Water Demand Management

UNIT 3

VERSION 1.1

WDM options and benefits

IUCN
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notes

course map

Unit 1: WDM in context

Unit 2: Municipal WDM

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outcomes

By the end of this unit, you should be able to…

- explain the costs and benefits of WDM, both in financial and social contexts;
- understand various demand projection methods, and the advantages and disadvantages of each, and analyse to what extent WDM measures have been taken into account into demand scenarios;
- give a broad overview of the various WDM measures that are available to you;
- discuss each measure in detail and select the most appropriate WDM measures for your MWSA, and
- understand the need for measures to reduce non-revenue water (NRW).

WDM has the potential to impact positively on the economies of SADC countries – and the region as a whole – and to enhance the lives of their individual citizens, but how does an MWSA decide on a way forward for WDM implementation? What means are available for evaluating WDM interventions against other water resource management strategies?

It is unlikely that an MWSA's decision to opt for a particular WDM strategy or measure will be a clear-cut choice. As a person working in this environment, you will have to weigh up the opportunities and constraints, and also be aware of the types of benefit, both short-term and long-term, that can accrue as a result.

WDM becomes more attractive and compelling, for example, when:

- The costs of water augmentation schemes are escalating beyond affordable limits
- There is an unhealthy reliance on shared or non-renewable water resources
- There are easy and cheap opportunities to save water e.g. non-revenue water (NRW)
- Water is currently used inefficiently

Opting for an integrated WDM solution would help to remedy some or all of these, but we need to determine what the bases are for decision-making. In this unit, we will examine the costs and benefits of WDM, ways of evaluating the future demand for water, and ways of deciding between the range of WDM options that are available.

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3.1 COSTS AND BENEFITS OF WDM

Any organisation that is considering the implementation of WDM interventions needs to consider the available options in terms of the financial, environmental, and social costs and benefits.

Generally, WDM should be implemented when the benefits exceed the costs. This seems straightforward, but several questions arise. What are the costs and benefits? What time horizon should be adopted? Do organisations know about WDM opportunities? Which constraints need to be addressed before WDM is implemented?

3.1.1 Financial costs and benefits

Financial costs and benefits determine an MWSA's economic performance and its degree of cost recovery, both of which are key concerns. One would expect that a well-informed and organised MWSA would spontaneously implement WDM measures to improve its economic performance (cost recovery or profit). The reality is that MWSAs, in addition to positive internal leadership and awareness, usually require external support or pressure to implement WDM measures.

MWSAs need to know the financial costs of these measures, categorised by source of supply and by type of WDM intervention. This is necessary to determine the net financial benefits (or costs) of individual WDM interventions compared to other interventions. This requires a financial Cost-Benefit Analysis (CBA) that could be part of a broader Multi-Criteria Analysis (MCA).

Table 1 outlines some of the financial costs and benefits that can accrue to MWSAs as a result of WDM implementation.

Table 1: Financial costs and benefits of WDM to MWSAs

FINANCIAL COSTS	FINANCIAL BENEFITS
WDM capital costs	Savings from postponement of large-scale investment schemes
WDM operation and maintenance (O&M) costs	Lower energy and wastewater treatment costs
Lower revenues due to lower sales	Decrease in non-revenue-generating NRW
Lower revenues due to lower water price	Reduced value of purchases of water

3.1.2 Social and environmental costs and benefits of WDM measures

It is the responsibility of government to consider all costs and benefits to the country, including social and environmental costs and benefits.

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The social costs and benefits are not necessarily the same as those for MWSAs. For example, NRW is not a cost to an MWSA, if the costs can be passed on to end-users through water tariffs. However, NRW is a social cost at all times. Water subsidies are a source of revenue to MWSAs, but do not appear as either an economic cost or benefit in a social CBA, as they constitute a transfer payment within society.

Examples of social and environmental costs and benefits are given in Table 2.

Table 2: Social and environmental costs and benefits of WDM

SOCIAL AND ENVIRONMENTAL COSTS	SOCIAL AND ENVIRONMENTAL BENEFITS
Investments of end-users and water service providers	More affordable water
WDM O&M costs	Fairer distribution of water access
	Energy savings
	Decrease in waste flows and treatment costs
	Protection of the environment
	Budgetary savings
	Better resource-use understanding, and ethics
	More future options for water use

The comparison of the financial to the social and environmental costs and benefits shows the large differences that may occur between a financial and social analysis. The following situations may occur:

- The WDM measure is financially *and* socially beneficial. Such a measure should be implemented immediately by an MWSA without government support.
- The WDM measure is only socially beneficial. Such a measure needs to be implemented but requires government support or regulation.
- The WDM measure is neither socially nor financially viable. Such a measure would normally not be implemented, unless there were unacceptable irreversible impacts or large risks and uncertainties attached to inaction.

example

Many southern African countries make every effort to supply water to their citizens, particularly in rural areas. This may be done by providing standpipes for lower income groups, or private connections for the medium and higher income groups. These two supply options have very distinct features, and pose different economic, social and environmental challenges.

The following case study from Botswana compares communal standpipes dispensing free water with the provision of in-house private connections (supplied at a charge).

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In examining the social cost-benefit issues of equity, sustainability, and water use efficiency, a decision-maker must attempt to isolate objective solutions that provide optimal social benefits at least cost.

STANDPIPES	PRIVATE CONNECTIONS
Facts These are an important tool to ensure access to safe drinking water for all people. Water use is not metered. Standpipe water is free in rural areas and there is a minimal flat rate in urban areas. Standpipes are meant for domestic use, but there is no control over livestock watering and other undesired uses.	**Facts** These are rapidly increasing in numbers. They are mostly metered. There is higher water use per connection. There is a significant difference in water use per connection. In larger villages, use is approximately 147 L/person/day, while in small rural villages with limited facilities, use is approximately 37 L/person/day. Charges may be effective in controlling household water use, but are not effective in controlling use with public and private institutions.
Equity All persons have reasonable access to water.	**Equity** Access to water for payment. The lifeline band is meant to ensure affordability and is set at less than 5% of monthly income.
Sustainability This depends on the water supply, but concerns exist in the form of wastage (leaving taps open, not repairing leaking taps). There is no incentive for water conservation.	**Sustainability** This depends on the water supply. Increased use may lead to groundwater depletion. Charges are an incentive to reduce water wastage and spillage, and to invest in water harvesting and water-saving devices.
Efficiency There is illegal use (e.g. for livestock). It is difficult to target water consumption and subsidy to specific groups and uses. There is resource wastage and losses of government revenues.	**Efficiency** This is reduced by continued access to standpipes. Such *dual water rights* condone the practice of activities that use a lot of water, such as building, livestock watering and gardening, being done free of charge from standpipes.
Possible solutions Solutions to achieve a better balance between equity, efficiency, and sustainability, include: Technical: meters to monitor water consumption, press-button taps, water payment cards Planning: fencing of standpipes Regulations: by-laws to curb abuse Management: social control through water management committees Education and awareness training	**Possible solutions** Management: denial of *dual water rights* Planning: monitoring of standpipe use

3.2 DEMAND PROJECTIONS AND ANALYSIS

Projecting future water demand as a part of regular planning activities is necessary in any MWSA. In the past, demand projections were treated as projections of a given quantity and quality of water that would be

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required over a specified period of time, and supply measures were designed to meet this forecasted demand.

However, with WDM, demand projections become integral components of the decision-making cycle, and the positive impact of WDM (as well as the associated costs) on demand projections are identified. This often leads to different demand projection scenarios through the implementation of different WDM options.

As we saw in unit 2, the prevention of the premature construction of augmentation schemes can be a major economic benefit of WDM. It is therefore imperative that an MWSA monitors and analyses the trends in consumption, and that it prepares for a series of future demand projections. Some key questions to be considered include:

- How has water use and consumption (level and composition) developed in the past, and how might it develop in future?
- When will current supply sources be fully utilised?
- What is the potential of WDM to reduce future demand growth?

It is extremely important that an MWSA communicate with end-users about its analysis so that it builds a readiness among end-users to implement WDM, and to pay for MWSA services. We will come back to the topic of communication in section 3.4.4.

3.2.1 Identifying and understanding users and customers

It is important to understand the nature of water use in your MWSA, and this information is vital to be able to project what demand will be in the future. To do this, you could group and classify customers and users according to similarities in their water use.

Urban water use is often the largest demand area for a MWSA.

3.2.1.1 Urban users

Urban water users are the largest sector of the customer base of many MWSAs, consisting as they do of a mixture of domestic and productive users. Table 3 gives a breakdown of the urban water supply for each SADC country in terms of percentages of population covered, with further details for the largest city in each country.

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Table 3: Overview of urban water supply for southern Africa

COUNTRY	TOTAL URBAN POPULA-TION (MILLION)	PERCENTAGE OF URBAN POPULATION COVERED (%)	LARGEST CITY	POPULATION OF LARGEST CITY (MILLION)	WATER PRODUCTION FOR LARGEST CITY (L/PERSON/DAY)
Angola	4.40	34	Luanda	4.0	30
Botswana	0.82	100	Gaborone	0.13	286
DRC	15.64	89	Kinshasa	5.7	86
Lesotho	0.60	98	Maseru	0.27	81
Malawi	2.72	95	Blantyre	0.80	100
Mauritius	0.48	100	Port Louis	0.15	200
Mozambique	7.92	86	Maputo	1.70	113
Namibia	0.53	100	Windhoek	0.27	241
Seychelles	0.26	100	Greater Victoria	0.12	140
South Africa	20.33	92	Johannesburg	3.5	314
Swaziland	0.54	90	Mbabane	0.27	100
Tanzania	11.02	80	Dar Es Salaam	3.00	150
Zambia	3.63	88	Lusaka	1.21	225
Zimbabwe	4.12	100	Harare	2.38	156

Note: The urban population is defined as the population living in urban centres according to national criteria.

Domestic users

- Domestic users need to be subdivided into the following categories:
  - Households using standpipes
  - Low-income households with their own water connection
  - Medium-income households with their own water connection
  - High-income households with their own water connection
- The percentage of the population covered by the water supply infrastructure is defined in terms of access to water, based on the type of technology employed, distance from the house, and quantity available. Access is defined as including:
  - Household water connections that have taps within the house or within a private plot of land

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  - Public water points, including public standpipes, boreholes with hand pumps, protected dug wells, protected springs, rainwater collection, or other locally defined technologies

- Reasonable access to a public water point is broadly defined as the availability of 20 litres per person per day of safe water from a public water point located within one kilometre of the user's dwelling.
- Key determinants of domestic water consumption include household income, living conditions, and household and plot size.

Productive users

- Productive users are normally classified according to some standard economic categorisation. It may be necessary to aggregate some sectors together. Key determinants of productive user categories are:
  - Type of product and production process
  - Expected output
  - Employment
  - Technologies used

3.2.2 Demand monitoring and projections

An MWSA needs to collate and analyse water consumption patterns in order to establish major demand trends and identify changes in demand composition as early as possible. For example, it is important to answer the following questions:

- How quickly has demand grown? Is it a continuous trend or a volatile movement? For example, what are the impacts of drought on demand?
- Have there been any changes in the composition of demand? For example, domestic use often grows rapidly, while productive use may show a more haphazard pattern linked to local economic developments.
- What factors could be responsible for the observed consumption patterns? It is important that such factors are incorporated in demand forecasting methods. What demand sectors should be prioritised for WDM?

Key factors that may influence water demand include:

- Domestic use: population numbers, income level, household size, living conditions, size of yard and garden

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- Productive use: value added, employment, local economic structure (e.g. service and manufacturing)

An MWSA should assess the importance of each factor, and identify additional demand determinants.

Different water demand projection methods exist, each providing different levels of accuracy and requiring differing logistical input. It is important that an MWSA either develops the forecasts itself or fully understands the findings of the projections and the advantages and disadvantages of the forecasting methods that have been used.

There are four main groups of forecasting methods:

- Judgemental-subjective
- Trend analysis
- Component analysis
- Regression analysis

Judgemental-subjective

The judgemental method is based on the opinion of experts and stakeholders about the demand trend. The method is cheap, but subjective, and the results depend strongly on the competency of the experts who have been consulted. It is usually difficult to justify the quantitative results.

Trend analysis

Trend analysis is commonly used, and is based either on an extrapolation of historical trends or on population growth figures multiplied by per capita consumption figures.

Component analysis

The component method dissects the main demand sectors, and develops separate forecasts for each of them based on the key determinants of water demand for each demand sector. A survey is often conducted to improve the understanding of water demand for each demand sector. This method is usually accurate, but costly and demanding.

Regression analysis

Regression analysis develops a regression equation that is used to project future demand. The equation contains expected demand determinants such as income, population and price, and the equation is tested with historical data.

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tip

For more information on water demand projections and forecasting refer to the Handbook for the assessment of catchment water demand and use (HR Wallingford, 2003) provided in the source material folder on the CD-ROM accompanying this training manual.

Some determinants will prove to be insignificant while others are significant and together explain variations in demand.

Table 4 compares the advantages and disadvantages of some of the more popular forecasting methods available.

Table 4: Advantages and disadvantages of forecasting methods

	FORECASTING METHOD	ADVANTAGES	DISADVANTAGES
Judgemental forecasts	• Based on personal or group knowledge	• Easy to implement and cheap	• Many biases such as professional, spatial and project, personal and seasonal/climatic.
Trend analysis	• Extrapolation of historical data-trend analysis	• Cheap and easy • Limited data requirements • Can deal with different types of end-users separately	• Assumption that past trends will continue • Inaccurate results as forecast depends on curve fitting • Method cannot incorporate *shocks* such as a decrease in NRW
	• Forecasts based on population growth and per capita consumption	• Cheap • Limited data needs	• Poor accuracy for long term forecasts • Risk of neglecting HIV/AIDS impact • No variation within sectors considered • Past trends projected in future
Component analysis	• Surveys conducted for each demand sector	• Separate forecasts by major end-user groups (e.g. changes in production technologies) • Indicates key water sectors for future intervention	• Requires large amount of data and in-depth analysis • May require costly surveys • Reliability depends on the quality of the analysis, hence varies
Regression analysis	• Multiple linear regression analysis • Multiple non-linear regression analysis	• Separate forecasts by major end-user groups possible • Indicates key water sectors for future intervention	• Requires large amount of data and in-depth analysis • Reliability depends on the quality of the analysis, hence varies

Source: HR Wallingford (2003)

notes

Before deciding which forecasting method to implement, the following questions should be considered:

- What was the previous forecast and are the results available?
- How do previous forecasts compare with actual consumption, and why were there differences?
- What is the objective of the new forecasts and what should the time horizon be, e.g. long-term or short-term planning, at sub-catchment or catchment level?
- What data are available, over what period, and at what level of detail, e.g. data on water demand, on population growth, and on demand management measures to be implemented?
- Which of the available forecasting methods are feasible given the various constraints on data, budget, and skills available to implement the method?
- Is the method used previously still satisfactory for the purpose, e.g. is a sophisticated method still preferable to a simpler method?
- Do additional data need to be collected in the future?

Suggested criteria for the selection of forecasting methods include the following:

- Consistency and transparency of the method
- Quality of the method
- Incorporation and explanation of historical trends
- Inclusion of historically neglected factors that have proven to be important for water demand
- Empirical validation of the method
- Acceptance of the method by regulatory bodies and other relevant organisations
- Available means (time, skills and funds)

The following example of the Mupfure sub-catchment area in Zimbabwe from HR Wallingford (2003) indicates what effect the method can have on the result.

example

Example of forecasts using trend and regression analysis

The Mupfure sub-catchment in Zimbabwe has 20 years of recorded and reliable water use figures for the catchment. Three different regression methods were used to fit curves to the available historical water use data to extrapolate the future water use. The three methods used were:

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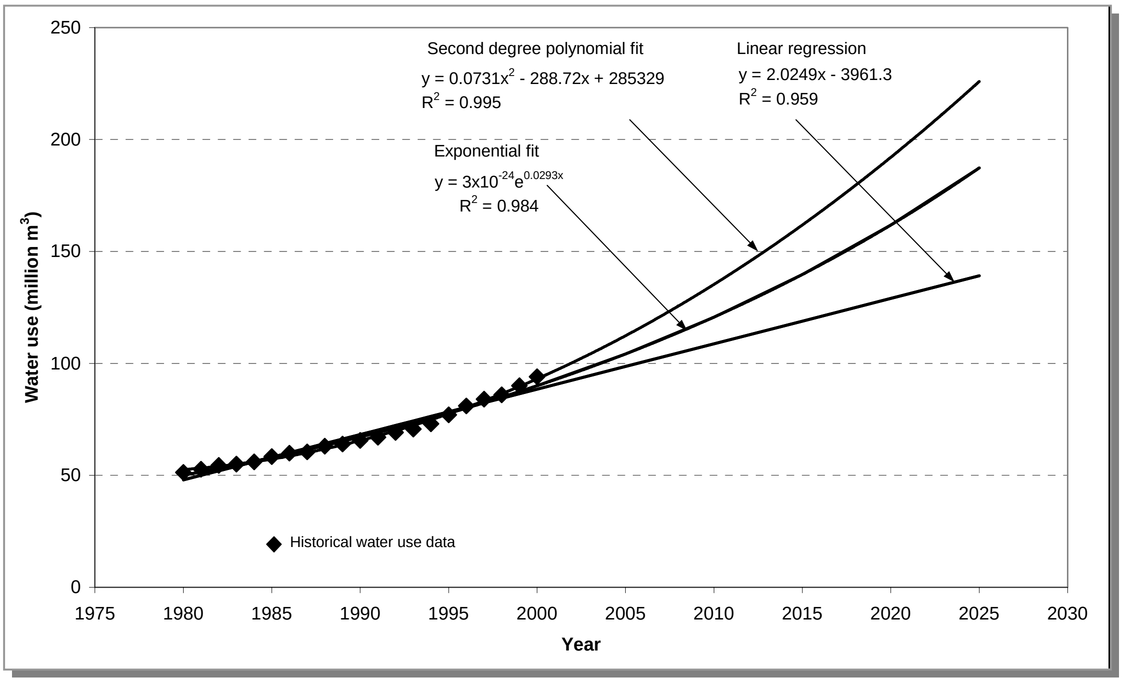
- Exponential fit
- Second degree polynomial fit
- Linear regression

The results of using the three methods are compared in Figure 1.

Figure 1: Results of trend analyses using different fitting techniques



This illustrates that even though each of the regression methods chosen to forecast future water use has a high correlation coefficient (R^2), the choice of technique has a significant effect on the trajectory of the curve and hence on the estimate of future water use in the year 2025.

