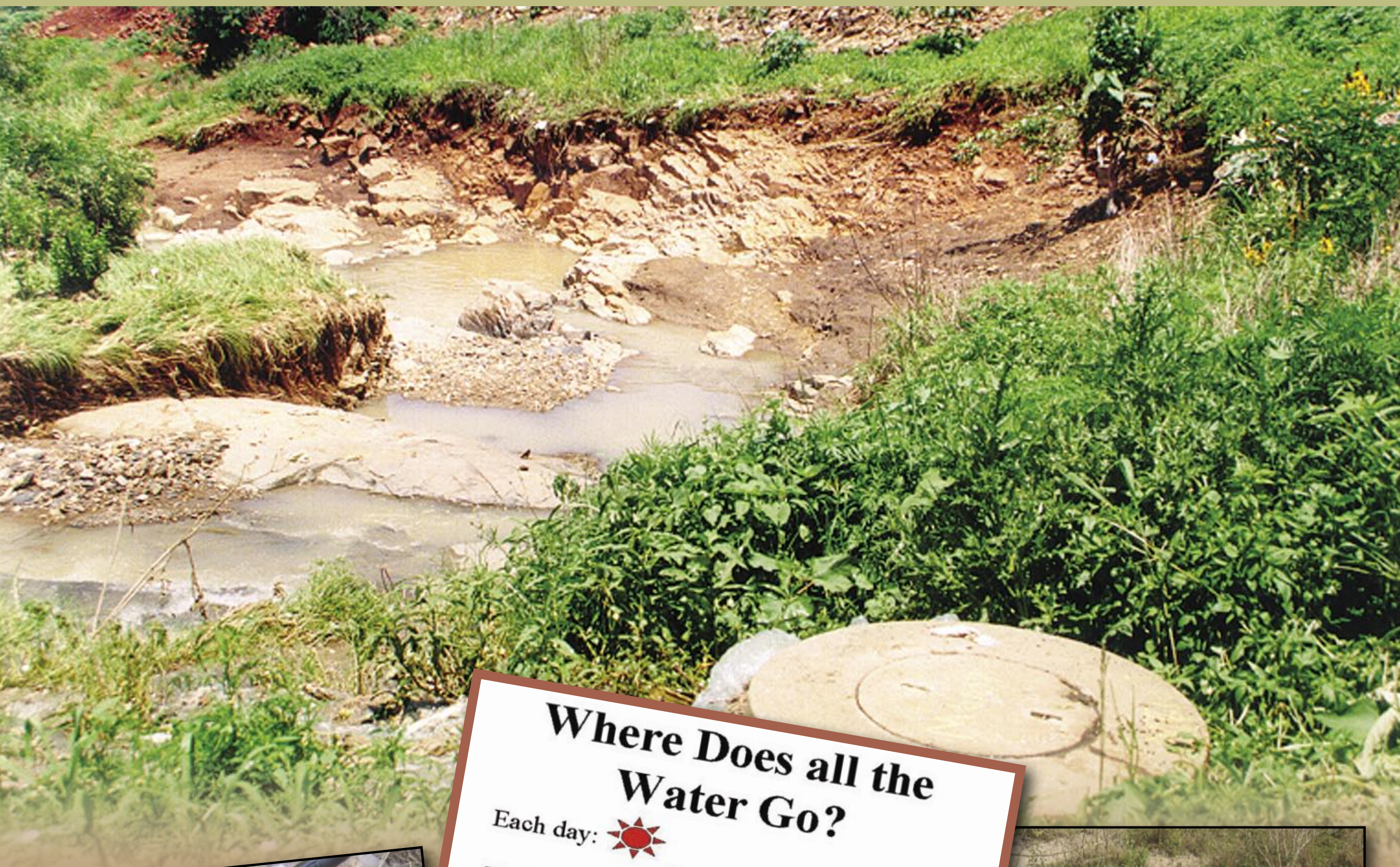
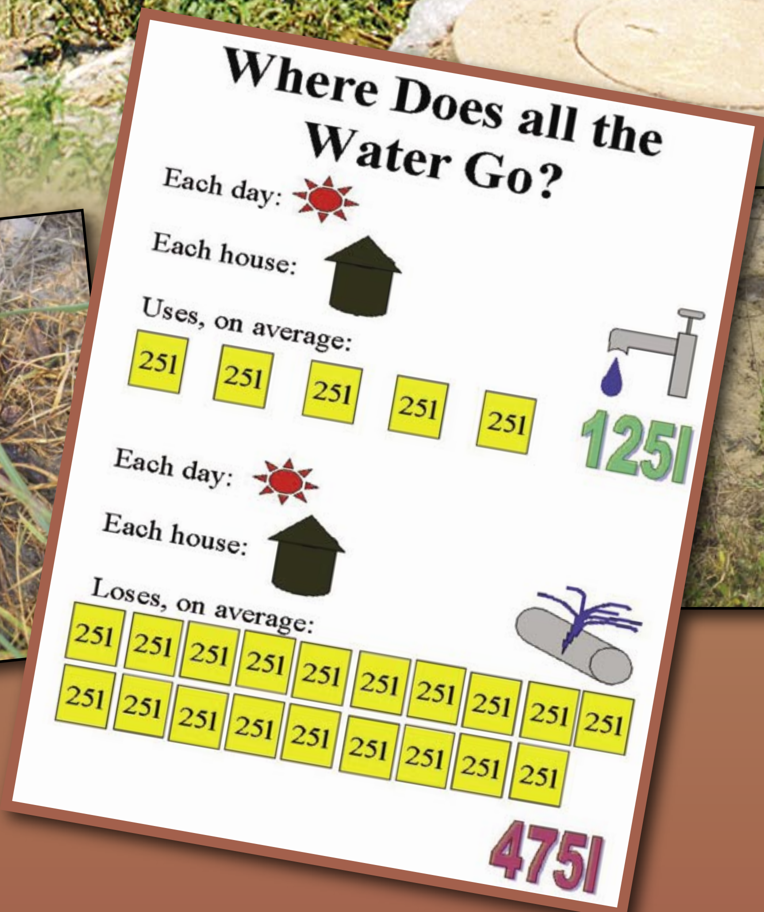
The Development of a Successful Unaccounted-for Water Management Programme in the Rural Water Supply Context

Janet Ross-Jordan





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Water Research Commission

THE DEVELOPMENT OF A SUCCESSFUL UNACCOUNTED-FOR WATER MANAGEMENT PROGRAMME IN THE RURAL WATER SUPPLY CONTEXT

Report to the

Water Research Commission

by

Janet Ross-Jordan

on behalf of

Partners in Development cc

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EXECUTIVE SUMMARY

Monitoring of rural water supply systems in KwaZulu-Natal, South Africa, showed average unaccounted-for water (UAW) levels, sometimes loosely called water losses, of 60%, which were having financially detrimental effects on these, and other, projects. Despite a regulatory requirement for the Water Services Authorities (WSAs) to manage UAW, there was little guidance on rural UAW management. Therefore research was necessary to establish a strategy for developing rural UAW management programmes that could be used and understood by all stakeholders and would fit into existing community based management systems. This development began with an assessment of the system, by gathering information on social, technical, financial and institutional aspects, followed by field studies and calculations to discover the sources and acceptable levels of UAW, leading to a participatory workshop with stakeholders. Two case studies revealed firstly a lack of community understanding of the system, and secondly that the greatest UAW volumes were from physical losses, whereas non-physical losses made relatively small contributions to UAW volumes. The management programmes developed consisted of night flow readings on bulk meters and bulk/domestic water balances, with the project administrator assessing the meter readings and informing locally trained plumbers of the location and level of unacceptable UAW. If the plumbers could not take action to reduce the UAW the committee requested external support to tackle the problem. Key Performance Indicators (KPIs) were found to be a useful tool for setting system performance targets and for project monitoring. KPIs provided a link between the WSA and the committee, helping the WSA to support the community based management system. Further research could be aimed at developing UAW management programmes on other rural systems, and to developing community education techniques, promoting the need to report leaks promptly and reduce vandalism, using local schools.

What follows is an outline of the developed UAW management programme procedure, from a research project that comprised four months' work with two rural communities in KwaZulu Natal; Montebello and Emayelisweni. These communities had fully metered yard tap water supply systems managed through local water committees.

Table 1 shows the UAW levels within the four month period of the research. UAW levels will vary month by month and an accurate assessment is only valid with at least 12 months' data.

The high percentages observed are due to low consumption levels, and highlight the sensitivity of rural projects to relatively low volumes of UAW. Volume/tap/day can be understood at a community level and translating these figures into financial equivalents helps to motivate UAW management. The South African Code of Practice (SABS, 1999) prefers the term specific loss, Q_{sl}, in l/km/hr. This term will be useful to Water Service Authorities (WSAs) when comparing different systems but is unlikely to be understood at rural community levels.

Table 1 - UAW Levels

		% of total supply	l/tap/day (average)	l/km/hr (average)
Emayelisweni	**12 month average prior to research**	66%	272	41
	After initial field tests/repairs	28%	40	6
	2 months after implementation of UAW management programme	43%	88	13
	6 month average, 18 months after implementation of UAW programme	22 %	32	5
Montebello	**12 month average prior to research**	77%	411	111
	After initial field tests/repairs	53%	196	53
	2 months after implementation of UAW management programme	47%	130	35
	6 month average, 18 months after implementation of UAW programme	56 %	320	103

The management systems developed used litre/tap/day.

It can be seen that the community level staff have taken ownership of the UAW programme at Emayelisweni, with UAW stable at low levels. The viability of the neighbouring Montebello scheme, however, is much less affected by water losses, and this may partly explain why there has little improvement in UAW there. Montebello was also been adversely affected by several staff changes, and so retraining in UAW management was required (after which point there was again a marked improvement).

PROCEDURE

Figure 1 shows the procedure used in the management of UAW. It is a cyclic procedure with the main management being done at community level on a monthly basis and the local authority assisting in the annual overall management. Developing the management system used the same procedure and was in effect the first cycle.

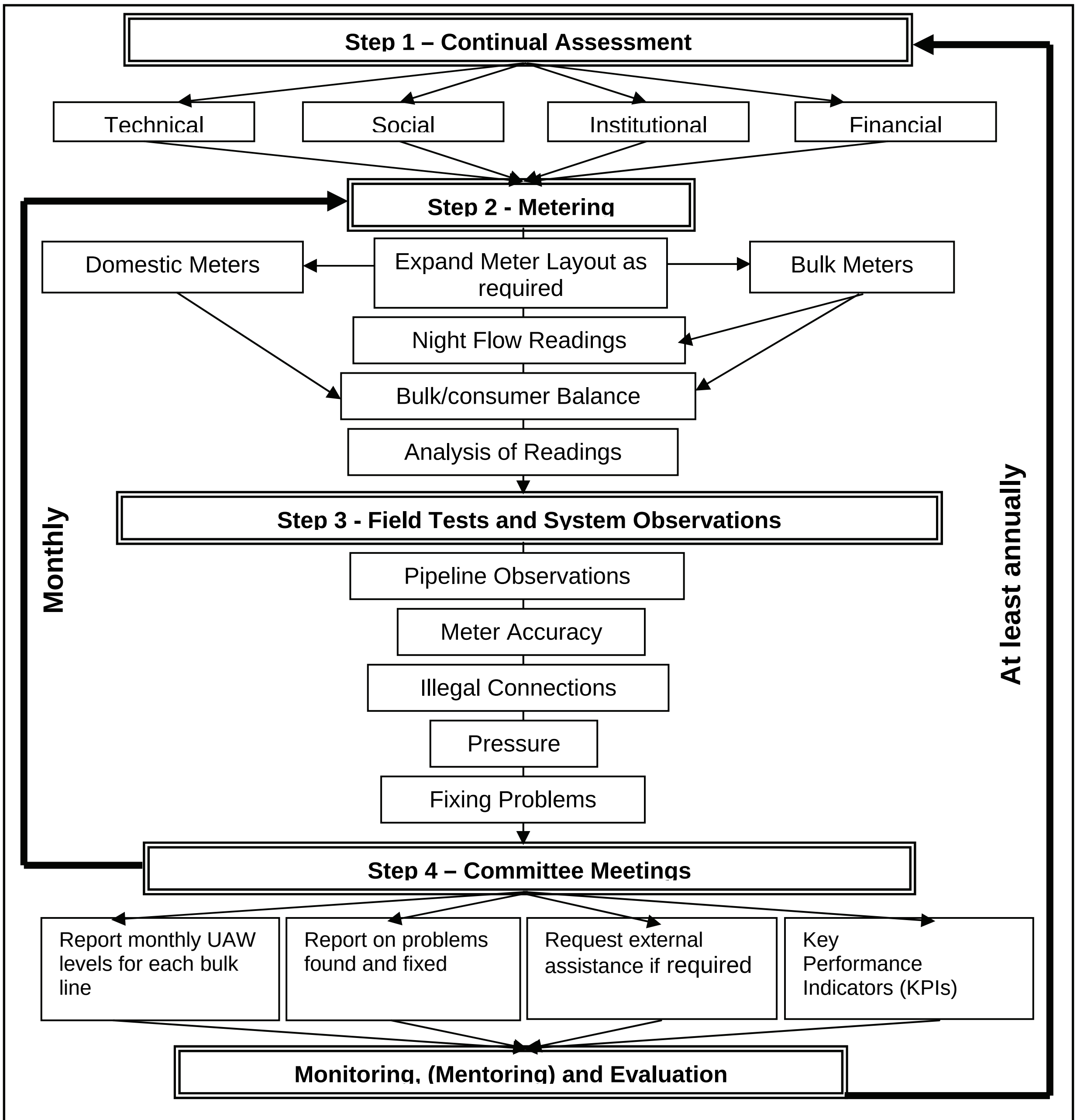

Figure 1 – UAW Management Programme

Continual Assessment

The project was assessed on institutional, social, financial and technical aspects, through field observations and by studying project records. Non-consideration of any one of these categories may render an inappropriate UAW management procedure.

Metering

Meter Layout: Where bulk meters are to be installed on a system, they should be accessible, affordable, and represent a manageable number of houses and a manageable length of pipeline. A system with adequate bulk metering makes UAW management feasible. Being able to read a bulk meter and all its associated domestic meters within, say, 3 hours improves the accuracy of any assessments of the readings. Locating bulk meters immediately after reservoirs or pipe junctions and at abstraction points breaks the infrastructure into manageable sections. Note that budgets in rural water supply usually preclude the use of the sophisticated continuous data logging which is becoming common in urban UAW management programmes.

Night-flow Readings: Generally people in poorer rural communities do not use water after nightfall. Taking bulk meter readings just before nightfall and at sunrise the following morning enables the night flow on each section to be calculated, giving an indication of leakage levels. At Emayelisweni these night flow readings are now taken once a week. The administrator or bookkeeper then calculates if the night flow is greater than 150 l/tap. If so technical staff investigate the section for UAW. 150 l/tap was considered an acceptable level of night flow, as this may include some consumption late in the evening or early in the morning.

