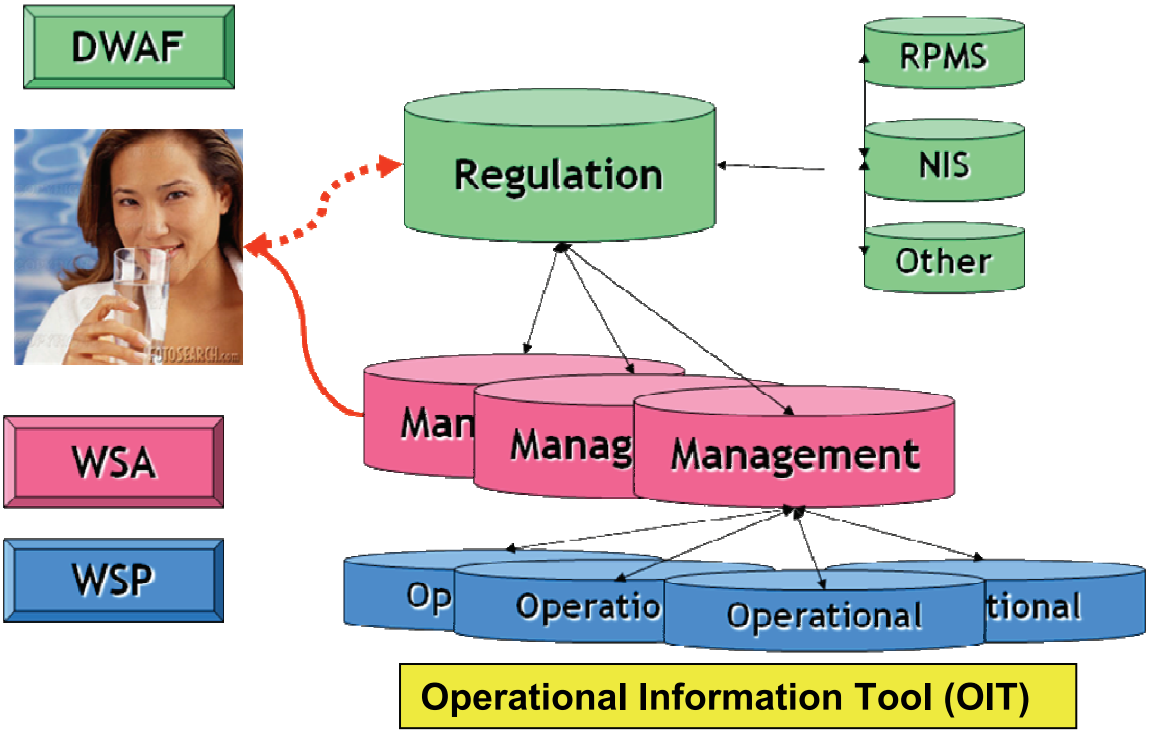


Figure 1: Drinking water quality information management structure

3.4 Expectations from a Drinking Water Quality Operational System

The following were initial requirements by DWAF for an operational information system:

- Simplistic; Robust and Practical.
- Not to be dependent on IT infrastructure or web connectivity only.
- Could be Spreadsheet based.
- Cater for capturing of Alert Levels as stipulated by SANS 241:
  - At least for Turbidity; Residual Cl; Total Coliforms & pH.
- Data feeds to be done by means of e-mail link or fax.
- System will only have 2 clients; WSA Management and DWAF.

3.5 Data Feed from DWQ Operational System to DWQMS

The DWAF furthermore suggested that the information and data transfer should fulfil the following requirements:

- High frequency reporting/data feeding.
- All results of each determinant to be reported upon.
- Daily, monthly and annual reports to be generated on each of the determinands and to be linked to DWQMS.

- Should allow for notes to be captured by process controller.

3.6 Benefits of an Efficient and Widely Used Management Information Tool

- it will assist WSA's and government departments (DWAF) with operation and maintenance of water treatment works
- WSA's will be made aware of issues of concern, required remedial measures and current best practice techniques
- WSA's will have a useful tool to assess and optimise the performance of their water treatment works
- more cost-efficient operation and maintenance = cost savings
- country wide improvement in quality of drinking water to consumers

3.7 Characteristics of an Effective Operational Monitoring System

- simple and user friendly system
- standardised active sheets (analogous to log-sheets)
- spreadsheets
- to be filled in by operations and management staff
- not only electronic format
- capture all information that requires immediate action or storage for later, viz.
    - flows
    - levels
    - water qualities
    - chemicals
    - assets
    - human resources
    - finances
    - stock
    - maintenance schedules
        - not only electronic format

The OIT should also link up with products of current WRC projects ("manual and training aids" and "compliance diagnostic tool"

The OIT should furthermore include the following:

- a set of minimum requirements for effective drinking water quality management
- numbers of experienced and skilled staff required; appropriate treatment processes; operations manual; operational and water compliance monitoring; planning and asset management
- ability to generate automatic reports
- use data for calculations that are required on the plant
- ability to be customized for specific treatment plant types
- include the water safety plan approach

3.8 Operational Information Tool Spreadsheets

The spreadsheets were developed during workshops attended by the project team members, and were improved during subsequent work sessions and also discussions with other role players in the water sector. The draft spreadsheets were then piloted at a number of Water Supply Authorities to assess the ease of use and practicalities, and to obtain feedback from the process controllers at the water treatment plants where the tool was tested.

This feedback was discussed at a subsequent project workshop and the spreadsheets further improved. A further summary spreadsheet was also developed, to be used in processing the most important data and generating (electronically) tables, graphs and reports.

A total of 9 spreadsheets were developed, each capturing different aspects of the operational management, process control and quality control at a water treatment plant, plus two summary spreadsheets. These spreadsheets, which combined forms the ***OIT***, are the following:

1. Operating Personnel Attendance and Working Hours

2. Daily Inflow Figures

3. Chemical Dosages and Chemical Stock Control

4. Settling and Filtration Operations

5. Water Quality Monitoring in a Water Treatment Plant

6. Water Quality Monitoring in a Distribution Network

7. Log (diary) of Events and Incidents

8. Monthly Data Summary including Cost Figures

9. Monthly Operational Summary for Graphs and Reports

The OIT appears in ***Annexure A*** of the report.

3.9 Functionality development of the tool and integration with the eWQMS

The following initial functionality was required:

- Download Excel template
- Create operational sample points
- Capture flow data and chemical usage data
- Import spreadsheet into eWQMS
- Download data for use by stakeholders (*e.g.* DWAF)
- Display data via graphs and tables

Following development of the technical requirements, the eWQMS Team tested the enhancements to ensure appropriate functionality. This included a number of iterations of review and modification before the functionality is deployed to the users.

The functionality developed follows a similar look and feel to other eWQMS features/functions, and should therefore be easy for users to access and utilise. It should, however, be noted that training of users will still be required (not only for modification and use of the WRC OIT spreadsheet but also for utilization of the eWQMS-OIT functionality).

Once the WRC OIT is operational/deployed, the necessary steps will be taken to ensure that the data gathered via the WRC OIT is also transferred to DWAF information systems, such as the Drinking-Water Quality Regulation System (DWQRS), the National Information System (NIS) and the Regulatory performance Management System (RPMS).

The eWQMS Team will assist DWAF to ensure that all required WSA/WSP operational data is received. This process will require development of appropriate linkages between the various systems (*e.g.* mapping of sample points, determinants, units, etc).

3.10 Training Tools for application of the Operational Information Tool

Development of the training aids consisted of the design of posters and interactive-media that can be used during training sessions when the Operational Information Tool is transferred to municipalities in

South Africa. The technology transfer will take place through presentation of five workshops at strategically chosen venues where all the targeted users of the tool will be able to attend.

A pamphlet and posters were designed and created by Chris Swartz Water Utilisation Engineers and Umgeni Water (Ms Kim Hodgson) to be used as promotional material during and after roll-out of the operational information tool to the South African municipal water sector.

The posters and interactive-media have been developed to be easy to use in training plant management and operating personnel how to use the tool spreadsheets in such a way that the maximum benefit will be derived for the municipality, and at the same time also ensuring that the requirements of DWAF are met regarding water quality compliance. It is also the intention that the training material will later be used by designated trainers within the municipalities themselves (this may be plant mangers and/or supervisors and/or training providers). For this reason, the training material is user-friendly and simple to use.

The pamphlet is shown in ***Annexure B*** and the posters are shown in ***Annexure C***.

Following development of the technical requirements, the eWQMS Team tested the enhancements to ensure appropriate functionality. This included a number of iterations of review and modification before the functionality is deployed to the users.

The functionality developed follows a similar look and feel to other eWQMS features/functions, and should therefore be easy for users to access and utilise. It should, however, be noted that training of users will still be required (not only for modification and use of the WRC OIT spreadsheet but also for utilization of the eWQMS-OIT functionality).

Once the WRC OIT is operational/deployed, the necessary steps will be taken to ensure that the data gathered via the WRC OIT is also transferred to DWAF information systems, such as the Drinking-Water Quality Regulation System (DWQRS), the National Information System (NIS) and the Regulatory Performance Management System (RPMS).

The eWQMS Team will assist DWAF to ensure that all required WSA/WSP operational data is received. This process will require development of appropriate linkages between the various systems (*e.g.* mapping of sample points, determinants, units, etc).

CHAPTER 4

PILOTING OF THE OPERATIONAL INFORMATION TOOL

During the second project workshop it was decided that as many as possible water treatment plants will be targeted for piloting of the operational spreadsheets, so as to obtain inputs across a wide spectrum in the water treatment sector. Whilst the original project proposal made provision for piloting at five WSPs, it was decided that 12 treatment plants would be provided with the spreadsheets and shown how the different monitoring and record-keeping spreadsheets should be customized by the managers or supervisors, and filled in by the process controllers on a daily basis.

A further three treatment plants were later added for the piloting, bringing the total number of plants that were used for piloting of sheets to 15.

The following criteria were identified for performing the piloting. It was the intention that the selected plants should be

- Located in at least four different provinces
- Represent all the different sizes of treatment plants, i.e. very small, small and medium-sized treatment plants
- Include peri-urban, rural and remote treatment plants
- Treat a variety of raw water types, i.e. medium to high turbidity; low turbidity; water containing natural organic matter (coloured water), etc.
- Range from plants with serious challenges to well-operated treatment plants

When the OIT spreadsheets were provided to the plant managers or supervisors at the selected water treatment plants, it was pointed out to them that there is a specific procedure to follow in implementing the tool at a treatment plant. The procedure is shown in Figure 2, and will be included in the Operational Information Tool and its Training Modules.

4.1 Emanti Management, Stellenbosch:

<u>*Paradyskloof Water Treatment Plant*</u>
Paradyskloof is one of two treatment plants supplying the town of Stellenbosch with drinking water. It is a conventional treatment plant consisting of aeration, pH adjustment, coagulation (using alum), flocculation, horizontal flow sedimentation, rapid gravity sand filtration, gas chlorination and stabilization.

The plant is well-operated by a team of skilled and well-trained operators. The plant also has a mentorship scheme whereby new enrolments in the water treatment field are provided with in-service training and guidance on water treatment as a career.

The plant has well-designed log sheets for water quality monitoring and process control. However, these sheets are not comprehensive and provide room for improvement. The Operational Information Tool spreadsheets were provided to the plant personnel and who were shown how to use the sheets.

The Water Treatment Superintendent of the Stellenbosch Municipality, Mr Allen Blanckenberg, also participated in the project workshop that was held in Stellenbosch in February, and provided valuable inputs regarding the needs from process controller perspective. He supervised the piloting of the sheets at Paradyskloof.

Supervisor receives generic Excel spreadsheet

↓

He customizes the sheets for his specific treatment plants

↓

Make hardcopies

↓

Provide to Process Controllers at the different treatment plants

↓

Process Controllers fill in the sheets

↓

Completed forms are returned to the supervisor

↓

Supervisors enters the information on computer

↓

Calculations are performed by the computer

↓

Reports are generated (including graphs, tables, diagrams)

↓

Feedback given to Process Controllers at the treatment plants

↓

Monthly reports are submitted to DWAF

Figure 2: Process flow diagram for application of the OIT at WSPs and WSAs

Feedback:

- They found the use of colour in the sheets to contribute to user-friendliness, and the process controllers indicated that it made it easier for them to distinguish between the different fields in the sheets. The existing sheets that were used before only contained black on white.
- They have loaded the electronic version of the sheets onto the computer at the treatment plant, and have been using the sheets effectively by recording observations, events and monitoring results directly on the computer.
- With the assistance of Emanti, they have also entered alert levels onto the system, and when these levels are exceeded, red flags immediately appear, so that this may receive attention.
- The process controllers initially regarded the sheets as "*a means for their superiors to check up on them*". However, once it had been explained to them what the real purpose and objectives of sheets were, and how it would assist the municipality in ensuring optimized and cost-effective treatment, they started to feel ownership of the operational sheets and currently feel very positive about the sheets.

Idas Valley Water Treatment Plant

Idas Valley Water Treatment Plant is the other treatment plant supplying Stellenbosch with drinking water. It is a slow sand filtration water treatment plant with limestone stabilization in upflow reactors to render the treated water less aggressive to the distribution network components (reservoirs and pipes). On entering the plant, the raw water is also subjected to cascade aeration. Gas chlorination is used for disinfection of the treated water.

The plant, being a slow sand filtration plant with limestone filtration for stabilization, does not require much operational control. Much less data is therefore recorded at the plant, and the operational sheets had to be customized for the process configuration employed.

The plant treats water with varying colour levels, depending on the occurrence of rainfall. The slow sand filtration process does not remove the colour in the water, and therefore measurement of colour is important at this plant.

Mr Blanckenberg, is also responsible for overall management of this plant and for the information management.