3.2.3 Dealing with uncertainty

There is likely to be a greater or lesser degree of uncertainty involved with any forecasting technique, whether we are discussing the weather, the stock market, politics or projected water demand. It is important that uncertainties are identified, recognised and incorporated into the forecasting process. This can take the form of a three-step process.

Step 1

Identify the main uncertainties such as droughts, floods, and population growth. The following aspects also need to be factored into demand projections for MWSAs:

- Changes in macroeconomic conditions

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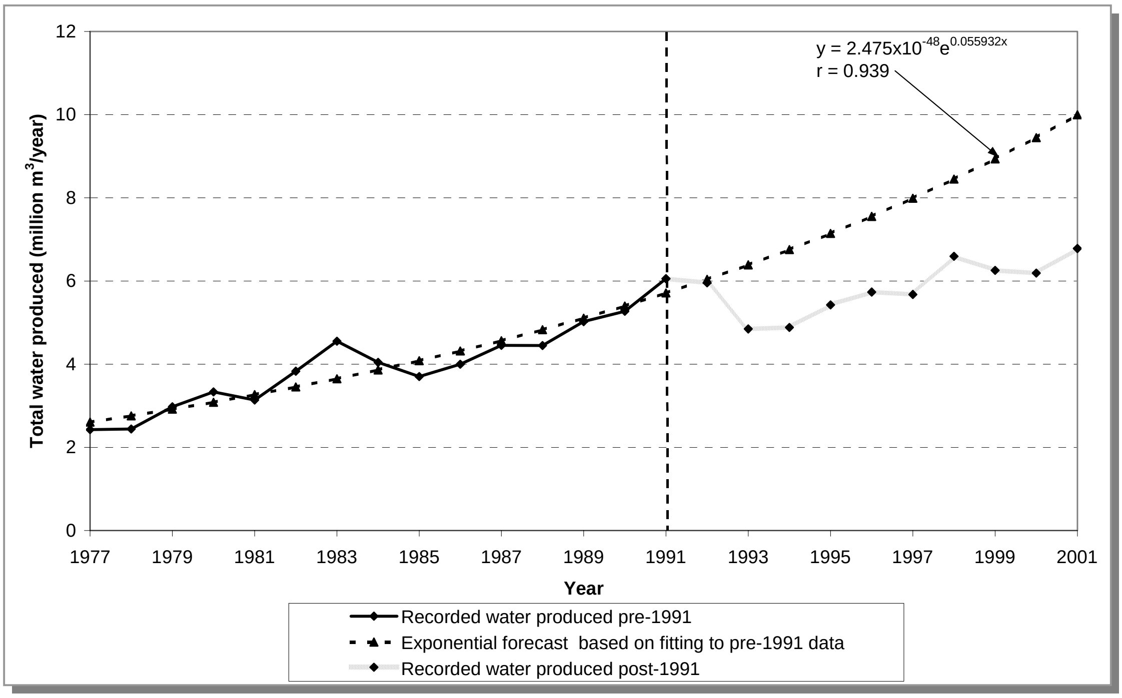
- Changes in health conditions, particularly HIV/AIDS-related diseases
- Changes in settlement patterns and migration
- Projected impacts of new policies and programmes
- Political stability

Step 2

Develop different demand scenarios based on the major uncertainties that have been identified. This is done through sensitivity analyses using different values for the uncertain parameters (e.g. low, medium, and high population and/or economic growth).

Ignoring uncertainties can lead to major inaccuracies of trend forecasts, as illustrated in Figure 2.

Figure 2: Extrapolation techniques for forecasting water demand for Masvingo in Zimbabwe



Source: HR Wallingford (2003)

Figure 3 shows the correct way of dealing with uncertainties through different scenarios.

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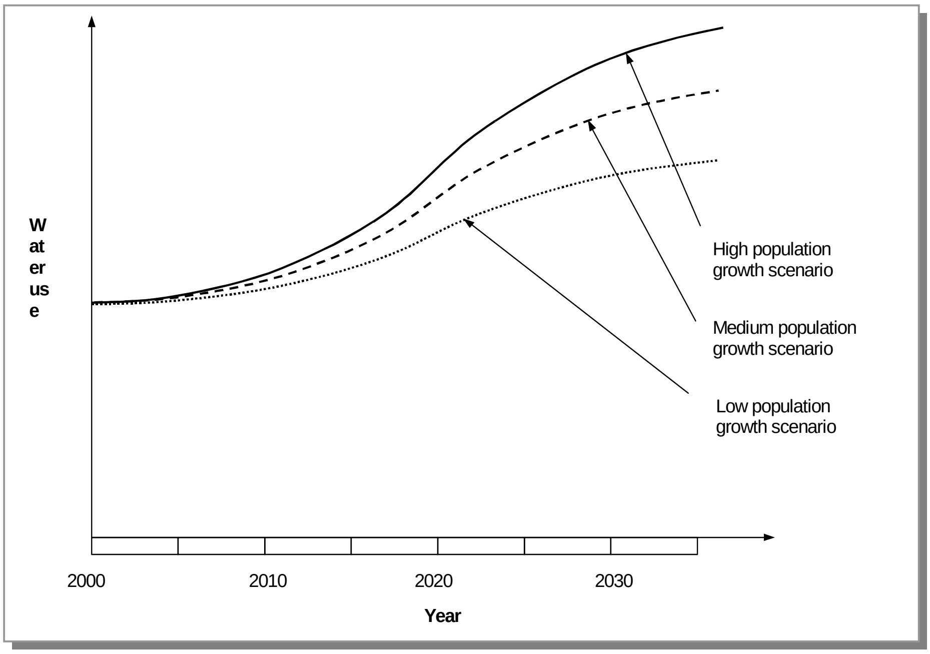
Figure 3: Dealing with uncertainties through different scenarios



Source: HR Wallingford (2003)

Step 3

Monitor the actual parameters and water consumption over time to validate the forecasts or adjust them. This step provides essential information for the next round of forecasts, and assists in improving the quality of forecasts. Predicting, monitoring, and adjusting projected and actual water demand can have a profound impact on the timing of augmentation schemes and hence on the capital and ecological costs involved.

Table 5 illustrates the impact of various factors on the timing of new augmentation schemes. The figures used are for the Rand Water distribution area, Gauteng, South Africa.

Table 5: Factors affecting the timing of augmentation schemes

FACTOR	TIMING IMPACT
Demand projections uncertain and sometimes wrong	This varies, depending on demand projections.
Ignoring HIV/AIDS in water planning and management	With a projected population growth of only 2.8% p.a., ignoring HIV/AIDS may lead to infrastructure being available (and therefore underutilised) up to nine years before it is needed.
Excessive water losses	If the actual loss rate (27%) could be reduced to a standard of 19%, augmentation could be delayed by five years.
Inefficient water use	Improving efficiency, through retrofitting and education, by around 25% would defer augmentation schemes by eight years and save R1.1 billion.

notes

Table 5 underlines the message that:

- The use of demand forecasting and monitoring is of paramount importance to MWSAs
- WDM measures have the potential significantly to defer augmentation schemes

activity

Premature augmentation schemes

MWSAs often develop premature augmentation schemes such as dams, pipelines and well fields. Reasons for this include the following:

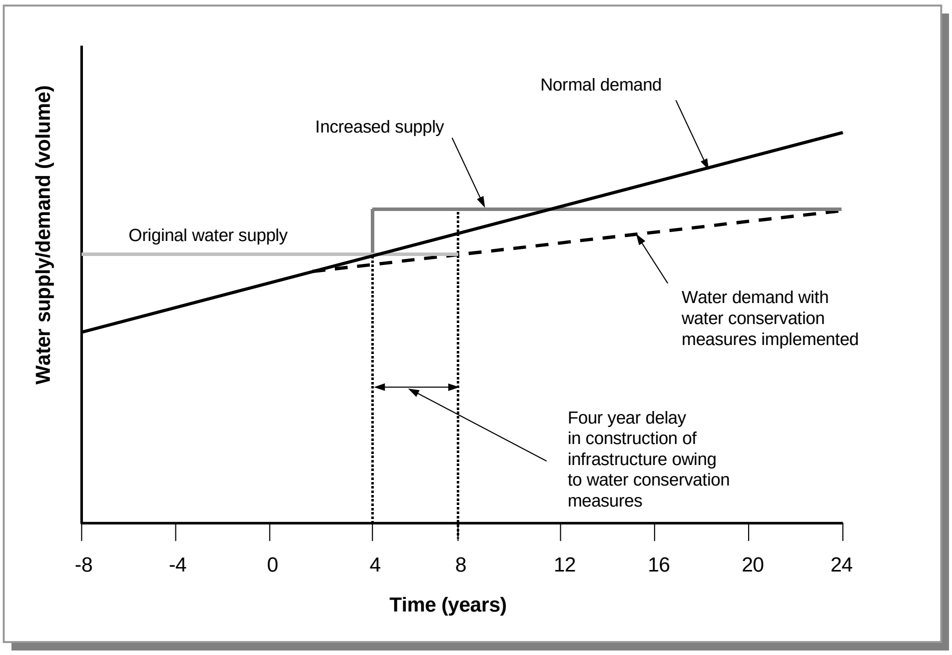
- Inaccurate demand projections, including neglect of HIV/AIDS impacts, overstating the expected growth in water consumption
- High water losses not being addressed
- Inefficient water use being tolerated

Put simply: wrong forecasts and neglect of WDM potential lead to the development of premature augmentation projects.

Source: IUCN-WaterNet WDM Tertiary Training Module (2003)

Figure 4 illustrates how effective WC/WDM measures impact on projects for augmentation of supply.

Figure 4: The effect WDM measures on augmentation



Source: HR Wallingford (2003)

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The wider the angle between normal demand and water demand with WC measures implemented, the more effective WDM is. This delays the need to construct facilities to sustain increased demand. Whilst savings of up to 30% may be achieved in the long term, short-term savings may be doubled. In addition:

- Less wastewater has to be treated
- Less energy is used
- The environment will benefit from reduced alterations of flow patterns and from fewer or reduced dams and other infrastructure

In the illustration depicted in Figure 4, construction of additional supply has been delayed by four years (Macy, 1999).

Can you think of any examples where dams or well fields have been prematurely built? Which ones? Why were they built, and what have the environmental, social and financial implications been?

e x a m p l e

Water demand projections for Richards Bay: Mhlathuze River System

In 2004, Mhlathuze Water (MW) appointed WRP Consulting Engineers (Pty) Ltd to undertake a study to revise the projected water requirements of the Mhlathuze River System, which incorporates Richards Bay, a major urban centre.

The Mhlathuze River System supplies water to the fast growing urban domestic, industrial, and mining sectors situated in and around the towns of Richards Bay and Empangeni, as well as the irrigated agricultural sector along the main stem of the river. Water for Richards Bay is sourced from Lake Msingazi, where it is abstracted, treated on site, and distributed in the town by the uMhlathuze Municipality. This source is augmented by a supply from the Nsezi waterworks, which is owned, operated, and maintained by Mhlathuze Water. It is planned that all growth in the water requirements in Richards Bay will be supplied from Lake Nsezi. A number of previous investigations have been undertaken of the water resources of the Mhlathuze River System, which have considered both the water requirements and the water resource availability. Of particular relevance is 'The Mhlathuze River Catchment Water Conservation and Demand Management Strategy' or WCDM Study (MW and DWAF, 2002).

Future water requirements were revised by engaging with stakeholders to update the projections made in the WCDM Study. These previous projections were updated based on information that had become available during the interim period from the completion of the WCDM Study. These requirements were verified with the various water users and then captured on a spreadsheet.

The activities undertaken to determine the water requirements were as follows:

- The records of historical water use in the Mhlathuze River Catchment were updated.

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- The various water users were consulted regarding their future water requirements.
- An assessment of the future water requirements was undertaken.

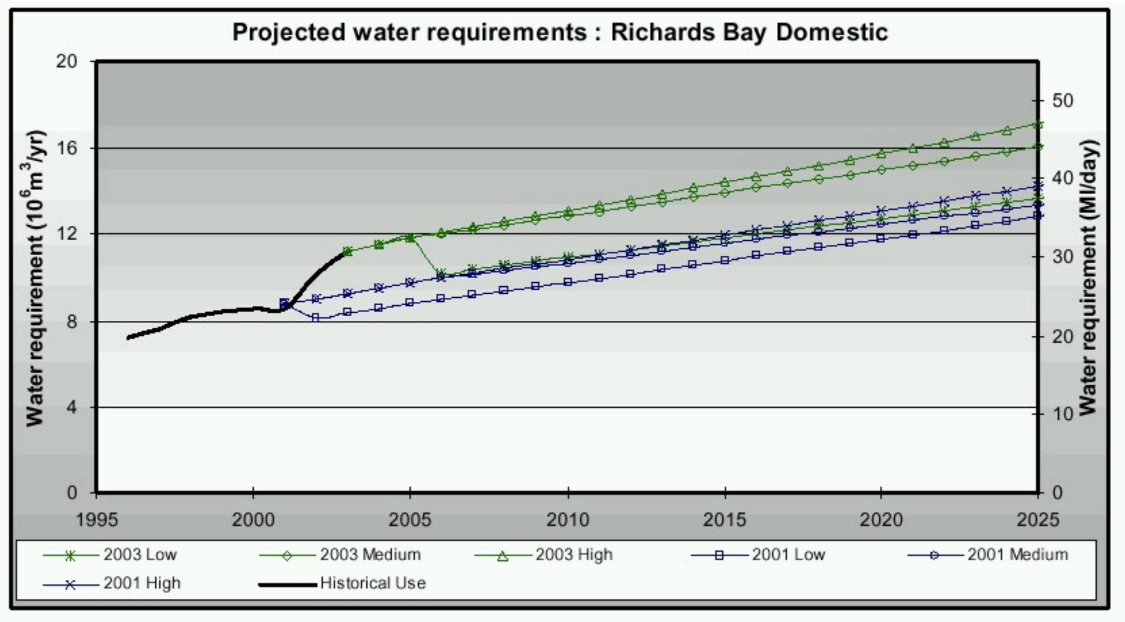
Values for actual water use from 2001 to 2003 were obtained from Mhlathuze Water, the relevant municipality, or the users themselves. Where Mhlathuze Water had bulk water consumption figures available, these figures were used in preference to those supplied by the users. The historical water use was compared with the previous projected requirements of the WCDM Study and any discrepancies were discussed with the users. The assumptions used for the previous projected requirements of the WCDM Study were reviewed and also discussed with the users; and finally, water use projections were prepared up to 2025 for the different water using sectors defined as industrial, irrigation, and domestic and commercial sectors.

The assumptions for the WCDM Study projections were as follows:

- Low scenario: 15% increase in efficiency on the medium scenario from 2005
- Medium scenario: Low population growth rates from the WCDM Study applied to the lower 2003 base demand (2.62% growth to 2004, 1.67% growth to 2014, and 1.42% growth to 2025)
- High scenario: High population growth rates from the WCDM Study applied to the lower 2003 base demand (2.70% growth to 2004, 2.00% growth to 2014, 1.73% growth to 2025)

The historical and projected water use by the domestic, commercial, and light industrial users in Richards Bay is shown in Figure 5. The actual water use has increased since the WCDM Study projections were made and is above even the high scenario. The revised projections for Richards Bay use the same growth rates as those provided in the WCDM study but are based on the higher 2003 base demand.

Figure 5: Projected water requirements: Richards Bay domestic



notes

The Richards Bay case study illustrates the following:

- Water use projections for urban areas are normally based on uncertain projected population growth rates estimated from Census results. There is a need for revision of the water use projections where these growth rates have been superseded by more recent Census figures.
- Accurate data and information that can be validated is the cornerstone of any forecasting of water use in an MWSA. Investing in such data and information systems can result in savings of money and the finite water resource.
- Urban water use projections have to take into account the various water service levels. Most urban centres in southern Africa have variable levels of service, and usually, efforts to improve levels of service result in higher water use. This increase has to be anticipated and incorporated into water use projections.
- To cater for uncertainty in both population and demand growth, it is important to consider a number of scenarios, and also to investigate and validate the underlying assumptions. Meeting the stakeholders and comparing projected water demands and actual water requirements could be a tedious yet indispensable exercise.
- In making projections, it is important to include a scenario where WDM or water conservation is anticipated, for example, the projected water use based on a 15% increase in water use efficiency.

Source: Mhlathuze Water (2004)

3.3 SELECTING THE RIGHT WDM INTERVENTION

There are many WDM measures available to you, but you may have to work hard to choose and implement the best options. Selecting the right WDM intervention can be difficult because the spectrum of WDM interventions is so broad. Whilst this offers greater choice and flexibility, it requires the careful and consistent application of appropriate criteria to help you make the best selection. Ideally, you should select the WDM measures that generate the largest benefits to your MWSA and/or country. In practice, you will also use pragmatic criteria to select the measures, such as ease of implementation.

What is more, you may be working in an organisation where the capacity for the design and implementation of the selected option may be less than adequate. You may need to temper your enthusiasm for the ideal and opt for the achievable. Remember that a phased approach to WDM implementation is likely to help overcome this constraint.

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3.3.1 Important things to remember

There are four useful pointers to guide you when making your choice.

- First of all, bear in mind that individual isolated WDM measures have a limited impact on overall water demand. Complementary and integrated measures are preferable.
- Secondly, awareness raising, training and information campaigns are vital to any WDM programme. Competency or the capacity to implement a measure is important.
- Thirdly, WDM interventions need to be evaluated together with traditional supply-augmentation interventions.
- Fourthly, the choice of intervention(s) needs to be informed by financial, social and environmental concerns and criteria.

So when you decide which WDM intervention you want to make, you need to consider the full range of measures available to you. The choice is not restricted to WDM interventions only, but the full range of possible IWRM interventions can be explored.

3.3.2 Selection tools, methods and rules

There are a number of tools, methods and rules available to assist you in your selection of the right WDM intervention to suit your circumstances.

3.3.2.1 Tools

Cost-Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA) are suitable evaluation techniques.

Cost-Benefit Analysis

CBA is essentially an economic evaluation method that assesses the economic efficiency of projects. To run a CBA, you must do the following:

- Identify the costs and benefits in a given time period, e.g. 20 years.
- Quantify and evaluate the costs and benefits.
- Conduct a sensitivity analysis using the interest rate and the economic lifespan of the project.
- Assess the economic efficiency using the Net Present Value (NPV) and the Cost/Benefit ratio (C/B ratio).