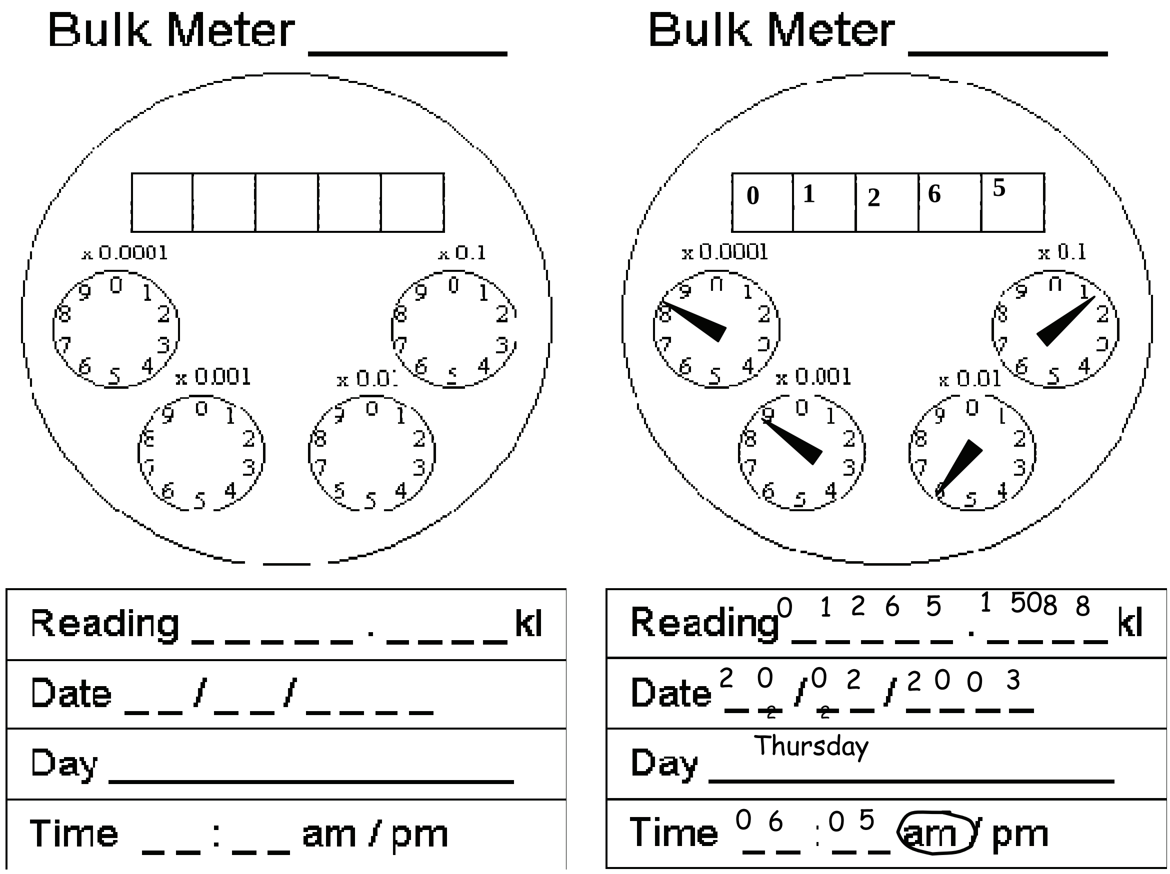

Figure 2 – Blank and Completed Bulk Meter Reading Sheets

Bulk Meter/Domestic Readings: On a fully metered system a water balance can be carried out by taking bulk meter readings with the domestic meter readings. If systems do not have domestic meter readings then an estimate must be made of the domestic water consumption, probably from a customer or household survey.

Bulk/consumer Balance: The UAW from a water balance could be due to leakage, illegal connections, faulty meters or faulty meter readings. Night flow readings can confirm or eliminate leakage.

Analysis: At Montebello and Emayelisweni a sheet was developed so meter readers could copy the bulk meter face. Figure 2 shows a blank meter reading sheet and an example of a completed sheet. This sheet helps the administrator to check the meter reading. At Emayelisweni and Montebello the determined acceptable level of UAW from the monthly water balance is 100l/tap/day.

The water balance is calculated by the administrator/bookkeeper who then informs the committee and the technical staff of any necessary action to be taken.

Many software packages exist which compute acceptable UAW levels but none have been developed for rural situations. Access to these facilities rarely exists in rural communities.

Field Tests And System Observations

Once the water losses are narrowed down to specific branchlines these lines can be inspected. The methods outlined below should be used in turn until the UAW is reduced to an acceptable level, from the continued meter readings.

Pipeline Observations: Leakage was the most common and greatest cause of UAW. Visual inspection is the least costly method of investigation as little equipment is required and it is therefore wholly appropriate to the rural situation. Each valve chamber, tap, meter or other connection should be visually inspected for leaks, as well as the ground surface for depressions or damp patches. If leaks are not visible on the surface a 1.2 m length of reinforcing bar can be inserted into the ground, initially near each connection or joint, and checked to see if it is wet when withdrawn. If the bar is wet then the ground should be dug to investigate the source. This method requires the ground to be generally dry during the investigation and therefore has limitations.

Domestic Meter Accuracy Tests: Meters should be checked for accuracy, particularly where the billed consumption is zero or seems low. Meters often under-record at low flows, or fail to record at all, and filling a container of known volume from a tap and recording the volume change on the meter will indicate the accuracy of the meter. Meters will not record a dripping tap so if faulty taps are not reported and fixed, water flowing through the meter may not be recorded, or billed, and is therefore both UAW and a financial loss.

Illegal Connections: Illegal connections are not easy to find and, depending on the perpetrator, not safe to search for. Field searches for illegal connections should be a last resort when all other avenues have been explored. At Emayelisweni and Montebello illegal connections were, surprisingly, not a significant problem. The community perception suggested that illegal connections were high but in reality these claims were highly exaggerated.

Pressure: High pressure will cause any leaks that do develop to increase and lose more water. Lower pressures result in less leaks and smaller leaks. While pipes and fittings can often withstand pressures of 10-16 bar, these pressures invite UAW problems and it is advisable to limit supply pressures to 5 bar where possible. A simple pressure gauge can be temporarily installed onto taps. If the pressure is unacceptable then pressure reducing valves should be installed on the pipeline. Fixed ratio pressure valves are simple and robust. If finances cannot be made available to reduce pressures then potentially high UAW must be accepted.

Fixing Problems: There must be a procedure for fixing leaks, urgently and competently. Where possible, local labour should be used to fix any problems as this enhances understanding and ownership of the system, which increases the self-sustainability. A sense of urgency comes from an understanding of UAW.

The level of technical competence depends on the quality of labour and training. A lack of local competence means external support must be available and contactable.

Committee Meetings

Committee meetings can be used to continually develop the UAW management programme by reporting on the UAW levels, the problems found and fixed, requesting necessary external assistance and reporting Key Performance Indicators (KPIs).

The committee meeting is where the WSA, local employees and the committee can interact.

Workshops: Workshops during the committee meetings helped to increase understanding of UAW, to develop the UAW management programme and allowed participation through discussion. These workshops were carried out with the committee members and local personnel including plumbers and the administrator.

The agenda used was as follows:

(i) *Why reduce losses?* An interactive discussion using pictures and asking which scenarios lose the project money. This led to a greater understanding of financial issues.

(ii) *Who lives where?* Participatory mapping aiding understanding of the pipe network. This map was then actually usable by the community.

(iii) *Where does all the water go?* A diagrammatic comparison of the daily household consumption and the equivalent daily UAW per household.

(iv) *What can we do?* Explaining night flow readings, domestic readings, inspections and repairs.

(v) *How we will manage losses.* Developing what they can do long term, including discussions of responsibilities and finances.

Monitoring, Mentoring And Evaluation

KPIs can be UAW specific. Other KPIs are also useful in monitoring the UAW management programme, e.g. monitoring the bank balance will highlight whether implementation of the UAW management programme is improving financial stability of the project.

Evaluation of the UAW management programme can be carried out by the water committee and the WSA. KPIs can be understood by both parties and serve as a link between them to demonstrate the effectiveness of the

UAW management programme. Monthly committee meetings, or further workshops, could be used to discuss and develop the programme further, even by setting targets for system performance.

The administrators at Montebello and Emayelisweni were trained to chart KPIs (Stephen and Still, 2000) using wax crayons and standard blank sheets with a title and gridlines, the y-axis being set according to the chart drawn.

Figure 3 shows a typical KPI chart.

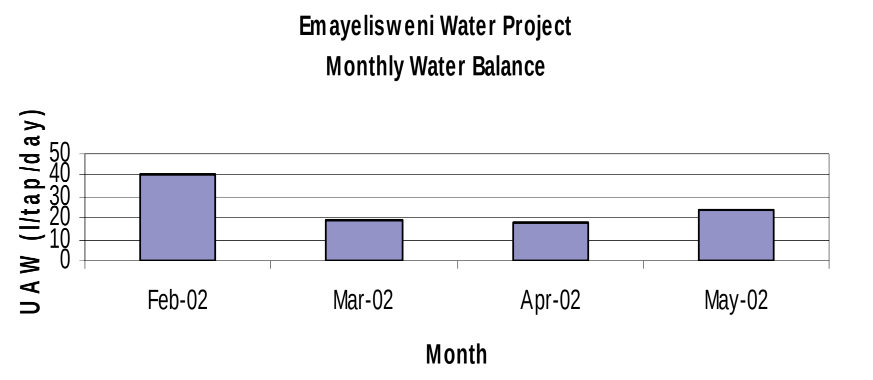

Figure 3 - KPI Chart Example

It is expected that intensive mentoring will be required for the first two months of implementation of the programme. After this, mentoring will form part of the general project mentoring requirements. If mentoring is required the WSA must ensure that such support is provided and financed.

LEARNING POINTS

- Development of the UAW management procedure should be started at the outset of the project, not after implementation.
- Participatory approaches, such as mapping, can be used to help the communities understand the infrastructure as the project progresses.
- Using local personnel from the outset, i.e. during the first cycle of developing the system, may result in the initial problems taking longer to be fixed but will increase understanding and reduce the need for later training.
- Simple low cost techniques should be used to record meter readings and to analyse them.
- To ensure ongoing mentoring there must be some level of commitment, both in time and finance, from the WSA.
- Further research could develop UAW management programmes on other systems, use community education techniques, promote the need to report leaks promptly and reduce vandalism, possibly through using local schools.

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Mr JN Bhagwan	:	Water Research Commission (Chairman)
Mr DA Still	:	Partners in Development cc (Project Leader)
Mr M Bannister	:	The Mvula Trust now with Umgeni Water
Mr LD Bosman	:	Development Bank of Southern Africa
Mr M Sirenya	:	Umgeni Water now with Amatola Water
Ms A Potter	:	The Mvula Trust

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GLOSSARY

DWAF	Department of Water Affairs and Forestry
IWA	International Water Association
KPI	Key Performance Indicators
IDM	Ilembe District Municipality
NRW	Non-Revenue Water
PID	Partners in Development
SABS	South African Bureau of Standards
UAW	Unaccounted-for Water
WISA	Water Institute of South Africa
WSA	Water Services Authority
WSP	Water Services Provider

1 INTRODUCTION

1.1 Reasons for Study

Unaccounted-for water (UAW) is a topical issue in the management of water distribution systems. Urban UAW management appears to be well researched and documented. In global terms the perceived need for research into rural UAW seems low, as rural water consumption figures are small compared with the high volumes consumed in urban areas. This renders the volumes of rural UAW and their financial values apparently insignificant.

However, ongoing monitoring of rural water systems within the KwaZulu-Natal region of South Africa suggested that UAW was having a critical detrimental effect on the financial sustainability of small community run water projects. Furthermore, despite the regulatory requirement for South African Water Services Authorities to manage UAW, no specific guidance appeared to be available and no research was being carried out to determine the way forward.

The aim of this study is therefore to present proposals for managing UAW in rural water supply systems.

1.2 Scope of Study

This study looks specifically at two case studies, namely Montebello and Emayelisweni, which are metered rural water distribution systems, in the KwaZulu-Natal region of South Africa. Figures 1.1 and 1.2 show the location of these two studies. By reviewing international and national literature on UAW and looking in lesser detail at other rural water supply systems within the KwaZulu-Natal region, this study will present a general UAW management programme, the principles of which can be adapted to other rural water supply systems.

1.3 Objectives

The objectives of the study are as follows:

- To research options for the management of UAW in rural water distribution systems.
- To carry out research, dialogue and interactive workshops with the stakeholders to assess their need for UAW management, their understanding of UAW, and their view on the most appropriate and sustainable ways of meeting their needs and enhancing their understanding.
- To develop methods of managing UAW in rural areas that can be understood and used by all stakeholders.
- To begin to implement these methods, integrating them into ongoing operation and maintenance and mentoring activities.