Bonnievale Water Treatment Plant
The town of Bonnievale is located next to the Breede River near to Ashton. It treats Breede River water to potable standard for distribution to consumers in town. The treatment process consists of coagulation, sedimentation, pressure sand filtration, chlorination and stabilization.

The plant is currently experiencing considerable challenges with the operation and maintenance, and deteriorating infrastructure, at the treatment plant.

Ukhahlamba Municipality, Eastern Cape
This plant has been experiencing considerable challenges with their drinking water treatment and supply, and the operational tool, then in second draft form, has been in use at this treatment plant from June this year. The manager and supervisors at this treatment plant were eager for operational assistance, and have reported that the sheets have been very useful and valuable in providing process control improvement.

4.2 Sedibeng Water, Balkfontein

Bloemhof Water Treatment Plant, North West Province

Pudimoe Water Treatment Plant, Free State

Brandfort Water Treatment Plant, Free State

Vrede Water Treatment Plant

4.3 Umgeni Water, KwaZulu-Natal

Ogunjini. Mvoti and Esidungwini Water Treatment Plants
These treatment plants are all rural water treatment plants in the Ilembe district to the north of Durban. They are managed by Umgeni Water.
The operational information sheets were discussed with the plant managers and process controllers at these plants, and they were requested to start using the sheets and to provide comments on the comprehension of the forms and their objectives, and on their perceived usefulness and user-friendliness.

The following feedback was provided by the operating personnel through the Area Manager: North.

Feedback:

- The supervisor and process controllers at Ogunjini felt that they did not want to change their current operational reporting.
- They have a computer on site and certain data is captured electronically on site (meter readings and pump hours).
- There is a gate register maintained by the contracted security services which acts as an attendance register.

- They have a separate telephone register to record all telephone calls made from site.
- The shift log sheet (attached) is used by the process controllers to capture the operating status of the plant and also acts as the site diary to record complaints and any other events on site.
- At Ogunjini, the polyelectrolyte dosage is controlled by streaming current detector which automatically alters the dosage when raw water turbidities change.
- The performance of flocculation and settling is checked by undertaking cascade tests at least once every shift and the results are captured on the Water Quality spreadsheet.
- The mass of poly dosage is not calculated daily, but the poly stock not in the make-up tanks is recorded daily.
- The chlorine dosages are calculated daily from the difference in scale readings.
- The Supervisor has suggested that the spreadsheets be rationalized into three sheets, as follows:
    - One for the capture of plant performance data and recording site activities (acting as the Shift Log sheet)
    - The second for the capture of water quality results
    - The third for chemical stock control
- They feel that the tool is excellent in that it encompasses all the site data and information required to effectively operate the plant, but it requires careful adaptation to suit individual site requirements.
- The do feel that the adaption of the OIT spreadsheets is not too difficult for an experienced Supervisor or Process Controller.

4.4 Chris Swartz Water Utilisation Engineers, Southern Cape

Swellendam, George and Mossel Bay Water Treatment Plants

The supervisors and process controllers at these three water treatment plants treating water with variable NOM content were requested to complete the operational spreadsheets and to provide comments and suggestions while they perform this task.

Swellendam

Their reaction was positive and they feel that these forms could be used beneficially to integrate all the information that they are otherwise (partially) recording in a book, without specific structure.

They did not have specific suggestions for improving the sheets, as they feel that everything will be an improvement to their current system

They feel that measuring chemical levels in the make-up tank could be a problem, as they do not currently have a means of doing that

George

The George Water Treatment Plant is generally well operated (being a larger plant), in this respect it was felt that the plant manager and process controller could provide valuable feedback.

Much of the information required in the Operational Information Tool spreadsheets is also recorded at George. The forms are somewhat different, and are entered on computer from time to time. They feel that the costing figures required in the monthly summary sheet are not readily available and might prove difficult to obtain in order for the worksheet to perform the calculations. (It was pointed out to them that data communication channels would be set up so that this information could be easily accessed by the plant manager or supervisor).

Mossel Bay

The water care section has designed log sheets that records dosages, flow rates, water quality data and indication of time and duration of settling tank desludging and filter backwashing. The latter is, however, just recorded as a remark, and not in a quantified matter (duration of backwashing/desludging). The same remarks regarding recording of chemical levels in the make-up tanks were made, but it was pointed out that measures could be provided whereby the levels can be recorded.

General comments

The reaction at these three plants was very positive and the personnel felt that the sheets would help them to optimize the treatment plant performance. It would also help them to build up a database of water quality information and dosages applied at the treatment plants.

The data will also assist external consultants with evaluating the treatment plant performance and efficiency during the past month since their previous visit to the plant.

The process controllers pointed out that some of their colleagues are not literate, and will not be able to calculate actual dosages. They can, however, record the applied dosages in mL/min by using a stopwatch and measuring cylinder. (It was also pointed out to them that the calculations will be done automatically when the data is entered on computer, and that it will also automatically generate graphs and reports – these will be provided to the process controllers without delay, so that they can see in which dosage rates they are operating for specific raw water quality (turbidity or colour).

It was noted during the discussions that it will be important for process controllers to make note of any dilutions of treatment chemicals on the treatment plant, so that this can be taken into consideration when calculating chemical dosages.

The supervisors were adamant that they would require support from the project team or consultants when the sheets are to be implemented at their municipality.

4.5 Ms Kim Hodgson, Umgeni Water

Ms Hodgson felt that overall it is a good spreadsheet that would be of great assistance to small water treatment plants.

It was suggested that an overview page be provided for the suite of spreadsheets containing the name of the treatment plant and Water Services Authority, so that this need not be specified on each sheet.

In sheet 1, it was indicated that it is also necessary to specify the Water Services Authority, and not just if there is a WSP.

It was necessary to also include the water works' classification, to evaluate whether the process controllers' class is adequate (in compliance with Regulation 2834/17).

For water quality monitoring (sheet 5), it was suggested that an alert level for final water turbidity is also added (possibly > 0.5 NTU).

It was also necessary to specify an alert level for final water free chlorine, perhaps < 0.5 mg/L (as specified in SANS 241 Operational Alert) and > 5 mg/L (as specified in WHO Guidelines).

For the monthly summary of water quality data, it was suggested that median and 95^{th} percentile values be used.

4.6 Kenny Charles, CSIR

Mr Charles was also of the opinion that the sheets are comprehensive and cover all the required data on the treatment plant.

It was suggested that the type and number of settling tanks be specified, and likewise for the type and number of filters (some plants have more than one type of filter – in some instances it could have as many as three).

4.7 Department of Water Affairs and Forestry, Charlie Crawford

Mr Crawford emphasized the importance of having the sheets in both hard copy and electronic format: electronic format for calculations, statistical data processing, web use, use in other information systems; hard copy to act as back-up for the electronic version if the electronic information is lost by accident or deleted on purpose.

He also pointed out that a form(s) is/are needed on which to collect the daily readings from which to calculate (either manually or by spreadsheet) the values that are to be placed in the monthly summaries. This is especially important if, for manual use, a *Total Column* is needed where the result can be recorded before being divided by the number of days to get averages, etc.

On the chemical use forms, it is necessary to also record the mass or volume of chemical used for the day, besides the dosages in mL/min or mg/L values.

CHAPTER 5

PRESENTATION OF TECHNOLOGY TRANSFER WORKSHOPS FOR TRANSFER OF THE OPERATIONAL INFORMATION TOOL TO THE MUNICIPAL WATER TREATMENT SECTOR

5.1 Planning and Preparation

The Technology Transfer Workshops for the Operational Information Tool were combined with the workshops for the Guidelines for O&M of Small Water Treatment Plants. Five workshops had to be given to introduce the operational spreadsheets to the municipal water treatment sector. It was decided that the five workshops were to be presented in the following provinces:

KwaZulu-Natal
Free State
Eastern Cape
Western Cape
North West

The venues and time schedules for the roadshow during which the workshops were presented, are given in the table on the next page.

5.2 Invitations

Invitations were sent out to water boards, district municipalities and local municipalities in the provinces where the workshops were held. This was followed up by personal telephone invitations to the municipalities, as well as requests by the regional Department of Water Affairs and Forestry and the Water Boards operating in those provinces, to municipalities to attend the workshop. Project Team members also invitation calls to the WSAs and WSPs in the provinces that they represented.

5.3 Workshops

Workshops were held in the Western Cape, Eastern Cape, KwaZulu-Natal, North West and the Free State. All the municipalities in the provinces were invited to send their water treatment managers, supervisors and senior process controllers to the workshops.

In the workshops, presentations were made on the OIT spreadsheets, firstly giving an overview of the WRC project and very specifically why the project was undertaken, *i.e.* an overview of the needs in the municipal water treatment sector for operational information management tools to improve the efficiency of the treatment plants. The operational information tool also provides a means for DWAF to obtain more complete data (daily) of the operational aspects and performance of the treatment plants, from which assessments could be made and outputs generated. It will also greatly assist with DWAF's Blue Drop certification.

The spreadsheets were then presented in detail by the Project Leader, followed by presentations on the training material that was developed to allow supervisors to introduce the spreadsheets to the operating personnel of their municipalities, and to train them on how to install and apply the sheets. For this purposes, the PowerPoint presentation has been shown to be a very valuable medium, as well as the posters which could be printed out in full colour and posted on the walls of the process controller's operations rooms or offices. In conclusion, a presentation was also given on how the spreadsheets will be integrated with the eWQMS system in order to facilitate management of the data from plant level (operational) to WSA level (management) and right up to DWAF level (regulatory).

The OIT, and posters and PowerPoint presentation for training purposes, were included in the *Small Water Treatment Systems Training Tool Boxes* that were provided to all the delegates at the workshops.

5.4 Attendance

Attendance at the workshops is summarised below.

5.4.1 Free State

Date:	Monday 16 February 2009
Venue:	Bloemfontein (Kopano Nokeng Conference Centre)
Presenters:	Chris Swartz (Project Leader) Kenny Charles (CSIR) Noeline Basson (Sedibeng Water) Danie Traut (Sedibeng Water)
DWAF:	Corinne de Kock
Number of attendees:	17
Affiliations:	Mangaung Municipality Setsoto Municipality Mohokare Municipality Phumelela Municipality Sedibeng Water Nketoana Municipality Bloem Water

5.4.2 North West

Date:	Tuesday 17 February 2009
Venue:	Stilfontein (Midvaal Water Company)
Presenters:	Chris Swartz (Project Leader) Mbhuti Hlophe (North West University (Mafikeng)) Noeline Basson (Sedibeng Water) Danie Traut (Sedibeng Water)
Water Boards:	Sedibeng Water Magalies Water Midvaal Water Company

5.4.3 Western Cape

Date:	Monday 23 February 2009
Venue:	Worcester (Slanghoek Resort Cenference Centre)
Presenters:	Chris Swartz (Project Leader) Kenny Charles (CSIR) Philip de Souza (Emanti Management)
Water Board:	Overberg Water
Number of attendees:	31
Affiliations:	Overberg Water George Municipality Cape Agulhas Municipality Cederberg Municipality Swellendam Municipality Theewaterskloof Municipality Oudtshoorn Municipality Stellenbosch Municipality Bergriver Municipality Laingsburg Municipality Witzenberg Municipality Knysna Municipality

5.4.4 Eastern Cape

Date:	Wednesday 25 February 2009
Venue:	East London (Blue Lagoon Conference Centre)
Presenters:	Chris Swartz (Project Leader) Rachi Rajagopaul (Umgeni Water) Philip de Souza (Emanti Management)
DWAF:	Rudzani Masamba / Ntsika Matana / Lwazi Mohamed (Andrew Lucas)
Water Board:	Amatola Water
Number of attendees:	29
Affiliations:	Amatola Water Maluti GSM Nelson Mandela Bay Metro Buffalo City Municipality Africon Rhodes University Makana Municipality Amathole District Municipality Ndlambe Municipality

5.4.5 KwaZulu-Natal

Date:	Friday 27 February 2009
Venue:	Durban (CSIR)
Presenters:	Chris Swartz (Project Leader) Rachi Rajagopaul (Umgeni Water) Kenny Charles (CSIR) Shabbir Habib (Umgeni Water) Gerald Jacks (Umgeni Water)
DWAF:	Viv Naidoo Pat Reddy
Water Board:	Umgeni Water Uthukela Water
Number of attendees:	33
Affiliations:	Umgeni Water Uthungulu District Municipality Uthukela Water Amajuba District Municipality eThekwini Water Services Umhlatuze Municipality Umgungundlovu District Municipality Ugu District Municipality Ilembe District Municipality WSSA

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The information tool at plant operational level was developed in close coordination with the strategic plans of DWAF for drinking water quality regulation and management. As water services sector leader, DWAF is deploying various supportive initiatives, and, in particular, has developed a Drinking Water Quality Management (DWQM) Framework to guide WSAs to comply with the promulgated Regulation 5 under Section 9(1) of the Water Services Act 108 of 1997. Addition of the Information Management Tool for Small Water Treatment Works onto the DWAF/IMESA WQMS will further enhance the present WQMS and allow the tool to be used by all WSAs within South Africa.

The requirements by DWAF for such an operational information system were met in the development of the Operational Information Tool, viz. simplistic, practical, not to be dependent on IT infrastructure or web connectivity only, cater for capturing of Alert Levels as stipulated by SANS 241:2006, data feeds to be done by means of e-mail link or fax, and the system having two clients, namely WSA Management & DWAF.

Benefits of the Operational Information Tool are that it will assist WSAs and government departments (DWAF) with support and regulation of water treatment works, while the WSAs will be made aware of issues of concern, required remedial measures and current best practice techniques.

The WSAs will also have a useful tool to assess and optimise the performance of their water treatment works. This will ensure more cost-efficient operation and maintenance, and ultimately cost savings.

On a national level, the OIT will contribute towards a country-wide improvement in quality of drinking water to consumers.