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- Make the decision, choosing WDM interventions with a positive NPV. If a choice has to be made from a range of measures, the ones with the highest NPVs are selected.

Multi-Criteria Analysis

MCA is a broader and more flexible selection tool, and MWSAs need to consider its use carefully. For an MCA, the following steps must be taken:

- Identify the positive and negative impacts of a measure in a certain period.
- Quantify (in physical units) or rank the impacts, e.g. large/medium/small.
- Identify selection criteria, e.g. economic, social and environmental.
- Weigh the selection criteria. It is possible to incorporate different weights for different stakeholders.
- Rank and analyse the performance of the measures.
- Make the decision. The best performing measure will normally be selected. Measures with an overall negative impact will not be selected.

3.3.2.2 The United States Environmental Protection Agency method

The United States Environmental Protection Agency recommends the following criteria for the selection of WDM interventions:

- **Economic:** programme costs, ease of implementation, timeliness of savings, cost-effectiveness, and budgetary considerations
- **Social:** ratepayers' impact, social justice/distribution, and public acceptance
- **Environmental:** environmental impacts and environmental justice
- **Contextual:** staff resources and capability, water rights/permits, regulatory approvals, legal issues, consistency with other programmes

3.3.2.3 The South African DWAF method

It is important that economic concerns are applied to the entire water supply and management chain. Therefore, the notion of Integrated Least Cost Planning (ILCP) that is used in South Africa by the Department of Water Affairs and Forestry (DWAF) is important for MWSAs. The issue is

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not whether the MWSA keeps its water costs to a minimum, but rather how the water costs throughout the supply chain can be minimised. Table 6 shows six major groups of impact criteria for the evaluation of WDM interventions: social, economic, institutional, technical, environmental, and risk.

Table 6: DWAF criteria and measurement parameters

TYPE OF IMPACT	PARAMETERS
Social impacts	Composite of affordability of services to consumers, job creation, sustainability of services, public acceptability, and service delivery to new consumers
Economic impacts	Economic efficiency, i.e. outputs in relation to inputs as measured by NPV in CBA; consider social costs and benefits
Institutional impacts	Ability of the water institution to plan, implement and maintain the appropriate measures
Technical impacts	Composite of time constraints, availability of appropriate technology, availability of capacity to implement, and overall practicality to implement
Environmental impacts	Composite of environmental impacts on wetlands, scenic resources, water quality, endangered species, and ecological water Reserve
Risk	Index indicating the uncertainty of a specific measure to supply or make water available, determined for each option

Source: DWAF (2003)

It is not stated how DWAF intends to implement the criteria, but an MCA could well be used to select DWAF WDM measures, in line with national-level issues.

3.3.2.4 The 80:20 rule

Decisions made based on either a CBA or an MCA must be tested for pragmatism using the 80:20 rule.

This rule prioritises WDM interventions that yield 80% of the desired results, i.e. water savings, with 20% of the required interventions. In other words, you can apply the 80:20 rule to help you to focus on WDM interventions that:

- Yield the largest results with the lowest current efforts and capacity burden
- Can yield tangible, immediate results

watch out!

While the 80:20 rule is well founded, care needs to be taken that WDM interventions that may only yield long-term results or that employ innovative approaches are not put on hold. These need to be integrated into a longer term WDM programme.

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3.4 WDM MEASURES/OPTIONS

We have examined the benefits of WDM, the ways of projecting water demand, and the impact that WDM can have on meeting demand. We have considered the tools, methods and rules at our disposal for the selection of the right method to suit your circumstances. Let us move on to examine the WDM options open to you.

These can be grouped into the following five areas:

- Technical
- Financial
- Policies, legislation and regulations
- Consumer service and public awareness
- Educational and training options

3.4.1 Technical options

Many technical options for WDM implementation are available, and to a certain extent these are amongst the most tangible efforts that can be made to reduce inefficiencies and increase the best possible use of water. Technical options provide a hands-on approach to WDM that engineers and planners can easily appreciate, and that consumers can easily understand, because the results are generally measurable and quantifiable in terms of water and money saved.

watch out

Technical options for WDM are not just about fixing leaking taps. WDM can be applied on a large scale too, for example:

- The second phase of the Lesotho Highland Water Scheme that provides water to Gauteng in South Africa
- The second phase of the North-South Water Carrier in Botswana

Technical measures aim to reduce unaccounted-for water or Non-Revenue Water (NRW), as well as water wastage among end-users. NRW refers to leaks as well as illegal water use and/or abstraction. It is therefore important to realise that a decrease in NRW will not lead to lower water consumption, if the loss was due to illegal abstraction.

NRW can be expressed as:

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- A percentage of net water production (delivered to the distribution system, %)
- m^3/day/km of water distribution pipe system network (specific water loss)

Calculating losses, as a percentage of net water production is the most common; however, it could be misleading for systems of different net productions with the same amount of real and apparent losses. This is illustrated by an example.

example

Calculating water losses

CITY	A	B
Population	120 000	200 000
Water supplied (L/person/day)	120	200
Length of pipe network (km)	900	1 600
Total supply (m^3/day)	14 400	40 000
Losses (m^3/day)	6 000	6 000
Losses (%)	42	15
Losses (m^3/day/km)	6.7	3.8

There are two main components of water losses:

1. Physical loss (Real loss)
   - Water lost through pipe breaks and leakage, overflows of distribution tanks, and house connection leaks
2. Commercial loss (Apparent loss)
   - Water consumed but not paid for (meter under-registration, illegal connections, or otherwise accounted for by government or other public use)
   - Revenue loss (billing anomalies)
   - Other non-physical loss

The block diagram given in Figure 6 is based on the International Water Association (IWA, 2000) water balance, whereby all of the components of the balance are accounted for. This approach is very useful because it is a simple but universal diagram that enables any definition of loss to be visualised and understood. The terms *revenue water* and *non-revenue water* are useful financial terms, and the makeup of each is evident from Figure 6.

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Figure 6: Components of a water balance and standard terminologies

System Input Volume	Authorised Consumption	Billed Authorised Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled Metered Consumption	
			Unbilled Unmetered Consumption	
	Water losses	Apparent Losses	Unauthorised Consumption	Non-Revenue Water
			Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tank	
			Leakage on Service Connections up to Point of Customer Metering.	

Sources: IWA (2000)

NRW represents the difference between the volume of water delivered into a network, and billed authorised consumption which is paid for.

NRW = Net production – Revenue water

Net production = Apparent and Real Losses + Billed and Unbilled consumption

tip

For more information with regard to components of a water balance for MWSAs, refer to the IWA paper on losses from water supply systems (IWA, 2000: Blue paper) and the 'Water Demand Management Cookbook' (Mckenzie *et al.*, 2003: UN-Habitat MAWAC report) provided in the source material on the CD-ROM accompanying this training manual.

NRW can vary significantly between countries and cities, and even between suburbs that are supplied by the same MWSA. In the SADC region it is generally high, in common with many other parts of the world, and exceeds norms for reasonable or economic losses. NRW represents a loss of revenue when MWSAs are unable to pass on the loss to end-users through price increases, even though passing on the

notes

costs of NRW to consumers may not be difficult in the monopolistic conditions that exist in many MWSAs.

Some figures for NRW, expressed as a percentage of total water use, are given in Table 7.

Table 7: Levels of non-revenue water

COUNTRY	URBAN AREAS
Angola	Luanda: 60%
Botswana	Gaborone: 20%, Urban areas: 9%
DRC	Kinshasa: 47%
Lesotho	Maseru: 32%
Malawi	Lilongwe and Blantyre: 15 to 30%
Mauritius	Port Louis: 45%
Mozambique	Maputo: 65%, Other estimate: 34%
Namibia	Windhoek: 18%, Other estimate: 11%
South Africa	1984: Pretoria 21.8% Johannesburg: 30%, Cape Town: 8.3%, Gauteng: 27%
Swaziland	Around 40%, Mbabane: 32%
Tanzania	Dar es Salaam: 60%
Zambia	Lusaka: 50% at costs of US$41 000/day. Other estimate: 56%
Zimbabwe	Bulawayo: 20 to 23%, Harare: 30%, Mutare: 52%
Other countries	Cities in developed countries: range from 2.3% (Amsterdam), to 23.7% (London). 1984: Montevideo: 32.2%, Paris 19.2%, and Oslo 46.8%

Sources: HR Wallingford (2003), IUCN WDM Guideline for municipal supply agencies (2004).

Table 8 compares the figures for large southern African cities, illustrating that NRW is often inversely related to the level of metering and WDM implementation/policies, i.e. more metering results in a lower proportion of NRW. Metering therefore helps to reduce NRW and has positive impacts on an MWSA's revenues.

Table 8: NRW for large southern African cities

CITY	PERCENTAGE OF CONNECTIONS THAT ARE METERED (%)	NRW (%)
Luanda, Angola	40	60
Gaborone, Botswana	100	20
Kinshasa, Democratic Republic of the Congo	76	47
Maseru, Lesotho	80	32
Port Louis, Mauritius	80	45
Maputo, Mozambique	45	55
Windhoek, Namibia	95	11

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CITY	PERCENTAGE OF CONNECTIONS THAT ARE METERED (%)	NRW (%)
Greater Victoria, Seychelles	90	26
Mbabane, Swaziland	80	32
Dar es Salaam, Tanzania	10	60
Lusaka, Zambia	44	56
Harare, Zimbabwe	85	30

Source: HR Wallingford (2003)

A certain level of NRW cannot be avoided from a technical point of view and/or is considered acceptable from an economic point of view. This represents a compromise between the cost of reducing NRW and the maintenance of the distribution system, and the cost (of water) saved.

NRW can be considered in two different ways:

- The technocratic approach compares actual losses with accepted norms. Norms for NRW are, for example:
  - Good – 10% or less
  - Reasonable – 11-15%
  - Poor – over 15%

  Few countries have formal norms for NRW. The National Water Supply and Sanitation Council of Zambia (NWASCO, 2003), which is a regulatory body for urban water and sanitation, has defined acceptable levels of NRW as:
  - <20% - good
  - 20-25% - acceptable
  - >25% - unacceptable
- The economic approach assesses the economically optimal loss level where the costs of decreasing NRW equal the marginal benefits of water savings. This approach has been used in Bulawayo. The price used for water is a major determinant of the optimal loss level. The higher the water price, the lower the optimal loss level. MWSAs normally apply WDM interventions when there are net financial benefits to be gained.

All examples of both the technocratic and economic approaches in southern Africa indicate that NRW needs to be reduced. Norms and reality are at odds: a recommended level of NRW for developed countries' water utilities is 10%, while the mean level is actually 16% (HR Wallingford, 2003). The American Water Works Association (AWWA, 1996) Leak Detection and Accountability Committee

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recommended 10% as a benchmark for NRW, and further defined three NRW levels and actions needed:

- <10% - acceptable, monitoring and control
- 10-25% - intermediate, could be reduced
- >25% - matter of concern, reduction needed

activity

- Do you know the level of NRW in your MWSA?
- Has a loss target been set?
- What do you think is the economically optimal loss level for your MWSA?
- If a NRW target has not been set, develop a short set-by-step action plan on how to get the process of setting this target going.

Record your answers and use them as input to your WDM implementation plan.

It is impossible to eliminate all real losses from a MWSA distribution system:

- Some losses are "unavoidable".
- Some leakages are believed to be undetectable (too small to detect) or uneconomical to repair.

An estimate of Unavoidable Average Real Losses (UARL) can help to evaluate the feasibility of real loss minimisation, i.e. provide a better understanding of real loss components. UARL is given by the following equation (IWA, 2000):

$$\mathbf{UARL = (A \times L_m + B \times N_c + C \times L_p) \times P}$$

(Litres/day when the system is pressurised)

Where:

L_m = Length of mains in km

N_c = Number of service connections

L_p = Total length in km of underground pipe (between the edge of the street and customer meters)

P = Average operating pressure in m

The definition of UARL and derivation of appropriate values for A = 18; B = 0.80; and C = 25 are explained in Lambert et al., (1999). The equation and its parameters A, B, and C are based on a statistical analysis of international data, including 27 different water supply systems in 20 countries.

notes

example

Estimation of UARL

A town water supply system (population = 250,000) has 60 000 service connections and 1 000 km mains. The density of connection is 60 service lines per km and the operating pressure is 50 m.

(a) Estimate UARL if

(i) all connections are at edge of street

(ii) 50% of the connections are at the average distance of 10 m from the street

(b) If the average annual supply rate is 130 litres per person per day, estimate what percentage of total supply is UARL.

Answer

UARL (L/day) = $(18 \times L_m + 0.80 \times N_c + 25 \times L_p) \times P$

(a)(i) UARL = (18 x 1 000 + 0.80 x 60 000) x 50

= (66 000) x 50 = 3 300 000 L/day

(ii) UARL = (18 x 1 000 + 0.80 x 60 000+ 25 x 30 x 10) x 50

= (66 000 + 7 500) x 50 = 3 675 000 L/day

(b) Total average supply = 250 000 x 130

= 32 500 000 L/day

UARL (%) = 3 300 000/32 500 000 ~ 10%

An MWSA's water distribution system is one means by which it generates revenue. It is also, however, a means by which it incurs losses through NRW. There are a number of technical WDM interventions aimed at reducing NRW.

A good understanding of the relative weights of NRW components is important for development of a sound NRW reduction programme. For example, in Walvis Bay, Namibia it was established that 50% of NRW was administrative, due to non-metering of the water company's premises and other government departments.

3.4.1.1 Installation and maintenance of water meters

Many MWSAs have customers with an unmetered water supply. You are probably aware of instances of supply to standpipes, blocks of flats, or to consumers, where meters have never been installed or have become dysfunctional. In these cases, neither the MWSA nor the individual end-users know how much water is being used. Effective billing cannot take place, and neither the potential for WDM implementation nor the results of interventions can be assessed.

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At present, the extent of metering tends to reflect the age of the water network and the O&M expenditure. Older, poorly maintained water networks have fewer functional meters, whilst newer, well maintained networks have more. The former is common in countries and cities with economic difficulties.

MWSAs need to maximise metering of individual end-users. Metering is an essential requirement for prudent water resource management and the extra costs of metering have to be compared with the benefits of reduced leakages and increased water conservation efforts. In order to ensure accuracy and reliability in both these areas, meters must be regularly checked and well maintained, particularly those of customers with identifiably high water usage.

Metering adaptation at household level offers considerable water-saving potential as it enables consumers to manage their own water demand, and to reap the benefit.

The calibration, repair, and replacement of meters is another important part of a water efficiency and conservation strategy. Inaccurate meters can be a significant contributor to unaccounted-for water, because meters seldom over-register, but will generally under-register or run slower. Meters may also be improperly sized. A periodic calibration of system supply meters will provide a more accurate measurement of the water being pumped into the system. Field-testing of customer meters consists of randomly replacing old meters with new ones, and then testing the old meters with a calibrated test bench.

Some meters on larger customers may need more routine inspection and calibration for accuracy.

t i p

The American Water Works Associations (AWWA) has published two useful publications in relation to water metering.

1. *Water Meters—Selection, Installation, Testing, and Maintenance* is an excellent overview of utility meter usage, including a history of water use measurement and the development of modern water meters. It covers all aspects of working with meters, from meter selection and installation to maintenance and repairs, and includes meter testing parameters, sample record-keeping forms, and helpful illustrations. It is an excellent resource for anyone who works with water meters, and is available for US$60.00 (Item number 30006).

2. *Evaluating Residential Water Meter Performance* is also available from AWWA (Item number 90571). The price is US$38.00. You can call AWWA Customer Service at +1 303 795-2114 to order both of these publications, or search the Internet for more details on online purchases.

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The Engineering Department of the City of Surrey in the UK has published a 'Water Meter Standards and Specification Manual (2004)'. A copy of the manual is included in the resource material on the CD-ROM accompanying this training manual.

Whilst metering, and meter testing and replacement, may potentially incur a loss of revenue from water sales for an MWSA, in practice it saves expenditure because it prevents premature augmentation to meet demand generated by a wasteful use of water. This allows an MWSA to redistribute saved water, perhaps in pursuit of social equity, or else to industry to support growth and development in the area.

Prepayment metering

Prepayment meters can be a powerful tool to help water service providers control water wastage and customer debt. They can also help customers to budget and, provided social issues such as negotiating levels of service, connection fees and water usage charges, and unauthorised connections are fully dealt with before units are installed, well maintained prepayment metering systems can prove popular with customers. Their most obvious feature is that revenue is collected 'up front' as opposed to 'in arrears', as happens in the conventional system.

Internationally they have been used in Brazil, the United States, the Philippines, Nigeria, and Venezuela. Within the SADC region, prepayment water meters and metering systems technology have been most widely used in South Africa, and the water meter industry in that country is hoping for an export venture. Other countries in the SADC region that have installed such systems include Botswana (see Table 9), Namibia, Malawi, Swaziland, and Tanzania. However, prepayment meters are not a universal panacea to an MWSA's problems of metering and cost-recovery. There are advantages and disadvantages inherent in their use.

The use of prepayment meters with shared standpipes gives water service providers the opportunity of making water available to customers twenty-four hours a day, seven days a week, in a regulated manner. In contrast to a conventional billing system, prepayment water metering offers a straightforward, efficient and accurate process involving a much smaller staff component, and hence has the potential of substantially lowering operating costs.

Well developed prepayment metering management systems facilitate the keeping of standardised records. This in turn improves the standard of monitoring, continuous evaluation, auditing and support.

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Prepayment meters are, however, an additional component in the line of the water supply chain that can go wrong. Thus, without properly trained, motivated, and managed staff, a high percentage of units will be out of service at any one time. Whilst failed household units usually continue supplying water free to customers until they are repaired, failed shared standpipe units usually stop delivering water to customers. This lowers rather than increases the quality of service being provided, causing dissatisfaction, which may lead to vandalism.

Additionally, the existence of reliable prepayment meters may encourage water service providers and their advisers to rely too much on technology in their strategies to solve what are often basically social problems. In cases where social issues such as negotiating levels of service, connection fees and water usage charges, and unauthorised connections are not resolved before the installation of prepayment meters, the outcome may be widespread vandalism and minimal cost recovery, as illustrated by the Johannesburg example given later in this unit.

Finally, prepayment water meters are sold as a high-tech solution and come at a higher price (US$ 150.00 per unit) than any other meter. Operating and maintenance costs of prepayment meters in most case studies in the region are currently higher than with conventional meters. This is primarily due to technical failures and the capital costs of the meters.