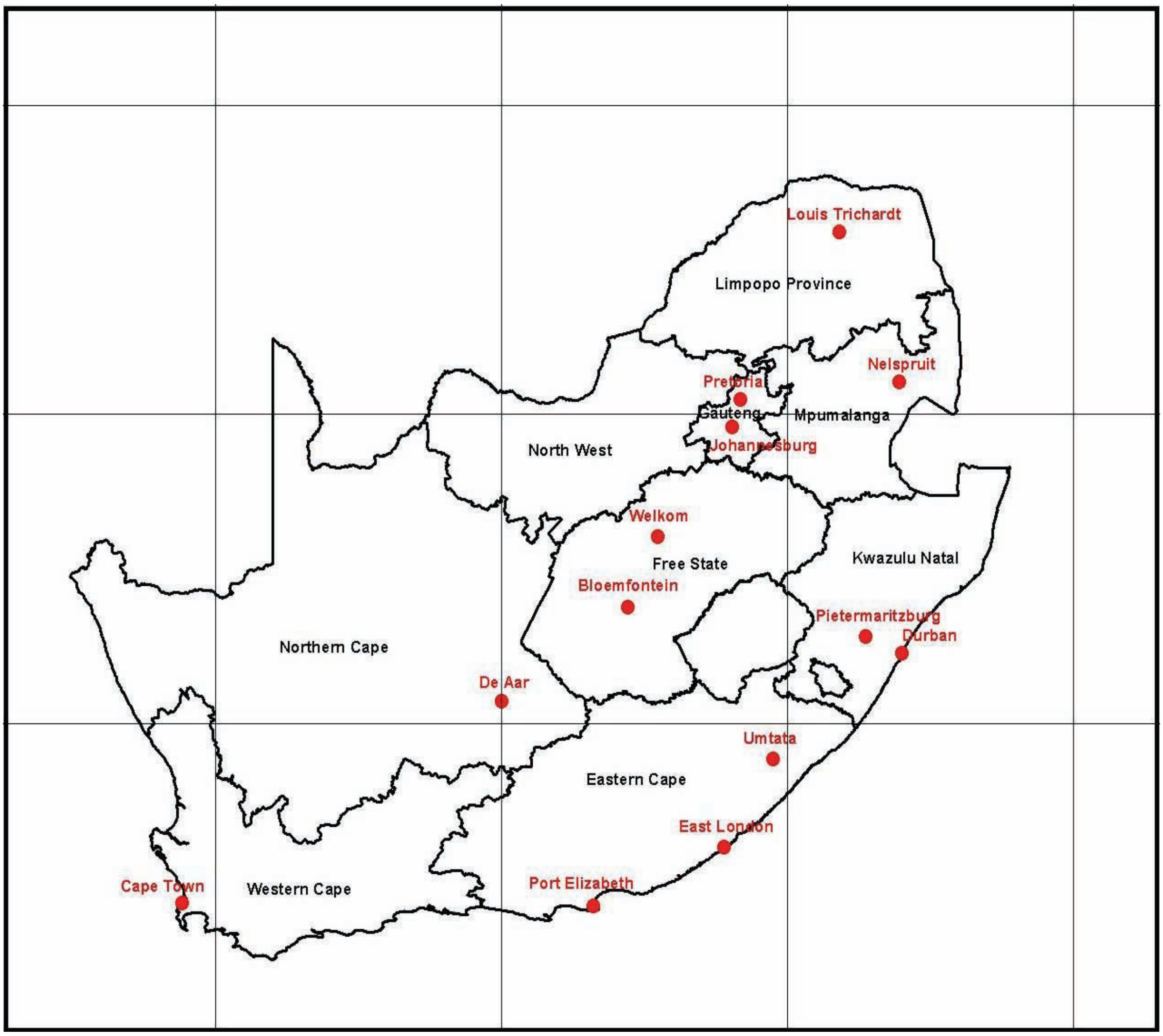


Figure 1.1 - Map of South Africa

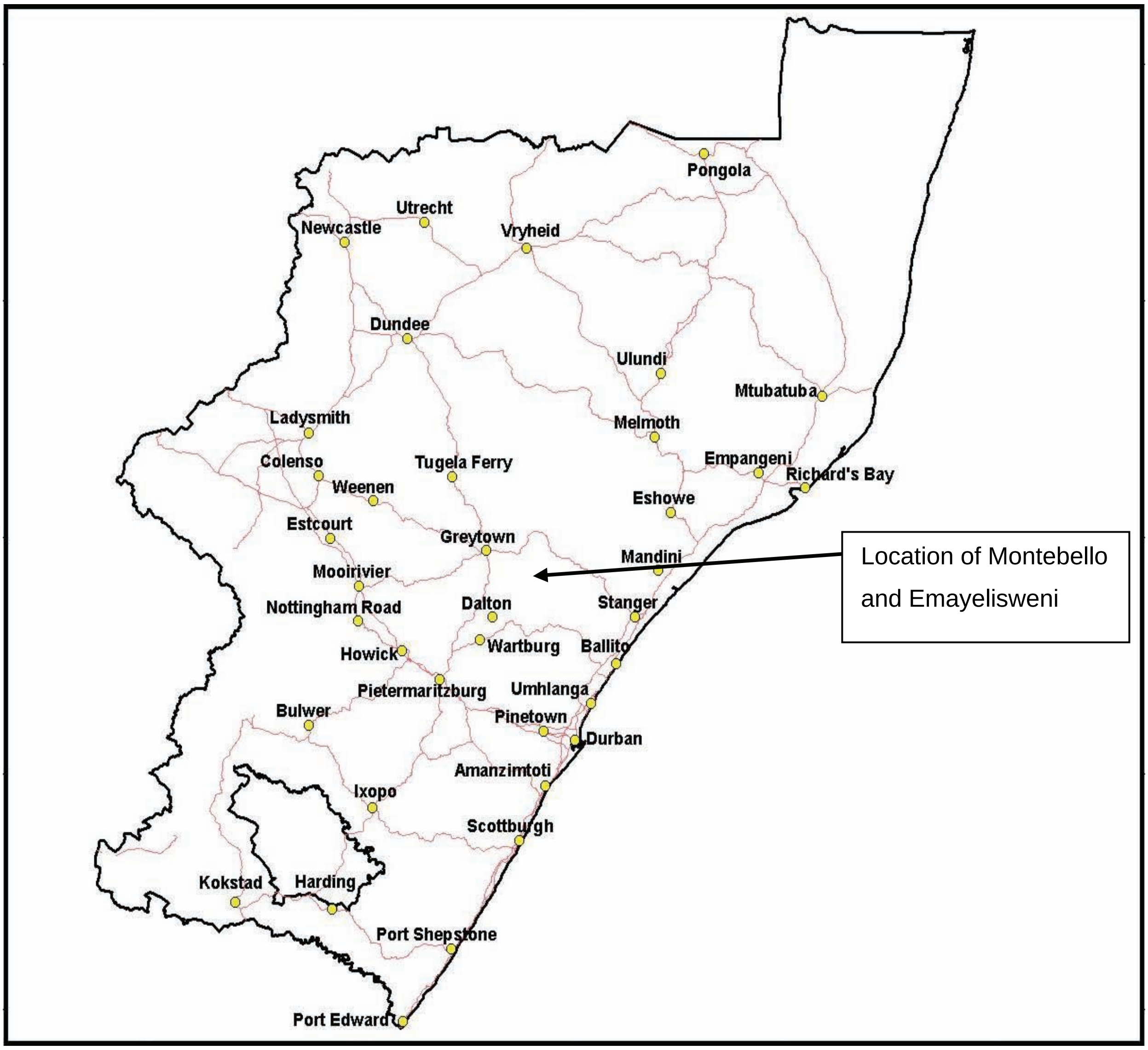


Figure 1.2: Location of Montebello and Emayelisweni Water Schemes

1.4 Methodology

(i) Carry out a literature review on the topic of UAW outlining the main contributing issues.

(ii) Critically review the existing international and South African guidelines and the South African Code of Practice for the management of potable water in distribution systems and examine their applicability to rural water supply systems.

(iii) Review South African regulatory requirements for Water Service Authorities to manage UAW.

(iv) Analyse previous research carried out on local rural water supply systems and establish what has been learned regarding the need for rural UAW management.

(v) Ascertain levels of UAW on rural water supply systems, where levels of UAW are known or can be derived from records, and the measures taken to reduce UAW on these systems.

(vi) Carry out field studies on two rural water supply systems, namely the Montebello and Emayelisweni water projects, to assess and account for the existing levels of UAW. These studies will include observations of illegal connections, operation and maintenance procedures and system performance, and the recording of bulk meter readings to establish night flows as well as dialogue with community members.

(vii) Assess the level of institutional support within the Montebello and Emayelisweni water projects through observation of the institutional structures, discussions with consultancy, community and committee members and a review of records.

(viii) Plan and implement workshops with the Montebello and Emayelisweni water committees to develop understanding of UAW and assess their need to manage and reduce it.

(ix) Develop monitoring systems that can be understood and utilised by all stakeholders, which enable Water Service Providers to manage UAW through community participation techniques.

(x) Begin implementation of the developed management systems in Emayelisweni and Montebello.

(xi) Recommend how management of UAW can be integrated into operation and maintenance programmes for rural water supply systems.

(xii) Comment on the applicability of the monitoring systems developed to other rural water supply projects.

1.5 Structure of Report

Chapter 2 provides an introduction and definition of UAW. The chapter then presents the findings of a literature review carried out on UAW and looks at international and national (South African) guidelines for the reduction and management of UAW. Finally, this chapter considers policies and attitudes that affect rural UAW management and reviews other research relating to rural UAW.

Chapter 3 presents the research methods used to assess the need for and understanding of UAW management in the two case studies, Montebello and Emayelisweni. This chapter outlines the assessment strategies used and UAW management programmes developed.

Chapter 4 discusses the findings of the field research carried out in chapter 3 in light of the background research presented in chapter 2 and presents both the general proposed UAW assessment strategy and the UAW management programme for rural water supply systems.

Finally, chapter 5 presents the conclusions and recommendations of this study, with a critical evaluation of the research and its findings. Recommendations for improvements to any continuation of this study are included along with suggestions for further work.

2 BACKGROUND

2.1 Overview

On two rural water supply systems within the KwaZulu Natal region of South Africa, namely Montebello and Emayelisweni, an average 60% of the bulk water supplied during the period June 2000 to May 2001 was unaccounted for. Other rural water supply systems in this region show similar figures. This chapter defines unaccounted-for water (UAW), discusses strategies for the reduction and management of UAW and reviews existing international and national standards for the control and reduction of UAW. The chapter then considers the implications of the new South African Free Basic Water policy on UAW management and reviews previous and current research carried out on rural distribution systems within South Africa, particularly in the KwaZulu Natal region.

2.2 Definition of UAW

The World Bank defines UAW as the difference between the volume of water delivered into a network, the ‘Net Production’, and the volume of water that can be accounted for by legitimate consumption, the ‘Consumption’. UAW can be split into three categories; physical, non-physical and miscellaneous losses; these are described below (Jeffcoate and Saravanapan, 1987).

2.2.1 Physical Losses

These are resource losses, and include system leakage, reservoir overflows and wastage on unmetered properties.

2.2.2 Non-Physical Losses

These are losses that are consumed but not recorded or otherwise accounted for, and include water lost through faulty meters, illegal connections, inaccurate meter readings and connections that are not billed.

2.2.3 Miscellaneous Losses

Water used for fire fighting, street cleaning, sewer maintenance and for parks and municipal properties is not a loss as its volume is legitimate and, if not metered, can be estimated. This water can be UAW if it is not known or estimated.

2.2.4 Non-Revenue Water

It is worth noting the difference between UAW and non-revenue water (NRW). NRW is the volume of water that is not recorded by a domestic, or consumer, meter and therefore does not generate revenue. In systems where metering is not universally available the concept of NRW is less relevant and hence UAW is more useful (Jeffcoate and Saravanapan, 1987).

2.2.5 Units of Measurement

UAW is usually expressed as a percentage of the net production but is often more usefully expressed as a volume per household (Twort et al., 2000). For rural situations the percentage measurement can be high suggesting, at first glance, that volumes of UAW are also high. In reality the volumes of UAW are often not high per kilometre of pipeline, but the high percentages are actually due to the low levels of consumption. So percentages are not useful in understanding the quantity of UAW but do highlight the sensitivity of rural projects to relatively low volumes of UAW.

The expression volume per tap connection is useful in the context of Montebello and Emayelisweni rural water supply systems as the household consumption indicator is based on the monthly domestic meter reading at each property. As the water bill is issued monthly a more useful expression of UAW is the average volume/tap/month, which can be compared with the average consumption volume/tap/month. When aiding understanding of UAW within the rural communities it may also be useful to use volume/tap/day as water is collected on a daily basis and lifestyles are concerned more with day-to-day, rather than monthly, practices.

The International Water Association (IWA) states that components of a water balance, which quantifies bulk water supplied and domestic consumption, should be measured for a twelve month period and therefore specified as volume per year (Lambert and Hirner, 2000). However, this is not helpful at a community level, as explained above. What the IWA refers to as the Technical Indicator for Real Losses and Unavoidable Average Real Losses, the IWA says should be measured in litres/service connection/day.

The South African Code of Practice (SABS, 1999) prefers the term specific loss, Q_{sl}, which is obtained from the following formula:

$$Q_{sl} = \frac{Q}{L} \qquad (2.1)$$

where Q_{sl} = is the specific loss rate per unit pipe length, in litres per hour per kilometre of pipe length; Q = volume of water in l/h; and, L = length of distribution mains only, excluding the length of connection pipes and trunk mains.

This term, as a South African standard, will be useful to Water Service Authorities (WSAs) when comparing different systems. However, it is unlikely to be understood at rural community levels.

Therefore, this report will express UAW using all three terms:

- Percentages to highlight the sensitivity of projects, particularly financial.
- Volume/tap/day for aiding understanding within the rural communities.
- Specific loss rate to enable WSAs to make comparisons with other systems.

2.3 Strategies for the Reduction of UAW

The first step in the reduction of UAW is to accurately assess UAW by measuring the net production and the consumption. Zonal bulk meters will indicate water quantities in each area, and at the point of production. Domestic meters will indicate the consumption at each property. Where domestic meters are not universally in place, the readings available will provide an indication of typical consumption. The difference between the production meters and the domestic meters will indicate the amount of UAW in the system (Jeffcoate and Saravanapan, 1987).

Once an idea of the volume of UAW is calculated each area of water loss contributing to the total UAW volume must be estimated and addressed. These areas are further discussed below.

2.3.1 Physical Losses

(i) Leakage

Leakage will be an on-going problem in the distribution system. As materials age they deteriorate. The quality of construction also affects the life of the system; joints poorly connected will fail sooner than anticipated and pipes in poorly backfilled trenches will crack earlier, amongst other failures.

Adequate procedures must be in place to report and repair leaks. Twort et al. (2000) suggest four leak detection strategies:

Waste metering/step-testing. This comprises metering the night flow, i.e. the flow during the hours of darkness, in one area of the distribution system, systematically shutting down the mains within the area and recording each drop in flow. A larger reduction than expected from the estimated night consumption by households would indicate a possible leak.

Sounding. A device called a ‘listening stick’ is used to listen to the sound of the pipes as water leaking from a pipe tends to make a distinctive ‘buzzing’ or ‘drumming’ sound. A listening stick can be any long metal object, such as a screwdriver or valve key.

Leak noise correlation. Leak correlators are sensitive and complex listening devices that are calibrated to pinpoint leaks accurately on a long pipe. These are relatively expensive and inappropriate for rural systems (Wyatt, 1991).

Visual inspection. This can be carried out by the consumer within the area supplied, where an adequate reporting procedure is in place. However, in the case of pipes located outside of the community’s residential area, an ‘inspector’ is required to walk the route of the system and note visual signs of leaks. These signs may be damp patches, extra vegetation or trickles of running water.

Within a developing country the latter is most appropriate in terms of cost but leaks will not always be visually identifiable. A listening stick is a simple piece of equipment, and combined with visual inspection provides a good system of leak observation. However it is unlikely to be appropriate on rural systems because it is more suitable on metallic pipes and paved surfaces. Noise correlation equipment is unlikely to be readily available or affordable, and like waste metering is time consuming to apply. However, waste metering would indicate if a leakage problem exists on sections of the system, and could be carried out on an occasional basis, with visual inspection then being used as a response to the results of waste metering. The choice and frequency of these techniques will be specific to each situation. Technology choices are dependent on many variables, costs and benefits being the most important (Churchill, 1987).

When a leak is identified, it is necessary to carry out a cost-benefit analysis for the repair, considering the cost of the leak, in terms of UAW, water pressure or quantity and revenue lost, and the cost of repair. If the leak is small and unlikely to increase but the cost of the repair is high it may be decided not to repair the leak at all (Twort et al., 2000).

(ii) Reservoir Overflow

It is necessary to determine whether the reservoir is leaking significantly. This can be done by measuring the flow in and out of the reservoir, any leakage being the difference between these two measurements.

Possible steps to detect leakage in a reservoir are as follows (Twort et al., 2000):

- Flows from under drains should be examined.
- Inlet and outlet valves should be tested.
- The rate of leakage at various water depths should be investigated to indicate at what level the leak does/does not occur.
- The reservoir could be emptied and examined internally. This would only be carried out if the above methods failed to detect the leak.
- Floor and wall joints should be inspected for broken seals or bonds.
- If the leak is still not detected then the reservoir can be filled by about 0.6 m, shallow enough to stand in, and potassium permanganate crystals introduced into the water. After the crystals have been left to stand for a period of time streaks of pink colouring will be seen, indicating flow towards the leakage points.

(iii) Wastage on Unmetered Properties

As well as contributing to UAW through the underestimation of household consumption, wastage can lead to water shortages (ITDG, 1980) where the water supply is limited. Wastage is higher where block metering is used, as individual consumers do not pay for their own wastage (Twort et al., 2000). By developing definitive rules and regulations well, through a water committee that is respected by the community, wastage should be reduced (ITDG, 1980). Improving public relations and education on water use and imposing regulations such as bylaws (Jeffcoate and Saravanapan, 1987) can further reduce wastage.

2.3.2 Non-physical Losses

(iv) Faulty Meters

It has been suggested (Jeffcoate and Saravanapan, 1987) that if 25% of a set of meters in the field are inoperative a further 25% will be recording a fraction of the actual flow. Where meters are known to give faulty readings, bills are usually based on an average consumption, which is usually estimated before the connection was made and will be lower than the current consumption.

Water meters are designed for certain flows. Where the flow is outside the design limits, particularly where it falls below the design figure, meter readings can be inaccurate. In some cases, where the flow is very low the meter does not record any flow at all (Welton and Goodwin, 1984). It is therefore necessary to ensure that the installed meter is appropriate for the flow rate of water consumed. However, it is also necessary to recognise that the flow from a dripping tap may not be high enough to turn a meter.

Meter accuracy can be affected by factors such as grit particles in the water stream and bends located near the meter (Twort et al., 2000).

Spot tests of meters and comparison with other meter readings, both from the same meter over time and with different meters, will highlight irregularities and indicate where meter repairs/replacements are necessary (Jeffcoate and Saravanapan, 1987).

(v) Illegal Connections

Illegal connections can be detected by visual inspection of the distribution system and by word-of-mouth within a community. Regular inspections, public pressure and enforced regulations will deter people from making illegal connections (Jeffcoate and Saravanapan, 1987).

(vi) Inaccurate Meter Readings

Meter readings can be inaccurate if meters are faulty, and this has already been discussed. However, readings can also be inaccurate due to human error. Adequate staff training and recruitment of reliable personnel should reduce, if not eliminate, this aspect of UAW (Jeffcoate and Saravanapan, 1987).

(vii) Connections Not Billed.

These are connections that are not billed because of inadequacies in record keeping (Twort et al., 2000). Sufficient training and management procedures will reduce the number of unrecorded connections.

2.3.3 Miscellaneous Losses

These are only 'losses' if they are not recorded. In hot climates, such as South Africa, authorities can use a considerable volume of water for municipal purposes. It is possible to meter these in order to eliminate them from the UAW figure (Twort et al., 2000). These types of losses are not typical of rural water supply systems where other municipal services are not provided.

2.4 Management of UAW

Community participation in the management of the operation and maintenance of water supply systems is essential in reducing UAW. Monitoring and evaluation procedures carried out by the water committee will highlight problems with the water supply earlier than external procedures (Cairncross et al., 1980).

Key Performance Indicators (KPIs) are one method of monitoring and evaluation. By developing specific, easily understood and measurable KPIs, the water system can be easily monitored. Monitoring and evaluation is not just about recording KPIs. Intervention is needed by the water committees to take corrective action where the KPIs indicate that such action is required (Stephen and Still, 2000).

Rules and regulations of water use have been mentioned as necessary to reduce UAW. Essential rules should be well defined by the community and petty rules should be excluded to simplify enforcement (ITDG, 1980).