The tool is a simple and user-friendly system, using standardised active log-sheets (developed as spreadsheets), that can be filled in easily by operations and management staff. It captures all information that requires immediate action or storage for later, *viz*. personnel attendance, plant in- and outflows, chemical dosages (including coagulants, oxidants and disinfection agents), chemical usage, water qualities, unit process operational control (including alert levels), water quality monitoring in the distribution network, daily sheets of tasks, events and incidents, and monthly summaries of costs and water qualities.

The OIT spreadsheets will also link up with operational support products developed in other WRC projects, such as the "*manual and training aids for small water treatment plants*" and the "*compliance diagnostic tool*".

Of particular advantage also to the water sector, is the integration of the OIT within the existing eWQMS. It is anticipated that with increased use of the OIT, user requests for additional features/functions requiring ongoing eWQMS modifications will result. The provision of resources to ensure ongoing user requirements are being met will be a key need for all stakeholders in the water sector in South Africa.

6.2 Recommendations

It is recommended that application of the OIT, as information management tool in the municipal water treatment sector, be actively promoted, and that the ***Technical Assistance Centre for Small Water and Wastewater Treatment Plants*** *play a leading role in ensuring dissemination of these and other tools to the small water market sector.*

On-site training should be provided by Centre personnel during installation and implementation of the OIT, with managers receiving intensive training in this regard, as they will be doing the further in-house training to their supervisors and process controllers at their various water treatment plants on an ongoing basis (*i.e.* training and re-training).

During the implementation, the OIT posters that are supplied electronically on disk with this report, should be printed out in full-colour and posted on the walls of the process control room, office or plant laboratory.

The OIT should form an integral part of the “Tool Box for Small Water Treatment Plants” that is being distributed to all water treatment plants in the country.

The OIT and it’s training material should form part of training programmes for process controllers at water treatment plants.

The eWQMS team members should also be encouraged to train WSAs in the use of the OIT during their routine interactions and site visits. This will ensure rapid/maximum deployment of the OIT.

Consideration should be given to further enhance the OIT to include wastewater treatment facilities. The WRC wastewater treatment-based OIT could then also be incorporated into the eWQMS. As wastewater challenges in South Africa are significant, a tool such as this will be of significant benefit.

6.3 Further Work

A follow-up project is proposed to roll out the OIT to all the WSAs and WSPs in South Africa, which could be facilitated by the TAC. This roll-out should ideally be combined with the roll-out of the diagnostic tool for water treatment plant that was compiled in WRC Project K5/1668.

References

Anthony, J (2006) Water Utility Uses Cell Phones to Gather Field Data. Water and Wastes Digest, City of Pearland, Texas

AWWA (2001) Self-Assessment for Treatment Plant Optimisation. Bill Lauer, Technical Editor *A Guidance Manual of the American Water Works Association.*

California Department of Health Services (2003) Small Water Treatment System Operation and Maintenance, *A Field Study Training Program*.

DWAF / DoH / WRC Quality of Domestic Water Supplies Series: Volume 4: Treatment Guide. Water quality series by the Department of Water Affairs and Forestry, Department of Health and the Water Research Commission.

Laing, RD (2002) Report of the Commission of Inquiry into matters relating to the safety of the public drinking water in the City of North Battleford, Saskachewan.
www.northbattlefordwaterinquiry.ca/final/showpage.asp

Schutte, CF (2006) Handbook for the Operation of Water Treatment Works, *Water Research Commission Report TT 265/06*.

Swartz CD, Charles K, Rajagopaul R, Mwiinga G, Meyer V, Hlophe M and Marler M (2008) Guidelines for the Sustainable Operation and Maintenance of Small Water Treatment Plants, Water Research Commission Project 1599, Draft Final Report.

Whittaker, J (2004) Development of Operational Manuals. *Paper presented at the 67th Annual Water Industry Engineers' and Operators' Conference*, Wodonga, Australia, September 2004.

WHO (2008) Guidelines for Drinking-Water Quality, Third Edition (Incorporating The First And Second Addenda), Volume 1: Recommendations, World Health Organisation, Geneva.

ANNEXURE A

Operational Information Tool Spreadsheets

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 9 - MONTHLY COST AND QUALITY SUMMARY

Name of Treatment Plant	KZ number	Month and Year Reported	Province
Prepared by	Position	Date	Water Scheme

Indicator	Units	Daily Average	Total for Month
Total Raw Water	m^3		
Clear Water Produced	m^3		
Production Losses	%		
Operating Hours per Day	Hours		
Energy Consumption	kW		
Diesel Consumption	L		
Coagulant Consumption	kg		
Flocculant Consumption	kg		
Alkali Consumption	kg		
Gas Chlorine Consumption	kg		

Indicator	Quality Parameter	Value	Remarks
Average Raw Water Quality	Turbidity (NTU)		
	pH		
	Colour (mg/L as Pt)		
	Alkalinity (mg/L as $CaCO^3$)		
	Metal (Al/Fe/Mn)(mg/L)		
Average Final Water Quality	Chlorine Residual (mg/L)		
	Turbidity (NTU)		
	pH		
	Alkalinity (mg/L as $CaCO^3$)		
	Metal (Al/Fe/Mn)(mg/L)		

TOTAL COSTS FOR MONTH

Indicator			
Raw Water	m^3		
Energy	kW		
Diesel	L		
Coagulant	kg		
Flocculant	kg		
Alkali	kg		
Gas Chlorine	kg		
Salaries	R		
Maintenance	R		
Monitoring	R		
Total Operating Cost	R		

OPERATING COSTS FOR MONTH (per m^3 of clear water produced)

				Remarks
Raw Water Cost (R/m^3)		Personel Cost (R/m^3)		
Energy Cost (R/m^3)		Maintenance Cost (R/m^3)		
Chemicals Cost (R/m^3)		Monitoring Cost (R/m^3)		
Diesel Cost (R/m^3)		Total Operating Cost (R/m^3)		

ANNEXURE B

Operational Information Tool Pamphlet

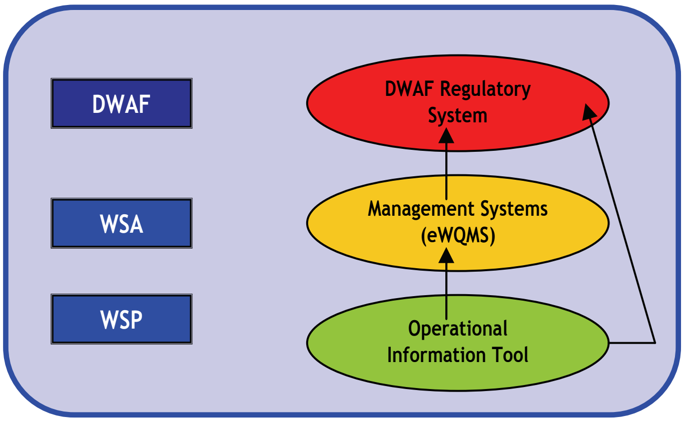
An Operational Information Tool for water treatment plants

Access to safe drinking water is a basic human right and essential to people's health. However, the performance of some small and medium-sized water treatment plants in South Africa is not always acceptable, primarily due to inadequate management of these plants.

An Operational Information Tool has been developed by the Water Research Commission for water treatment plant Process Controllers, and can result in significant improvements in sustainable performance and cost-efficient operation and maintenance of water treatment plants.

The Operational Information Tool will assist water treatment plant Process Controllers to operate their works and manage their information in a logical and efficient way

The Operational Information Tools also facilitates the flow of information between the water treatment plant operations staff and the Water Services Manager. Information can also be provided to the Department of Water Affairs and Forestry Regulatory System to assist them in their regulatory function.



What is the Operational Information Tool?

The Operational Information Tool is a set of standardised, active sheets (analogous to log-sheets) which are to be filled in by operations and management staff at a water treatment plant. The sheets are in an electronic format, but also available in hard copies for plants without adequate computer facilities.

The Operational Information Tool comprises various sheets in a spreadsheet format and includes information on:

- **Personnel**: Details and attendance of Process Controllers per shift, including their Regulation 17 classification relative to the water treatment plant classification;

- **Flows**: Daily inflows and outflows, and calculated and measured losses;
- **Chemical dosing**: Chemical dosages and concentrations, and levels of all chemicals dosed on the plant, and chemical makeup tanks per shift;
- **Settling and filtration**: Time and duration of sludge withdrawal and backwashing;
- **Water quality from catchment to consumer**: Operational monitoring of critical determinands at key process control points from the raw water source to consumer taps, and the comparison of results to preset Operational Alert limits;
- **Tasks/events and incidents**: Log of security/safety issues, maintenance undertaken, deliveries received, visits to and communications with the water treatment plant (the Process Controller 'diary');
- **Summary of cost and quality indicators**: Monthly management information on volume of water produced, raw and final water quality, consumption of resources and operating costs.

Each sheet on the Operational Information Tool will be accompanied by a set of guidelines and instructions for ease of use by Process Controllers

How can the Operational Information Tool be used?

The Operational Information Tool is recommended to be used as follows:

Supervisor receives generic Excel spreadsheet and customizes sheets for his/her specific water treatment plant

↓

Supervisor makes hardcopies and provides sheets to Process Controllers at the different treatment plants

↓

Process Controllers fill in the sheets

↓

Completed forms are returned to the Supervisor

↓

Supervisors enters the information on computer

↓

Calculations are performed by the computer

↓

Reports are generated (including graphs, tables, diagrams)

↓

Feedback given to Process Controllers at the treatment plants

↓

Monthly reports are submitted to DWAF (if required)

How can the Operational Information Tool assist me to run the water treatment plant?

The Operational Information Tool will assist water treatment plant personnel to practice comprehensive, preventative drinking water quality management from catchment to consumer.

Data from operational monitoring should be used to trigger corrective actions to operational procedures

Some of the benefits of using the Operational Information Tool include:

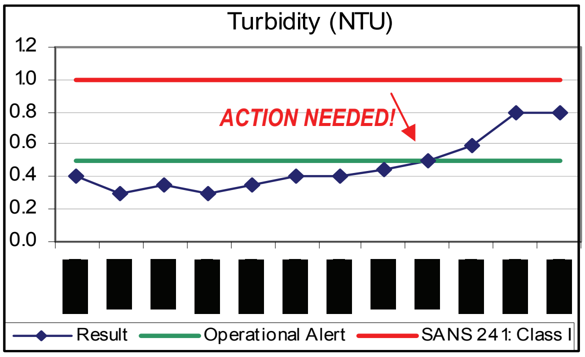
- Attention will be focused on the use of trained, and experienced staff;
- Attention will be focused on addressing water losses;
- The use of automated formulas and examples of calculations will assist Process Controllers to optimize chemical dosing rates. Improved chemical dosage control will reduce the potential for overdosing or underdosing which could have significant health impacts (for consumers) and economic impacts (for the municipality).
- Operational monitoring of water quality from catchment to consumer, and comparison of results to Operational Alerts can be used as a trigger for immediate short-term corrective action to operational procedures, thereby improving final drinking water quality and protecting the health of consumers.

- The preparation of unit operating cost information will assist with the budgeting and financial management of the water treatment plant;
- The tool will assist design engineers on aspects to include during the planning and design of small water treatment plants.

What are the minimum requirements to be able to use the Operational Information Tool?

The following are considered the minimum requirements to be able to use the Operational Information Tool:

- Flow meters on the water treatment plant inflow and outflow to be able to calculate process loadings and plant losses. These meters are required to be calibrated at least once per year.
- A set of customized Operational Alerts or warning limits at key process control points which are stricter than the South African National Standard (SANS) Drinking Water Specification limits. This will ensure that any process problem can be identified and addressed early in the process and will reduce the chances of exceeding SANS 241 limits in the final water.



Operational Alerts prompt action before the SANS 241 Class I limit is exceeded

- Equipment and standards (for calibration and use) to undertake operational pH, chlorine and turbidity monitoring. Documented procedures are required to perform these analyses according to accepted laboratory practice.

Operational monitoring equipment is required to track turbidity, pH and chlorine concentrations through the plant

- Awareness of the organization's safety, health, environment and quality (SHEQ) requirements.

The minimum information that should be filled in on the Operational Information Tool sheets includes:

- Water quality (at least pH, turbidity and chlorine residuals every 4 hours)
- Flows (inflow and outflow) (daily)
- Dosing rates for all chemicals used (once per shift)
- Chemicals used per day (daily)
- Pump running hours (daily)
- Time of day and duration of sludge withdrawal and filter backwashing.

Use of the Operational Information Tool to manage water quality will facilitate the provision of safe drinking water and the protection of public health

It is recommended that each Water Services Authority or Provider identifies a champion that will drive the use of the Operational Information Tool and ensure that it is used according to its intended purpose. Proper management of the Operational Information Tool should ideally be a key performance area at the water treatment plant.

Where can I get further information?