Thus, despite management savings, prepayment water meter systems could result in higher water costs to the end-user compared to a traditional billing and metering system. Savings in operating costs will not all be achieved in the short-term, especially in a retrofit-type project.

Adapted from: International Metering (1998); DWAF (2000, 2002)

Table 9: Meter appliances

MEASURE	WATER USE DETAILS	WATER SAVINGS
Prepayment meters for end-users (Botswana)	Individual connections: 25 households, recorded consumption one year before and after meter installation	Pre-metering: 12.4 m^3/month After metering: 9.3 m^3/month Savings of 25%
Prepayment meters for standpipes (Botswana)	Five standpipes (recording for 1 300 days or over 8 months per standpipe)	Pre-metering: 73.5/standpipe/month After metering: 15.3/standpipe/month Savings of almost 80%
Retrofitting in four communal residence blocks (Botswana)		Pre-retrofitting: 381 L/block/day After retrofitting: 145 L/boarder/day Savings of over 60%

notes

example

Prepayment metering: Community to fight water wars

Prepaid water meters are at the centre of a war for water waged by a group of informal settlement residents who will challenge Johannesburg Water in court over the lawfulness of these devices. The residents have enlisted leading constitutional lawyer Wim Trengove, SC, to fight in their corner. The case is likely to be precedent-setting, with implications for municipalities and the delivery of services around the country.

Phiri, Soweto, together with Orange Farm, an informal settlement south of the city, has become the testing ground for a massive cost-recovery drive. The campaign is called Operation Gcin'amanzi, and prepaid meters are its centrepiece. On Friday 06 August 2004, the residents sent a legal letter demanding that their water be reconnected, failing which they would commence court action. The City of Johannesburg had until Friday 13 August to respond.

The residents are members of the newly formed Coalition Against Water Privatisation, a social movement group. The Centre for Applied Legal Studies (CALS) at the University of the Witwatersrand is providing the coalition with legal and research support. Johannesburg Water, a self-contained business utility, with the city as its sole shareholder, is driving Operation Gcin'amanzi. Lawyers are amassing evidence to support their unprecedented attack on the meters, which they say may contravene the Constitution because the nationally allocated 6 000 litres a month of free water that they dispense for people's needs may be insufficient. Six thousand litres gives households an estimated 40 baths a month or 500 toilet flushes.

Ahead of this rights-based case, however, the community will first argue that prepaid water meters are unlawful. The dispute concerns the residents' claim that Johannesburg Water allegedly installed prepaid meters in Phiri without first attempting other water service-delivery options that the City of Johannesburg by-laws stipulate. This case will be argued under the City of Johannesburg Metropolitan Municipality Water Services By-Laws and the Water Services Act. The reason for the decision to run with this case first is that if it succeeds, it will provide immediate relief to the Phiri residents, whose water has allegedly been cut off. CALS is representing two sets of clients from Phiri who approached the centre for legal assistance. They, in turn, are representative of other Phiri and Orange Farm residents. "The one group were offered a choice between standpipes or prepaid water meters and refused both, so consequently have no water. The second group agreed to prepaid meters, given their limited choice, but are unhappy with them," said Theunis Roux, head of the law and transformation programme at CALS.

Standpipes are taps that operate on a trickle system and only allow the user 6 000 litres of free water a month. The prepaid meters also provide the user the allocated free water, but this can be replenished by adding credit to a plastic key with a chip that has the information needed to activate the meter.

According to Roux the municipal by-laws state that three levels of service provision need to be exhausted before prepaid meters can be installed. Service level one is communal water points, level two is an unmetered individual yard pipe, and level three is a credit-metered water connection.

"Prepaid meters are unlawful in terms of the by-laws," said Roux. "According to the by-laws, prepaid meters are only a punitive measure for consumers who have violated the level two

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standpipe option by consuming more than 6 000 litres a month or by connecting the standpipe to any other water supply." CALS says the Phiri residents were never offered the level three service (credit-metered supply), and prepaid meters were installed in the area without first "trying out" the level-two option (standpipes).

The Water Services Act requires Johannesburg Water to provide reasonable notice if it intends to limit or discontinue services. It also requires a customer's ability to pay for services to be taken into account. "It is impossible to satisfy these procedural requirements through the use of prepaid water meters," said Roux. "Using the meter system means that inability to pay results in immediate disconnection, without any space for notice or a hearing." The crucial difference between this case and the constitutional case is that "the constitutional case would knock out prepaid water meters for all. If this case is successful it will simply knock them out for as long as the Water Services Act exists in its current form," said Roux.

Brian Hlongwe, chairperson of municipal services entities for the City of Johannesburg, and a member of the mayoral committee, says he is not surprised about the pending court action. "We saw it coming. When we started installing the prepaid meters, the social movements embarked on their half-truths, half-lies campaign to try and win the support of the poorest of the poor by appealing to a bread-and-butter issue like water. We said let them — we will continue with our mandate. This is a group of people who are pursuing a long-term political agenda. All that I hope is that if this is the democracy that it claims to be, these social movements will be prepared to live with the decision of the judges."

Source: http://www.citizen.org *(Accessed in October 2004)*

3.4.1.2 Leak detection

Leak detection is a vital aspect of WDM. Leaks increase demand projections. The IUCN WDM Guidelines outline leak detection measures, stating that MWSAs should become local champions of WDM and lead by example. Therefore, MWSAs need to get and keep their own houses in order.

A leak detection survey should be budgeted for and performed routinely to minimise water loss.

Many MWSAs believe that fixing the larger leaks, those that can be identified visibly when they bubble to the surface, is sufficient. However, smaller leaks are of just as big a concern. Not only do leaking pipes cause water loss, but they also create openings for contamination in the distribution system, causing outbreaks of water-borne disease.

There are three main methods for locating leaks. These are:

- Visual inspection (passive leakage management)
- Regular soundings (proactive leak detection)
- Pressure control

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Leak detection strategies may include regular on-site testing using electronically assisted leak detection equipment, sonic leak detection surveys, water audits, or other methods for detecting leaks along water distribution mains, valves, services, and meters.

3.4.1.3 Water audits and analysis at district level

Once an MWSA has gone through the process of putting its own house in order, it should start to organise leak detection strategies in its supply area. The following steps need to be taken:

- The supply area needs to be broken up into zones and districts, and these areas should be supplied through only one or two points. Water meters must be installed at these points.
- The meters should be read regularly and a water balance for each zone and district prepared.
- The minimum night flows should be measured at 04:00 when most consumers are asleep, by installing a pressure and flow data logging device onto the water meter for a period of at least a week. Flow during the night can be ascribed to leakage from the network and on properties. If such leakage is high, WDM interventions need to be implemented.

Water auditing is the first step in discovering water unaccountability and determining systems conservation needs. The zoning of the supply area allows water audits to be carried out. These audits will reveal how much water enters and leaves each section, and how much reaches end-users. If losses and night flows are high, WDM interventions are needed in the form of leak repair, pressure management and/or the replacement of piping and other infrastructure (retrofitting).

A thorough examination of water system records and field control equipment help to identify and quantify water loss and associated costs.

Normally, water audits should be performed on a monthly basis and a yearly summary kept for maintaining accurate accountability of records. Accurate information is needed for a complete and factual water audit.

tip

The Water Research Commission of South Africa (WRC) have a variety of research products, including, where applicable, software programs designed either to support a specific research report, or to be distributed as stand-alone programs. The software models are available for free or at a fee, and can be used to assist MWSAs in reducing their NRW, and in understanding the relationship between leakage and pressure. These include BENCHLEAK, ECONOLEAK, SANFLOW, and PRESMAC. The models have been developed in collaboration with local and international

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consultants. Further details and examples where they have been applied are contained in the UN-Habitat and Rand Water 'WDM Cookbook' (refer to the source material contained in the CD-ROM accompanying this training manual or visit the WRC website).

URL: http://www.wrc.org.za/downloads/software/default.asp

3.4.1.4 Water supply system maintenance

The maintenance strategy for the water supply network must be asset-driven and based. The maintenance process within an MWSA encompasses anticipating, predicting, preventing, detecting, and/or correcting failures.

There are various Engineering Infrastructure Management Systems (EIMSs) on the southern African market, which are designed to meet a variety of water supply network maintenance strategy needs. MWSAs should consider their own needs carefully and select an EIMS that can meet them satisfactorily, or be easily adapted to do so.

A typical EIMS can assist an MWSA to provide a more cost-effective and efficient service to consumers, but not all of them may appear to contribute directly to a WDM strategy. However, any action which increases the efficient operation of an MWSA, will show a return in terms of reduced water losses or more effective water use.

This could be through the selection of better quality components, or the stricter adherence to personnel time-keeping leading to completed maintenance schedules.

Internationally, it has been shown that companies with good environmental management are generally better managed, and more profitable than the average company. This is also likely to be the case for MWSAs.

Many EIMSs incorporate the following features:

- Water loss management
- Water meter management
- Customer service and service requests
- Notifications of pipe breaks and leaks
- Pipe isolation and valve database
- Hydraulic pressure and hydrant database
- Work scheduling and maintenance
- Asset register and stock inventory

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- Costing and accounting
- Time keeping and leave monitoring

Whether or not an MWSA elects to use an EIMS to manage its maintenance, each of the following elements plays a specific role within an overall maintenance plan.

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A report entitled Urban Water Demand Management in southern Africa: Information management system for implementation and monitoring, (IUCN, 2002: Analytical paper to inform the development of Water Demand Management Guidelines, IUCN Water Demand Management Phase II Project for southern Africa) deals with EIMSs and their specifications, and is available from IUCN at URL: http://www.iucnsa.org/WDM.htm, and is also provided in the IUCN source material on the CD-ROM accompanying this training manual.

Routine preventative maintenance

Activities include regular inspections to determine deterioration characteristics, and evaluation of the system's maintenance condition. Typical components that fall into this category are water meters and pressure-reducing valves.

Corrective preventative maintenance

This is directed at addressing known deterioration in the network, as detected by routine condition monitoring techniques and ad hoc detections. Steps to take corrective action are triggered at the potential failure stage. Typical components that fall into this category are water pipes, water meters, pressure reducing valves, etc.

Breakdown maintenance

This includes responding to minor breakdowns such as broken pumps, minor pipes, and pressure-reducing valves, as well as major breakdowns that seriously affect services or pose other hazards. Major breakdowns require contingency plans in accordance with specified procedures. A key aspect here is timing. An MWSA could introduce a leakage reporting system, and guarantee consumers that the reported leakage will be repaired within a certain period, e.g. a few hours.

notes

Project maintenance

Project maintenance can include a range of different maintenance actions that constitute a single plan, and can involve the large-scale replacement and re-engineering of components.

example

The consequences of non-maintenance of assets in a water supply system

If the condition of pressure reduction valves in a water supply system is allowed to deteriorate through a lack of effective preventive maintenance, they will cease to function effectively. The resulting high pressure may lead to valve leaks causing water losses, or even to pipe bursts, reducing the operational lifetime of sections of the water supply system.

This high pressure in the water supply system would also affect consumers' endpoint fittings, shortening the lifetime of fittings such as taps, toilet inlet valves and the heat expansion valves of hot-water cylinders. This would result in increased costs to consumers, as these fittings would fail sooner than would normally be expected, and might even lead to damage to property caused by sudden failure and resulting leakage from fittings.

3.4.1.5 Pressure management

Pressure management helps to reduce water loss and to prolong the lifespan of the piping network. Intelligent pressure management, where the pressure is lowered by controllers that are set to time or predetermined outlet pressures, may be utilised in areas where large water losses occur, including on private property.

If the municipality does not receive payment for services, this method can be very successful in reducing losses. It must, however, be stressed that pressure management does not offer a complete solution to the problem of non-payment and losses on properties – it is only a quick, short-term way of handling the problem until a proper solution is found.

Water pressure should normally lie between 300 to 600 kPa (or 30 to 60 m of water weight). In areas of low cost-recovery, pressure could be kept as low as 150 kPa (15 m) and still offer adequate supply. Fire-fighting water pressure requirements must, however, be considered.

If pressure management is implemented, regular maintenance programme for the controllers and the pressure-reducing valves needs to be scheduled.

notes

examples

Khayelitsha Pressure Management Project – Cape Town Metro

Project objective

To improve the level of service to the Khayelitsha community (70 km^2, serving 450 000 people) by reducing excessive water pressure to lower internal plumbing leakage.

Situation

Khayelitsha has 70 000 stands with water pressures ranging between 60 to 80 m of water height. It is characterised by very high internal water losses (leakage) with 80% sewage return flows.

Action

It was possible to control the pressure to the whole of the township at just two points. Two pressure-reducing installations were established on the 450 mm diameter pipe and the 1065 mm diameter pipelines supplying the township with water. The community was involved to a large extent in the installation.

Pressure management systems led to a flow reduction from 2500 to 1800 m^3/hour or savings of 6 Mm^3/year or 28% savings. Advanced pressure control through electronic controllers led to a further saving of 3 Mm^3, leading to total savings of 9 Mm^3 or 42% in total water savings.

Summary

- Savings of R27 million per year at a cost of R2,5 million
- Savings represent more than 10% of the yield from the proposed R2 billion Berg Augmentation River Scheme
- A simple but innovative approach can work.

Source: Mckenzie et al., (2003)

Bulawayo, Zimbabwe

Example for a low-density suburb

Queens Park East is a low-density (high-income) residential area in the city of Bulawayo that was included as part of a pilot water conservation study in 2001.

- The total population of the suburb was calculated to be 3 101, with 460 connections.
- The total length of the water distribution system is 12 640 m, and the estimated length of connection pipes is 9 500 m.
- Total water consumption during a 24-hour period was recorded as 614 m^3/day.
- The minimum night flow was recorded at 4.4 L/s.
- Minimum night flow consists of legal night consumption and leakage. The legal night consumption was estimated to be 0.8 L/s.
- The losses in the area at night are therefore 4.4 L/s - 0.8 L/s = 3.6 L/s.

notes

- Adjusted for pressure changes during the daytime, this corresponds to a per connection loss of 580 L/day.

Pressure was reduced from an average of 43 m to 37 m, resulting in an average consumption reduction of 0.7 L/s. The flow was reduced by a factor of 1.09. This clearly verifies pressure reduction as an effective method for the reduction of losses.

Example for a high-density suburb

Emganwini is a high-density (low-cost) housing development in the city of Bulawayo. In December 1999, a study revealed that the pressure in Emganwini's water distribution system was up to 106 m at night, with an average of 95 m. This is an extremely high pressure for a water distribution system.

- The minimum night flow was recorded at 7.9 L/s.
- The legal night consumption was calculated to be 1.5 L/s.
- Adjusting for the legal night consumption the leakage at night was estimated to be 6.4 L/s. This is equivalent to a daily leakage of 495 m^3/day or 215 L/day/connection.
- Using 1.5 L/s/connection as an average waste/loss figure at private premises, adjusted for the existing pressure, the losses in the distribution system can be calculated to be 338 m^3/day.

In April 2000, a new pressure reducing valve was installed for Emganwini and the pressure was reduced to 5.5 bar. A total consumption of 916 m^3/day and a minimum night flow of 1.7 L/s were recorded. Adjusting for the legal night consumption, the leakage in the area at night was only 0.5 L/s. The reduction in the leakage resulting from reducing the pressure was considerable. Part of this might have resulted from repairs carried out to the distribution system between December 1999 and April 2000. As the pressure is constant, the net night flow can be converted into a daily leakage of 43 m^3/day, corresponding to a per-connection loss of only 38 L/day.

Pressure was reduced further to an average of 43 m. The corresponding minimum night flow was measured at only 1.12 L/s. This is almost identical to the calculated legitimate night consumption. This example clearly illustrates the effect that reductions in pressure can have on water saving.

Source: Norplan et al., (2001); HR Wallingford (2003)

activity

- Do you know the water pressure used by your MWSA?
- What would be the water-saving potential of pressure reduction?
- Record your answers for later use in your WDM implementation plan.

notes

3.4.1.6 Regulation of fire connections and other illegal connections

Large water losses can occur through illegal use of water at fire hydrants, where connections are made to the fire supply pipelines and the water used for non-emergency purposes. Unless fire hydrants are metered it can be challenging to detect losses from them during water loss audits, except through physical inspection. These inspections may be costly, but they must be done to ascertain the integrity of fire connections and their readiness in case of an emergency. Combination-type water meters can be fitted to fire hydrants to allow remote detection of illegal water use.

In a combination water meter, the main flow is through a large water meter. When the flow drops below a certain threshold, flow is diverted through a small (domestic type) water meter.

example

In Windhoek, Namibia, all fire connections have been retrofitted with a combination type water meter. New connections in the city are only allowed if fitted with such a meter. If illegal use on a fire connection is detected, the consumer can be penalised according to municipal by-laws. This can be combined with a water meter audit when the billing database is validated.

The sophisticated equipment used to search for leaks in pipelines can also assist with the detection of illegal connections to the network. Equipment used for this purpose includes leak/noise correlators, which are installed in the water supply network. When data from these instruments is analysed, it reveals leaks in the network as well as illegal connections to the network.

3.4.1.7 End-user fixtures, fittings and retrofitting

It is important to encourage end-users to install water-saving devices at the time of their investment, for example, when they build a house or factory, or invest in irrigation. End-users will only do so if they are aware of the water saving options and the benefits their use brings to them in terms of cost savings.

MWSAs should inform their end-users of water-saving devices and the associated costs and benefits. Where end-users do not benefit, but society at large does, subsidies or tax advantages, such as differential tariff rates, could be considered to encourage end-users to install water-saving devices. MWSAs and governments could also consider introducing

notes

standards or norms for products and appliances. For example, the size of toilet cisterns and baths could be restricted to save water.

In South Africa, for example, the South African Bureau of Standards, in consultation with water service providers, have started discussions on regulating end-user water fittings and fixtures. This is in response to the ready availability of cheap fittings and fixtures which are not durable and hence fail frequently, causing extensive water losses.

Retrofitting should be encouraged for end-users who have water-wasting technologies and devices. Often, these are in older houses and factories. Retrofitting requires extra work from end-users, and may therefore be unpopular. Where possible, retrofitting should be integrated into existing plans for renovations of houses, buildings, and factories through building and product standards.

It would be unwise for MWSAs to rely heavily on retrofitting for WDM. However, MWSAs can encourage retrofitting and investments in water-saving devices by making WDM appliances physically available and creating a favourable retrofitting environment, usually with the support of government.

Table 10 offers some examples of practical measures for WDM in the urban domestic setting. End-users would need to be encouraged to invest in water-efficient fittings and fixtures through the amendment of the by-laws and codes that regulate building practices. Standard-setting and quality control institutions could then showcase these water fixtures as the preferred option.