Enforcement of regulations will be more successful if the water committee is representative of the community and accountable to it. This will ensure respect from the community and enable the committee to exercise authority over those who break the rules (Fortmann, 1983).

Training is required to ensure that meters are read accurately, repairs are reported quickly and carried out adequately (Jeffcoate and Saravanapan, 1987).

The Mvula Trust has developed tools for community based monitoring and evaluation of water supply systems, including the monitoring and evaluation of UAW. However, they also note that using tools can only help to promote long-term sustainability if the institutional community structures are strong and united (Netshiswinzhe and Potter, 2000). This implies that time, and therefore money, must be spent building up community structures if effective community management of UAW is to occur.

Previous research on rural water loss suggests a two-stage approach of investigation followed by reduction of water loss (Wyatt, 1991) using background information, field studies and analyses of consumption figures. However, this research was not based on any case studies and the only rural system mentioned had suggested UAW figures of just 10%. The same research also suggested the involvement of schools in educational UAW reduction strategies.

2.5 Review of International Guidelines

The IWA established a task force to produce recommendations for international Performance Indicators on water losses (Lambert and Hirner, 2000). They stressed that metering is essential for loss determination and therefore for loss management and does not recognise that low-cost, rural, systems may not be able to afford metering. However, it does emphasise the use of night flow measurement, which can be carried out on metered or unmetered supplies, using different techniques. The recommendations then outline the components of a water balance, that should be carried out over a twelve-month period, which include:

- *"A thorough accounting of all water into and out of a utility system, including inspection of system records*
- *An ongoing meter testing and calibration program*
- *Due allowance for time lags between production meter and customer meter reading."*

The Association gives a formula for Unavoidable Annual Real Losses (UARL):

$$UARL = (A * Lm/Nc + B + C * Lp/Nc) * P \qquad (2.2)$$

where *UARL* is measured in litres/service connection/day when system is pressurised; *A* = 18; *Lm* = Length of mains in km; *Nc* = Number of service connections; *B* = 0.80; *C* = 25; *Lp* = Total length of service connections from the edge of the street to customer meters in km; and, *P* = average pressure in metres

The values of A, B and C are derived in an earlier review of Performance Indicators (Lambert et al., 1999). This formula is used in the water loss model Benchleak (WRC, 2001), which has not yet been developed for rural situations.

The task force concluded that the greatest proportion of real losses, in well-managed systems, was associated with service connections.

2.6 Review of South African Standard Code of Practice

2.6.1 Background to the Code of Practice

In 1997 the South African Water Research Commission (WRC) published a report (De Vallier and Broadhurst, 1997) because of research into developing procedures for controlling UAW and reducing water loss. The main findings of these results were as follows:

- Few Local Authorities had comprehensive structures in place to deal with the control or reduction of UAW. Most structures that were in place were reactive and not pre-emptive.
- The varying definitions of UAW led to inconsistencies in the data recorded and difficulties in comparing this data.
- Anomalies in meter readings were present.
- Invisible leaks within systems were felt to be the most significant component of UAW.

- Errors existed with meter sizing and reading.
- The number of unmetered connections had increased since the late 1980s due to urbanisation.
- National records for UAW were incomplete and inconclusive.

In addition, the report stated that South Africa was water stressed and approaching conditions of water scarcity. This position has not changed (DWAF, 2000).

These findings led to a guidance manual on UAW control and reduction (De Vallier, 1997), which formed the basis of the existing standard Code of Practice.

In the same year of the initial report, 1997, the Department: Water Affairs and Forestry (DWAF) issued guidelines for rural water supply design criteria stating that the design loss factor (i.e. UAW) is 10% (DWAF, 1997a). This figure is still quoted in rural water supply business plans for new systems. The DWAF guidelines have not been updated since the Code of Practice was issued in 1999.

2.6.2 Aim of the Code of Practice

The aim of the South African Code of Practice for the management of potable water in distribution systems (SABS, 1999) is “to present a uniform approach for all Water Services Authorities”. This statement implies that the Code of Practice is to be applicable to all situations, and therefore includes rural areas.

2.6.3 Institutional Breakdown and Management Responsibilities

There are principally 3 levels of responsibility for the rural water supply systems considered in this dissertation.

At the government level is DWAF which is responsible for overall regulation of the water industry, catchment management, water boards and river water quality, in order to provide and convey bulk water (DWAF, 2001a). DWAF are responsible for implementing the recently announced policy of providing 6 kl/household/month free of charge to all people within South Africa (DWAF, 2001b). This would exceed the minimum health requirements of 20 l/person/d recommended by WHO (WSSCC, 2000), where there are less than ten people per household. This policy was due to be implemented from 1st July 2001 and is an attempt to address the fact that 12 million people in South Africa are still without adequate water supplies. This is in line with the Water Act of South Africa (DWAF, 1997b), which states that it is every person’s right to have access to clean water. The Ilembe District Municipality (IDM) is the WSA for Montebello and Emayelisweni.

Working under DWAF are the District Municipalities, which act as WSAs and Water Boards. WSAs have the responsibility for water supply, and can delegate this responsibility to other agents (DWAF, 1997b). Umgeni Water is the water utility responsible for the Durban-Pietermaritzburg corridor (Umgeni, 2001), and is the delegated Implementing Agent for Emayelisweni and Montebello.

The consulting firm, Partners in Development (PID) has been contracted by Umgeni Water and IDM to support the community based Water Services Provider (WSP) to the Montebello and Emayelisweni rural areas within their rural development programme.

Section 4 of the Code of Practice concerns management, policy and systems, and states that WSAs must "gather adequate quantifiable data on the extent of the problem and to take action to reduce unaccounted-for water". This clearly puts responsibility for UAW reduction with the WSA and implies a more proactive approach than had been taken until 1997.

The section further outlines that water conservation, economic, technical and managerial control measures for UAW are divided between two parties, namely the WSA and the consumer. However, in rural supply systems the WSP, often the local water committee, controls all the above measures, acting on behalf of the consumer and reporting to the WSA. There is no mention of the WSP within the Code of Practice or any appreciation of the responsibility carried by the WSP in rural situations.

2.6.4 Metering

The Code of Practice states that to promote conservation of water the supply area should be metered, otherwise it is difficult to encourage water conservation. Clearly if metering is not in place it is more difficult to understand the extent of UAW.

2.6.5 Economic Value

The Code of Practice also indicates that WSAs need to spend money on resolving UAW issues.

However, the costs of rural UAW reduction strategies are high compared to the revenue gained from low per capita water consumption or from low water conservation relative to overall district quantities. Therefore there is little motivation to spend the required time or money on rural UAW reduction. This motivation will be further reduced if the new policy of Free Basic Water comes into full effect (see section 2.9).

However, the motivation to control UAW at community level, if understood, is high as the revenue generated through water consumption is often much less than that lost through UAW. The relationship between UAW and consumption is the key to sustainable rural water supply.

2.6.6 Water Conservation

The Code of Practice suggests that the WSA responsibilities concern technical control measures, such as leak detection and repair, and that consumer responsibilities concern the need to reduce water consumption, in order to aid water conservation.

The remoteness of rural areas raises questions of appropriate levels and costs of leak detection strategies for low-revenue, low-tech water supply systems.

Concerning water consumption, this needs to be encouraged in rural areas, not discouraged, as many current consumption figures of less than 20 l/person/day are recorded (Still, 2001).

2.6.7 Strategy for UAW Management

The Code of Practice outlines steps for managing UAW that are directed at WSAs though it states that for village water committees the steps should be developed in conjunction with experts in water management, as follows:

- Appoint an UAW committee.
- Design and install a network of meters.
- Carry out a meter survey, locating unmetered properties and faulty or incorrectly sized meters.
- Take an inventory of each area to calculate the expected consumption.
- Collect data from domestic and bulk meters and compare with bulk night flow readings to identify possible leaks or illegal connections.
- For comparison of different systems, apply correction factors to convert all pressures to 50 m.
- Prioritise areas for corrective action.
- Continue monitoring priority areas.
- Generate an annual UAW report for submission to UAW committee.

2.7 UAW in the Context of the New SA Government Policy to Provide Free Basic Water

2.7.1 Public Attitude

South Africa's history of unequal development has left the majority of the country's wealth in the hands of the urban population, where most white and Asian people live, while many rural and peri-urban black communities lack basic needs and services. The poorer communities now feel that the richer population should compensate for this through a redistribution of wealth that includes financing water supplies in areas that currently lack such facilities (Guardian, 1999). There is also the perception that water, as a natural resource, should be free to the consumer. The government has attempted to compromise on this perception by introducing the aforementioned policy to provide basic water free of charge (DWAF, 2001b). These public perceptions are neither new nor unique to South Africa; the World Bank was aware of these attitudes at least as early as 1976 (Saunders and Warford, 1976) and Churchill suggested that richer societies should subsidise poorer ones in 1987 (Churchill, 1987).

2.7.2 Potential Effects of Policy

The Water Research Commission (De Vallier and Broadhurst, 1997) found that due to the relatively cheap cost of water, most local authorities would compensate for revenue losses by increasing tariffs rather than implementing measures for UAW control or reduction. Recent evidence suggests that this is still the case (Shepherd, 2001) and that the Free Basic Water policy will be financed through cross-subsidising. Hence the introduction of the Free Basic Water policy will further diminish the motivation of

WSAs to deal with UAW. Shepherd also suggests that a cost-benefit analysis needs to be applied to measures used to maximise income and reduce losses.

If the focus of WSAs is purely financial then rural UAW will not be addressed with the introduction of the Free Basic Water policy. However, if the focus is catchment management orientated, particularly in water-stressed rural catchments, then UAW will have to be addressed in order to ensure that everyone receives the benefits of the Free Basic Water policy.

It has been suggested that where rural water supply systems currently exist not all households within these communities are part of the water systems, and many that are part currently use less than the 6 kl/month target of the Free Basic Water policy. Therefore if the Free Basic Water policy is to be achieved in these areas, water consumption will have to increase and catchments will be more stressed. If consumption does not increase above the 6 kl/month figure then WSPs, usually the local water committees, will have no scope for income, reducing their empowerment, with consequences on the long-term sustainability of water supply systems (Still, 2001).

The Mvula Trust recognise that community based monitoring and evaluation techniques, which include UAW management, are essential to promoting long-term sustainability, which means enabling the community to run projects without external support, both institutional and financial (Netshiswinzhe and Potter, 2000). If water is perceived as free then the local motivation to fix leaks or other technical faults will lower, reducing community participation and therefore decreasing long-term sustainability as systems fall into disrepair.

2.8 Previous Research on Local Rural Water Supply Systems

2.8.1 Performance Benchmarking

Very little research has been carried out on UAW in the context of rural water supply systems within South Africa. However, one research project (Cyllok, 2000) was carried out on eight different rural water supply systems for which Umgeni Water is the Implementing Agent. One of these eight systems was Emayelisweni. The aim of the research was to develop a model that could be used to benchmark acceptable losses on rural water supply systems. These benchmarks could then be compared with actual losses to assess system performances.

The project compared the South African Code of Practice procedure for calculating acceptable losses (SABS, 1999) with another procedure outlined in a Water Institute of South Africa (WISA) presentation, which is being developed into a WRC report and associated model, Benchleak (McKenzie, 2002). Both procedures use a standard acceptable loss of 200 l/connection/day. If this standard is to be applied to rural systems then with current consumption rates the acceptable losses will be more than consumption rates. Even with the Free Basic Water policy target of 6 kl/household/day, acceptable losses will be equal to consumption rates, meaning that UAW will be acceptable at 50%. On rural supply systems this would usually be financially unacceptable. The research concluded that neither of these procedures could be accurately applied to rural systems but might be a starting point for further development of a benchmarking model.

2.8.2 KwaSandaneswe

A community standpipe system is in operation at KwaSandaneswe. One bulk meter measures the water abstracted from the river and 15 other bulk meters measure the bulk water from each reservoir to the 48 standpipes. Water is sold using a coupon system where a coupon can be exchanged for a unit volume of water, so the domestic water consumption can be calculated from the coupons sold each month. Figures from September 2000 show that UAW was about 20%, 12 l/tap/day and 0.6 l/hr/km. UAW was due to vandalism and theft, particularly due to illegal recycling of coupons. The UAW target is currently to implement a basic water loss management programme as per the procedures outlined in the South African Code of Practice (SABS, 1999), meter readings and calculations being carried out by the local water committee.

2.8.3 Nkwambase

One rural water supply system in the KwaZulu Natal region is Nkwambase. There were initially 240 yard tap connections on the system but this has now increased to 620 connections. The water is pumped from one of Umgeni Water's Water Works to a reservoir from which is gravitates to 80% of the project area with the remaining 20% being served from a booster-pumped supply from a command reservoir. All domestic connections are metered and customers pay R3.20/kl. The purchase price for bulk water is R2.50/kl. The system had problems with huge UAW figures of about 74%, with actual bulk consumption of 500 kl/day though the target was 200 kl/day. The consulting engineers therefore implemented a meter reading programme and found that 50% of the UAW was due to poor meter reading, either through meters not working or not even being read and that 10-15% of meters were under recording or not recording at all due to sand blockages. There were also problems with illegal connections and vandalism, and from high pressures where new connections had bypassed break pressure tanks due to a lack of local understanding of the technical issues of the system. Although the meter reading programme reduced UAW levels to 50% it was not continued as the local water committee was disbanded in May 2001 and finances were not available to train the new committee. The WSA does not provide enough support to continue the programme, which had aimed to reduce UAW to 30%.

2.9 Summary

UAW is defined as the difference between the net production and the consumption in water. Within this study these are referred to as the bulk and domestic consumption respectively. UAW can be divided into physical, non-physical and miscellaneous losses.

The units of measurement to be used throughout this study will be %, l/tap/day and l/km/hr, otherwise known as the specific loss rate.

Strategies for the reduction of UAW include pipe and reservoir leakage detection, wastage reduction, faulty meter correction, illegal connection elimination, accurate billing of all accounts and reduction of miscellaneous losses.

The management of UAW should involve all stakeholders but could be carried out by the community who could then report to the WSA through KPIs, or more directly in the case of emergencies. Some training will be required to manage UAW.

International guidelines recommend that systems be fully metered and provide a formula for calculating UARL values. These guidelines are not specific to rural situations.

The South African Code of Practice outlines the responsibility of the WSA to manage and reduce UAW in all situations. The Code promotes a metered system and stresses that UAW management is both a financial and conservation issue. The Code does not give a specific strategy for rural UAW management.

The Free Basic Water policy could have the effect of diminishing motivation to reduce UAW. It could also have the effect of creating a feeling of entitlement about water, where it is not highly valued, but taken for granted.

Previous research on rural water supply systems in South Africa is limited and does not propose an UAW management strategy.

The next chapter presents both the methods used in the assessment of the two case studies, Montebello and Emayelisweni, and the development of their UAW management procedures.

3 DEVELOPMENT OF RURAL UAW MANAGEMENT PROCEDURE

3.1 Introduction

This chapter outlines the procedure used to develop an unaccounted-for water (UAW) management programme within two case studies, Montebello and Emayelisweni. Emayelisweni was developed first, followed by Montebello so that lessons learnt from Emayelisweni were incorporated into the work at Montebello.

The procedure consists of an assessment phase of information gathering, meter reading, field tests and system observations, which assess the needs and capacities of the projects and stakeholders with regard to UAW management. This is followed by participatory workshops with stakeholders, which allow the stakeholders to develop an UAW management programme that they can implement, monitor and evaluate.

Each rural water supply project is unique and though there may be similarities across projects, the differences mean that the individual procedures for UAW management will vary from project to project. The steps taken to develop the UAW management procedure in the two case studies, Emayelisweni and Montebello, form the basis of a proposed procedure for other rural water supply projects.

Tables 3.1 and 3.2 show the levels of UAW, in reticulation lines only, in Emayelisweni and Montebello prior to the research period, immediately after the initial field studies and a period of time after the implementation of the UAW management programme had begun. These figures will be referred to throughout this chapter.

Table 3.1 - UAW Levels at Emayelisweni

	%	l/tap/day	l/km/hr
Beginning of research	66%	272	41
After initial field tests/repairs	28%	40	6
2 months after implementation of UAW management programme	43%	88	13

Table 3.2 - UAW Levels at Montebello

	%	l/tap/day	l/km/hr
Beginning of research	77%	411	111
After initial field tests/repairs	53%	196	53
2 months after implementation of UAW management programme	47%	130	35

3.2 Background Information

The aspects to be assessed on each project were broken down into four categories, institutional, social, financial and technical. It is necessary to consider each of these and while some categories influence rural projects more than others do, non-consideration of any one of the categories may render an inappropriate UAW management procedure.