For further information on the Operational Information Tool, please contact:

- **Water Research Commission**: 012-330-0340 http://www.wrc.org.za/ WRC Project K5/1718: *An Operational Information Tool for the Efficient Operation and Maintenance of Small Water Treatment Plants.*
- **Department of Water Affairs and Forestry – Sector Support**: 0800 200 200
- **Technical Assistance Centre**: www.watersupport.co.za

ANNEXURE C

Operational Information Tool Posters

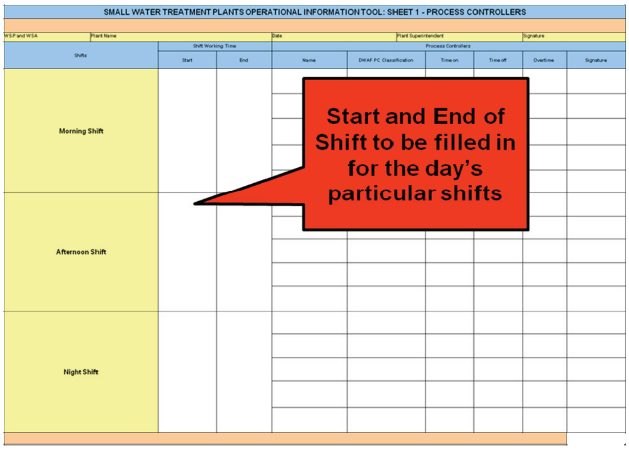
An Operational Information Tool for water treatment plants

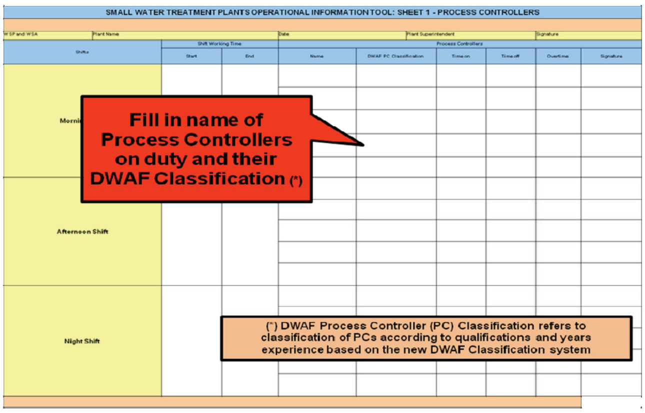
An Operational Information Tool has been developed by the Water Research Commission to assist water treatment plant Process Controllers to operate their works and manage their information in a logical and efficient way. The Operational Information Tool is a set of standardised, active sheets (analogous to log-sheets) which are to be filled in by operations and management staff at a water treatment plant. Use of the tool can result in significant improvements in sustainable performance and cost-efficient operation and maintenance of water treatment plants.

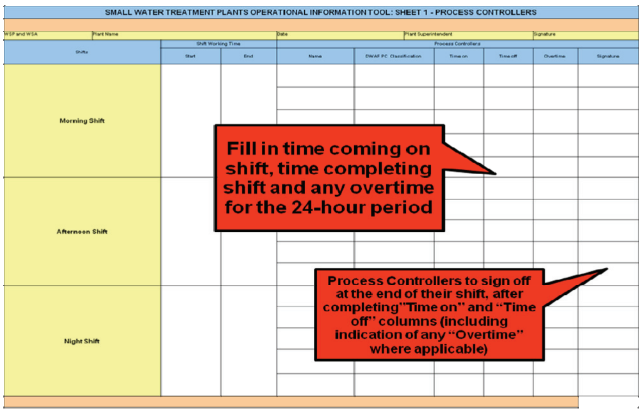
Operating Personnel Attendance and Working Hours - Sheet 1

The Operational Information Tool includes details and attendance of Process Controllers per shift, including their Regulation 17 classification relative to the water treatment plant classification:

Each sheet on the Operational Information Tool will be accompanied by a set of guidelines and instructions for ease of use by Process Controllers







water & forestry
Department: Water Affairs and Forestry
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For further information on the Operational Information Tool, please contact:

❖ **Water Research Commission**: +27-12-330-0340; http://www.wrc.org.za/ - WRC Project K5/1718:

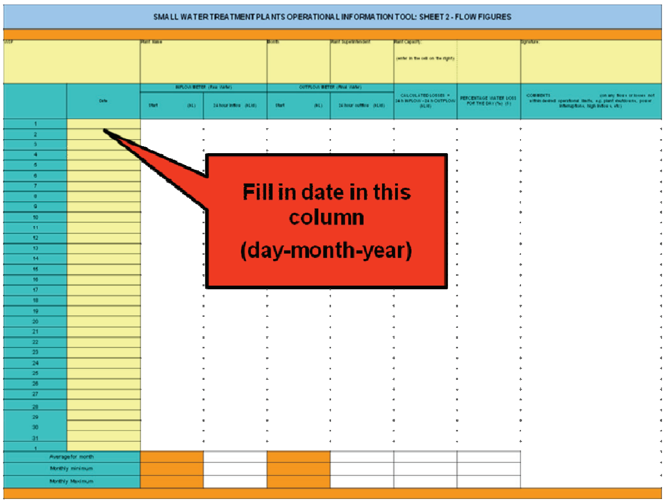
An Operational Information Tool for the Efficient Operation and Maintenance of Small Water Treatment Plants.

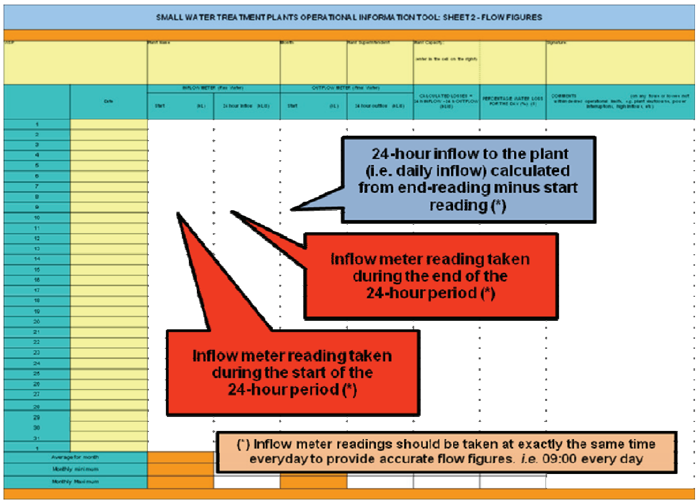
or contact the TECHNICAL ASSISTANCE CENTRE at www.watersupport.co.za

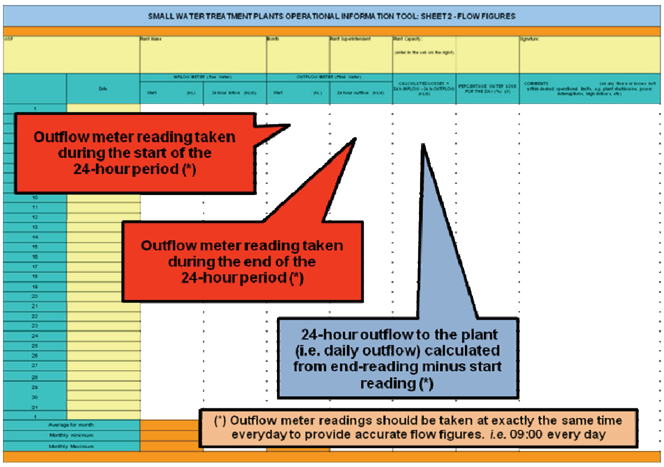
An Operational Information Tool for water treatment plants

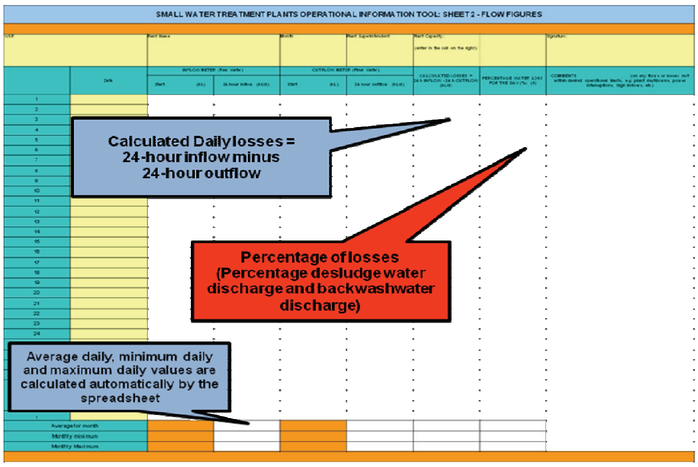
Daily Flows - Sheet 2

The Operational Information Tool focuses attention on addressing water losses by measuring daily inflows and outflows, and calculating losses. Flow meters on the water treatment plant inflow and outflow are thus a minimum requirement to be able to calculate process loadings and plant losses. These meters are required to be calibrated at least once per year.









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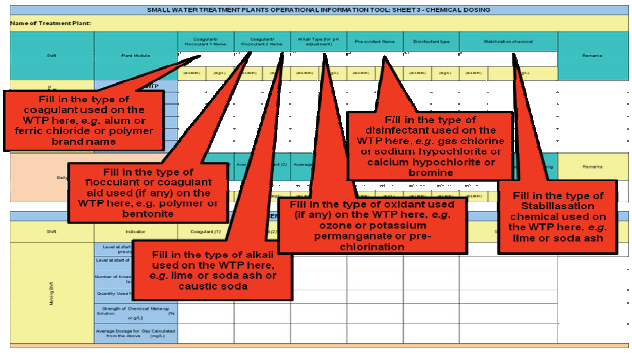
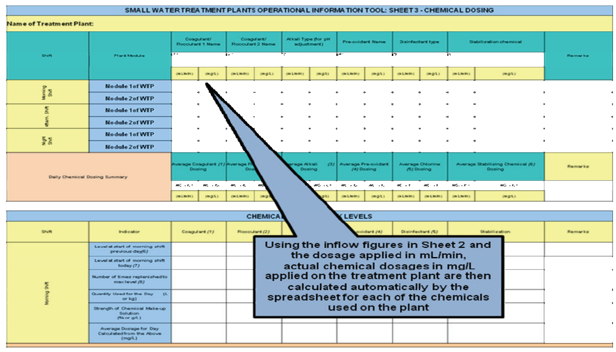
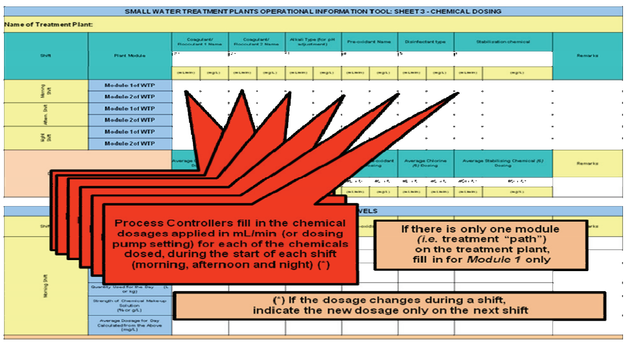
An Operational Information Tool for water treatment plants

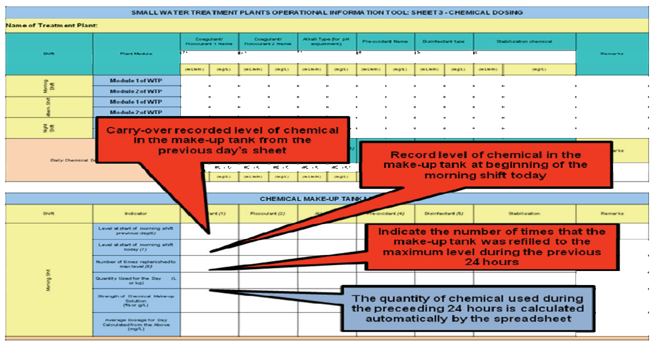
Chemical Dosages and Chemical Stock Control - Sheet 3

The Operational Information Tool measures chemical dosages and concentrations, and levels of all chemicals dosed on the plant, and chemical makeup tanks per shift. The use of automated formulas and examples of calculations will assist Process Controllers to optimize chemical dosing rates. Improved chemical dosage control will reduce the potential for overdosing or underdosing which could have significant health impacts (for consumers) and economic impacts (for the municipality).









The use of the Operational Information Tool will assist Process Controllers to optimise chemical dosing

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For further information on the Operational Information Tool, please contact:

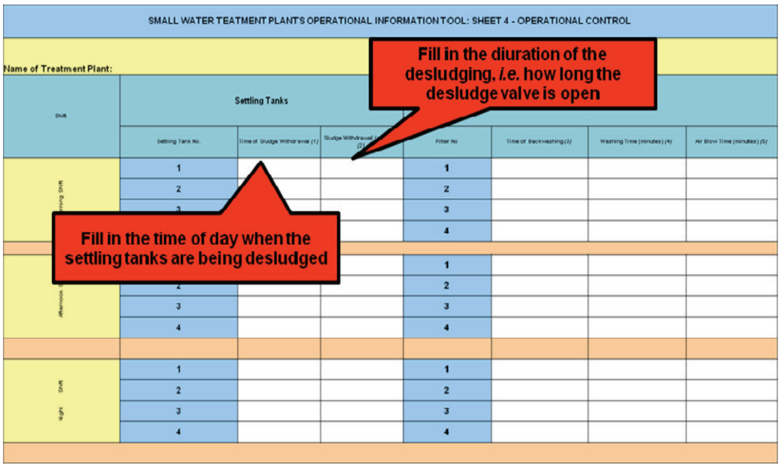
- **Water Research Commission**: +27-12-330-0340; http://www.wrc.org.za/ - WRC Project K5/1718: *An Operational Information Tool for the Efficient Operation and Maintenance of Small Water Treatment Plants*

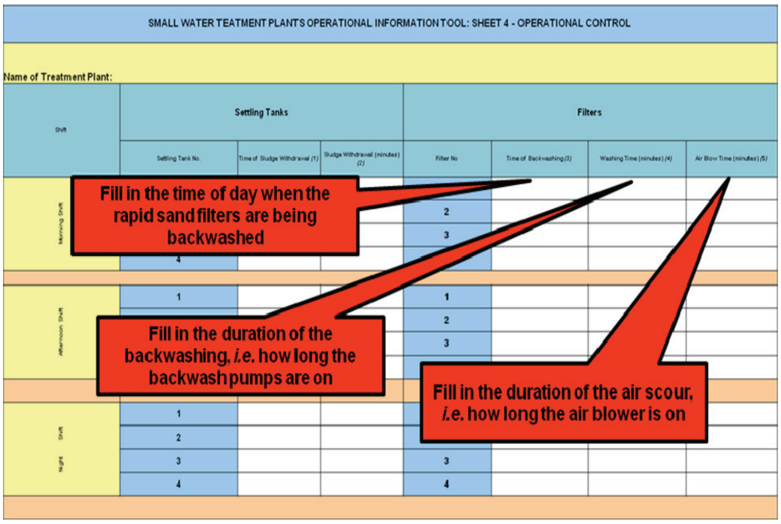
or contact the **TECHNICAL ASSISTANCE CENTRE** at **www.watersupport.co.za**

An Operational Information Tool for water treatment plants

Settling and Filtration Operations - Sheet 4

The Operational Information Tool records the time and duration of sludge withdrawal and backwashing.