Advertising by retailers and the availability of stock is also critical to the success of this approach, and MWSAs can also be proactive. For example, Johannesburg Water has commissioned a design for a water closet toilet cistern that fills before, rather than after the flush, in order to reduce leakage losses.

Table 10: Domestic facilities and practices

MEASURE	WATER USE DETAILS	WATER SAVINGS
Toilets	Water savings possible through low volume toilets, dual flush systems, waterless toilets, and retrofitting Normally around 30% of domestic use	Traditional: 9-11 L/flush Dual flush systems: 4.5 L/flush, Low flush toilets: 6 L/flush Savings of over 18-67% on water flushing or up to 15% of domestic use
Urinals	Low and high volume urinals	Low volume flushes use 3l as compared to 8-12 L/flush for high volume flushes
Retrofitting, including toilets and shower heads		Saving potential of over 25%

notes

MEASURE	WATER USE DETAILS	WATER SAVINGS
Taps	Low volume taps, tap aerators, self-closing taps, repair of leaking taps	
Shower heads	Low volume heads, retrofitting, pressure reducers	
Watering of gardens	Efficient irrigation systems	Figures of 25 to 75% are common in southern Africa. Norm could be 10 to 15%. Savings of 100 to 500%

3.4.1.8 Non-conventional sources of water

Whenever good quality water is scarce, water of inferior quality must be considered for agricultural use, domestic garden irrigation, pavement washing, and other uses not requiring high quality water. Inferior quality water is also designated as non-conventional water or marginal quality water.

Non-conventional water can be defined as water that possesses certain characteristics, which have the potential to cause problems when it is used for an intended purpose. Thus, the use of non-conventional water requires the adoption of more complex management practices and more stringent monitoring procedures than when good quality water is used.

Non-conventional waters most commonly include:

- Saline water
- Brackish water
- Agricultural drainage water
- Treated or untreated wastewater effluents
- Grey water
- Water containing toxic elements and sediments

All these waters are of inferior or marginal quality. Also included under the designation of non-conventional waters are desalinated seawater, and water obtained by fog capturing, weather modification, and rainwater harvesting.

Rainwater harvesting

Rainwater can provide a considerable water resource, not only in humid regions, but also in semi arid and arid regions. Large volumes of water can be intercepted by flow from roofs.

In many regions, roof water has not customarily been collected, because traditional roofing materials did not permit easy collection, and storage of collected water was difficult and expensive. However, in recent years

notes

the availability of roof sheeting combined with innovative water storage ideas have made roof water a serious water resource consideration. There is a great need to encourage its use and to teach simple, low-cost means of collecting water from roofs, and of constructing suitable storage facilities.

Measures may be needed to keep insects such as mosquitoes and flies away from the stored water, to avoid increases in diseases such as malaria, and dengue fever that are carried by these creatures. This can be achieved by covering the opening of storage jars with mosquito netting and/or by disinfecting the stored water with bleach.

Rainwater harvesting is commonly practiced in areas of water scarcity. However there is always a need to enlist and stimulate the thinking and ideas of the local population to find better ways to maximise the beneficial use of all water that is precipitated. A climate of discussion and interchange of ideas needs to be encouraged so that maximum benefits can be achieved for a community from the small amount of rain that falls.

Professional, expert help can be enlisted to develop better water-use and capture methods, but the local people need to be enlisted as the greatest source of ideas. There may be long-established traditional practices of water use that may need to change. It will usually only be possible to effect such changes by first understanding the culture and traditions that surround them, and then developing a sensitive, locally adapted educational program. Actions to direct or coerce changes in traditional practices are unlikely to be successful.

Rainwater harvesting is a vital aspect of WDM at household level. Table 11 illustrates some rainwater harvesting benefits in Botswana.

Table 11: Rainwater harvesting (Botswana)

MEASURE	WATER USE DETAILS	WATER SAVINGS
Rainwater harvesting		Around 5% of total water consumption.

Sources: DWA (2000)

Wastewater reuse and recycling

The expansion of urban populations and the increase in the population served by domestic water supply and sewerage give rise to greater quantities of municipal wastewater. With the current emphasis on environmental health and water pollution issues, there is an increasing awareness of the need to dispose of these wastewaters safely and

notes

beneficially. As a result, the use of wastewater in agriculture is already expanding in the region.

tip

For more information on options for wastewater reclamation, reuse, and recycling, refer to the documents provided in the source material on the CD-ROM accompanying this training manual. Pay particular attention to the UNEP/WHO/HABITAT/WSSCC Guideline, 2004, *Municipal wastewater management. A practical guide for decision-makers and professionals on how to plan, design, and finance appropriate and environmentally sound municipal wastewater discharge systems.*

Other examples of reuse (Table 12) include the reuse of treated industrial effluents for low quality uses in the same industrial plant, the reuse of treated municipal wastewater in aquaculture, for the irrigation of lawns and recreational areas, and for low quality domestic water uses in dual municipal distribution systems such as Bulawayo, Zimbabwe, and for potable reuse as in Windhoek, Namibia.

Table 12: Categories of municipal wastewater reuse and potential constraints

REUSE CATEGORY	POTENTIAL CONSTRAINT
1. Agricultural irrigation o Crop irrigation o Commercial nurseries 2. Landscape irrigation o Parks o School yarsd o Freeway medians o Golf courses o Cemeteries o Greenbelt o Residential	o Surface and ground water pollution if not properly managed o Marketability of crops and public acceptance o Effect of water quality, particularly salts, on soils and crops o Public health concerns related to pathogens (bacteria, viruses, and parasites) o Use area control including buffer zone - may result in high user cost
3. Industrial recycling and reuse o Cooling o Boiler feed o Process water o Heavy construction	o Constituents in reclaimed water relating to scaling, corrosion, biological growth, and fouling o Public health concerns, particularly aerosol transmission of pathogens in reclaimed water
4. Groundwater recharge o Groundwater replenishment o Salt water intrusion control o Subsidence control	o Organic chemicals in reclaimed wastewater and their toxicological effects o Total dissolved solids, nitrates, and pathogens in reclaimed wastewater

notes

REUSE CATEGORY	POTENTIAL CONSTRAINT
5. Recreational/environmental uses o Lakes and ponds o Marsh enhancement o Stream flow augmentation o Fisheries o Snowmaking	o Health concerns of bacteria and viruses o Eutrophication due to nitrogen and phosphorus in receiving water o Toxicity to aquatic life
6. Non-potable urban uses o Fire protection o Air conditioning o Toilet flushing	o Public health concerns on pathogens transmitted by aerosols o Effects of water quality on scaling, corrosion, biological growth, and fouling o Cross-connection
7. Potable reuse o Blending in water supply reservoir o Pipe to pipe water supply	o Constituents in reclaimed wastewater, especially trace organic chemicals and their toxicological effects o Aesthetics and public acceptance o Health concerns about pathogen transmission, particularly viruses

Source: Metcalf and Eddy Inc. (1991)

example

Reuse of treated effluent in Windhoek

In Windhoek, Namibia, 1.14 Mm^3 of reclaimed wastewater was used for the irrigation of sports fields, parks, cemetery gardens and nurseries in 1997. A total of 99 consumers, including municipal departmental consumption, are connected to the system. All connections are metered, meters are read, and consumers are charged on a monthly basis. Quotas are calculated at 1 m^3/m^2 of irrigation area per annum under normal times, and during periods of drought the quota is lowered to 0.7 m^3/m^2 of irrigation area per annum. Should the quota be exceeded, a block tariff of double the normal tariff is applied. Commercial and industrial properties are also linked to the system and pay a higher price than the departmental tariff and sporting bodies. A private farmer utilises the industrial effluent from the Ujams oxidation pond system for the irrigation of fodder.

Water quality guidelines issued by the Department of Health are used on the irrigation water system. The incorporation of the existing Goreangab Water Reclamation plant and pipelines, after completion of the new water reclamation plant and new pipelines in September 2000, in the irrigation water system made high quality irrigation water available, which is suitable for unrestricted irrigation. It increased the capacity of the irrigation system fourfold to be able to absorb the growth and extension of the irrigation pipe network until 2010.

A cost comparison shows that the installation of a dual pipe system in existing townships would be at least three times more expensive than the reclamation of water to a potable standard. Longer retention times in the existing potable supply network would also lead to deterioration of potable water quality due to the high water temperatures in Windhoek. The high cost is mainly related to the higher capital cost.

notes

Water reclamation for potable reuse from domestic sewage effluent was pioneered in Windhoek in 1968. The system was upgraded several times over the past 30 years and the current plant can be described as the 5th generation.

The current capacity of the plant is 8 000 m^3/day which is 18,8% of the average daily potable water demand of 42 510m^3 in 1998. The production cost of N$2.40/$m^3$ of reclaimed water is the same as the cost of N$2.40/$m^3$, which is charged by NamWater for the bulk supply of water.

A new extension plant producing 21 000 m^3/day was completed in year 2000. The German Development Bank (Kreditanstalt für Wiederaufbau) financed part of the extension of the plant while the European Investment Bank financed the shortfall. The cost of the project was N$80 million (1998). The loans were provided at subsidised rates and the estimated production cost inclusive of capital charges was calculated at N$2.50/kl. This was only 42% of the estimated unit cost of water supplied through the planned extension of the Eastern National Water Carrier from Grootfontein to the Okavango River based on 1996 prices if 50% of the Okavango pipeline project could be financed through soft loans.

The reuse of water forms part of the integrated Water Demand Management policy, which was accepted for implementation in Windhoek.

The possible health risk involved with the use of direct reclaimed water is limited through the guideline that the maximum percentage reclaimed water is limited to 35% of the potable water supply. It is further the aim that reclaimed water should always be of the same or even better quality than water from other sources. Intensive bio-monitoring programmes are also carried out on the reclaimed water. Over the past 30 years, no negative health effects were detected as a result of the use of reclaimed water.

Source: Haarhoff and van der Merwe (1996); IUCN Namibia WDM country study report (1998)

3.4.2 Financial options

The combined effects of market forces and government regulations on the water chain determine the economic and financial measures that can be implemented by MWSAs.

As water is a vital good (and often treated as a public good), most governments have a strong influence on water supply and management, both in terms of water reticulation control and water pricing. Currently, some governments are strengthening market forces in water pricing, for example, by privatising MWSAs and introducing water markets. In these cases, water becomes primarily an economic good.

Key questions are:

- How many water suppliers operate in a given municipal area? Many MWSAs have a monopoly, and hence are not exposed to competition.
- They may be able to pass on the costs of unaccounted-for water to consumers by increasing prices. This would discourage WDM.

notes

- Who determines the water prices? MWSAs may be government departments, parastatals, or private companies, but few can determine water tariffs and structures independently. Frequently, government influences or even sets the water prices.
- What opportunities do MWSAs have to raise their own funding for WDM? Three cities in southern Africa (Windhoek, Bulawayo and Johannesburg) have a small WDM levy (0.5 to 1% of the water price). Such WDM funds could be established through local by-laws.
- What happens to the water revenues? Are they directed towards improving the water supply network and/or the overall level of service? Who controls their destination? It is important that MWSAs develop a strategy for revenue distribution to ensure that revenues are reinvested in water management and that sufficient funds are reserved for maintenance and other WDM measures.

activity

Characterise and compare the role of the market and government in determining water prices, expenditure levels, and destination of revenues in your country:

- How much funding is earmarked for WDM?
- What portion of water revenues does not benefit the water sector?

As before, record your answers for use in your WDM implementation plan.

3.4.2.1 Water subsidies

Historically, water has been treated as a public good whose management and supply is paid for from general government revenues. The price of water was not related to the cost of the service, and often remained far below the supply costs. In other words, water was subsidised from general government revenues. The higher the subsidies were, the lower the water price was.

These low prices discouraged WDM, and the rising supply costs put increasing pressure on government and MWSA budgets.

The shift in the treatment of water from a public to an economic good implies that subsidies need to be revisited. The remaining subsidies should only be justified on social and environmental grounds, for example, ensuring adequate access to water for all and ensuring a sustainable water supply with sufficient water for maintaining existing ecosystems.

notes

There are two different perspectives on water subsidies, namely the MWSA (or financial) perspective, and the national (or social) perspective. Both are briefly discussed below.

The MWSA (or financial) perspective on water subsidies

Government subsidies for water supply provide substantial income for MWSAs, and are a source of financial revenue. In the absence of water subsidies, water tariffs would be higher, and end-users would pay more. For MWSAs, it is not important whether the revenues come from government or from end-users.

The national (or social) perspective on water subsidies

Water subsidies lead to lower end-user prices, and put a burden on the government budget. Government has to evaluate its budget allocations critically, particularly in view of competing demands such as educational and health expenditures. Subsidies may be justified on social, economic and/or environmental grounds. Economic arguments are not strong as water costs are a small part of the production costs. The social argument for water subsidies is strong for those who cannot afford to pay. This can be addressed by cross-subsidisation among end-users and does not necessarily require water subsidies.

Some governments use the rule of thumb that water payments should not exceed 5% of monthly income. Affordable water for low-income groups can also be paid by cross-subsidisation by the large end-users (the high-income groups and companies). Cross-subsidisation has been built into the tariff structure in Botswana and Namibia.

In South Africa, water for basic needs is free, but the costs of this are recovered through higher prices in the high-use bands.

It is quite possible that an MWSA may not reap net benefits from WDM, but that the nation at large would. In that event, government needs to bridge the gaps between financial and social benefits in order to entice MWSAs and ultimately the end-users to apply WDM.

From an MWSA's perspective, WDM is pursued to the point where the net social benefits are zero. Taking WDM further would lead to welfare and development losses to society at large.

The environmental perspective on water subsidies

Subsidies could have negative environmental impacts where they encourage water wastage, and discourage WDM. For example, a domestic leak of 20 m^3 per month would cost the end-user nothing if the water were free, $20 if the water cost $1/$m^3$ but $100 if the water cost

notes

\$5/m^3. Obviously the end-user has a much stronger financial incentive to repair the leak if the water price is high. In other words, efficient water use is encouraged by higher water prices.

Thus, water subsidies need to be carefully reviewed and targeted.

example

The impact of water subsidies by employers on water use (BCL Copper Nickel Mine, Botswana)

A water use and affordability study found that the domestic consumption in Selebi-Phikwe was much higher than that in the other urban areas of Botswana. The study mentioned the lower water tariffs, the fact that the BCL mine paid the water bills of some of its employees, and cultural factors as possible causes.

This study investigated the second cause, i.e. the impact of the subsidisation of water by the BCL mine. There was a 100% subsidy on charges of water used in BCL houses without water meters. In addition, the low-income employees in the category of standard staff received 150 m^3 of free water per month, whereas the high-income employees in the category of senior and executive received 200 m^3 of free water per month.

Such subsidies on water charges were associated with a culture of wasteful use of water and insensitivity in reporting water leaks. To determine the impact of water subsidies on water consumption, 40 households were interviewed in the high-income area of Selebi-Phikwe. A multiple regression analysis was used to determine the relationships between water consumption and the dummy variable for water subsidy. Other independent variables such as income of the head of household, type of household, and household size were also included in the regression as factors likely to affect water consumption.

A significant relationship was found between water consumption and independent variables of income and the dummy variable for water subsidy. The regression equation of this relation was as follows:

W_e =	**0.016Y**	**+**	**41.85S**	**–**	**25.94**	
T Statistics	**(3.87)**		**(4.44)**		**(-1.86)**	**R^2 = 0.54**
F =	**21.83**		**Sign. F**	**=**	**0.0000**	

W_e is monthly water consumption in m^3, Y is income of the head of household in Pula, and S is the dummy variable for water subsidy such that a value of 0 represents those who have no subsidy, and 1 represents those who have a subsidy. The F value shows that there is a very significant relationship between water consumption and the independent variables of income and the dummy variable for water subsidy in Selebi-Phikwe.

A household with an income of P3 000 per month and not receiving any water subsidy will consume 22.36 m^3 per month. However, water consumption for a household with the same income and access to a water subsidy will increase consumption by 40.85 m^3, to 63.21 m^3 per month.

notes

In other words, the income of the head of household and access to a water subsidy are important determinants for water consumption, since water consumption increases as income increases and access to water subsidy is attained. The coefficient of determination, R2, shows that 54% of the variation in water consumption was attributable to income and the dummy variable for water subsidy.

The regression model therefore indicates that those who have access to a water subsidy, and are BCL employees living in BCL houses, tend to consume more water than those who live in non-BCL houses and who have no access to a water subsidy.

It is surprising that BCL offers such an incentive that encourages wastage of water, when the same company is active in reusing and recycling water in its mining operations.

Source: Adapted from IUCN Botswana WDM country study report (1998)

3.4.2.2 Water tariffs

Tariffs are often co-determined by government, when water is owned by the state. The role of MWSAs in determining water tariffs varies from country to country. For example, in Botswana, the government sets the general principles for water tariffs, but the MWSAs propose specific water tariffs, which need ministerial approval.

The pricing principles vary greatly, as they are the result of a political decision based on social, economic and environmental conditions. MWSAs may, however, have some influence on water tariffs through surcharges or levies.

This is the case, for example, in Windhoek, where a WDM surcharge is applied, and in South Africa, where a small research levy on water use is used to fund the operations of the Water Research Commission.

The foundation of tariffs

There are three common foundations of water tariffs:

- Average historical supply costs, for example Zimbabwe's blend price, which adds the redemption of the historical capital costs of all Department of Water dams to the actual operating and maintenance costs, and divides this by the sums of the yields. When supply costs are rising, this price is below the costs of new supplies.
- Replacement costs, which are based on the cost of replacing existing dams and well fields. While higher than the average historical cost price, these remain below the actual current resource value, as they do not take into account the greater complexity of new supply schemes, e.g. transfer pipelines.

notes

- Marginal supply costs, which indicate the costs of augmentation schemes, reflect the current water value best, as they are based on the current measures that need to be taken. This is an attractive method for MWSAs, as the application of marginal supply pricing will lead to greater profits than the older supply systems.

Most southern African countries are moving towards marginal pricing, but there is still an implementation discrepancy between policy and reality.

In theory, it is economically and environmentally correct to base water tariffs on the marginal opportunity costs (MOCs), which include the costs of production, transport, environmental externalities, and predicted benefits of resource depletion. In practice, it is difficult to determine the exact level of the MOC, but it is usually higher than the marginal cost of supply. The difference reflects the external costs and any future costs associated with possible water depletion or pollution.