The questions to be asked in assessing each project depend on whether the project is in the planning, implementation, commissioning/operation, maintenance and mentoring stage. Emayelisweni and Montebello were both in the operation, maintenance and mentoring stage so questions were chosen to fit this situation.

Affordability levels and probable level of cost recovery:

- Willingness to pay
- Effectiveness of tariff collection
- Level of financial management
- Tariffs vs. financial needs of project
- Level of cost management

Existing water supplies and optional new water sources:

- Accessibility of water collection points
- Quality of the water
- Amount of water to be provided
- Demand for water
- Minimum water needs

The WSP, and village water committee:

- Acceptability of the institutional structures
- Acceptability of election or appointment methods
- Level of skills of Project Steering Committee or Village Water Committee
- Level of involvement of key role players
- Level to which Project Steering Committee or Village Water Committee carry out their responsibilities
- Level of participation by target groups

The involvement and level of communication within the communities:

- Level of vandalism in the community
- Level of labour contribution
- Level of communication between the committee and the community

The appropriateness of the planned technological options:

- Level of skills required for Operation and Maintenance
- Level of use of local skills for Operation and Maintenance
- Level of environmental impact

The level of planning and breakdowns and to ensure reliability:

- Level of planning for disasters and breakdowns
- Level of external support available
- Comprehensiveness of Operation and Maintenance planning
- Level of spares maintained
- Availability of mentorship and after-care

Figure 3.1 - Project Questionnaire Contents

A questionnaire has been developed (Pearson, 2000) that is accompanied by a one page Excel spreadsheet that is easy to understand. The questionnaire is the same for the planning, design, commissioning and operation stages of projects but the author has compiled guidance notes, as to which questions should be completed for each stage. The questions to be answered for the operation, maintenance and mentorship phase are listed in Figure 3.1.

At Emayelisweni and Montebello the water committees act as the Water Service Providers (WSPs) on behalf of the community. Generally the projects have the same external support structure, both from Partners in Development (PID) and Ilembe District Municipality (KSDM), who is the Water Services Authority (WSA), but the projects differ internally.

As it is the committees who will be carrying out the UAW management programme, the assessment must accurately reflect the true project situation and the views of the community. For these reasons, questions were answered through field observations and by studying project records. Where necessary information was found by asking the local water committee or community. Project records were found to be most accurate at the community level so the community project administrator was an invaluable resource. The nearer to community level that the information was gathered, the more time-consuming it was to get that information but the more accurate the information tended to be. Generally, most institutional, social and financial information was gained from the water committee as the committee was felt to accurately represent the views of the community, whereas technical information was not understood well by the committee or community. Therefore the implementing agent, PID, was also used here.

The questionnaire (Pearson, 2000) was completed for both the Montebello and Emayelisweni projects at the beginning of this research and from this process the projects were assessed for their institutional, social, financial and technical needs and capabilities.

3.2.1 Institutional

The external support on both projects was good. A representative from IDMattended each monthly committee meeting and takes an active interest in the operation and maintenance of the projects. PID offer extensive support to both committees, by attending meetings and assisting in the technical and financial problems that arise.

The Emayelisweni committee members generally attend meetings but showed little active interest in the problems facing the project. The paid project administrator, responsible for book keeping, was considered the key to the project's survival up to that time, even though her salary was considered unacceptably low.

The internal structures on both projects are similar in establishment but differ in operation. Each project has an unpaid committee consisting of nine members of the community who are elected at annual community meetings. No member can serve on the committee for more than three years without being re-elected. Each committee contains both male and female members, with specific roles, such as chairperson or secretary, being shared between both genders.

BOX 3.1 – Montebello Case 1

The Montebello committee was due for re-election at the annual community meeting at the start of the research. At the same time the community sacked both the project operator, who was responsible for pump maintenance, general plumbing and meter readings, and the project administrator. Both the operator and administrator were considered inefficient and possibly corrupt. The community meeting had been arranged on four previous occasions but had been postponed at the last minute for various reasons, usually because at least one 'key' person had failed to attend. Many previous committee meetings had been postponed because less than four members had attended, meaning decisions could not be made under the terms of the constitution. However, three committee members were re-elected and two of these were considered to be committed to the project, all putting unpaid time and effort into the running of the project.

3.2.2 Social

Both genders are represented on the project committees and it is considered that male and female views are adequately addressed.

Emayelisweni has a relatively small project area with only 91 homes, about 50% of these are currently connected to the community water project. There is vandalism on the project. There were problems in the past when a previous plumber was discharged from his position and took revenge by opening all the scour valves and hence releasing huge quantities of water and costing the project money.

BOX 3.2 – Emayelisweni Case 1

After the implementation of the UAW management programme a leak was quickly detected and reported on the main pipeline into Emayelisweni. However, between fixing the leak and backfilling the trench an act of vandalism occurred when the pipe was sliced with a large knife. It is not known, or admitted, who carried out this act but there are rumours that one of the current plumbers did it as he was not employed to carry out the repair. Fortunately the water supply was still switched off so little water was lost but a 3 m section of pipe had to be replaced.

Customers generally pay their accounts within a month of receiving their monthly invoice and this indicates satisfaction with the supply.

Montebello has a much larger project area with about 250 homes, 169 of which are currently connected to the community supply. There are problems with occasional vandalism on the project but it is unclear whether this is carried out by people within or outside the project area. There are problems with payment of accounts, which are exacerbated by the fact that the chairperson of the committee had not paid his account for nearly 3 years. At the last community meeting mention was made of the Free Basic Water policy to be introduced by the government. However, people seemed satisfied that this had not yet yielded any funding for Montebello and that until it does they should continue to pay their accounts.

Despite the proximity of the two communities the working relationship between them is defensive and territorial. Suggestions have been made, from outside the project area, to combine the two committees but this is not considered feasible at this time due to the territorial culture of each project area, even though the water supply systems are effectively one system, serving two communities.

Related to the institutional structures, there was a general attitude in both committees that because of the extensive external support offered by PID there was little need for the committees to be concerned with UAW. Although committees were aware that UAW was costing the projects money, it was felt that PID would solve the problem. In contrast, PID and IDMbelieved that the committees had to take responsibility for UAW if it was to be managed long term. The Zulu culture generally does not include maintenance, e.g. housing is not maintained but rebuilt after a few years when required.

BOX 3.3 – Emayelisweni Case 2

At one committee meeting it was even observed that the committee felt it would not matter if their project went bankrupt, as the WSA would rebuild it, however the WSA was quick to correct this perception.

3.2.3 Financial

The financial situations of both systems are quite different.

Montebello pays for its water through the electricity costs of pumping water from the river. This costs about R0.55 per kl (where R is the South African unit of currency, the Rand). It then sells water to Emayelisweni at R2.00 per kl and to its own customers in Montebello at R4.00 per kl. Prior to this research, pumping costs were at about R1500 per month and income generated should have been R2000 per month, though approximately 50% of customers had not paid their accounts for 6 months or more. In addition to this there were expenses of about R400 per month. So the project should have been breaking even. However, this was with UAW values of about 77%, 411 l/tap/day, 111 l/km/hr, where consumption rates in Montebello were 66 l/tap/day and sales to Emayelisweni were 400 l/tap/day. Hence, if the project were running with lower rates of UAW the project could have been making a profit. Montebello had also had problems paying its electricity accounts resulting in disconnection to the supply, though this was due mainly to poor administration. The loss of the project operator had also meant there was no one to read the domestic meters for billing purposes and PID took over this role until a new operator was found.

Emayelisweni pays R2.00 per kl to Montebello for its water. It then sells water to its customers at R10.00 for the first 2 kl and R3.00 per kl thereafter. Prior to this research, purchase costs were at R1000 per month and income generated should have been R600 per month, though approximately 10% of customers had not paid their accounts. In addition to this there were expenses of about R200 per month.

However, this was with UAW values of about 66%, 272 l/tap/day, 41 l/km/hr, where consumption rates in Emayelisweni were 121 l/tap/day. Hence, if the project were running with lower rates of UAW the project could have been breaking even but probably not making a profit on a month by month basis. However, there were two sources of additional income, hiring out the water office as a polling booth during elections and selling water to a religious group who visit the area each January. These sources of income are used as a reserve fund. Although monthly water bill payments were fairly up to date, payment of initial tap connections were not and recovery of these debts could be a short term financial resource.

In short, UAW was draining both projects of necessary finances, and without external financial support the projects would not be sustainable. Montebello had the capacity to recover its current losses by increasing the number of people paying monthly bills. By reducing UAW the project could be making a profit. Emayelisweni could solve its current debts by recovering connection payments but a reduction of UAW would be necessary for long-term financial sustainability.

As an aside, the rate that Montebello charges Emayelisweni for water, R2.00 per kl, could be reduced but this requires the agreement of the Montebello community and despite external recommendations that the tariff be lower, they would not agree to less than R2.00 per kl.

3.2.4 Technical

With the loss of the project operator, Montebello lost local technical operation and maintenance support. The result of this was that PID offered temporary technical support until a new operator was found. One problem that regularly faced Montebello was failure to pay electricity accounts resulting in electricity supplies being cut off. Other problems occurred with the pump system. The telemetry system often failed meaning pumps had to be switched on and off manually, which without a local operator was difficult. Vandalism had previously taken place on the pumps at the river, and these pumps had experienced technical problems in the past.

UAW was being calculated from comparisons of domestic and bulk consumption, and indications were that UAW was high and financially unacceptable but there was no local understanding of where this water was going or how to find it and solve the problem. Initial meter readings were taken at the end of September, with fixing of leaks commencing in October.

Emayelisweni has no pumps and therefore does not have an operator. Instead two plumbers are trained to install new connections and fix taps, meters, valves and broken pipes. Again comparisons of domestic and bulk consumption showed financially unacceptable levels of UAW. There was a little local understanding of the financial implications of this UAW, mainly by the project administrator but there was no local understanding of how to detect and fix the causes of UAW. With the exception of two committee members and the project administrator there was no motivation or interest to learn or actively tackle UAW and there seemed to be the perception that ‘someone else’ would sort it, ‘someone else’ being PID in the first instance. Initial meter readings and fixing of leaks were carried out at the end of August.

It was clear that PID had offered continuous technical support in the past. This was essential to the short term survival of both projects but was having a negative effect on the long term independence and sustainability of both projects. However, it was also evident that the WSA was not yet in a position to take full responsibility for the external support, having only been institutionally created in December 2000.

3.3 Metering

3.3.1 Meter Layout

In Emayelisweni and Montebello all domestic connections are metered for billing purposes. At Emayelisweni and Montebello all bulk meters lie close to the main roads through the villages. This means that bulk meters could be accessed quickly and safely.

In Montebello each bulk meter covers a pipe length of up to 3.4 km. The bulk meters clearly define different branch lines of the pipe, making it easier to narrow down areas of inspection for leaks, but lengths of up to 3.4 km are difficult to inspect if there is a leak, which is not visible above ground. The number of houses on each bulk line varies from six to 40. The particular branch which has 40 houses has smaller branch lines off it, fed by reservoir tanks, which could have bulk meters on them, reducing the number of houses per bulk meter and the length of pipe per bulk meter. However, at this time, finances are not available to install further bulk meters.

In Emayelisweni each bulk meter covers a pipe length of up to 2.7 km. Again branch lines of pipe are clearly defined but 2.7 km of pipe are time consuming to inspect for underground leaks. The number of houses on each bulk line varies from 3 to 12, but this is considered manageable.

Most reservoirs, on both systems, are located near the main road through the villages. Bulk meters are usually located after the reservoirs or where a significant branch line exists. Locating more bulk meters after all the reservoirs would reduce the pipe lengths associated with each meter. However, some reservoirs are located up to 2 km from the road and it would be unfeasible to attempt to implement a system of night flow readings on these meters. These meters could be used in the monthly balance calculations and would then reduce the length of pipe to be investigated if a leak was suspected.

In short, where bulk meters are to be installed on a system, consideration should be given to the length of pipe and the number of houses represented by each bulk meter, as well as to the available capital to purchase and install meters. The benefit of a system with adequate bulk metering is that UAW management is feasible and therefore aids sustainability.

3.3.2 Night-flow Readings

In Emayelisweni and Montebello it was observed and agreed by the committees that few people use water during hours of darkness. This combined with the impracticality of taking meter readings in the dark when few people possess torches, and the safety risks involved in wandering about in the dark, meant that meter readings were taken just before nightfall and at sunrise. During the South African winter period the committee recommended that these times were approximately 6pm and 6am respectively.

For the initial assessment of UAW night-flow readings were undertaken each night for a period of one week. Reading times varied slightly. Some readings were taken earlier in the evening and later in the morning to see how much water was used last thing in the evening and first thing in the morning. On one occasion readings were taken late at night and earlier in the morning while it was still dark, to see if indeed little water was used after nightfall and before dawn.

From all these readings an analysis was made of typical water consumption during the hours of darkness and how close to nightfall and dawn readings should be taken. These values will vary from project to project with different consumption patterns.

At Montebello the initial night flow readings were partially inconclusive. This was because just before the week of meter reading problems had occurred with the pumps and the reservoirs were still refilling. During the week problems occurred with the rising main resulting in the pumps being switched off for two days. However, the readings still indicated where leaks might be and these suspicions matched the results of the domestic/bulk balances taken that week.

At Emayelisweni there were no technical problems during the week of meter readings and night flow readings immediately indicated where leaks might be present. As these leaks were investigated, and some fixed, during the week, lower night flow readings confirmed that the repairs had been successful.

The assertion that few people use water during the hours of darkness was confirmed in both places by the night flow readings.

3.3.3 Bulk Meter/Domestic Readings

At Emayelisweni and Montebello domestic meters are read on the 25th of each month for billing purposes. During the initial assessment the domestic meters were read on three occasions at Emayelisweni and four occasions at Montebello during the course of one week. Bulk meters were read at the same time. This allowed a comparison to be made between the bulk and domestic consumption, between sets of readings, on each branchline.

The initial meter reading week helped to clarify where leaks might exist on both systems. It gave a quick assessment of the UAW situation within the project and allowed immediate investigations and repairs to be carried out where necessary. Taking readings three or four times within a week is only necessary during the development of the UAW management programme. This period serves as good training for new local employees and alerts the community to ask questions leading to an increased understanding of the need for accurate meter reading, not just for domestic billing purposes but for the benefit of the project as a whole. With new meter readers it is also likely that there will be mistakes and three or four sets of readings increases the chance of at least one reliable set of results.

Reading bulk and domestic meters manually introduces a margin for error, as all meters cannot be read at the same time. To reduce this error meter readers were assigned to read certain bulk lines so that readings would be carried out on one bulk line at a time, thus reducing the time interval between reading the bulk meter and the domestic meters associated with it.

By considering the time delay between reading the bulk and the domestic meters on each branchline, and the possible 'unread' consumption during this time period, the potential error in estimated consumption was calculated. This error was found to be less than 4% of the bulk consumption during a five day period, and for monthly periods less than 1%. On some branchlines there may be few domestic meters, or they may be located close to the bulk meter, and here it should be possible to take readings without water being consumed between the first and last meter readings of each set of readings.

3.3.4 Personnel

As it likely that meter reading work will form part of the UAW management procedure it is important to try and employ people to take meter readings who will be involved in the long-term. This has several advantages. Firstly, it uses local knowledge on the systems as local people know where the houses and meters are. Secondly, residents will be more co-operative with people from their own community than with 'outsiders'. Thirdly, it creates local employment. Finally, if these people are to be used in the long-term then the exercise forms the basis of some form of training that may not have to be repeated later. The disadvantages are that local people with little technical knowledge of the system may not understand the links between the bulk meters and the domestic meters which can lead to inconsistencies in the order that meter readings are taken.

At Emayelisweni PID took a more active role in the meter reading and investigation of leaks. This helped to develop external understanding of the work involved and the nature of the projects but did not help with local employment. For the long term meter readers had to be trained after the initial assessment period which could have been avoided. At Montebello local personnel were used for all meter reading and field investigation work. This will improve the long term sustainability and local understanding of the work but lengthens the time taken to solve short term problems.