For further information on the Operational Information Tool, please contact:

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An Operational Information Tool for the Efficient Operation and Maintenance of Small Water Treatment Plants.

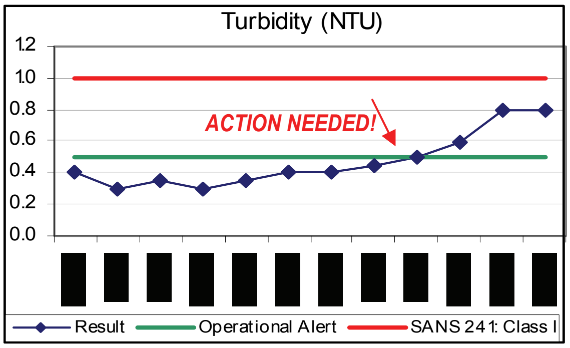
or contact the **TECHNICAL ASSISTANCE CENTRE** at **www.watersupport.co.za**

An Operational Information Tool for water treatment plants

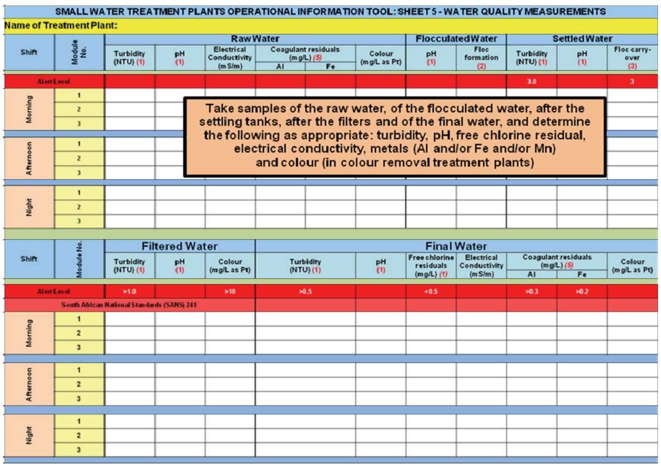
Water Quality Monitoring at the Water Treatment Plant - Sheet 5

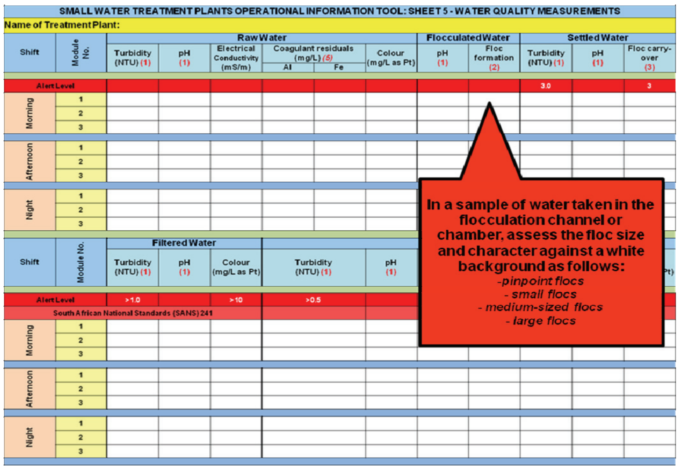
The Operational Information Tool promotes monitoring of critical determinands at key process control points from the raw water source to consumer taps, and the comparison of results to preset Operational Alert limits.

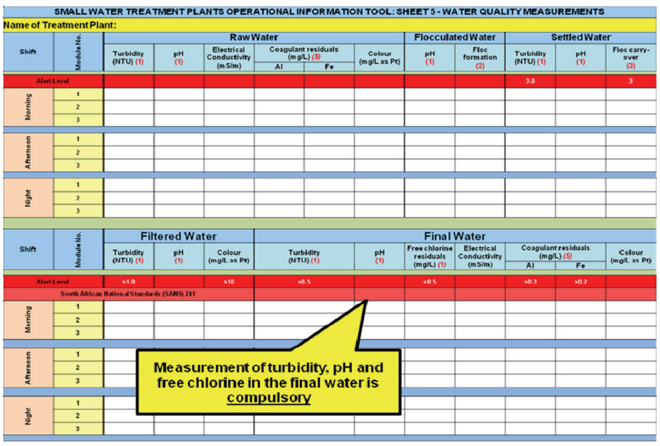
A set of customized Operational Alerts or warning limits are therefore needed at key process control points which are stricter than the South African National Standard (SANS) Drinking Water Specification limits. This will ensure that any process problem can be identified and addressed early in the process and will reduce the chances of exceeding SANS 241 limits in the final water, thereby improving final drinking water quality and protecting the health of consumers.

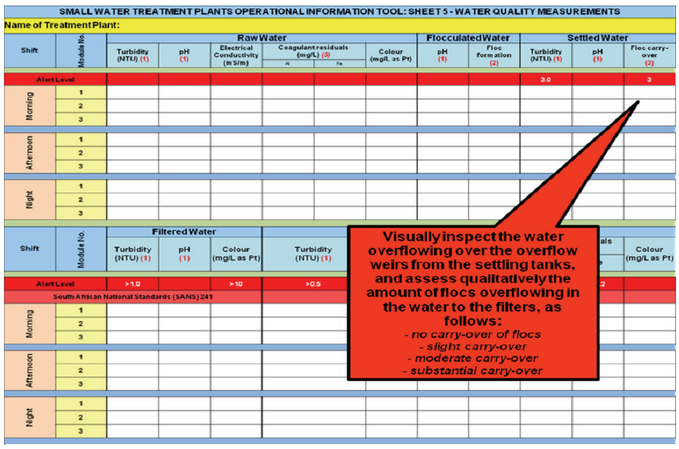


Operational Alerts prompt action before the SANS 241 Class I limit is exceeded





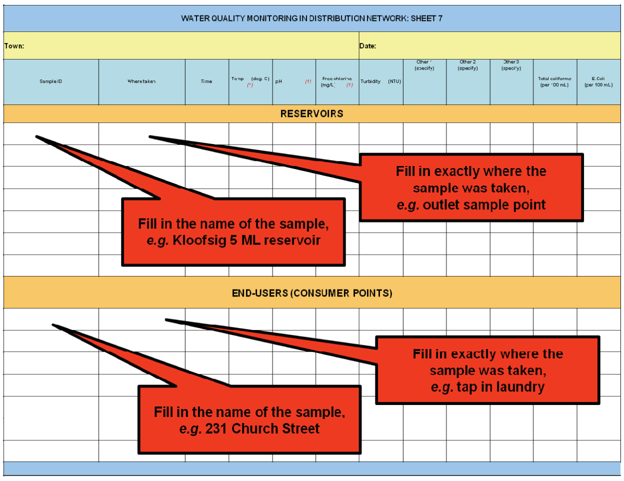


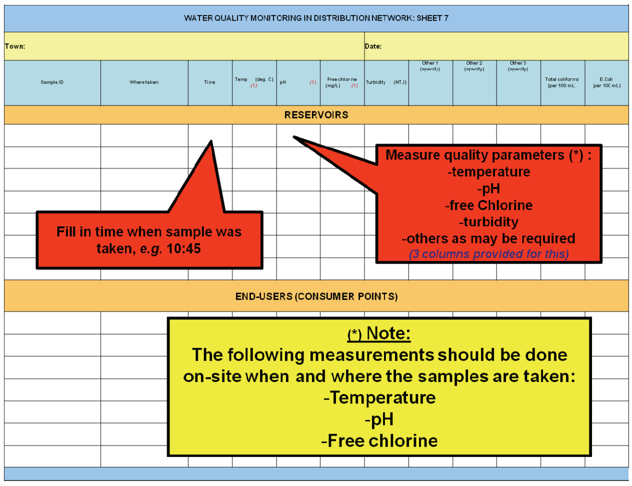


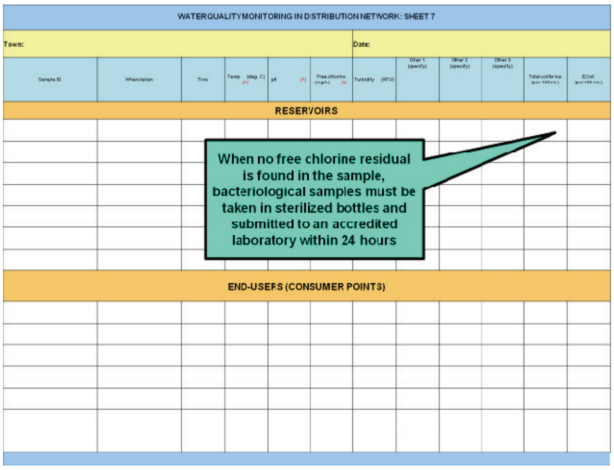
An Operational Information Tool for water treatment plants

Water Quality Monitoring in the Distribution Network - Sheet 6

Operational monitoring is required at strategic sites within the distribution network. Special consideration should be given to network dead-ends, high occupancy buildings, hospitals and schools.







Operational monitoring equipment and standards (for calibration and use) are required to undertake pH, chlorine and turbidity monitoring in the distribution network. Documented procedures are required to perform these analyses according to accepted laboratory practice.

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For further information on the Operational Information Tool, please contact:

❖ **Water Research Commission**: +27-12-330-0340; http://www.wrc.org.za/ - WRC Project K5/1718:

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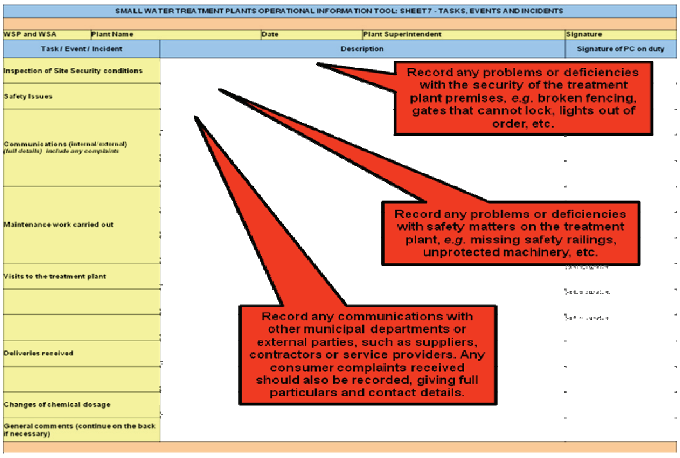
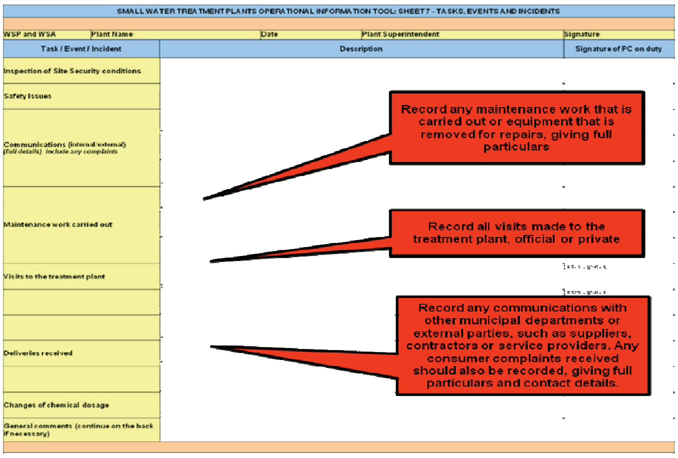
or contact the **TECHNICAL ASSISTANCE CENTRE** at **www.watersupport.co.za**

An Operational Information Tool for water treatment plants

Log (Diary) of Events and Incidents - Sheet 7

The Operational Information tool records a log of security/safety issues, maintenance undertaken, deliveries received, visits to and communications with the water treatment plant (the Process Controller 'diary').





The Operational Information tool records any maintenance that is carried out on Drinking Water Treatment infrastructure.