Marginal opportunity costs (MOC)

=

Marginal user costs:

Costs of abstraction or exploitation incurred by abstractor / exploiter

+

External costs:

Costs of resource use that are not incurred by the abstractor / exploiter (e.g. external costs of dams and water pollution)

+

Forgone future benefits:

Forgone future uses because of current resource use (e.g. due to groundwater mining)

Whilst the environmental externalities and predicted benefits may be difficult to calculate in some cases, they could be pragmatically interpreted as a levy on top of the production costs. This levy could be used for environmental compensation, WDM funding and for water research.

notes

activity

Description and analysis of your MWSA tariff structure

- What pricing principles form the foundation of the water tariffs?
- What tariff structure does your MWSA have?
- Who determines the water tariffs and when were they last adjusted?
- Compare and contrast the tariff systems of the MWSAs that are represented. Analyse and understand the similarities and differences.

As before, record your answers for use in your WDM implementation plan.

The choice of tariff system

MWSAs have the choice between a flat rate, with a constant unit charge irrespective of the amount used, and the block tariff system where unit charges are the same within a user band, but differ between bands:

- A flat rate of $1/m^3 means that the cost of a monthly use of 10 m^3 is $10 and that of 20 m^3 is $20.
- A block tariff system could have a charge of $1/m^3 for the first 10 m^3 and $2/m^3 for the 11-20 m^3 band. In that case, the cost of the monthly use of 10 m^3 would be $10, but that of 20m^3 would be $30.

The block tariff system usually has rising water tariffs, making increased use more expensive.

The block tariff system is most suitable from an economic, social and environmental perspective. It permits cross-subsidisation from high to low users, and offers a financial incentive for efficient water use. Moreover, high tariffs for high use discourages water wastage.

Most countries in southern Africa have adopted a block tariff system, usually with a small fixed monthly charge. It is important for equity and resource purposes to keep the fixed charge to a minimum. For each end-user group, consumption bands are set with a distinct unit price per m^3. For higher-user bands, the unit price is normally higher to penalise high water consumption and to subsidise the low-user bands, where water is either free, for example, in South Africa, or subsidised, as in Botswana and Namibia.

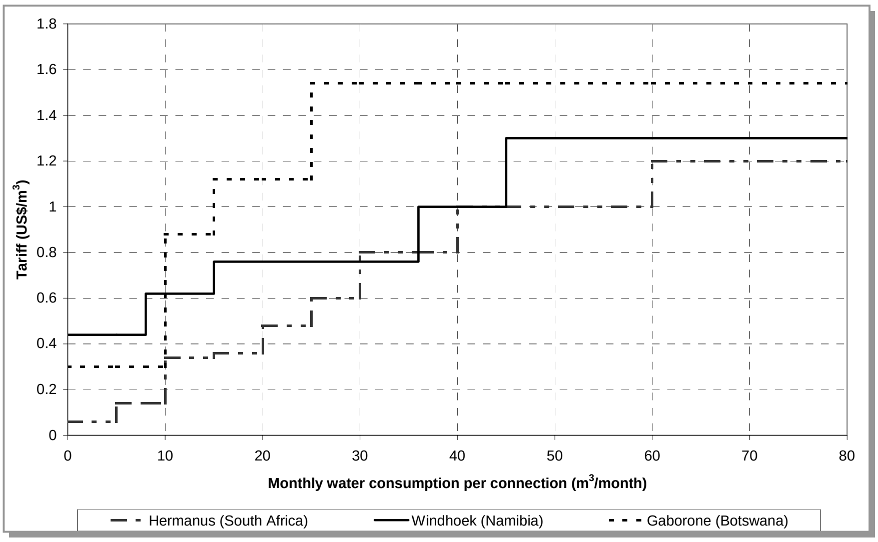
Block tariff systems can only work in conjunction with metering and effective and regular monitoring of consumption through a programme of water meter readings.

notes

The band tariff system is better suited to domestic rather than production-sector WDM, because the variable nature of productive activities makes it difficult to determine bandwidths that will encourage companies across all sectors to conserve water.

Figure 7 gives examples of block tariff systems for Hermanus, Windhoek and Gaborone. The examples show that the costs of water consumption increase sharply with increasing levels of use; that there is no uniformity in bandwidth and number of bands; and that there are considerable differences in price levels, with Gaborone being the highest. There may be three reasons for this: differences in resource scarcity and costs, differences in pricing principles, and differences in supply efficiency.

Figure 7: Examples of block tariff systems in southern Africa



Source: HR Wallingford (2003)

Where the conditions are not conducive for a block tariff, a flat rate system for monthly water consumption is usually charged irrespective of water consumption. Whilst a comparatively cheap and simple system to administer, this permits water wastage without a penalty, and could be unfair on low-income groups, as their water bill for basic needs could be high in comparison to their income. Short-term savings on metering and monitoring may be offset by the long-term capital costs of augmentation and/or environmental costs through over-use of the water resource.

Variations in water tariffs

Water tariffs may vary:

- Between user groups, e.g. domestic and productive
- Spatially, i.e. from area to area

notes

- Between different user bands

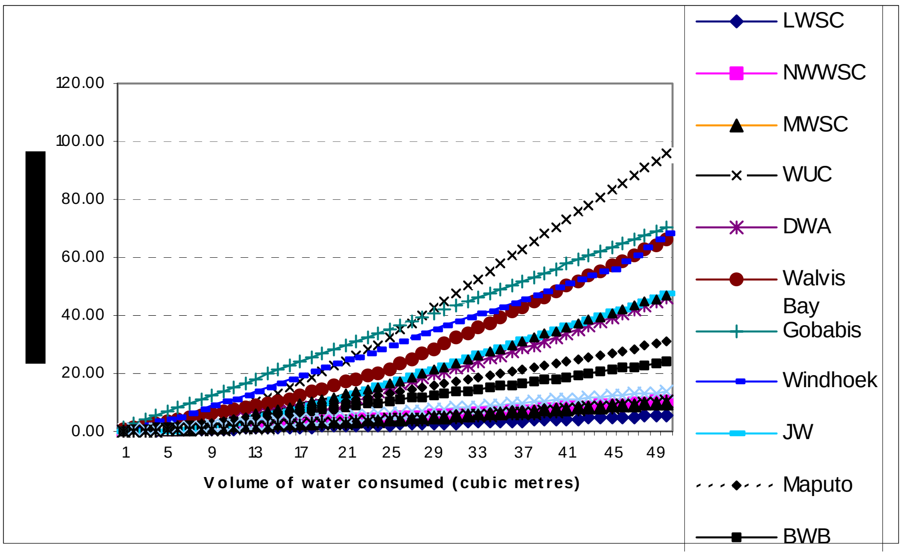
example

Comparison of water tariffs and monthly bills for a selected MWSAs in southern Africa

During the presentation of the IUCN pilot WDM Guidelines Training Module for MWSAs conducted in Lusaka, Zambia, in July 2004, the latest water tariff figures for selected MWSAs in southern Africa were provided by the participants. The data were analysed and comparisons were made by the facilitators. Data were obtained for MWSAs in Botswana, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. The water tariffs of July 2004 were used to calculate the monthly water bill for variable consumption rates, as shown in Figure 8.

Out of the fourteen MWSAs represented, thirteen have a progressive block tariff structure and only one has a flat rate system (Gobabis in Namibia). Five cost clusters emerge from the data. IN the first cluster, water supplied by WUC in Gaborone results in the highest water bill for consumption levels higher than 40 m^3/month. This is partly due to the steep increase in block rates for any consumption above 40 m^3/month. The second cluster consists of MWSAs in Namibia that have slightly lower tariffs, and different block increases. But families that use 50 m^3/month pay virtually the same in Windhoek, Walvis Bay or Gobabis. In Johannesburg as supplied by JW, large rural villages in Botswana by DWA, and (peri-) urban Swaziland by SWSC, constitute a third cost cluster with monthly water bills of just under US$50.00 for a consumption level of 50 m^3/month. The fourth cluster covers Blantyre as supplied by BWB and Maputo with monthly bills of around US$25.00 for a 50 m^3/month rate of domestic consumption. Water bills are lowest in the fifth cluster consisting of MWSAs in Zambia (LWSC, NWWSC and MWSC) and in Zimbabwe (Harare and Gweru). Overall, LWSC supplies the cheapest water among the fourteen MWSAs for a consumption rate of 50 m^3/month.

Figure 8: Monthly water bill for domestic users for different MWSAs in southern Africa



Note:1. LWSC = Lusaka Water and Sewerage Company; NWWSC =North Western Water and Sewerage Company (Zambia); MWSC = Mulonga Water and Sewerage Company (Zambia), WUC = Water Utilities Corporation (Botswana);

notes

DWA = Department of Water Affairs (Botswana); JW = Johannesburg Water; BWB = Blantrye Water Board; SWSC = Swaziland Water Services Corporation.

2 .Exchange rates used to convert local currencies to United States dollars (US$). 1 US$ = 6.00 South African Rand, 6.00 Namibian Dollars, 6.00 Swazi Emlangeni, 4.90 Botswana Pula, 5 600.00 Zimbabwe Dollar, 5 000.00 Zambian Kwacha, for Malawian Kwacha, and Mozambican Meticals the figures were already converted to US$.

Reasons for the cost differences could include water scarcity and high supply costs, economies of scale, technical inefficiencies and different principles applied to the setting of water tariffs, as well as currency devaluations, as in Zimbabwe. For example, the high costs in Botswana and Namibia can be attributed to water scarcity, whilst in Walvis Bay the water revenues are meant to subsidise the provision of other services such as roads (refer to comments from participants in the ILCP examples in Unit 2).

The table below (Table 13) summarises the average unit cost of domestic water when households use 10, 25 and 50 m^3/month, respectively. The table shows that increasing block tariffs lead to a substantial increase in average unit costs. Such a structure creates an incentive for consumers to conserve water whilst at the same time providing a lifeline supply of water at reduced rates for poor domestic water consumers. (Note that in Johannesburg, South African constitutional requirements mean that the first 6 m^3/month per household is supplied for free. This is the so-called 'free basic water' policy, and hence the low average unit cost of US$0.23 for the first 10 m^3.)

Table 13: Average unit water cost for selected MWSAs using July 2004 water tariffs for three levels of consumption rate

MWSA	DOMESTIC WATER CONSUMPTION RATE PER MONTH		
CONSUMPTION LEVEL	10 m^3/MONTH	25 m^3/MONTH	50 m^3/MONTH
LWSC	0.09	0.09	0.11
NWWSC	0.16	0.18	0.21
MWSC	0.16	0.17	0.20
WUC	0.58	1.30	1.92
DWA	0.39	0.60	0.93
Walvis Bay	0.68	0.86	1.32
Gobabis	1.41	1.41	1.41
Windhoek	1.00	1.19	1.37
JW	0.23	0.67	0.95
Maputo	0.32	0.53	0.61
BWB	0.26	0.42	0.48
SWSC	0.33	0.65	0.94
Gweru	0.20	0.25	0.27
Harare	0.08	0.15	0.20

notes

The application of different rates for domestic and productive users can provide a stimulus for greater productive use of water if productive end-users pay lower rates, or could provide a social benefit where there is cross-subsidisation of domestic users by productive users, as in Zimbabwe. In the case of industrial water tariffs there is still a tendency amongst MWSAs to lower the tariff after a certain usage for large consumers, as a tool to lure industrial clients. This discourages WDM, but could stimulate investment and development.

Spatial tariff variations based on differences in production costs could offer incentives for productive users to locate in areas with lower water tariffs.

Production activities would then follow water rather than water being brought to activities. This location incentive has not worked in Botswana, as water costs are only a small portion of the production costs, and hence not a key location factor.

example

Water pricing in southern Africa

Water prices may be based on the average historical price of the supply water, as in the case of Zimbabwe's blend price, or they may be based on the marginal costs of water supply, i.e. the costs of the most recent or planned new water supply source. When supply costs are rising, the marginal supply costs exceed the average supply costs. Marginal pricing leads to higher revenues for MWSAs and gives the end-users a better feel for the current resource scarcity and value. The extra revenues (over average production costs) can be used for further WDM implementation.

Table 14: Outline of prevailing pricing mechanisms in southern Africa

COUNTRY	PRICING DETAILS
Angola	The pricing policy enunciated in the Water Sector Development Strategy consists of the following elements: • Full cost recovery (capital and O&M) • A reduced *social tariff* for a basic level of supply • Differential tariffs across consumer categories (those better able to pay cross-subsidising the social tariff) and across the country • Incentives for the proper use of water The previous policy of uniform national tariffs for water was abandoned in 1998. In practice, tariffs remain remarkably uniform across the country at levels that the Strategy document describes as *derisory*.

notes

COUNTRY	PRICING DETAILS
Botswana	Band unit tariffs with spatial differences. No differences between domestic and productive users. The water pricing policy for water in Botswana is based on principles of equity and affordability. There is no government subsidy on water in urban areas, but those who use large quantities, pay more to subsidize those who use less. The WUC supplies urban areas and its tariffs are set in line with the long run marginal cost of the water supply systems in urban areas. All tariffs are subject to ministerial approval. In rural areas, the target is to recover the full recurrent costs of all the major village water supply schemes, and part of the capital costs (NDP8). However, cost recovery is slightly above 50%. Water from communal standpipes is free to consumers in villages, thus ensuring that everyone has access to safe drinking water. For private connections in rural areas, staggered rates exist so that those who use excessive quantities pay a price that is roughly equal to the production cost.
DRC	The water sector is reliant on foreign donor support in the form of grants and loans. Water prices for public standpipes (where implemented) amount to about US$0.25 per person per month. No further information is available.
Lesotho	Water for basic human needs is an *entitlement* and any requirement beyond this has to be paid for by the user. The three strategies to implement this policy are as follows: • Implementation of fully cost-reflective tariffs for *private systems* (e.g. individual connections for domestic users and all institutional, commercial and industrial connections). • Introduction of tariffs to cover *installation costs* for public systems. Presumably these refer to communal type systems (public standpipes, hand pumps, etc.). • Introduction of a cross-subsidy to ensure affordable basic supplies of 30 litres per capita per day.
Malawi	Government aims to broaden the coverage of the provision of water supply while at the same time reducing its share of financial support to the sector while supporting the poor. It has therefore outlined a pricing strategy to facilitate a cost-sharing mechanism for the sector. This strategy aims to: • Provide incentives for investment in the sector • Ensure efficient O&M • Provide incentives to efficient users of water • Ensure cost recovery through income from charges for water
Mauritius	The cost of water supply is recovered in the urban centres and at commercial irrigation projects. No further information is available.
Mozambique	Users should pay for water or at least for the utilisation of hydraulic infrastructure. The price of water should come to reflect its economic value, eventually covering the cost of supply. After years of remaining frozen, urban tariffs were raised from 1993, thereby setting the scene for private sector participation, which followed in 1998. In practice, the introduction of a commercial structure in the urban water sector, with higher tariffs and more rigorous metering and billing of customers, has raised controversy.
Namibia	Pricing aims at full financial cost recovery, but in cases where the population cannot afford to pay for water services, special provision must be made by the government to assist those people. NamWater aims to recover the cost of bulk water sold to its customers in full. The local authorities pay the full cost of the water supplied by NamWater and recover that from the consumers, in addition to the cost incurred to distribute the water. In some cases a block tariff system is used to charge high water consumers more as a punitive measure to encourage water demand management and to subsidise the *lifeline quantity* of water. Those who cannot pay for water at all can obtain water from standpipes, thus making a contribution in kind by carrying the water to the household.

notes

COUNTRY	PRICING DETAILS
South Africa	**Raw water** A national water pricing strategy has been developed in terms of the National Water Act. This strategy applies to untreated water. The strategy provides for charges for the following: • The right to use water related to the scarcity of water. This charge is to help achieve the equitable and efficient allocation of water and may be determined administratively or through public tender or auction. This charge has not yet been implemented. • Use of water • Waste discharge Funding of water resource management • Paying for water resource related infrastructure based on a return on assets of 4% • Water services Water and sanitation services are priced in terms of the Water Services Act. Prices are cost-reflective but take the need to ensure affordability of access to basic services and for basic use for the poor into account.
Swaziland	Government relies heavily upon foreign aid in the water sector. Presently there are no tariff structures for rural water projects and so far the government has not envisaged cost recovery as water supply is considered to be a social service. Sliding-scale tariffs have been introduced for urban water supplies and consumers are categorised as *residential* or *non-residential*. About 60% of the cost of water supply is recovered.
Tanzania	In urban areas, the urban water and sewerage boards decide upon the water tariffs. Generally the tariffs are low and do not reflect the real costs and are not based on economic or financial principles. Water tariffs are now moving towards cost recovery as, since 1994, the regional authorities have the legal basis to review the tariffs.
Zambia	Government policy on cost recovery in the water sector has two objectives, namely to make beneficiaries pay for benefits they enjoy, and to ensure that the beneficiaries gain a sense of ownership and thereby a concern for maintaining the facilities. However, the economic situation in the country makes it difficult for the communities/consumers to pay purely on economic considerations. In the rural areas, water is not sold by unit volume. Basically, the user fees paid by the communities are for O&M and not for the consumption rate. The capital cost is subsidised by government and development partners. The response in rural areas, particularly where awareness has been created, is good and payments are made either in kind or cash. In urban areas the objective is to have full cost recovery. Water prices are set by each individual utility but have to be approved by the regulator, the National Water Supply and Sanitation Council. Progressing block tariffs are the most common. However, irregular billing (where customers receive their bills late), collection inefficiencies (less than 50% on average), and high NRW hampers the extent of recovery of costs by service providers. In most areas, industrial water is also provided by the utilities. Irrigation water (as well as that for other uses) obtained from surface water is subject to having a water right from the Water Board as governed by the Water Act, Chap 198, of the Laws of Zambia. There are prescribed charges associated with surface water abstraction as indicated in the Statutory Instrument No 20 of 1993 – *The Water Board (Charges and Fees) Regulations*. A fixed amount is charged for water abstracted up to 500 m^3/day. For every cubic metre of water per day abstracted above 500 m^3 the unit cost is higher. Collection of water charges has not been effective due to the incapacity of the Water Board to monitor the water users as well as water right holders.

notes

COUNTRY	PRICING DETAILS
Zimbabwe	**Bulk water:** In the past, Zimbabwe had a uniform national price for raw water (blend price). The blend price was intended to recover the historical capital costs and O&M costs of public dams. There were two national blend prices, one being for agricultural water and the other for UIM (Urban Industrial Mining) water. A Water Resource Management document lays out principles for water pricing. This document endorses *for now* the national blend price system *despite reservations*, but advocates shifting the basis of the blend price from historical to replacement capital costs. As of December 1999, the actual blend prices were around 40% of the replacement cost value. The intention has been expressed to introduce real increases spread over a number of years, together with adjustments to compensate for inflation to bridge this gap. In practice, this intention has been subsumed by the political and macroeconomic crisis in Zimbabwe from 2000 onwards. Water service pricing: prices are below economic levels (i.e. long-term marginal costs), and most do little more than cover O&M costs. In the past, no provision has been made for investment, as major projects have been funded partly by central government and partly by low interest loans from central government to the municipality. With the national budget under increasing pressure, there is a growing realisation that urban water has to be self-financing, but urban councils remain reluctant to increase water tariffs to the levels that would be required for this.