Employing local people to read meters was successful at both Montebello and Emayelisweni. More meter readers were employed during the initial meter reading week than were needed for the long term UAW management programme giving a choice of readers for the committee to employ long term.

3.3.5 Analysis of Meter Readings

Calculating the night-flows and the differences between bulk and domestic consumption is fairly simple. What is less simple is deciding acceptable, or achievable, levels of night-flow and UAW. Many software packages exist which compute acceptable water loss levels but to date none have been developed for rural situations. At Emayelisweni and Montebello software packages are inappropriate, as access to these facilities does not exist.

Because there was little to no nightly consumption, the night-flow readings and levels of UAW from domestic readings can be used to estimate what is causing the UAW. If the night flow rate fully explains UAW, then leakage is the only significant cause of the UAW. However, if the night flow rate is less than the UAW then other factors, such as inaccurate meter readings, either from the meter recording flows incorrectly or human reading error, or illegal connection(s), are significant.

Initial analysis of the meter readings was carried out by PID to quickly assess where possible leaks were occurring. The methods used and the results obtained were presented to the stakeholders in a workshop, which is discussed further in Section 3.5.

From the night flow readings the acceptable level of night flow for both places was determined as 150 l/tap/night. This acceptable level is higher than the acceptable level of UAW because allowance has to be made within the night flow for the small amount of domestic consumption that happens just after dark and just before dawn. Hence this level will depend on the consumption patterns in each area and field observations will be required.

It was felt that the administrator should be responsible for calculating the night flow and the bulk/domestic balances in the long term. The initial reading week was used as a training period for this outcome.

On each system the administrators currently calculate monthly domestic consumption for each household for billing purposes. As part of their Key Performance Indicators (KPIs) they also already compare total domestic consumption with the main bulk meter consumption. Breaking this process down into each bulk line was a small step forward. Once administrators had grasped an understanding of the layout of the system, and the relationships between houses and bulk meters, the calculations were the same as before but just separated into areas.

As UAW is a financial issue on both projects, acceptable levels of UAW depend on the cost of repair compared with the cost of the water lost. At Emayelisweni there is a fixed rate of R30 per plumbing job, and as the bulk water costs R2/kl, the threshold of acceptability is 15 kl/month. At Montebello the bulk water costs only R0.55/kl but the operator is paid a monthly salary of R150 so the cost of repair is the cost of materials, which depends on the source of the UAW. Therefore, levels of acceptability are required for each source of UAW, rather than the overall UAW figure. From field tests, and considering the financial costs, levels of acceptability of UAW were set at 100 l/tap/day. The UAW is calculated by the administrator in l/tap/day for each bulk line. If the UAW on a line is greater than 100 l/tap/day then the administrator informs the plumbers/operator and the line is investigated.

It was also observed that the specific loss rate unit of measurement for flow provided a good benchmark indicator for leakage but is not yet understood by the local people responsible for assessing leakage. The acceptable level of specific loss rate was determined as 30 l/hr/km. It was found that flow per tap was much easier to understand and calculate and also provided a figure to compare with household consumption rates, thereby providing a financial indicator of the loss. This then showed the committee whether the 'leak' was financially worth investigating. Other projects may suffer more from the loss of valuable quantities of water where catchments are stressed, rather than from the financial implications, and in these cases benchmarks should reflect this.

3.4 Field Tests and System Observations

Because the effects of UAW were already having a financially crippling effect on the Emayelisweni project the major leaks were investigated immediately by PID, with support from local plumbers. This was because immediate repairs were required. For the smaller leaks, it was left to the committees to organise investigation of the leaks. However, at Montebello the financial effects, though critical, were not felt to require instant attention. Therefore it was left to the Montebello committee to organise investigation of all leaks on this system. This method helps to ensure that the committee understands what is required so the procedure can be continued long term.

Table 3.1 shows that the levels of UAW reduced immediately at Emayelisweni from 66% to 28%, from 272 l/tap/day to 40 l/tap/day. This was because of leaks being repaired by PID. These figures later increased to 43% and 88 l/tap/day as the local staff were left to implement their UAW management programme with little external support.

Table 3.2 shows that the Montebello levels of UAW initially reduced from 77% to 53% and from 411 l/tap/day to 96 l/tap/day. Unfortunately these figures are misleading as the pumps failed during this month reducing the domestic consumption and bulk water availability.

However, Table 3.2 shows that the UAW at Montebello was further reduced to 47%, and 130 l/tap/day, 2 months after implementation of the UAW management programme when the local staff began leak detection and meter readings without intensive external support.

3.4.1 Pipeline Observations

Analysis of the meter readings showed where potential UAW was. Once the water losses were narrowed down to specific branchlines then these lines were inspected for leaks.

The first stage in inspecting pipelines was to physically walk along the pipeline route looking for evidence of leaks such as depressions or damp patches on the ground surface. Each valve chamber, tap, meter or other connection was visually inspected for leaks. Visual inspection was the least costly method of inspection as little equipment was required and was therefore wholly appropriate to the rural situation.

BOX 3.4 – Emayelisweni Case 3

Most leaks at Emayelisweni were detected through pipeline observations and occurred at meters or valves. A few saddle connections, where a valve joins the main pipe, had become loose. These connections were probably slightly loose on construction but pipes had been adequately pressure tested at this time. As time had passed, plant roots had located this water source and grown into the leak forcing the connection apart and increasing the leak. These leaks could have been avoided had the connections been constructed properly, but could also have been reduced if regular inspections had been done on the pipeline, especially considering that these leaks had developed over a period of three years unnoticed.

A visual inspection of the pipeline with the largest UAW level, of about 600 l/hr, did not reveal any leaks. Inspection of the layout of the pipeline showed that the pressure head at the bottom of the line was about 160 m. This suggested that the leak may be at this end of the line, where the pressure was highest and leaks had occurred in the past. Further investigations confirmed this. A pressure of 160 m was considered too high, with pressure heads of 50 m maximum preferred in the system design. Pressure reducing valves or break pressure tanks had not been installed, to reduce the pressure, due to lack of capital finance.

Had leaks not been visible on the surface, the pipeline would have been investigated by inserting a 1.2 m length of reinforcing bar into the ground, initially near each connection or joint, and checking to see if the bar was wet when withdrawn. If the bar is wet then the ground above and around the connection should be dug to see whether the connection was loose, and if so then it should be tightened. This method requires the ground to be generally dry during the investigation and therefore has limitations.

These leaks at Emayelisweni raised issues concerning training, in terms of construction of new connections, of ongoing inspections and maintenance, and acceptable pressure heads.

BOX 3.5 – Montebello Case 2

A major leak was discovered on the rising main at Montebello. This leak was from an mPVC joint that had either become loose or had not been tightened adequately when constructed. The leak was only discovered when it became so large that it forced itself through a hole in the ground and became visible. Inspection of the leak revealed a large cavity around the joint where the leak had previously flown underground unnoticed. It is possible that this leak had started months beforehand. Further water balances have shown that about 2000 kl/month is still being lost on the rising main but these figures do not form part of the UAW figures for the reticulation lines. These leaks are being investigated along with the suitability of mPVC for pressured mains. One leak of about 40 l/hr was discovered on a reticulation line. Again it was a loose joint, this time on HDPe pipe, but the leak was visible. In fact the leak had been directed to flow over a piece of corrugated metal sheeting and was possibly a free water source for the neighbouring property. The neighbour concerned was very obstructive when personnel went to repair the leak. Other minor leaks were discovered on reservoirs and other pipe joints.

If after these inspections, night-flow readings still indicate that there is an unacceptable level of UAW, then other methods outlined below should be followed.

3.4.2 Domestic Meter Accuracy Tests

The comparison between bulk and domestic readings combined with night-flow analyses will give an indication of the accuracy of the domestic and the bulk meter readings and hence, the accuracy of the meters themselves. For example, if there is known to be no night-flow through the bulk meter then theoretically the difference in bulk consumption should equal the difference in domestic consumption. If the differences are not equal then it is possible that one or more of the meters is not recording accurately and further investigations should be made.

It is well researched that meters can under-record at low flows and simply filling a container of known volume from a domestic tap and recording the recorded volume change on the meter will indicate the accuracy of the meter. In rural South Africa 25 l containers are common so these were used to test the domestic meters. The installed meters are designed to record minimum flows of 0.5 l/min which is higher than a dripping tap so if faulty taps are not reported and fixed water flowing through the meter may not be recorded, or billed, and is therefore both UAW and a financial loss.

From the weekly night flow readings carried out from August to September at Emayelisweni, after the August investigations and fixing of leaks, it was seen that most bulk lines had no leaks and that overall UAW figures were down to 28%, 40 l/tap/day, and 6 l/km/hr. Night flow readings and the bulk/domestic balance for each line showed that these figures were mainly due to one line where there was still UAW. As the monthly bulk/domestic balance from August and September readings for all other branchlines showed no evidence of UAW, there was no reason to suspect that the domestic meters were generally under-recording. Therefore no tests were carried out on the accuracy of any domestic meter. However, tests are carried out on domestic meters if customers complain about their bills being too high.

The same types of meters are installed in Emayelisweni and Montebello. Since the previous operator in Montebello appeared to have estimated readings below what they really were, many customers complained that their bills were now too high, when the readings were known to be read accurately.

Domestic meter tests showed that in most cases the meters were accurate but out of 167 meter installed at Montebello, 3 have recently been reported as not working. The reasons for this are not yet known and investigations are continuing but the meters have been renewed. It is possible that other meters are not recording flow and the operator will be investigating all connections where the monthly consumption is zero. If these investigations suggest that a high proportion of meters are broken then further investigations of meter accuracy on other meters will be required.

3.4.3 Illegal Connections

If meters are found to be accurate then the next stage is to check for illegal connections. Illegal connections are not easy to find and, depending on the perpetrator, not safe to search for. Field searches for illegal connections should be a last resort when all other avenues have been explored.

It must be stressed that the first step is to analyse the night-flow and domestic readings to discover whether there is any unexplained consumption. A constant rate of UAW indicates that there is no illegal connection, unless the connection is continuously drawing water from the system at a constant rate, which is unlikely.

At Emayelisweni no evidence of illegal connections has been found. Where leaks have been fixed there is no indication of UAW levels that could be due to illegal consumption. The Emayelisweni community is small and illegal connections would not easily go unnoticed. The committee is representative of the community and it is considered unlikely that any known illegal connections would be unmentioned, though if there were such connections then dealing with the perpetrators would be difficult, particularly if the perpetrators held any position of influence in the community.

BOX 3.6 – Montebello Case 3

There was one illegal connection found at Montebello. The customer concerned had a legal yard tap connection but had made an additional connection to his bathroom and kitchen prior to the meter.

3.4.4 Connections Not Billed

There was evidence at Emayelisweni of connections that were not billed because the owners claimed not to be using the community supply. In fact some were still using the community supply. Aiding understanding of the need to still read these meters was fairly simple. However, recovering past payments from customers who had used the supply but had not been billed for three years was more difficult. The Emayelisweni project is supported by the local tribal chief and he will be able to enforce payment, if the committee fails to persuade customers to settle their debts.

At Montebello 5% of connections had not been billed regularly. Some meters were lockable and not enough keys were available to meter readers making the readings at times inaccessible. This has been addressed.

3.4.5 Pressure

Manage pressure and you can manage losses (Shepherd, 2001). If the pressure in a system is too high then it is likely to cause leaks, particularly at the end of pipes and at pipe joints. High pressure will also cause any leaks that do develop to expand and therefore lose more water. So lower pressures result in less leaks and smaller leaks.

At Emayelisweni and Montebello design pressure at the lower ends of many of the reticulation lines is 10 bar. In at least two incidents where pipes were extended the pressures are higher than 10 bar. It is now realised that while pipes and fittings are rated and can withstand pressures of 10-16 bar, supplying water at these pressures invites UAW problems. Because of this experience a policy decision has now been taken to limit supply pressures to 5 bar as far as possible. This is not always achieved in the field due to the capital costs and maintenance needs of break pressure tanks or break pressure valves. Break pressure valves are cheaper but can be easily tampered with. However fixed ratio pressure valves are simple and robust, and plans have now been made to introduce these where appropriate.

A simple pressure gauge can be temporarily installed onto taps to determine the pressure at each tap. If the pressure is unacceptable, because the potential levels of UAW are unacceptable, then additional pressure reducing valves should be installed on the pipeline. If finances cannot be or are not made available to reduce pressures then a relatively high level of UAW is to be expected and must be accepted.

As previously mentioned, one line at Emayelisweni had pressure heads of up to 160 m, much higher than the preferred limit of 50 m. This line has had previous leaks at the lower end of the line where the pressure is high. On other parts of the system where high pressure has been an issue, pressure reducing valves have been fitted. Currently there are no connections at the lower end of the pipe and the pipe has been disconnected to stop the leakage. However, Emayelisweni school is located at the end of the pipe and before they can be connected to the system, a benefit to both the school and the project, pressure reducing valves will need to be fitted and the pipe reconnected. Where pressure reducing valves have been fitted elsewhere on the system there have been no further pressure related problems.

3.4.6 Fixing Problems

Having done an initial assessment of the project the reporting procedure for leaks and necessary repairs should be known. Where possible local labour should be used to fix any problems. There are two aspects to address: the sense of urgency required to fix leaks and the technical competence required to make the repairs.

A sense of urgency will come from an understanding of UAW. The level of technical competence available in the field will depend on the quality of labour and training. However, a lack of the technical competence required in the field does not mean the repairs should go unmade but that a reporting procedure should be in place to call upon the correct level of competence. This requires technical support to be available.

At Emayelisweni and Montebello people have been trained and are employed to fix taps, meters, valves and pipe faults. Where the problems fall outside the capacity of the local employees, PID are available to deal with more technical issues, such as placement of pressure reducing valves. The financial support for these technical issues does not always exist. However, one result of this research has been an increased awareness within the IDM of the need for UAW management. It is hoped that as these results and recommendations are made available to them that they will understand the need for financial support, which it is the responsibility of the WSA to provide.

Developing strategies for fixing leaks was the most difficult part of the field research. From the social observations made at the start of the project it was clear that the local community do not see maintenance as their responsibility.

3.5 Workshops

Workshops are a useful tool for:

- Developing understanding of the importance of UAW.
- Developing understanding of the system operation (if required).
- Reporting on the findings of the initial assessment procedure.
- Reporting on the field studies.
- Reporting on repairs carried out or still required.
- Developing an UAW management programme.
- Allowing discussion of any issues raised.

If the committee are representative of the community then they should participate in the workshop. Plumbers or other local technical personnel, such as meter readers or pump operators, should also be involved. However, if the committee is not representative of the community, or not competent, this needs to be resolved before any UAW management programme can be developed.

The committee, the administrator and the meter reader were present at a workshop carried out in Emayelisweni. The IDM planned to attend the workshop but unfortunately failed to attend. The committee, the meter readers, the operator and the administrator were present at a workshop carried out in Montebello. A copy of the agenda can be found in Appendix A, though these notes were originally hand-written on a flipchart.

The agenda used in both places was generally as follows:

(i) *Why reduce losses?* An interactive discussion using pictures of leaking reservoirs, taps, meters and pipes and asking which of these scenarios cost the project money. This led to a greater understanding of the financial need to reduce water losses.

(ii) *Who lives where?* Using participatory mapping to aid understanding of the location of each customer in relation to each bulk meter and improving understanding of the pipe network. This map is now used by the administrator to calculate UAW on each line.

(iii) *Where does all the water go?* A diagrammatic comparison of the average daily household consumption and the equivalent loss per household per day, both in terms of water volume and money.

(iv) *What can we do?* Explaining what was done during the week of meter readings, i.e. night flow readings, domestic readings and inspections to repairs.

(v) *How we will manage losses.* Getting the participants to develop what was done during the initial meter reading week into what they can do long term. This included discussions of who would carry out meter readings, how they would be paid and how often night flow readings could be done.

(vi) *How we will pay for management.* Discussion of options to increase income on the project, including increasing tariffs, using more unpaid labour through committee members carrying out simple tasks and the need to keep UAW low.