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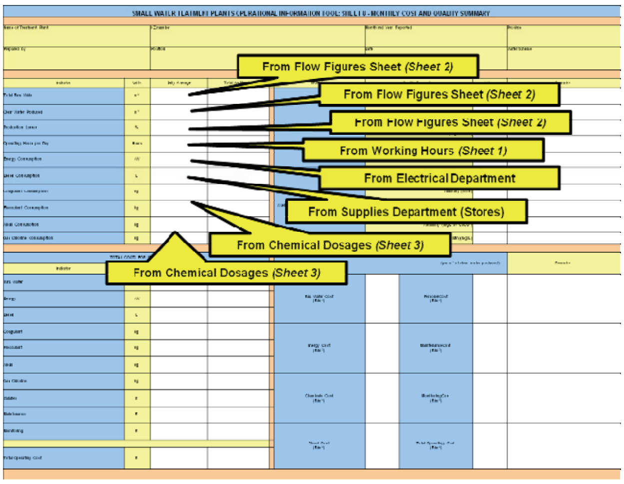
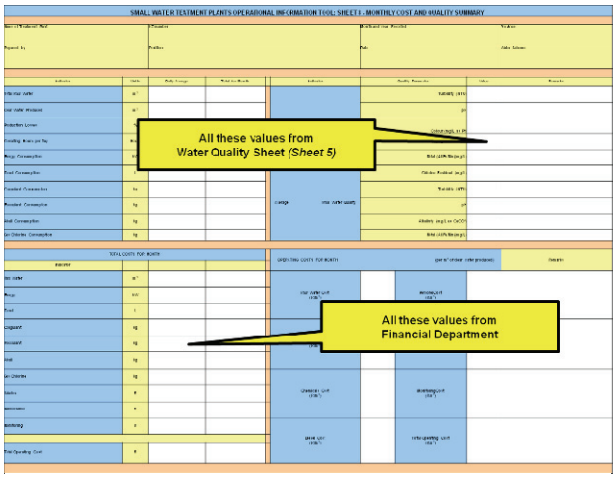
Contact the **TECHNICAL ASSISTANCE CENTRE** at **www.watersupport.co.za**

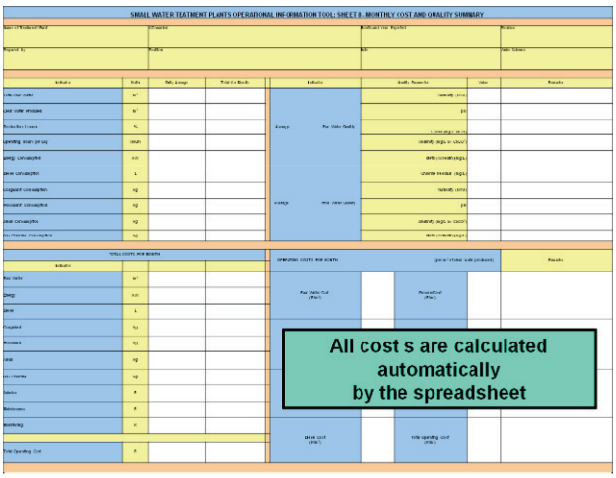
An Operational Information Tool for water treatment plants

Monthly Data Summary including Cost Figures - Sheet 8

The Operational Information tool produces monthly management information on volume of water produced, raw and final water quality, consumption of resources and operating costs. The preparation of this unit operating cost information will assist with the budgeting and financial management of the water treatment plant.







Use of the Operational Information Tool to manage water quality will facilitate the provision of safe drinking water and the protection of public health

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For further information on the Operational Information Tool, please contact:

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or contact the **TECHNICAL ASSISTANCE CENTRE** at **www.watersupport.co.za**

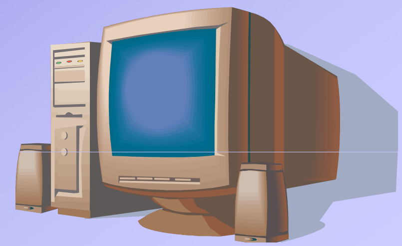
ANNEXURE D

Operational Information Tool Training Presentation

TRAINING PRESENTATION

Operational Information Tool for the Operation and Maintenance of Small Water Treatment Plants

Water Research Commission

Index of Operational Information Sheets:

1. Operating Personnel Attendance and Working Hours
2. Daily Inflow Figures
3. Chemical Dosages and Chemical Stock Control
4. Settling and Filtration Operations
5. Water Quality Monitoring in Water Treatment Plant
6. Water Quality Monitoring in Distribution Network
7. Log (diary) of Events and Incidents
8. Summary of Main Daily Parameters per Month
9. Monthly Data Summary including Cost Figures

1. Operating Personnel Attendance and Working Hours

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 1 - PROCESS CONTROLLERS

WSP and WSA	Plant Name	Date	Plant Superintendent	Signature

Shifts	Shift Working Time		Process Controllers					
	Start	End	Name	DWAF PC Classification	Time on	Time off	Overtime	Signature
Morning Shift								
Afternoon Shift								
Night Shift								

Water Research Commission

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 1 - PROCESS CONTROLLERS									
WSP and WSA	Plant Name		Date		Plant Superintendent			Signature	
Shifts	Shift Working Time		Process Controllers						
	Start	End	Name	DWAF PC Classification	Time on	Time off	Overtime	Signature	
Morning Shift									
Afternoon Shift									
Night Shift									

Start and End of Shift to be filled in for the day's particular shifts

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 1 - PROCESS CONTROLLERS

WSP and WSA	Plant Name	Date	Plant Superintendent	Signature

Shifts	Shift Working Time		Process Controllers					
	Start	End	Name	DWAF PC Classification	Time on	Time off	Overtime	Signature
Morning								
Afternoon Shift								
Night Shift								

Fill in name of Process Controllers on duty and their DWAF Classification (*)

(*) DWAF Process Controller (PC) Classification refers to classification of PCs according to qualifications and years experience based on the new DWAF Classification system

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 1 - PROCESS CONTROLLERS

WSP and WSA	Plant Name	Date	Plant Superintendent	Signature

Shifts	Shift Working Time		Process Controllers					
	Start	End	Name	DWAF PC Classification	Time on	Time off	Overtime	Signature
Morning Shift								
Afternoon Shift								
Night Shift								

Fill in time coming on shift, time completing shift and any overtime for the 24-hour period

Process Controllers to sign off at the end of their shift, after completing"Time on" and "Time off" columns (including indication of any "Overtime" where applicable)

2. Daily Inflow Figures

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 2 - FLOW FIGURES

WSP	Plant Name	Month	Plant Superintendent	Signature

	Date	INFLOW METER			OUTFLOW METER			CALCULATED LOSSES = 24 h INFLOW - 24 h OUTFLOW (kL/d)	ACTUAL MEASURED LOSSES (kL/d)	DEVIATION (CALCULATED LOSSES minus ACTUAL LOSSES)
		Start (kL)	End (kL)	24 hour inflow (kL/d)	Start (kL)	End (kL)	24 hour outflow (kL/d)			
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31										
Average for month										
Monthly minimum										
Monthly Maximum										

Water Research Commission

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 2 - FLOW FIGURES

WSP	Plant Name	Month	Plant Superintendent	Signature

	Date	INFLOW METER			OUTFLOW METER			CALCULATED LOSSES = 24 h INFLOW - 24 h OUTFLOW (kL/d)	ACTUAL MEASURED LOSSES (kL/d)	DEVIATION (CALCULATED LOSSES minus ACTUAL LOSSES)
		Start (kL)	End (kL)	24 hour inflow (kL/d)	Start (kL)	End (kL)	24 hour outflow (kL/d)			
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Average for month										
Monthly minimum										
Monthly Maximum										

Fill in date in this column

(day-month-year)

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 2 - FLOW FIGURES

WSP	Plant Name	Month	Plant Superintendent	Signature

	Date	INFLOW METER Start (kL)	INFLOW METER End (kL)	INFLOW METER 24 hour inflow (kL/d)	OUTFLOW METER Start (kL)	OUTFLOW METER End (kL)	OUTFLOW METER 24 hour outflow (kL/d)	CALCULATED LOSSES = 24 h INFLOW - 24 h OUTFLOW (kL/d)	ACTUAL MEASURED LOSSES (kL/d)	DEVIATION (CALCULATED LOSSES minus ACTUAL LOSSES)
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31										
Average for month										
Monthly minimum										
Monthly Maximum										

24-hour inflow to the plant (i.e. daily inflow) calculated from end-reading minus start reading (*)

Inflow meter reading taken during the end of the 24-hour period (*)

Inflow meter reading taken during the start of the 24-hour period (*)

(*) Inflow meter readings should be taken at exactly the same time everyday to provide accurate flow figures. *i.e.* 09:00 every day

Water Research Commission

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 2 - FLOW FIGURES

WSP	Plant Name	Month	Plant Superintendent	Signature

	Date	INFLOW METER			OUTFLOW METER			CALCULATED LOSSES = 24 h INFLOW - 24 h OUTFLOW (kL/d)	ACTUAL MEASURED LOSSES (kL/d)	DEVIATION (CALCULATED LOSSES minus ACTUAL LOSSES)
		Start (kL)	End (kL)	24 hour inflow (kL/d)	Start (kL)	End (kL)	24 hour outflow (kL/d)			
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31										
Average for month										
Monthly minimum										
Monthly Maximum										

Outflow meter reading taken during the start of the 24-hour period (*)

Outflow meter reading taken during the end of the 24-hour period (*)

24-hour outflow to the plant (i.e. daily outflow) calculated from end-reading minus start reading (*)

(*) Outflow meter readings should be taken at exactly the same time everyday to provide accurate flow figures. *i.e.* 09:00 every day

Water Research Commission

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 2 - FLOW FIGURES

WSP	Plant Name	Month	Plant Superintendent	Signature

	Date	INFLOW METER			OUTFLOW METER			CALCULATED LOSSES = 24 h INFLOW - 24 h OUTFLOW (kL/d)	ACTUAL MEASURED LOSSES (kL/d)	DEVIATION (CALCULATED LOSSES minus ACTUAL LOSSES)
		Start (kL)	End (kL)	24 hour inflow (kL/d)	Start (kL)	End (kL)	24 hour outflow (kL/d)			
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24										
31										
Average for month										
Monthly minimum										
Monthly Maximum										

Calculated Daily losses =
24-hour inflow minus
24-hour outflow

Actual Measured Daily losses
(sum of desludge water
discharge and backwashwater
discharge)

Deviation =
Calculated daily losses minus
Actual measures daily losses
(provides a control measure)

Average daily, minimum daily and
maximum daily values are calculated
automatically by the spreadsheet

Water Research Commission

3. Chemical Dosages and Chemical Stock Control

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 3 - CHEMICAL DOSING

Name of Treatment Plant:

Shift	Plant Module	Coagulant Name *(1)*		Flocculant Name *(2)*		Alkali Type *(3)*		Pre-oxidant Name *(4)*		Disinfectant type *(5)*		Remarks
		(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	
Morning Shift	Module 1of WTP											
	Module 2of WTP											
Aftern. Shift	Module 1of WTP											
	Module 2of WTP											
Night Shift	Module 1of WTP											
	Module 2of WTP											
Daily Chemical Dosing Summary		Average Coagulant *(1)* Dosing		Average Flocculant *(2)* Dosing		Average Alkali *(3)* Dosing		Average Pre-oxidant *(4)* Dosing		Average Chlorine *(5)* Dosing		Remarks
		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
		(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	

CHEMICAL MAKE-UP TANK LEVELS

Shift	Indicator	Coagulant *(1)*	Flocculant *(2)*	Alkali *(3)*	Pre-oxidant *(4)*	Disinfectant *(5)*	Remarks
Morning Shift	Level at start of morning shift previous day *(6)*						
	Level at start of morning shift today *(7)*						
	Number of times replenished to max level *(8)*						
	Quantity Used for the Day (L or kg)						
	Strength of Chemical Make-up Solution (% or g/L)						
	Average Dosage for Day Calculated from the Above (mg/L)						

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 3 - CHEMICAL DOSING

Name of Treatment Plant:

Shift	Plant Module	Coagulant Name (1)		Flocculant Name (2)		Alkali Type (3)		Pre-oxidant Name (4)		Disinfectant type (5)		Remarks
		(mL/min)	(mg/L)	(mL/min	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	
Shift	Mo... P											
Night	Module 2of WTP											
Daily Chemical Dosi...		Aver... ...sing		Average Flocculant (2) Dosing		...i (3) Dosing		Average ... ...ing		Average Chlorine (5) Dosing		Remarks
				...IV/0!	#DIV/0!		#DIV/0!					
				.../min)	(mg/L)		(mg/L)					

...EMICAL MA... K LEVEL...

Shift	Indicator	Coagulant (1)	Flocculant (2)	...kali (3)			Remarks
Morning Shift	Level at start of morning shift previous day (6)						
	Level at start of morning shift today (7)						
	Number of times replenished to max level (8)						
	Quantity Used for the Day (L or kg)						
	Strength of Chemical Make-up Solution (% or g/L)						
	Average Dosage for Day Calculated from the Above (mg/L)						

Fill in the type of coagulant used on the WTP here, *e.g.* alum or ferric chloride or polymer brand name

Fill in the type of flocculant or coagulant aid used (if any) on the WTP here, e.g. polymer or bentonite

Fill in the type of alkali used on the WTP here, *e.g.* lime or soda ash or caustic soda

Fill in the type of oxidant used (if any) on the WTP here, *e.g.* ozone or potassium permanganate or pre-chlorination

Fill in the type of disinfectant used on the WTP here, *e.g.* gas chlorine or sodium hypochlorite or calcium hypochlorite or bromine

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 3 - CHEMICAL DOSING												
Name of Treatment Plant:												
Shift	Plant Module	Coagulant Name		Flocculant Name		Alkali Type		Pre-oxidant Name		Disinfectant type		Remarks
		(1)		(2)		(3)		(4)		(5)		
		(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	
Morning Shift	Module 1of WTP											
	Module 2of WTP											
Aftern. Shift	Module 1of WTP											
	Module 2of WTP											
Night Shift	Module 1of WTP											
	Module 2of WTP											
Da…		Average Coa…						Average Pre-oxidant (4) Dosing		Average Chlorine (5) Dosing		Remarks
						…V/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
							(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	

…s		
Shift		
Morning Shift	Le…	
	Number o… (8)	
	Quantity Used for the Day (L or kg)	
	Strength of Chemical Make-up Solution (% or g/L)	
	Average Dosage for Day Calculated from the Above (mg/L)	

Process Controllers fill in the chemical dosages applied in mL/min (or dosing pump setting) for each of the chemicals dosed, during the start of each shift (morning, afternoon and night) (*)

If there is only one module (*i.e.* treatment "path") on the treatment plant, fill in for *Module 1* only

(*) If the dosage changes during a shift, indicate the new dosage only on the next shift

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 3 - CHEMICAL DOSING

Name of Treatment Plant:

Shift	Plant Module	Coagulant Name		Flocculant Name		Alkali Type		Pre-oxidant Name		Disinfectant type		Remarks
		(1)		*(2)*		*(3)*		*(4)*		*(5)*		
		(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	
Morning Shift	Module 1of WTP											
	Module 2of WTP											
Aftern. Shift	Module 1of WTP											
	Module 2of WTP											
Night Shift	Module 1of WTP											
	Module 2of WTP											
Daily Chemical Dosing Summary		Average Coagulant *(1)* Dosing		Average [illegible] sing		Average Alkali *(3)* Dosing		Average Pre-oxidant *(4)* Dosing		Average Chlorine *(5)* Dosing		Remarks
		#DIV/0!	#DIV/0!	#DIV/0!	[illegible]	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
		(mL/min)	(mg/L)	(mL/min)	[illegible]	[illegible]/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	

CHEMICAL M[illegible]EVELS

Shift	Indicator	Coagulant *(1)*	Flocculant *(2)*	[illegible]	Pre-oxidant *(4)*	Disinfectant *(5)*	Remarks
Morning Shift	Level at start of morning shift previous day *(6)*						
	Level at start of morning shift today *(7)*						
	Number of times replenished to max level *(8)*						
	Quantity Used for the Day (L or kg)						
	Strength of Chemical Make-up Solution (% or g/L)						
	Average Dosage for Day Calculated from the Above (mg/L)						

Using the inflow figures in Sheet 2 and the dosage applied in mL/min, actual chemical dosages in mg/L applied on the treatment plant are then calculated automatically by the spreadsheet for each of the chemicals used on the plant

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 3 - CHEMICAL DOSING

Name of Treatment Plant:

Shift	Plant Module	Coagulant Name (1)		Flocculant Name (2)		Alkali Type (3)		Pre-oxidant Name (4)		Disinfectant type (5)		Remarks
		(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	
Morning Shift	Module 1of WTP											
	Module 2of WTP											
Aftern. Shift	Module 1of WTP											
	Module 2of WTP											
Night Shift												
Daily Chemical Dosing			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#D					
			(mg/L)	(mL/min)	(mg/L)	(mL/min)	(m					

CHEMICAL MAKE-UP TANK LE

Shift	Indicator	lant *(1)*	Flocculant *(2)*	*(3)*	Pre-oxidant *(4)*	Disinfectant *(5)*	Remarks
Morning Shift	Level at start of morning shift previous day*(6)*						
	Level at start of morning shift today *(7)*						
	Number of times replenished to max level *(8)*						
	Quantity Used for the Day (L or kg)						
	Strength of Chemical Make-up Solution (% or g/L)						
	Average Dosage for Day Calculated from the Above (mg/L)						

Carry-over recorded level of chemical in the make-up tank from the previous day's sheet

Record level of chemical in the make-up tank at beginning of the morning shift today

Indicate the number of times that the make-up tank was refilled to the maximum level during the previous 24 hours

The quantity of chemical used during the preceeding 24 hours is calculated automatically by the spreadsheet

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 3 - CHEMICAL DOSING

Name of Treatment Plant:

Shift	Plant Module	Coagulant Name		Flocculant Name		Alkali Type		Pre-oxidant Name		Disinfectant type		Remarks
		(1)		*(2)*		*(3)*		*(4)*		*(5)*		
		(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	
Morning Shift	Module 1of WTP											
	Module 2of WTP											
Aftern. Shift	Module 1of WTP											
	Module 2of WTP											
Night Shift	Module 1of WTP											
	Module 2of WTP											
Daily Chemical Dosing Summary		Average Coagulant *(1)* Dosing		Average Flocculant *(2)* Dosing		Average Alkali *(3)* Dosing		Average Pre-oxidant *(4)* Dosing		Average Chlorine *(5)* Dosing		Remarks
		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
		(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	(mL/min)	(mg/L)	

Record the strength of the chemicals in the make-up tanks (take note of any dilutions that may have been made)

...LEVELS							
Shift				*(3)*	Pre-oxidant *(4)*	Disinfectant *(5)*	Remarks
Morning Shift	Lev...						
	Level at start of morning shift						
	Number of times replenished to max lev... *(8)*						
	Quantity Used for the Day (L or kg)						
	Strength of Chemical Make-up Solution (% or g/L)						
	Average Dosage for Day Calculated from the Above (mg/L)						

Average daily dosages of chemicals are calculated automatically based on the quantity of chemicals used during the previous 24 hours

Water Research Commission

4. Settling and Filtration Operations

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 4 - OPERATIONAL CONTROL

Name of Treatment Plant:

Shift	Settling Tanks			Filters			
	Settling Tank No.	Time of Sludge Withdrawal *(1)*	Sludge Withdrawal (minutes) *(2)*	Filter No	Time of Backwashing *(3)*	Washing Time (minutes) *(4)*	Air Blow Time (minutes) *(5)*
Morning Shift	1			1			
	2			2			
	3			3			
	4			4			
Afternoon Shift	1			1			
	2			2			
	3			3			
	4			4			
Night Shift	1			1			
	2			2			
	3			3			
	4			4			

Water Research Commission

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 4 - OPERATIONAL CONTROL

Name of Tr

Fill in the time of day when the settling tanks are being desludged

Fill in the diuration of the desludging, *i.e.* how long the desludge valve is open

Shift	Settling Tank No.	Tim… thdrawal *(1)*	Sludge Withdrawal (minut… *(2)*	Filter No	Time of Backwashing *(3)*	Washing Time (minutes) *(4)*	Air Blow Time (minutes) *(5)*
Morning Shift	1			1			
	2			2			
	3			3			
	4			4			
Afternoon Shift	1			1			
	2			2			
	3			3			
	4			4			
Night Shift	1			1			
	2			2			
	3			3			
	4			4			

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 4 - OPERATIONAL CONTROL							
Name of Treatment Plant:							
Shift	Settling Tanks			Filters			
	Settling Tank No.	Time of Sludge Withdrawal *(1)*	Sludge Withdrawal (minutes) *(2)*	Filter No	Time of Backwashing *(3)*	Washing Time (minutes) *(4)*	Air Blow Time (minutes) *(5)*
Morning Shift				1			
				2			
				3			
				4			
Afternoon Shift	1			1			
	2			2			
				3			
				4			
Night Shift	1						
	2						
	3			3			
	4			4			

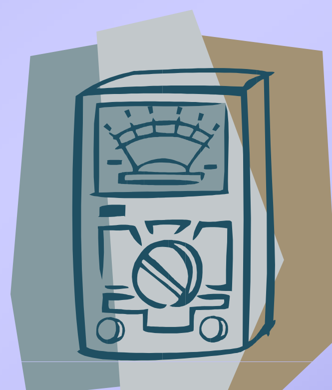
Fill in the time of day when the rapid sand filters are being backwashed

Fill in the duration of the backwashing, *i.e.* how long the backwash pumps are on

Fill in the duration of the air scour, *i.e.* how long the air blower is on

Water Research Commission

5. Water Quality Monitoring in Water Treatment Plant



TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 5 - WATER QUALITY MEASUREMENTS

Name of Treatment Plant:

Shift	Module No.	Raw Water						Flocculated Water		Settled Water		
		Turbidity (NTU) (1)	pH (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)	pH (1)	Floc formation (2)	Turbidity (NTU) (1)	pH (1)	Floc carry-over (3)
					Al	Fe						
Alert Level										3.0		3
Morning	1											
	2											
	3											
Afternoon	1											
	2											
	3											
Night	1											
	2											
	3											

Shift	Module No.	Filtered Water			Final Water						
		Turbidity (NTU) (1)	pH (1)	Colour (mg/L as Pt)	Turbidity (NTU) (1)	pH (1)	Free chlorine residuals (mg/L) (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)
									Al	Fe	
Alert Level		>1.0		>10	>0.5		<0.5		>0.3	>0.2	
South African National Standards (SANS) 241											
Morning	1										
	2										
	3										
Afternoon	1										
	2										
	3										
Night	1										
	2										
	3										

(1) Compulsory measurements at all water treatment plants

(2) Pin Point; Small; Medium; Large flocs

(3) None; Slight; Some; Substantial carry-over

(4) Record twice per shift, i.e. every 4 hours

(5) Depends on raw water quality and type of coagulant chemicals used

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 5 - WATER QUALITY MEASUREMENTS

Name of Treatment Plant:

Shift	Module No.	Raw Water						Flocculated Water		Settled Water		
		Turbidity (NTU) (1)	pH (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)	pH (1)	Floc formation (2)	Turbidity (NTU) (1)	pH (1)	Floc carry-over (3)
					Al	Fe						
Alert Level										3.0		3
Morning	1											
	2											
	3											
Afternoon	1											
	2											
	3											
Night	1											
	2											
	3											

Take samples of the raw water, of the flocculated water, after the settling tanks, after the filters and of the final water, and determine the following as appropriate: turbidity, pH, free chlorine residual, electrical conductivity, metals (Al and/or Fe and/or Mn) and colour (in colour removal treatment plants)

Shift	Module No.	Filtered Water			Final Water						
		Turbidity (NTU) (1)	pH (1)	Colour (mg/L as Pt)	Turbidity (NTU) (1)	pH (1)	Free chlorine residuals (mg/L) (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)
									Al	Fe	
Alert Level		>1.0		>10	>0.5		<0.5		>0.3	>0.2	
South African National Standards (SANS) 241											
Morning	1										
	2										
	3										
Afternoon	1										
	2										
	3										
Night	1										
	2										
	3										

(1) Compulsory measurements at all water treatment plants

(2) Pin Point; Small; Medium; Large flocs

(3) None; Slight; Some; Substantial carry-over

(4) Record twice per shift, i.e. every 4 hours

(5) Depends on raw water quality and type of coagulant chemicals used

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 5 - WATER QUALITY MEASUREMENTS

Name of Treatment Plant:

Shift	Module No.	Raw Water						Flocculated Water		Settled Water		
		Turbidity (NTU) (1)	pH (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)	pH (1)	Floc formation (2)	Turbidity (NTU) (1)	pH (1)	Floc carry-over (3)
					Al	Fe						
Alert Level										3.0		3
Morning	1											
	2											
	3											
Afternoon	1											
	2											
	3											
Night	1											
	2											
	3											

Shift	Module No.	Filtered Water			Final Water						
		Turbidity (NTU) (1)	pH (1)	Colour (mg/L as Pt)	Turbidity (NTU) (1)	pH (1)	Free chlorine residuals (mg/L) (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)
									Al	Fe	
Alert Level		>1.0		>10	>0.5		<0.5		>0.3	>0.2	
South African National Standards (SANS) 241											
Morning	1										
	2										
	3										
Afternoon	1										
	2										
	3										
Night	1										
	2										
	3										

Measurement of turbidity, pH and free chlorine in the final water is <u>compulsory</u>

(1) Compulsory measurements at all water treatment plants

(2) Pin Point; Small; Medium; Large flocs

(3) None; Slight; Some; Substantial carry-over

(4) Record twice per shift, i.e. every 4 hours

(5) Depends on raw water quality and type of coagulant chemicals used

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 5 - WATER QUALITY MEASUREMENTS

Name of Treatment Plant:

Shift	Module No.	Raw Water						Flocculated Water		Settled Water		
		Turbidity (NTU) (1)	pH (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)	pH (1)	Floc formation (2)	Turbidity (NTU) (1)	pH (1)	Floc carry-over (3)
					Al	Fe						
Alert Level										3.0		3
Morning	1											
	2											
	3											
Afternoon	1											
	2											
	3											
Night	1											
	2											
	3											

Shift	Module No.	Filtered Water									
		Turbidity (NTU) (1)	pH (1)	Colour (mg/L as Pt)	Turbidity (NTU) (1)	pH (1)					Colour (mg/L as Pt)
Alert Level		>1.0		>10	>0.5						
South African National Standards (SANS) 241											
Morning	1										
	2										
	3										
Afternoon	1										
	2										
	3										
Night	1										
	2										
	3										

(1) Compulsory measurements at all water treatment plants

(2) Pin Point; Small; Medium; Large flocs

(3) None; Slight; Some; Substantial carry-over

(4) Record twice per shift, i.e. every 4 hours

(5) Depends on raw water quality and type of coagulant chemicals used

In a sample of water taken in the flocculation channel or chamber, assess the floc size and character against a white background as follows:

-pinpoint flocs

- small flocs

- medium-sized flocs

- large flocs

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 5 - WATER QUALITY MEASUREMENTS

Name of Treatment Plant:

Shift	Module No.	Raw Water						Flocculated Water		Settled Water		
		Turbidity (NTU) (1)	pH (1)	Electrical Conductivity (mS/m)	Coagulant residuals (mg/L) (5)		Colour (mg/L as Pt)	pH (1)	Floc formation (2)	Turbidity (NTU) (1)	pH (1)	Floc carry-over (3)
					Al	Fe						
Alert Level										3.0		3
Morning	1											
	2											
	3											
Afternoon	1											
	2											
	3											
Night	1											
	2											
	3											

Shift	Module No.	Filtered Water				
		Turbidity (NTU) (1)	pH (1)	Colour (mg/L as Pt)	Turbidity (NTU) (1)	pH (1)
Alert Level		>1.0		>10	>0.5	
South African National Standards (SANS) 241						
Morning	1					
	2					
	3					
Afternoon	1					
	2					
	3					
Night	1					
	2					
	3					

Visually inspect the water overflowing over the overflow weirs from the settling tanks, and assess qualitatively the amount of flocs overflowing in the water to the filters, as follows:

- ***no carry-over of flocs***
- ***slight carry-over***
- ***moderate carry-over***
- ***substantial carry-over***

(1) Compulsory measurements at all water treatment plants

(2) Pin Point; Small; Medium; Large flocs

(3) None; Slight; Some; Substantial carry-over

(4) Record twice per shift, i.e. every 4 hours

(5) Depends on raw water quality and type of coagulant chemicals used

Water Research Commission

6. Water Quality Monitoring in Distribution Network

WATER QUALITY MONITORING IN DISTRIBUTION NETWORK: SHEET 7

Town:

Date:

Sample ID	Where taken	Time	Temp (deg. C) (1)	pH (1)	Free chlorine (mg/L) (1)	Turbidity (NTU)	Other 1 (specify)	Other 2 (specify)	Other 3 (specify)	Total coliforms (per 100 mL)	E.Coli (per 100 mL)
RESERVOIRS											
END-USERS (CONSUMER POINTS)											

Water Research Commission

WATER QUALITY MONITORING IN DISTRIBUTION NETWORK: SHEET 7

Town:						Date:						
Sample ID	Where taken	Time	Temp (deg. C) (1)	pH (1)	Free chlorine (mg/L) (1)	Turbidity (NTU)	Other 1 (specify)	Other 2 (specify)	Other 3 (specify)	Total coliforms (per 100 mL)	E.Coli (per 100 mL)
RESERVOIRS											
END-USERS (CONSUMER POINTS)											

Fill in the name of the sample, *e.g.* Kloofsig 5 ML reservoir

Fill in exactly where the sample was taken, *e.g.* outlet sample point

Fill in the name of the sample, *e.g.* 231 Church Street

Fill in exactly where the sample was taken, *e.g.* tap in laundry

WATER QUALITY MONITORING IN DISTRIBUTION NETWORK: SHEET 7											
Town:						Date:					
Sample ID	Where taken	Time	Temp (deg. C) (1)	pH (1)	Free chlorine (mg/L) (1)	Turbidity (NTU)	Other 1 (specify)	Other 2 (specify)	Other 3 (specify)	Total coliforms (per 100 mL)	E.Coli (per 100 mL)
RESERVOIRS											
END-USERS (CONSUMER POINTS)											

Fill in time when sample was taken, *e.g.* 10:45

Measure quality parameters (*) :
-temperature
-pH
-free Chlorine
-turbidity
-others as may be required
(3 columns provided for this)

(*) Note:
The following measurements should be done on-site when and where the samples are taken:
-Temperature
-pH
-Free chlorine

Water Research Commission

WATER QUALITY MONITORING IN DISTRIBUTION NETWORK: SHEET 7

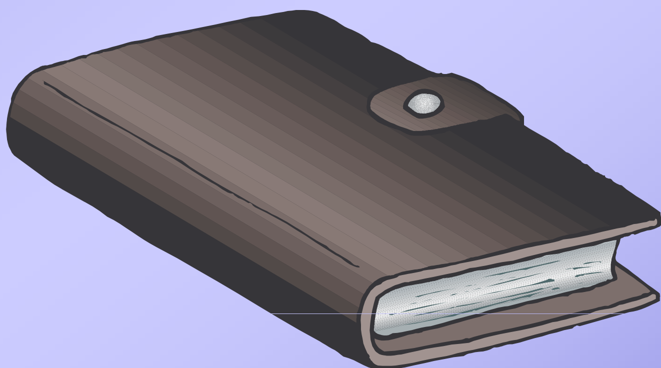
Town:

Date:

Sample ID	Where taken	Time	Temp (deg. C) (1)	pH (1)	Free chlorine (mg/L) (1)	Turbidity (NTU)	Other 1 (specify)	Other 2 (specify)	Other 3 (specify)	Total coliforms (per 100 mL)	E.Coli (per 100 mL)
RESERVOIRS											
END-USERS (CONSUMER POINTS)											

When no free chlorine residual is found in the sample, bacteriological samples must be taken in sterilized bottles and submitted to an accredited laboratory within 24 hours

7. Log (diary) of Events and Incidents



TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 6 - TASKS, EVENTS AND INCIDENTS

WSP and WSA	Plant Name	Date	Plant Superintendent	Signature

Task / Event / Incident	Description	Signature of PC on duty
Inspection of Security		
Safety Issues		
Communications (internal/external) *(full details)*	1	
	2	
	3	
Maintenance work carried out	1	
	2	
	3	
Visits to the treatment plant	1	
	2	
	3	
Deliveries received	1	
	2	
	3	
General comments		

Water Research Commission

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 6 - TASKS, EVENTS AND INCIDENTS		
WSP and WSA / Plant Name	Date / Plant Superintendent	Signature
Task / Event / Incident	Description	Signature of PC on duty
Inspection of Site Security		
Safety Issues		
Communications (internal/external) *(full details)*	1	
	2	
	3	
Maintenance work carried out	1	
	2	
	3	
Visits to the treatment plant	1	
	2	
	3	
Deliveries received	1	
	2	
	3	
General comments		

Record any problems or deficiencies with the security of the treatment plant premises, *e.g.* broken fencing, gates that cannot lock, lights out of order, etc.

Record any problems or deficiencies with safety matters on the treatment plant, *e.g.* missing safety railings, unprotected machinery, etc.

Record any communications with other municipal departments or external parties, such as suppliers, contractors or service providers. Any consumer complaints received should also be recorded, giving full particulars and contact details.

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 6 - TASKS, EVENTS AND INCIDENTS				
WSP and WSA	Plant Name	Date	Plant Superintendent	Signature

Task / Event / Incident	Description	Signature of PC on duty
Inspection of Site Security		
Safety Issues		
Communications (internal/external) *(full details)*	1	
	2	
	3	
Maintenance work carried out	1	
	2	
	3	
Visits to the treatment plant	1	
	2	
	3	
Deliveries received	1	
	2	
	3	
General comments		

Record any maintenance work that is carried out or equipment that is removed for repairs, giving full particulars

Record all visits made to the treatment plant, official or private

Record any communications with other municipal departments or external parties, such as suppliers, contractors or service providers. Any consumer complaints received should also be recorded, giving full particulars and contact details.

8. Summary of Main Daily Parameters per Month

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TREATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 8 - SUMMARY OF MAIN DAILY PARAMETERS PER MONTH

WSP	Plant Name	Month	Plant Superintendent	Plant Capacity:	Signature:

	Date	24 hour inflow	24 hour outflow	Calcu- lated losses	No of hours in operation for the day	Plant Capacity	CHEMICAL USE												QUALITY												
							Coagulant/ Flocculant 1 Name		Coagulant/ Flocculant 2 Name		Alkali Type (for pH adjustment)		Pre-oxidant Name		Disinfectant type		Stabilisation chemical		Raw Water				Flocculation	Mix after Settling	Mix after Filters	Final Water					
							mg/L	Kg	mg/L	Kg	mg/L	Kg	mg/L	Kg	mg/L	Kg	mg/L	Kg	Turb	pH	EC	Colour	pH	Turb	Turb	Turb	pH	Chlorine Residual	EC	Colour	Metals
1																															
2																															
3																															
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29																															
30																															
31																															
Average for month																															
Monthly minimum																															
Monthly Maximum																															

9. Monthly Data Summary including Cost Figures

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 8 - MONTHLY COST AND QUALITY SUMMARY

Name of Treatment Plant	KZ number	Month and Year Reported	Province
Prepared by	**Position**	**Date**	**Water Scheme**

Indicator	Units	Daily Average	Total for Month
Total Raw Water	m^3		
Clear Water Produced	m^3		
Production Losses	%		
Operating Hours per Day	Hours		
Energy Consumption	kW		
Diesel Consumption	L		
Coagulant Consumption	kg		
Flocculant Consumption	kg		
Alkali Consumption	kg		
Gas Chlorine Consumption	kg		

Indicator	Quality Parameter	Value	Remarks
Average Raw Water Quality	Turbidity (NTU)		
	pH		
	Colour (mg/L as Pt)		
	Alkalinity (mg/L as $CaCO^3$)		
	Metal (Al/Fe/Mn)(mg/L)		
Average Final Water Quality	Chlorine Residual (mg/L)		
	Turbidity (NTU)		
	pH		
	Alkalinity (mg/L as $CaCO^3$)		
	Metal (Al/Fe/Mn)(mg/L)		

TOTAL COSTS FOR MONTH			
Indicator			
Raw Water	m^3		
Energy	kW		
Diesel	L		
Coagulant	kg		
Flocculant	kg		
Alkali	kg		
Gas Chlorine	kg		
Salaries	R		
Maintenance	R		
Monitoring	R		
Total Operating Cost	R		

OPERATING COSTS FOR MONTH		(per m^3 of clear water produced)		Remarks
Raw Water Cost (R/m^3)		PersonelCost (R/m^3)		
Energy Cost (R/m^3)		MaintenanceCost (R/m^3)		
Chemicals Cost (R/m^3)		MonitoringCost (R/m^3)		
Diesel Cost (R/m^3)		Total Operating Cost (R/m^3)		

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 8 - MONTHLY COST AND QUALITY SUMMARY

Name of Treatment Plant	KZ number	Month and Year Reported	Province
Prepared by	Position	Date	Water Scheme

Indicator	Units	Daily Average	Total for Mo…	Indi…			Remarks
Total Raw Water	m^3						
Clear Water Produced	m^3						
Production Losses	%						
Operating Hours per Day	Hours						
Energy Consumption	kW						
Diesel Consumption	L						
Coagulant Consumption	kg				Turbidity (NTU)		
Flocculant Consumption	kg			Aver…			
Alkali Consumption	kg				Alkalinity (mg/L as $CaCO_3$)		
Gas Chlorine Consumption	kg				…/Mn)(mg/L)		

TOTAL COSTS FOR M…

Indicator					(per m^3 of clear water produced)			Remarks
Raw Water								
Energy	kW			Raw Water Cost (R/m^3)		PersonelCost (R/m^3)		
Diesel	L							
Coagulant	kg			Energy Cost (R/m^3)		MaintenanceCost (R/m^3)		
Flocculant	kg							
Alkali	kg			Chemicals Cost (R/m^3)		MonitoringCost (R/m^3)		
Gas Chlorine	kg							
Salaries	R			Diesel Cost (R/m^3)		Total Operating Cost (R/m^3)		
Maintenance	R							
Monitoring	R							
Total Operating Cost	R							

From Flow Figures Sheet *(Sheet 2)*

From Flow Figures Sheet *(Sheet 2)*

From Flow Figures Sheet *(Sheet 2)*

From Working Hours *(Sheet 1)*

From Electrical Department

From Supplies Department (Stores)

From Chemical Dosages *(Sheet 3)*

From Chemical Dosages *(Sheet 3)*

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 8 - MONTHLY COST AND QUALITY SUMMARY

Name of Treatment Plant	KZ number	Month and Year Reported	Province
Prepared by	Position	Date	Water Scheme

Indicator	Units	Daily Average	Total for Month	Indicator	Quality Parameter	Value	Remarks
Total Raw Water	m^3				Turbidity (NTU)		
Clear Water Produced	m^3				pH		
Production Losses	%				Colour (mg/L as Pt)		
Operating Hours per Day	Hou						
Energy Consumption	kW				Metal (Al/Fe/Mn)(mg/L)		
Diesel Consumption	L				Chlorine Residual (mg/L)		
Coagulant Consumption	kg			Average Final Water Quality	Turbidity (NTU)		
Flocculant Consumption	kg				pH		
Alkali Consumption	kg				Alkalinity (mg/L as $CaCO^3$)		
Gas Chlorine Consumption	kg				Metal (Al/Fe/Mn)(mg/L)		

All these values from
Water Quality Sheet *(Sheet 5)*

TOTAL COSTS FOR MONTH			
Indicator			
Raw Water	m^3		
Energy	kW		
Diesel	L		
Coagulant	kg		
Flocculant	kg		
Alkali	kg		
Gas Chlorine	kg		
Salaries	R		
Maintenance	R		
Monitoring	R		
Total Operating Cost	R		

OPERATING COSTS FOR MONTH (per m^3 of clear water produced)				Remarks
Raw Water Cost (R/m^3)		PersonelCost (R/m^3)		
(R/m^3)				
Chemicals Cost (R/m^3)		MonitoringCost (R/m^3)		
Diesel Cost (R/m^3)		Total Operating Cost (R/m^3)		

All these values from
Financial Department

Water Research Commission

TRAINING TOOLS: OPERATIONAL INFORMATION TOOL FOR SMALL WATER TREATMENT PLANTS

SMALL WATER TEATMENT PLANTS OPERATIONAL INFORMATION TOOL: SHEET 8 - MONTHLY COST AND QUALITY SUMMARY

Name of Treatment Plant	KZ number	Month and Year Reported	Province
Prepared by	Position	Date	Water Scheme

Indicator	Units	Daily Average	Total for Month
Total Raw Water	m^3		
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Production Losses	%		
Operating Hours per Day	Hours		
Energy Consumption	kW		
Diesel Consumption	L		
Coagulant Consumption	kg		
Flocculant Consumption	kg		
Alkali Consumption	kg		
Gas Chlorine Consumption	kg		

Indicator		Quality Parameter	Value	Remarks
Average	Raw Water Quality	Turbidity (NTU)		
		pH		
		Colour (mg/L as Pt)		
		Alkalinity (mg/L as $CaCO^3$)		
		Metal (Al/Fe/Mn)(mg/L)		
Average	Final Water Quality	Chlorine Residual (mg/L)		
		Turbidity (NTU)		
		pH		
		Alkalinity (mg/L as $CaCO^3$)		
		Metal (Al/Fe/Mn)(mg/L)		

TOTAL COSTS FOR MONTH			
Indicator			
Raw Water	m^3		
Energy	kW		
Diesel	L		
Coagulant	kg		
Flocculant	kg		
Alkali	kg		
Gas Chlorine	kg		
Salaries	R		
Maintenance	R		
Monitoring	R		
Total Operating Cost	R		

OPERATING COSTS FOR MONTH		(per m^3 of clear water produced)		Remarks
Raw Water Cost (R/m^3)		PersonelCost (R/m^3)		
Diesel Cost (R/m^3)		Total Operating Cost (R/m^3)		

All cost s are calculated automatically by the spreadsheet