Source: Adapted from Eberhard et al., (2003)

The following conclusions can be drawn from these southern African tariff examples:

- There is a move towards higher water prices and greater cost recovery.
- Differences exist between policy and strategy and practice; cost recovery and decreasing subsidies are difficult to achieve.
- Governments usually determine water prices, except in Tanzania. MWSAs have very limited influence over water pricing.
- Social concerns are typically addressed through the provision of free or cheap water from standpipes and for the lowest user, or lifeline, band.
- Countries that rely heavily on donor assistance have less incentive to encourage cost recovery, e.g. DRC and Swaziland.

a c t i v i t y

- Update and correct the pricing details for your country and MWSA.
- Discuss and determine the required changes in pricing mechanisms for your MWSA.

Effectiveness of water tariffs as a WDM tool

Water tariffs are usually considered central to MWSA WDM strategies for at least three reasons:

- Most MWSAs are faced with increasing costs due to augmentation schemes, expanding the range of their services and, in some countries, non-payment problems. Most MWSAs are tasked with improving cost recovery and decreasing dependence on government

notes

subsidies, and therefore there is a strong tendency towards higher water tariffs.

- Traditional economic theory suggests that higher prices will lead to a decrease, or at least a slower increase in water consumption. Therefore, higher water tariffs are emphasised in most WDM literature.
- Some local authorities seek to make a profit out of the water sector to finance other sectors, and use their tariff structure to do this.

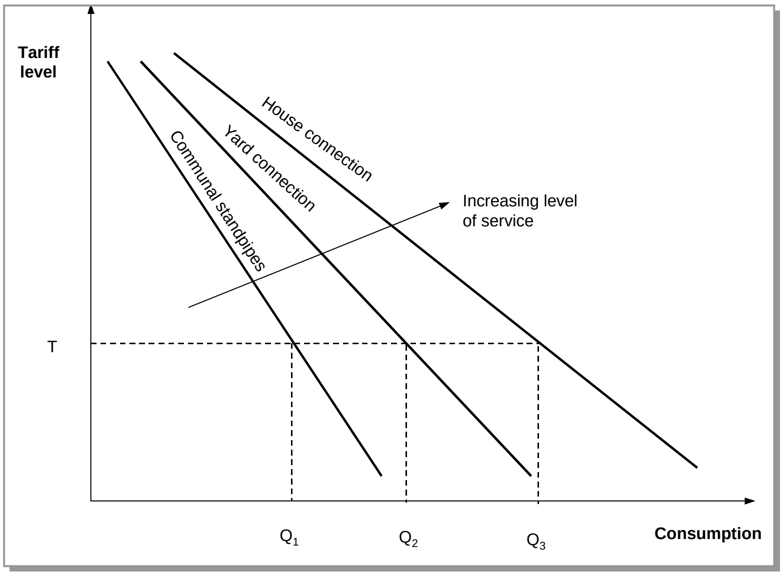
There is no doubt that higher water tariffs usually lead to higher MWSA revenues. Revenue equals the amount consumed multiplied by the price paid. Therefore, higher tariffs will normally lead to higher revenue, unless the consumption drops significantly. The impact of tariffs on water consumption is less clear, however, as this depends on the largely unknown demand characteristics of different user categories.

The price elasticity of demand

With ordinary economic goods the relation between the price, or tariff, and demand, is expressed graphically as a demand curve. The slope of this demand curve is called the elasticity of demand (Figure 9). It is defined as the percentage of increase in demand resulting from a percentage of increase in price.

It is very important that MWSAs carry out research on the price elasticity of the major user categories, since the impact of water prices on consumption is determined by the price elasticity of demand, or in other words the extent to which the demand changes following an increase in water prices. The price elasticity is reflected by the slope of the demand curve.

Figure 9: The effect of rising tariffs on consumption



notes

Figure 9 illustrates the relationship between rising tariffs that have been applied according to the type of service provided (standpipes, yard and house connection) and demand. Consumption is greater at lower tariff levels.

If the demand curve is almost vertical, the consumption will not change after changes in prices, but the MWSA's revenues will change.

If the demand curve is almost horizontal, the consumption will decrease sharply after a 1% price increase (and the MWSA revenues may not change a lot!).

activity

This table explains the price elasticity concept by using a simple example. Assuming that the original consumption of a customer is 100 m^3/month and the price of water is US$1.00/$m^3$, what would the impact be of a 10% tariff increase to the consumer and on the MWSA?

The effect of rising tariffs on consumption

PRICE ELASTICITY AND PRICE	VOLUME OF WATER CONSUMED (M^3)	IMPACT ON MWSA REVENUES/COSTS (US$)
Price elasticity = -0.5 Price = US$1.10/m3	95	104.50
Price elasticity = 1.0 Price = US$1.10/m3	110	121.00
Price elasticity = -2.0 Price = US$1.10/m3	80	88.00

Simple demand curves are depicted as straight lines, but in reality, it is likely that water demand curves are kinked, as the composition of the demand changes. For example, high-income domestic users may have a kinked curve that becomes more horizontal in the higher user bands. This would reflect luxury uses such as pools and gardening. Consequently, this use would be more receptive to price increases.

Price elasticity is expressed as a negative number, because demand is expected to decrease as price increases, and normally ranges between -1and 0. The problem is that elasticity is not a constant. It depends on the price and on water use and it may vary over time, associated as it is with living conditions and income. It is therefore an equation with limited applicability.

notes

The price elasticity of productive users can be expected to vary widely, based on:

- The nature of the productive activities and the amount of water used (in m^3 and as part of the production costs)
- The available alternative water-saving production technologies

For most productive companies, water costs are a small portion of the production costs, and therefore changes in water prices have a small impact on the production costs.

Government users are often the least price responsive, particularly when the Ministry of Finance centrally pays the water bills, e.g. Botswana. Decentralised water billing is an important WDM requirement for the public sector.

activity

It is very important for MWSAs to know the nature of the demand curve for the main categories of end-users. Do you know the demand curve for your MWSA?

- Find out and feed the results into your implementation plan.

According to HR Wallingford (2003), the following can be concluded about the effect of tariff levels on water consumption:

- The elasticity of water consumption is generally low.
- The price elasticity is greater when the price is higher.
- In the household sector, the price elasticity varies between -0.15 and -0.70.
- With respect to drinking water the demand-price relation will never be elastic (E <-1).
- In the industrial sector, the majority of estimates are in the range of -0.45 to -1.37.

case study

Masvingo's tariff structure

The city of Masvingo in Zimbabwe derives the largest portion of its income from the water account, which has contributed between 25% and 40% of the council's revenue since 1995. The City Council made, on average, about 80% profit on each cubic metre of water sold during 1999 to 2001. The water account is able to meet the present O&M needs of the water supply utility.

notes

Since 1999 Masvingo has adopted an increasing block tariff, with the first block covering consumption up to 18 m^3/month per connection and the second anything in excess, in conjunction with a fixed monthly charge.

The fixed charge is differentiated between households in affluent neighbourhoods and those in other areas. Owing to the unstable economic climate since 2001, the tariffs are reviewed every six months. Table 15 shows that the tariffs were increased significantly during 2001 and 2002.

Table 15: Domestic water tariffs for Masvingo 2001 and 2002

YEAR	FIXED CHARGE		CONSUMPTION	
	Poor	Rich	Less than or equal to 18 m^3/month	More than 18 m^3/month
	(Zim$/connection/month)		(Zim$/m^3)	
January 2001	80	287.30	8.98	12.82
July 2001	100	359.13	11.23	16.03
January 2002	155	556.45	17.41	24.85
July 2002	186	667.74	20.89	29.80

Table 16 shows that low water consumers pay a relatively high price per cubic metre of water. This is due to the relatively high fixed charge that, for a household consuming only 12 m^3/month, contributes 43% to its water bill. The largest water users, the affluent, pay on average about the same unit water price of water as the non-affluent users.

Table 16: Average water price at different consumption levels in Masvingo January 2002

HOUSEHOLD	MONTHLY CONSUMPTION	TOTAL WATER BILL	AVERAGE WATER PRICE	FIXED CHARGE (%)
	(m^3/connection/month)	(Z$/month)	(Z$/m^3)	
Less affluent	12	364	30	43
Less affluent	18	468	26	33
Less affluent	30	767	26	20
Affluent	60	1 914	32	29
Affluent	120	3 405	28	16

Note: In January 2002, 1 US$ was equivalent to Zim$ 55 (official rate) and Zim$ 300 (parallel or black market rate)

Income levels of the majority of residents in Masvingo are not high. An oral opinion survey was carried out which found that Z$3 500/month was the average cash income per household for the low-income bracket (the minimum set by government is Z$8 900 per month).

Using tariffs applicable from January 2002, and 12 m^3/househehold/month as the average water consumption per household in the poorest neighbourhoods, a household would pay Z$364 per month, or 10% of their estimated cash income. World Bank studies have recommended that not more than 5% of income should be spent on water for basic requirements.

notes

The high-income consumers, however, spend less than 5% of their income on water. Assuming an average income of an affluent household of Z$60 000 per month, and average water consumption of 60 m^3/month, its monthly water bill would amount to Z$1 914, or only 3% of household income.

It therefore appears that Masvingo's water tariff structure could be improved: the fixed charge must go down because it compromises equity; whereas the tariff of the second block should be increased relative to the first block, as that would give a clear signal to high water users to reduce their consumption.

Such a change in the tariff structure is likely to have little effect on water consumption by poor households, as these have a relatively inelastic demand for water. However, the tariff change would influence consumption levels of the affluent households, which have a much higher elasticity of demand.

In 2002 a study carried out by the University of Zimbabwe proposed an alternative tariff structure. This structure abolishes the fixed charge and introduces a four-stepped rising block tariff structure that is based on the same principles developed by the city of Windhoek.

The first block considers the lifeline amount (12 m^3/household/month), and its tariff recognises the limited ability of the poor to pay, assuming that the low-income bracket may not spend more than 3.5% of cash income on water.

The tariff for the second block, the wellbeing quantity of 24 m^3/household/ month), is set at the real cost of water supply. The third block has a tariff that meets the full cost of water supply.

The tariff for the highest block compensates for the subsidies enjoyed by the lowest two blocks, and caters for the financial requirements of future extensions of the water supply utility. This structure is shown in Table 17.

Table 17: An alternative tariff structure for domestic water users in Masvingo January 2002

BLOCK (m^3/CONNECTION/MONTH)	TARIFF (Z$/$m^3$)
0 to 12	10
13 to 24	20
25 to 36	35
>37	55

The alternative tariff would result in the following:

- The same revenue yield as at present (including an estimated 50% of income over and above O&M costs, meant to cover infrastructure development)
- The limited ability of the poor to pay being considered, in that the water bills of the poorest households would be reduced by more than a third
- Water demand management being assisted, in that as consumption increases, the average charge per unit of water also increases.

notes

Source: HR Wallingford (2003)

3.4.2.3 Other economic measures

A range of other economic/financial incentives can be used to stimulate WDM:

- Tax relief or targeted subsidies for productive users that install the latest WDM technologies – justified as a way of streamlining the net private and net social benefits as explained earlier
- Water-efficient standards for goods and production processes
- Water efficient product labelling

In a similar style as for wood products, products could be labelled as water friendly if they are produced in a water efficient manner.

3.4.3 Policies, legislation and regulations

Policies and regulations are critical to the successful implementation of local WDM, and need to be developed at both national and local levels. They should be designed within the broader perspective of IWRM, meaning that water issues should be integrated into other aspects of local planning such as town planning and economic development and growth strategies.

3.4.3.1 IWRM and WDM policies and strategies

While most countries are moving towards IWRM policies, the challenge of implementation is only just starting. WDM is an integral part of IWRM, but to accelerate its implementation, separate WDM programmes or policies are needed. Table 18 examines the implications of recent policy reform trends for WDM implementation.

Table 18: Trends in recent policy reforms and implications for WDM efforts

ISSUES	IMPLICATIONS FOR WDM
Formal policies do not exist in several southern African countries (e.g. Angola, Botswana, DRC, Mauritius, Swaziland)	• No *enabling* environment to stimulate WDM interventions • Flexibility and opportunities for champions to implement relevant local WDM interventions
Legislation without policy can suffice to promote IWRM (e.g. Angola and Botswana)	• WDM requires champions to take off • Seize opportunities for local IWRM/WDM plans

notes

ISSUES	IMPLICATIONS FOR WDM
Decentralisation of water management to catchment area level (Namibia, South Africa, Mozambique, Zimbabwe)	• Opportunities to demonstrate finite water resources, and competition among end-users (allocative efficiency) • Seize opportunities for sub-national IWRM/WDM plans
Water as an economic good	• Opportunities for higher water prices, compensation of environmental costs, and use of other economic instruments
Gaps between policy and practice larger than gaps between policies themselves	• Typical for a new and rapidly changing policy area • Utilise existing gap to implement IWRM and WDM • Ensure that successful practical experiences inform policy reform and development at the national and local level
Largest policy gap refers to water quality (effluent standards and charges)	• Design and implement effluent charges and standards to ensure water standards
Large gap between pricing policy and practice	• Keep pricing policies realistic and pragmatic
Many policies are too ambitious in changing too much too quickly	• Consider WDM as an explicit part of IWRM, particularly at policy and programme level • Focus on implementation of WDM measures using the 80:20 principle • Minimise extra bureaucratic and administrative burdens of WDM
Growing recognition of shared water resources	• SADC protocol to be used as an incentive for WDM in individual countries • Streamline IWRM and WDM plans with the protocol

Source: Expanded from Eberhard et al., (2003)

3.4.3.2 Local WDM plans and by-laws

Municipal authorities should design a specific IWRM and WDM plan, with clear targets and instruments.

Regulatory instruments may include the following:

- By-laws that deal with regulating water use in swimming pools, watering of gardens, and the control of invasive alien species etc.
- Regulations against wastage
- Formal certification and registration of plumbing contractors
- Pollution control by means of effluent charges and the application of standards

3.4.3.3 WDM and regional and town planning

This area is often neglected in water management, even though water has traditionally been one of the key settlement factors in southern Africa. Regional and municipal planning influences water demand, and

notes

therefore water management should be a factor in town and regional planning.

Some examples:

- The plot size influences water consumption. Smaller plots:
  - Have a lower water consumption, mostly due to smaller gardens
  - Lead to proportionally lower NRW as the pipe system is smaller
- Industries can be directed to areas with a better or cheaper water supply through regulations and/or different water prices.
- Water resources could be used to limit municipal development (number of inhabitants and economic activities).
- The size of a settlement and the level of services could take into account water scarcity and costs.

example

Example of the role of town planning in WDM

In Windhoek, the capital of Namibia, the Council has allowed the erection of two dwellings on one erf. This has led to densification, which makes for a more efficient water supply system, as well as smaller areas of an erf left for gardening, leading to a reduction in domestic water use.

Town planning in Windhoek does not allow heavy industry to be established in the catchment area of the sewage purification plant that delivers effluent to the reclamation plant that provides the city with reclaimed water for potable use.

It also does not allow the establishment of industry that uses more than 20 kilolitres of water per hectare per day in the southern industrial area of the city. The reason for this is that the main source of water to the city is from the north, and it is not cost effective to move large volumes of water to the southern part of the city.

Big townhouse developments are also being built. These developments do not allow for large gardens to be developed and make for a smaller per capita consumption.

3.4.3.4 WDM and municipal economic development

While each municipality wants to attract as many employment and income opportunities as possible, it is important to consider whether it is better (environmentally, socially, and economically) to bring water to productive activities or to locate such activities in water-endowed areas. This is equally important at the regional, national and local level.

notes

MWSAs need to be part of the long-term development plans of municipalities. Water-scarce areas should focus on attracting economic activities such as services that use little water, while water-intensive activities such as food processing would be located near water resources.

example

Municipal implementation responsibility

- To adopt progressive service delivery arrangements
- To adopt and implement specified standards
- To agree on a tariff model
- To review all current water care works and bulk reticulation in terms of WDM initiatives

Outline of a local WDM proposal

The local authorities will pledge individually to WDM targets (in line with regional targets) and as a consequence will undertake the following functions:

- Establish real NRW limits and set revised WDM targets.
- Agree on appropriate response measures if the above targets are not met.
- Establish funding mechanisms to undertake WDM initiatives within their own areas of influence or elect to join the WDM Fund and combine scarce resources to undertake WDM initiatives.
- Review all current water treatment works and bulk reticulation in the light of WDM initiatives.
- Implement agreed standard practices and policies on service payments.
- Adopt and implement progressive service delivery arrangements.
- Adopt and enforce relevant standards for materials and implementation of services.

Source: Adapted from IUCN WDM Guideline for bulk suppliers of treated water (2004)

3.4.4 Consumer service and public awareness

WDM will not work if MWSAs do not provide adequate services to end-users, or do not respond in time to queries and leak reports. Nor will it work if end-users are not informed about the need for WDM, the costs and benefits involved, and WDM methods that they can use. It is critical that MWSAs adopt a customer friendly approach rather than telling the customer what to do.

Good service delivery enhances relationships with consumers, increasing their willingness to pay for services whilst reducing bad debt and the

notes

incidence of illegal connections. This in turn supports the implementation of WDM at MWSA level.

3.4.4.1 WDM and participation of end-users

End-users need to participate in the development of water plans, and consideration should also be given to their being involved actively with management, for example of standpipes, with interventions that impact on water prices, and on the affordability criterion of 5% of monthly income.

3.4.4.2 Effective meter reading and information provision

It is important that MWSAs provide proper information about their rates and billing system. This could lead to a stronger positive response to WDM on the part of end-users.

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example

Recent work on price elasticity in Gaborone showed that most domestic users have a general perception that water is expensive, but:

- They do not know that the MWSAs have annually increased the tariffs by an average of 17% over the last five years
- They do not know how much they pay per month

It is not surprising therefore that such users do not respond to price changes!