Participants were very interactive and the mapping exercise was the most beneficial part of the workshop, both in terms of getting participants involved and the long term use of the map. The outcome of the workshops was that the meter reader would take the bulk meter readings monthly with the domestic readings. At Emayelisweni the committee members would take turns to take night flow readings one night each week, whereas at Montebello this would be done by the meter readers. The administrator would then carry out the calculations informing the committee of any possible leaks and the committee would then organise inspections and repairs as necessary.

Workshops should be carried out at a time and place convenient to those required to attend and to those running the workshop. Informing attendants as near to the proposed time as possible, say three to four days before, increased attendance. The amount of understanding that has to be developed will determine the length and number of workshops. Within the rural Zulu areas the motivation to attend workshops seems low, particularly if people are not paid. If motivation to attend workshops is low participants could be paid a nominal fee for attendance, or refreshments could be provided. However, where participants attend without financial incentive the motivation to apply what is learnt and developed from the workshop will be higher. Workshops should be carried out using participatory tools such as mapping and brainstorming. This allows for as much interaction as possible from the participants.

3.6 Implementation

At Emayelisweni, further training was required for the night flow readings as committee members had not carried these out during the initial meter reading week. The administrator also required further training to understand the readings and calculate the night flow as well as to assess whether each line had a possible leak or not. Monthly reading of the bulk meters with the domestic meters was well understood and needed no further training.

At Montebello, no further training was required as some of the people employed during the initial reading week will be employed long term and have therefore already been trained. Training was given to the administrator for calculating the flows and assessing leaks.

As far as possible the UAW management programme must be designed to slot in with the existing project management programme. For example, where domestic readings are taken for billing purposes little extra work is required to include bulk meters within the meter reading schedule. On the other hand, night-flow readings are often inconvenient and consideration must be given to location of bulk meters relative to the meter readers and of what is a reasonable demand on their time. Maybe once a week is sufficient. On most already operational rural projects the UAW management programme must be developed before profits will be available to finance the programme. In these cases motivation to implement the programme is difficult to achieve but can be done if understanding of the implications of UAW reduction is good. This difficulty emphasises the need to incorporate UAW management into the early stages of project planning. UAW management should be an active control method, not just passive or reactive.

The committee felt that in Montebello there was a need to promote a sense of responsibility amongst consumers to report leaks immediately. This led to the committee designing posters. It was suggested that the local school be involved in this but the committee decided that they were not equipped to provide the accompanying education without external training. A neighbouring project, Esidumbini, which comprises approximately 700 unmetered yard tap connections is keen to develop the involvement of schools, in order to reduce vandalism and possibly to use the schools to monitor the water quality and reliability and to carry out leak detection. This is outside the scope of this research but its potential could be developed further for rural projects generally. The involvement of schools may well increase the sense of community ownership which is lacking at Montebello and Emayelisweni.

Training and mentoring is an ongoing process. Once the programme has begun to be implemented meter readers and committee members will need continuous guidance. Indeed the programme may continue to develop and evolve after it has begun. Once again institutional support is crucial to the success of the UAW programme.

3.7 Monitoring and Evaluation

PID and IDMare still involved in the overall mentoring of both Emayelisweni and Montebello projects. As the administrator reports the status of the system to each monthly committee meeting an external assessment can be made here of further training needs. It is also here that the committee will be able to request external help should leaks not be locally found or fixable.

Depending on the size of the project it may be appropriate to develop a system of ‘zonal representatives’ where one person represents each bulk meter area, say, of the project. That person could be responsible for collecting meter readings, reporting problems and reporting to the committee each month. This system can be incorporated into the overall project programme if these people are also responsible for collecting payments or even, say, for carrying out plumbing tasks. Zonal representatives have not been used in Emayelisweni or Montebello as the projects are fairly small and cannot currently financially support many employees.

KPIs (Stephen and Still, 2000) in the form of bar charts are simple to develop and understand. These are completed by the administrators on both projects for indicators such as ‘Water Bought less Water Sold’, or ‘Water Losses per household per month’, by colouring in bar charts with wax crayons, say. This indicator allows the committee and external parties to set targets and to see how the UAW management programme is proceeding and is therefore the link between the community and the WSA. Two months after the implementation of the UAW management programmes UAW levels had significantly reduced, as shown previously in Figures 3.1 and 3.2. Further monitoring is required to fully assess the effect of the UAW management programme and institutional support is necessary to ensure continued motivation for UAW reduction and to guide communities in the ongoing development and implementation of their UAW management programmes.

3.8 Summary

The steps used for developing an UAW management procedure in Emayelisweni and Montebello were to gather background information, to take and analyse meter readings, to conduct field studies and to carry out interactive workshops with all stakeholders.

The initial assessment of the projects considered the institutional, social, technical and financial needs and capabilities. Institutional support was crucial to the success of an UAW management procedure. Social aspects varied between projects. Local understanding of UAW was initially low to non-existent. UAW could best be understood by the local people if explained in financial terms and this was the main motivating factor for UAW management.

Meter readings were already a part of the general project management procedure and were easily expanded to include UAW management. Employing local people to carry out the initial meter reading procedures as well as the long term procedures, was good training and aided understanding. The administrator was made responsible for collating meter readings and carrying out the necessary calculations.

Most leaks were visibly detectable and therefore quickly and locally fixable. Domestic meters were generally found to be accurate. No evidence was found of illegal connections though unbilled meters were evident. Pressure was too high on some lines and finances were not available to retrofit pressure reducing valves. This will have to change if UAW is to be reduced, otherwise UAW due to high pressure will have to be accepted.

Development of the UAW management procedure should involve all stakeholders. Interactive workshops were very successful in reporting the status of the project, aiding understanding of UAW and developing the UAW management procedure. Communities need a technical support structure starting with local support followed by external support and a clear understanding of the need for urgency in reporting and fixing problems.

Further training was required for implementation of the UAW management procedure but this was minimised where local people were involved in the initial assessment of UAW. Ongoing external support is required in monitoring and evaluating the procedure but existing monthly committee meetings enable this to be part of the general mentoring procedure. Simple KPIs are useful tools for reporting information to, and are a link between, all stakeholders.

Less time and money may have been spent if the UAW management procedure had been developed during the planning and implementation phase, as part of the overall water project management procedure.

The next chapter outlines how this procedure could be applied to rural water supply projects generally.

4 DISCUSSION

4.1 Introduction

This chapter outlines the options available for developing, implementing and monitoring an unaccounted-for water (UAW) management programme in the context of a rural water supply project. It discusses the initial research into the project and then critically examines how an appropriate UAW management programme can be developed with the local community concerned. Finally it reviews how such a programme can be implemented, monitored, evaluated and mentored, in line with existing national and international guidelines and in a way that is appropriate to all stakeholders. It will be clear that the assessment, development and implementation stages of the proposed UAW management programme overlap and separation of this discussion into each stage should not negate that fact. Discussions are based on the background information from Chapter 2 and the assessment and development procedures carried out on the two case studies in Chapter 3.

4.2 Options for Management of Rural UAW

There are three aspects to consider in developing an approach to managing rural UAW: by whom UAW should be managed, i.e. an internal vs. external approach; when it should be managed, i.e. a proactive vs. a reactive approach; and, how it should be managed, i.e. the level of technicality to be used.

4.2.1 External vs. Internal

A purely external approach would be for the Water Services Authority (WSA) to carry out its own assessments of the levels of UAW, possibly through occasional meter readings, or site inspections, and to reduce levels of UAW through externally employed personnel carrying out modifications or repairs to the system. The monitoring of UAW would be carried out using units of measurement appropriate to the WSA's record keeping system. In South Africa this would probably be the specific loss rate, l/km/hr, as instructed in the South African Code of Practice (SABS, 1999).

A purely internal approach would be for the local committee to carry out its own assessment of the levels of UAW and to implement its own strategy of UAW management through locally employed people. Any monitoring would be appropriate to their levels of understanding, units of measurement possibly being l/tap/month or l/tap/day.

The disadvantages of an external approach are that the financial cost of the UAW management programme would far outweigh the financial benefit to the WSA (see Section 2.3.1). The level of motivation for the WSA to carry out UAW management is therefore low. By contrast, UAW management is the WSA's responsibility under the South African Code of Practice, see Section 2.6.3, and for them to monitor different projects they need a record of each project's UAW levels.

The disadvantages of an internal approach are the lack of understanding that often exists locally as to the need for UAW management, and the lack of local capacity for carrying out a management programme, as discovered at Emayelisweni and Montebello, see Section 3.2.4.

This research has found that both internal and external parties have an interest in UAW management and therefore both should be part of the UAW management programme. However, it is financially more viable for the local committee/community to carry out the management programme with external support, than for the WSA to carry it out. External parties are needed for capital finance, training and capacity building amongst the local community but careful consideration must be given to the methods developed. Local people know what their needs are and what they are capable of, and what is therefore feasible for them to implement, but the WSA can provide valuable resources to increase the local management capacity.

Units of measurement used, see Sections 2.2.5 and 3.3.5, must be initially appropriate to the local community which is implementing the UAW management programme. Provided the levels of UAW are reported clearly then the units can easily be converted by the WSA to meet their requirements.

These findings contradict the South African Code of Practice, which implies an approach with less internal management.

4.2.2 Proactive vs. Reactive

A purely proactive approach would be to regularly inspect the water supply system for signs of UAW and take action to maintain the system well enough so that UAW did not occur, or that when it did it was eliminated as soon as possible. The requirement for WSA to gather information on UAW and take steps to reduce it is a proactive approach, see Section 2.6.3.

A purely reactive approach would be to compare the monthly bulk consumption with the monthly domestic consumption to gauge levels of UAW. Where these levels were found to be unacceptable then steps could be taken to find the source(s) of the UAW and reduce it. This was the approach that was being taken in Montebello and Emayelisweni at the start of this research, but the effectiveness of leak detection was not good.

The disadvantages of a purely proactive approach are that personnel are required to be trained and finances are required to pay for training and employment and there must be a balance between the cost of reducing UAW and the revenue saved through the reduction of UAW.

The main disadvantage of a reactive approach is that the revenue lost through UAW is lost before any steps can be taken to reduce UAW. This lost revenue cannot be recovered. This means that financially sensitive rural projects could potentially go bankrupt before UAW is discovered. This would have been the situation at Emayelisweni had no work been done on UAW when it was, see Section 3.2.3.

From developing an UAW management procedure at Emayelisweni and Montebello it was found that some level of proactive approach was required to avoid crippling financial deficits in both projects.

By developing a procedure that could be achieved through adaptation of the existing general operation and maintenance procedures, and using local personnel for the initial assessment of the project, it was found that the costs of training and labour were reduced. This was particularly apparent for meter reading procedures, see Section 3.3.

4.2.3 Level of Technicality

From the field tests carried out on Montebello and Emayelisweni and the responsibilities of the WSAs (Section 2.6.3) it is clear that the UAW management procedure should be part of the general operation and maintenance procedure. This implies that the UAW management procedure should be considered during design and construction, as well as during the operation and maintenance stage.

(i) Design

During the design of systems two major factors should be considered; metering and pressure.

Both bulk and domestic metering is necessary if UAW is to be monitored. This fact is clear from background research of South African and international policies (Sections 2.3 and 2.6.4). Meters must therefore be designed into the system. From the study of Montebello the placement of these meters should be carefully considered (Section 3.3.1) to ensure that there are not so many domestic connections on a bulk line that all meters on this line cannot be read within an acceptable time period, in line with international recommendations (Section 2.5). Bulk meters should also be located where they can be accessed easily and safely. A suggested guideline is that bulk meters should be located where all the associated domestic meters could be read in not more than two hours. Generally speaking this would mean a maximum of 20 domestic meters per bulk meter, though this depends on the distance between meters.

Whereas most system components, such as pipes and fittings, are rated for working pressures of 10-16 bar, UAW is substantially reduced if pressures in reticulation can be kept to below 5 bar (Section 3.4.5). Therefore if UAW is to be minimised, the pressure must be kept to a maximum of 5 bar, or substantial UAW must be accepted as unavoidable. On systems such as Emayelisweni high UAW levels due to high pressures render the system financially unsustainable therefore pressure must be reduced if the project is to survive. This issue has now been addressed at Emayelisweni.

(ii) Construction

If construction standards are not adequate then the life of the system will be compromised (Section 2.3.1). At Emayelisweni and Montebello 10% of the UAW was from leaking connections that had not been tightened sufficiently when they were constructed. Construction techniques and practices can have an effect on the UAW levels of a project although problems can take time to develop. It is important that construction workers are adequately trained and use appropriate techniques during construction to minimise unnecessary UAW levels.

(iii) Operation and Maintenance

If systems are metered then there still remain options as to how often meters should be read and how these readings should be analysed. In rural areas, where domestic water consumption is low overnight, night flow readings give a quick indication of constant flow rates that may be above normal consumption levels. Ideally, night flow readings should be carried out during the hours of darkness (Section 2.3.1) but research at Montebello showed that taking readings just before nightfall and just after sunrise gave results adequate enough to assess whether there were unacceptable leakage rates or not. Taking readings at these times was easier and safer for meter readers, and people were therefore more willing to do the job (Section 3.3.2).

There are many methods available for detecting physical losses (Section 2.3.1) but not all were found to be appropriate for the rural situation. Low-cost, low-tech solutions were more easily understood by local people, who were carrying out the detection. Visual inspections were easiest to carry out and often revealed sources of UAW. However, the most significant leaks detected were invisible, which agrees with the South African Water Research Commission Report (De Vallier and Broadhurst, 1997). From the research at Montebello and Emayelisweni it was found that invisible leaks could be investigated by local people by inserting a stick, or preferably a length of 10 mm reinforcing rod, into the ground near the pipe and checking to see if the stick was wet when withdrawn (Section 3.4.1). If this did not reveal the source of the leak then external advice was required to check tap pressures and dig for leaks. The stick method has the significant limitation that it can only be used if the ground is generally dry. From Montebello and Emayelisweni it was also found that most leaks occurred at pipe joints and connections, therefore it is suggested that for HDPe pipe, pipe markers are placed above ground at each joint, approximately every 100 m.

4.3 Needs Assessment of Water Supply Projects

The literature review of UAW management covered technical and financial aspects of UAW. A review of management procedures suggested that institutional support must be strong if communities are to manage water projects generally (Section 2.4). The initial reviews of the South African Basic Free Water policy suggest that this will be a significant social issue in the rural areas where the policy has not yet been implemented (Section 2.7) and a review of specific rural water supply projects highlighted the need to fully consider social and institutional aspects (Section 2.8).

An information gathering assessment on Montebello and Emayelisweni showed that even though the two projects are, in broad terms, the same there are specific technical, financial, social and institutional differences between them (Section 3.2). The assessment also highlighted that social issues, such as vandalism, working relationships and attitudes, can cause UAW and reduce the community motivation to manage UAW. These differences suggest that any UAW management policy for rural water supply systems must be flexible to accommodate any issues specific to each system.

Having accepted that these four issues must be considered, i.e. institutional, social, financial and technical, this research set out to determine the stakeholders' need for UAW management, their understanding of UAW and their views on appropriate and sustainable management methods.

The South African Code of Practice implies that the stakeholders are the WSA and the consumer (Section 2.6.3). Field research confirmed this but also showed that the water project committee acts as the Water Services Provider (WSP) and acts on behalf of the consumer.

4.3.1 The Need for UAW Management

The WSA needs to manage UAW as it is a requirement under the South African Code of Practice (SABS, 1999). Field research clearly showed that the WSP needs to manage UAW, as rural projects are financially very sensitive even to relatively small, internationally acceptable, levels of UAW. Other rural projects are known to be in catchments where the water resources are stretched and high UAW levels will result in an insufficient water supply to the consumers. This is best seen where projects are reliant on groundwater sources in marginal aquifers, a common scenario in South Africa.

4.3.2 Understanding of UAW

The general issue of UAW has been well researched internationally but the issue of rural UAW has received little attention. WSAs know their responsibility to manage UAW but do not understand the issues that make rural UAW management so different from general UAW management policies. WSAs consider UAW to be a financial issue and with the introduction of the Free Basic Water policy the WSAs see no incentive to reduce rural UAW where consumption levels are less than the Free Basic Water limit. However, the Free Basic Water policy has not yet been fully implemented and there are no clear signs of when it will be fully implemented. Also UAW is a catchment management issue as well as a financial one. From the field research it was shown that although communities may understand the need to manage UAW they do not understand what it is or what they can do about it. There is often the perception that the external support structures should be carrying out any management of UAW, as it is a maintenance issue.