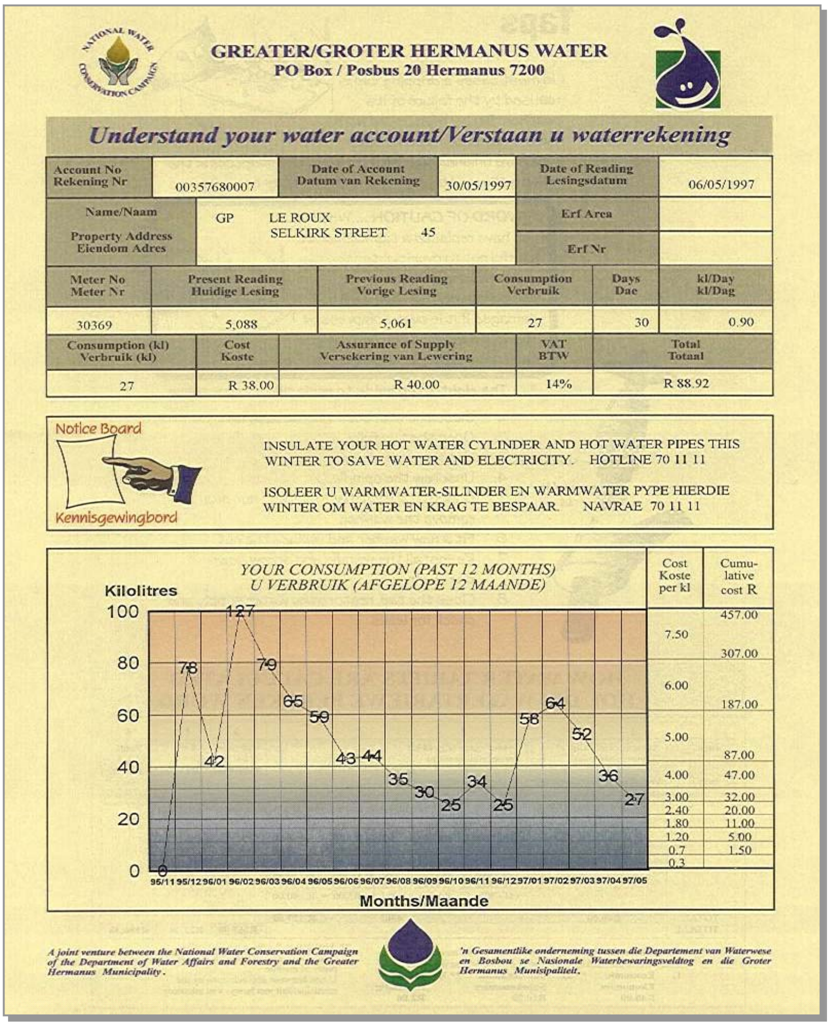
Effective and informative monitoring and billing can be greatly facilitated by the use of a Management Information System (MIS). If an MIS has been acquired and installed by an MWSA, the first step towards commissioning it is the compilation and/or validation of the consumer database in order to detect irregularities such as consumers missing from the database, or incorrect address details. Following this, water meters must be read and informative bills generated on a regular, systematic, and accurate basis.

When a water bill is generated, it must reach the consumer. An informative water bill is essential for the purposes of WDM, in order to provide consumers with the means to regulate their own water demand and make effective savings in water and costs.

The water bill shown in Figure 10 was developed for the MWSA of the town of Hermanus in South Africa.

notes

Figure 10: Example of informative water bill



GREATER/GROTER HERMANUS WATER
PO Box / Posbus 20 Hermanus 7200

Understand your water account/Verstaan u waterrekening

Account No / Rekening Nr	00357680007	Date of Account / Datum van Rekening	30/05/1997	Date of Reading / Lesingsdatum	06/05/1997
Name/Naam; Property Address / Eiendom Adres	GP LE ROUX SELKIRK STREET 45			Erf Area / Erf Nr	

Meter No / Meter Nr	Present Reading / Huidige Lesing	Previous Reading / Vorige Lesing	Consumption / Verbruik	Days / Dae	kl/Day / kl/Dag
30369	5,088	5,061	27	30	0.90

Consumption (kl) / Verbruik (kl)	Cost / Koste	Assurance of Supply / Versekering van Lewering	VAT / BTW	Total / Totaal
27	R 38.00	R 40.00	14%	R 88.92

Notice Board / Kennisgewingbord

INSULATE YOUR HOT WATER CYLINDER AND HOT WATER PIPES THIS WINTER TO SAVE WATER AND ELECTRICITY. HOTLINE 70 11 11

ISOLEER U WARMWATER-SILINDER EN WARMWATER PYPE HIERDIE WINTER OM WATER EN KRAG TE BESPAAR. NAVRAE 70 11 11

A joint venture between the National Water Conservation Campaign of the Department of Water Affairs and Forestry and the Greater Hermanus Municipality.

'n Gesamentlike onderneming tussen die Departement van Waterwese en Bosbou se Nasionale Waterbewaringsveldtog en die Groter Hermanus Munisipaliteit.

3.4.4.3 Service-related measures

There are a number of service-related steps that can be taken by MWSAs to improve their interaction with the public and improve accessibility.

- Establish a call centre or place where consumers can lodge complaints or obtain information. If this avenue is used, the call centre must be functional and staffed by competent personnel.

  The call centre is the facade of the MWSA, and if a consumer has to wait to be connected to an agent, the MWSA will be rated poorly on service delivery. The call centre would benefit from a MIS, where a service call will generate a job card that will be tracked until it has

notes

been appropriately finalised. If, for example, a consumer reports a burst pipe, and no reaction is forthcoming from the municipality, consumer relationships suffer as a result of poor service.

- Consult consumers before and during the planning and installation of new services such as water supply and sanitation schemes if they are to be expected to pay for them afterwards. A range of service levels should be offered that will cater for basic needs as well as for higher levels of service for those that want and can afford to pay for them.
- Provide more and better information. This can be done via the monthly water bills in various forms and through awareness-raising campaigns. Important information that customers need to know includes the following:
  - What is the trend in water consumption (in m^3 and financial terms)?
  - What is the composition of the water consumption, e.g. gardening?
  - What is the potential for WDM, and what are the net benefits?

  In Hermanus, South Africa, information is provided on the back of the monthly water bill. In Windhoek a monthly newsletter, the Aloe, is distributed, while in Johannesburg a call centre was established.

  An MWSA can also enter into a dedicated awareness campaign such as the Water Wise campaign undertaken by Rand Water, a bulk potable water supplier in South Africa. A successful programme was launched in Hermanus as part of a wider water awareness programme in South Africa.
- Establish an MWSA web site with a WDM page and links to other WDM sites. This would allow customers with access to the Internet to ask questions and to search for information.

example

Greater Hermanus Conservation Plan

- Intensive communication campaign
- Education and water audits at schools
- Water loss management
- Clearing of invasive alien plants in the catchment area
- Water-wise gardening

notes

- Water-wise food production
- Initiatives to save water in the home
- Water regulations
- Assurance of supply tariffs
- Escalating eleven-step block-rate tariffs
- Informative billing approach
- Masakhane metering project for Mount Pleasant

The results of the Hermanus campaign show that 96% of consumers supported the programme, school water consumption dropped by 50%, and NRW was lowered from 18% to 11% between 1996 and 1997. Water consumption dropped by 16.5% in the first year while revenue increased by R1.3 million.

The clearing of invasive alien plants increased catchment run-off and provided job opportunities, firewood and wood for furniture to local residents. The retrofitting programme was abandoned, however, because of consumer resistance and high costs. Communication is one of the most vital components of this programme. No water conservation programme of this nature can be implemented without the support of the community. Equally important is the fact that the political leaders of the town/city, and the municipal staff members must be fully committed to water conservation principles.

Source: IUCN WDM South Africa country study report (1998)

Awareness-raising campaigns

Awareness-raising campaigns aim to target specific audiences, but can be quite broad in their appeal. They are of great value in boosting public support for WDM by improving public perceptions of WDM.

- **National water weeks** can be instituted in which government officials and well-known celebrities undertake activities that are heavily publicised to create awareness for WDM issues.
- **Competitions** can be run in which consumers are encouraged to participate in some activity that highlights the value of WDM.
- **Articles or advertisements** in newspapers and popular magazines can highlight some aspects of WDM.
- **Water-wise posters** can be displayed at all garden centres to explain effective garden watering and how to minimise irrigation requirements.
- **Pamphlets** on how to save water and use it more effectively can be sent to consumers with their water and electricity bills.

notes

- **Stickers** on how to save water can be displayed in hotel bathrooms, and in public toilets at airports, railway stations, and government buildings.
- **Sponsorship** of appropriate events where WDM can be promoted, e.g. road races and football events, can be undertaken.

It is necessary to target awareness campaigns at different groups of water users, and, where possible, to design and implement the efforts with the participation of the targeted groups.

tip

The Global Water Partnership has published two useful documents that are you can use for sourcing ideas for consumer service and public awareness programmes. These are:

1. Schaap and Van Steenbergen. (2001). *Ideas for Water Awareness Campaigns*. Stockholm, Sweden: The Global Water Partnership.

2. Van Ittersum and Van Steenbergen. (2003). *Ideas for local action in water management*. Stockholm, Sweden: The Global Water Partnership.

These two books attempt to bring together the many ideas developed in many worldwide initiatives, and these ideas are combined with suggestions from communications theory and commercial marketing with an emphasis on practical suggestions and clues. Copies of the two books have been provided in the CD-ROM containing the source material for this training manual. They can also be downloaded from the Global Water Partnership website URL: http://www.gwpforum.org, email: gwp@gwpforum.org.

example

Issues related to water-wise gardening

There are many issues related to proper water-wise gardening, and the following items represent only a few of the most important and obvious considerations:

- **Watering times:** Watering should be restricted to the morning or evening. Evaporation is highest between the 10:00 and 16:00, when watering should be avoided.
- **Use of drought resistant lawn and plants:** Many varieties of grass used in garden lawns are not drought resistant and require regular irrigation. Certain drought resistant plants and grasses are now available, and these should be used whenever possible.
- **Proper sprinkler design:** In areas where sprinkler systems are used, care should be taken to ensure that the sprinkler system is not over-designed.
- **Timing of automatic sprinkler systems:** In cases where automatic sprinkler systems are used, there should be some facility to prevent the sprinklers being used during wet

notes

periods. It is a common sight in some areas to see sprinkler systems operating at full capacity during a downpour. Use a tap timer for sprinklers and dripper systems.

- **Use of soil moisture activated controller:** In cases where expensive irrigation systems are used, they should be equipped with a soil moisture controller, which will only allow irrigation when required.
- **Grouping of plants:** Plants with similar water needs should be grouped together so that they can be watered at the same time.
- **Trenching:** Small trenches should be used in gardens to direct any natural runoff and irrigation water to the areas where this is needed. Creating small mounds of earth around specific plants will enable them to be watered individually, using a watering can if necessary.
- **Mulching:** Spreading mulch on a garden reduces the water lost to evaporation by up to 70%. It also prevents excessive runoff from natural rainfall, inhibits weed growth, and supplies nutrients to the soil. Mulch can be made from wood chips, tree bark, composted straw, manure, peat, moss, etc., and is one of the most effective measures for reducing garden water requirements.
- **Trigger-operated hose nozzles:** If a hosepipe is used for garden watering it should be equipped with a trigger nozzle to minimise wastage.
- **Duration and frequency of watering:** The duration and frequency of watering should be consistent with the needs of the plants. It has been shown that one single application is more effective than several smaller applications because it encourages deep root growth.
- **Drip irrigation:** Drip irrigation uses significantly less water than normal irrigation systems and is equally effective. If possible, normal irrigation systems should be replaced with drip irrigation systems.

Obviously, many of the items mentioned in this section are completely irrelevant in many parts of Africa where consumers have insufficient funds to pay for water, let alone install automatic irrigation systems. The full range of issues has been provided to cover the full range of conditions experienced in Africa, and a water supplier should concentrate on issues that are relevant.

Source: IUCN WDM Guideline for municipal water suppliers (2004)

3.4.5 Education and training in WDM

Persuading the public to embrace the concepts and challenges of WDM is a vital part of its success at community and MWSA level; education and training makes reaching hearts and minds possible.

3.4.5.1 School education

This may be the most important part of the educational component of any WDM strategy.

notes

If children can be convinced of the benefits of WDM measures to the community and themselves, they are more likely to implement WDM naturally. In the short term, they may also influence their parents, who could be more difficult to educate as far as WDM is concerned.

Much material is available to assist MWSAs in setting up and implementing education campaigns for schools. In some countries, water suppliers and relevant government departments work together to create education campaigns that form part of the official school syllabus.

When developing a training programme for schools, the following steps should be taken:

- Set up site visits to water treatment works and sewage treatment works.
- Provide ideas for class work that include projects such as undertaking a water audit in the school, painting competitions, and essays on water conservation. The search for information should include directing learners to the MWSA's web site, thus familiarising them and their families with this facility.
- Develop water audit kits for use in schools.
- Distribute posters, booklets and pamphlets on WDM.
- Conduct retrofitting projects, e.g. changing rooms and toilets, in combination with water audits. Water consumption in most schools can be reduced by more than 50% in cases where automatic flushing toilets are replaced by toilets with user-activated flushing mechanisms.

3.4.5.2 MWSA training

Personnel of the MWSA need to be fully aware of the need to manage water demand. It is essential that training sessions (such as the one you are currently participating in!) are provided to introduce and explain in detail the various concepts of WDM throughout the MWSA. Normally such training sessions are developed at various levels of detail and are aimed at addressing the following levels of responsibility: top management, middle management and operational staff, and the remainder of personnel.

3.4.5.3 Education at home

WDM education at home can be achieved through a variety of measures. Material that can be used as a starting point for any new campaign is already available from many organisations in Africa and overseas.

notes

The materials will vary from one area to another and from country to country, depending on the level of service and the availability of the specific media to the consumer. Different consumer groups have different characteristics and therefore need different, targeted campaigns.

Factors to be taken into account in the design of campaigns and the selection of the medium and mode of education include access to computers, TV and/or radio, education/literacy, and income level.

Competitions that encourage consumers to seek information and answer questions using material provided by the MWSA are an excellent way of raising awareness and educating the public.

3.4.5.4 Education in the workplace

It is important to design an educational WDM campaign for productive users too. These campaigns should be targeted particularly towards the employees (how to do it) and to top management (cost saving). Companies could sign up for meeting WDM targets and certification.

Table 19: Summary of methods of reducing non-revenue water

AREA	ISSUES	ACTIONS
Metering	Unmetered connections Faulty meters Under-registration of meters Lack of confidence on billings Lack of confidence in number of customers	Meter installation Meter replacement/repair Bulk metering Management metering Consumer metering
Leakage	Leakage in reservoirs and mains Poor quality pipe material and installation Lack of information on pipe network Lack of maintenance, e.g. pipes, air and scour valves, pump glands or mechanical seals	Systematic maintenance, detection, monitoring and maintenance of old pipes, and reservoirs Information programmes to public and others Standardisation of installation, material and control Pipe database Replacement connection policy Adequate pressure regulation
Operational control	Deficient operational control e.g. reservoirs overflowing, pipelines being over pressurised, scouring being carried out inefficiently	Monitoring indicators Water distribution system automation Designing operations control units Maintaining controls

notes

AREA	ISSUES	ACTIONS
Commercial systems	Inefficient billing system Poor connection and/or disconnection procedures High level of accounts receivable Low-income consumers not billed Illegal/unregistered connections Water pricing policies	Database of users Design/implementation of better commercial systems Improved users/demand data Disconnection policies Control of high volume users
Consumer awareness	Persuading public to embrace WDM Educating consumers Accurate and consistent information and billing Information on efficient water use, water saving fixtures and fittings	Posters and pamphlets National water weeks Competitions Education programmes in schools, workplaces, and homes Setting up consumer helpdesks or kiosks

Sources: Adapted from Norplan et al., (2001).

3.5 WDM PLAN

Now that you have reached the end of Unit 3, your real work begins. Now you will need to apply all the concepts you have covered to the development of a WDM plan for your MWSA, using the information from the manual, from the field visits, and from the data and publications we have collected together.

Consider the reasons for WDM, the constraints, the options and the benefits, and consult with your colleagues to synthesise your plan from the knowledge, attitudes, and experience gained so far.

Good luck!

notes

Table 20: WDM and water strategies for southern African cities

	BULAWAYO	LUSAKA	MUTARE	MAPUTO	WINDHOEK	JOBURG	HERMANUS	MASERU
BACKGROUND								
Managing institution	Municipal	Private	Municipal	Private	Municipal	Private	Municipal	Parastatal
Exchange rate to US$	60	4 000	60	10	10	10	10	10
Water resources								
Average rainfall	460	900	900	800	360	710	760	780
Annual yields from sources (Mm^3)	47.5		42	54	22.2		3.3	1.8
Population	1 000 000	1 100 000	200 000	1 700 000	250 000	3 500 000	32 000	170 000
m^3/person/annum	47.50	69.72	210.00	31.76	88.80	114.61	103.13	10.59
Water network details								
Level of metering		44		100				97
Water supplied (m^3/day)	100 000	210 000	60 000	120 000	48 000	1 100 000	9 000	29 000
PC water supply (L/day/cap)	100	191	300	71	192	314	281	171
No of connections	106 000	34 800	23 000	80 000	38 000	614 000	12 400	32 000
Length of network (km)	2 100	2 300	660	840	1 300	9 500	290	480
Connections/km of network	50.5	15.1	34.8	95.2	29.2	64.9	42.8	66.7
Performance indicators								
% of NRW	20	56 or 58	52	34 or 65	11 or 18	30	19	31
Ave costs of water (US$/$m^3$)	0.3	0.14	0.22	0.4	0.65	0.25	0.38	0.38
Revenue generated	10 000 000	8 750 000	666 667		4 500 000	200 000 000	1 400 000	2 800 000
Revenue/connection	94.34	251.44	28.99	0.00	118.42	324.15	112.90	87.50
WDM status								
WDM financing	1%	no	no	no	1%	yes	0.50%	no
WDM strategy/policy	yes	no	yes	yes	yes	yes	yes	no
WDM legislation	no	no	no	no	no	yes	yes	no
WDM educational campaign	yes	no	no	no	yes	yes	yes	no
WDM dedicated section	yes	no	no	no	yes	yes	yes	no

Sources: Adapted from Gumbo (2003)

notes