4.3.3 Views on Appropriate and Sustainable Management Methods

The literature review outlines methods of management that include metering, leak detection and repair, pressure management and system maintenance. The South African Code of Practice (SABS, 1999) states that all these methods should be carried out by the WSA and outlines a strategy for managing leakage (Section 2.6.7). This strategy is aimed at WSAs and Municipalities. The Code states that simpler systems could be developed for village water committees but gives no guidance as to how these should be made appropriate to smaller situations. The strategy includes steps for monitoring leakage rates and identifying problem areas but does not include a step(s) to fix any problems encountered. However, this strategy is generally not dissimilar to the strategies developed at Emayelisweni and Montebello. Research of the rural situation shows that meter reading strategies are appropriate as metered systems have meter readers for billing purposes (Section 3.3.1). Appointment of an UAW committee is inappropriate to small systems but appointing one person, probably the existing administrator, to be responsible for UAW management is appropriate (Section 3.3.4). Reporting can be done to the water committee, which should be attended by the WSA at least on a quarterly basis, though at Montebello and Emayelisweni the WSA attends all monthly committee meetings. The most difficult part of the strategy to develop was the corrective action procedures, mainly because of the rural Zulu attitude that maintenance is unnecessary and is not the community's responsibility (Section 3.4.5). This is further evidence that rural UAW management is not wholly a technical or financial issue but also a social and institutional one.

4.3.4 Assessment Strategy

The assessment strategy devised to develop an understanding of rural UAW, the need to manage it and appropriate management methods, is as follows:

Step 1. The first step is background information gathering, which can be carried out through site visits and desk studies and should cover the institutional, social, technical and financial aspects of the project as discussed above. During the field studies a questionnaire format was used to collate the information gathered. This questionnaire was completed prior to development of the UAW management programme and a period of time after implementation to assess the progress of the programme.

Step 2. The second step concerns metering, including layout of meters, reading and analysis of readings. Issues to be considered here would be which personnel to employ and what the sufficient time period of readings is that allows an adequate assessment of the UAW situation. After analysing the meter readings the bulk lines should be prioritised for corrective action.

Step 3. The third step concerns the corrective action taken on lines with higher than acceptable values of UAW and includes leak detection methods and fixing encountered problems.

Step 4. The final step is to bring all the information gathered to a workshop. The workshop is for reporting the information gathered and developing an understanding amongst the stakeholders of UAW issues. Within the field research at Montebello and Emayelisweni one of the most useful workshop exercises was a participatory mapping exercise, as it had become clear from Steps 1 to 3 that the local understanding of the infrastructure layout of the systems was minimal, particularly with regard to bulk meters.

All stakeholders should be part of the assessment strategy, particularly the workshop, though the reality of this will depend on the commitment of individual stakeholders. At Montebello and Emayelisweni the water committee participation was, with persuasion, good, but WSA input was minimal.

This assessment strategy is designed to be similar to the UAW management programme so that where local personnel are trained and employed for the assessment strategy, particularly for Steps 2 and 3, minimal training will be required to implement the management programme. The workshop can be concluded by developing the UAW management programme.

4.4 Development of UAW Management Programme

The general UAW management programme is shown in Figure 4.1. The programme is basically the same as the assessment strategy, the main difference being that where there was a workshop in the assessment strategy there are now regular monthly water committee meetings. Although the number of meters should be adequate when the UAW management programme is implemented, additional bulk meters may be required if the project grows.

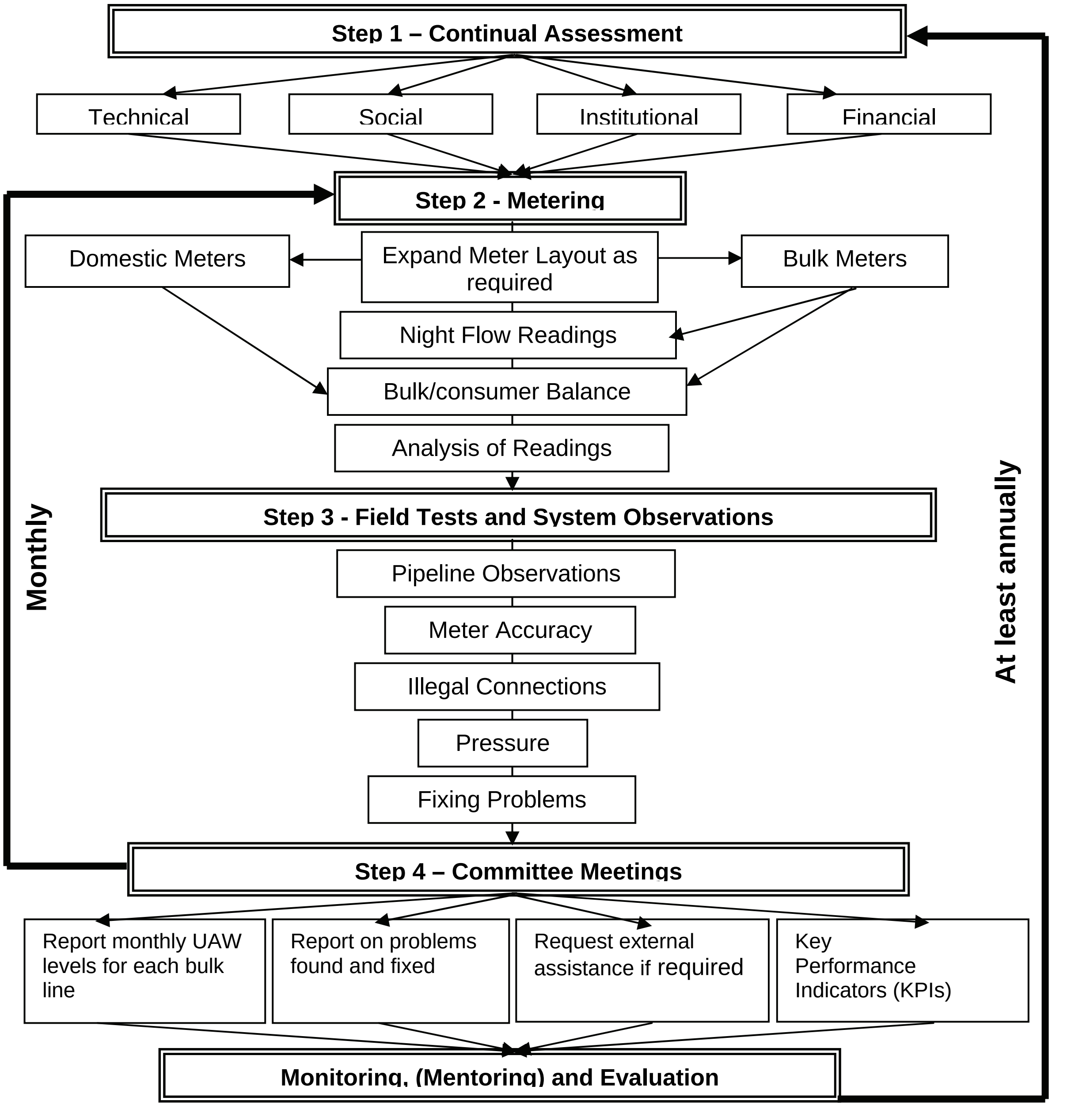


Figure 4.1 – UAW Management Programme

4.4.1 Acceptable UAW Levels

One aspect of developing the UAW management programme is to develop acceptable levels of UAW. Units of l/tap/day are understandable to the community water committees and are the units of measurement used internationally when calculating Unavoidable Annual Real Losses (UARL) (Section 2.5).

Table 4.1 – Unavoidable and Acceptable UAW Values

	UARL (l/tap/day)	Acceptable UAW (l/tap/day)	Average domestic consumption (l/tap/day)
Montebello	101	100	66
Emayelisweni	141	100	121

Table 4.1 shows the value of UARL, calculated using the formula in Section 2.5, the acceptable UAW from research carried out on the field studies as described in Section 3.3.5 and the average domestic consumption values from the monthly bills. It can be seen that the UARL figure for Montebello is about the same as the acceptable limit. By contrast, at Emayelisweni the UARL figure is higher than the acceptable limit. If the UARL figure was used at Emayelisweni the project would not be financially sustainable as the cost of losses up to 140 l/tap/day would outweigh the profits made each month.

4.4.2 Responsibilities

The WSA has overall responsibility to determine the extent of UAW and to reduce it. but they cannot justify the expense of carrying out this work in the field (Section 2.6.5). The UAW management programme is designed to be implemented from the 'bottom up' but to be used and understood by all stakeholders.

- Meter readers are responsible for reading meters regularly and accurately and taking readings to the project administrator or bookkeeper.
- The project administrator, or bookkeeper, is responsible for calculating the night flows and UAW levels from the meter readings, completing the Key Performance Indicators (KPIs) and reporting to the water committee. The administrator should also prioritise which pipelines need to be checked for leaks and report to local plumbers, or operators, for the initial pipeline checks to be carried out.
- The water committee is responsible for reporting to the WSA through the monthly committee meetings and through KPIs and for requesting external assistance where UAW issues are not resolved. The water committee is also responsible for the recruitment of meter readers, administrator, operator and plumbers.
- The WSA has a responsibility to ensure the UAW management programme is being implemented, through their monitoring and evaluation of the programme using KPIs, and to support the committees where necessary, both institutionally and financially.

This approach ensures that the WSA can carry out its responsibilities under the South African Code of Practice without spending excessive amounts on 'external experts' from outside the community and allows the WSP, usually the committee, to manage their projects effectively and efficiently.

4.5 Implementation, Monitoring, Evaluation and Mentoring of UAW Management Programme

4.5.1 Implementation

Implementation of the UAW management programme may require training (see Section 3.6). At Montebello and Emayelisweni training was required for reading bulk meters. The domestic meters just have numbers to read and these cause few meter reading errors. The bulk meters have both numbers and dials that both need to be read accurately, for night flow readings in particular. From the work carried out at Emayelisweni it was discovered that just writing down the number from the bulk meter meant that any reading errors could not be corrected.

A reading sheet was developed so that readers could copy the arrows on the dials and the numbers. Figure 4.2 shows a blank meter reading sheet and Figure 4.3 shows an example of a completed sheet. By drawing the meter face the administrator is able to check the meter reading given, especially if the administrator finds that the morning and evening readings do not correspond, e.g. if an error in the meter reading suggests that the meter is moving backwards.

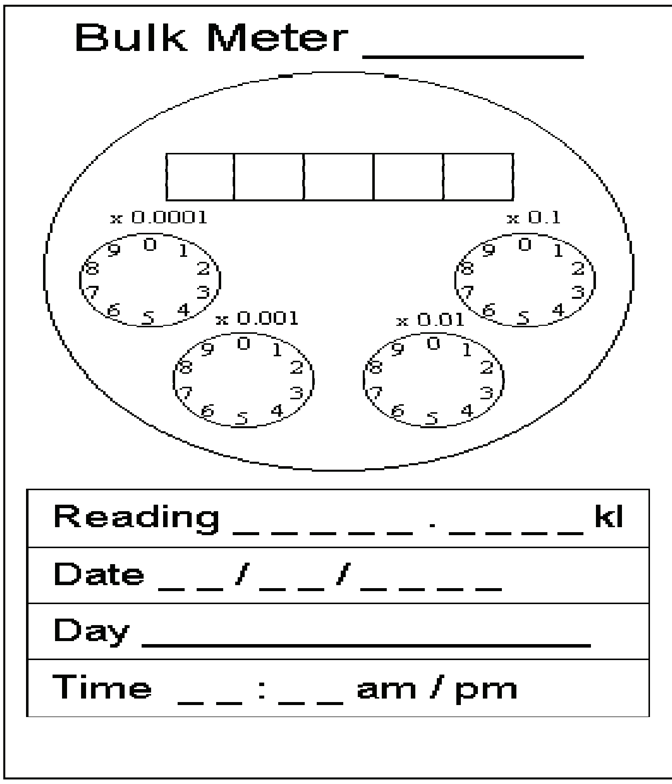


Figure 4.2 – Blank Bulk Meter Sheet

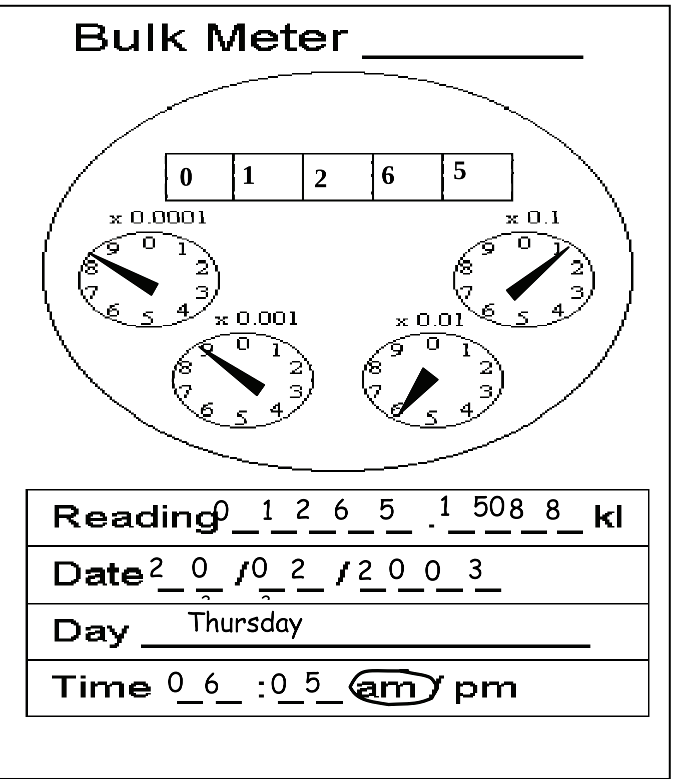


Figure 4.3 – Sample Bulk Meter Sheet

As discussed in Section 3.3.4, there were two implementation approaches used in the field studies as regards personnel employed. The first approach is to use external resources to fix any problems encountered during the UAW assessment. This approach was quicker in the short term in that problems were fixed within a couple of weeks of the assessment period. However, this approach did not utilise local resources and resulted in further training being required for implementation of the UAW management programme. The second approach was to use local resources to fix initial problems and use this time as a training period for the UAW management programme. This resulted in the initial problems taking over a month to be fixed but meant that the local understanding of the UAW management programme was higher.

The approach used will depend on the project. It is recommended that the second approach always be used where possible as the need for ongoing training is reduced. The main reason to use the first approach would be if the project were in such financial difficulties that immediate corrective action on the system was required, as in the case of Emayelisweni.

4.5.2 Monitoring

The use of KPIs (see Section 3.7) has already been implemented at Montebello and Emayelisweni as part of the overall project monitoring programme. KPIs can be specific to UAW and can record levels of water sold and water bought, or the difference between these, UAW. Other KPIs are also useful in monitoring the UAW management programme, e.g. monitoring the bank balance on a project such as Emayelisweni that is financially sensitive to UAW will highlight whether or not implementation of the UAW management programme is improving the financial stability of the project. The recent figures for UAW for Montebello and Emayelisweni are given in Section 3.1.

Again the use of KPIs is designed to fit into the general monitoring procedures for the water projects.

4.5.3 Evaluation

Evaluation of the UAW management programme can be carried out on two levels, by the water committee and by the WSA. KPIs can be understood by both the committee and the WSA and can serve as a link between both levels.

If simple KPIs are used to monitor the projects then both the committee and the WSA will be able to see at a glance whether the UAW management programme is effective or not. Monthly committee meetings, or further workshops, could then be used to discuss the programme and to develop it further, even by setting targets for system performance.

The administrators at Montebello and Emayelisweni were trained to chart KPIs, including those relating to UAW. Figure 4.4 shows an example of a typical KPI chart for UAW. These charts are completed on a monthly basis and are based on the information reported to each monthly committee meeting. The charts provided to the administrator are standard blank sheets with a title and gridlines. The administrator can then set the scale of the y-axis according to the chart drawn. Charts are completed with wax crayons.

If WSAs use the Specific Loss Rate (Section 2.2.5) to quantify UAW then values from the KPIs will be easy to convert. The UAW management programme therefore allows the WSAs to evaluate each individual programme by its own indicators and to compare different programmes under their responsibility.

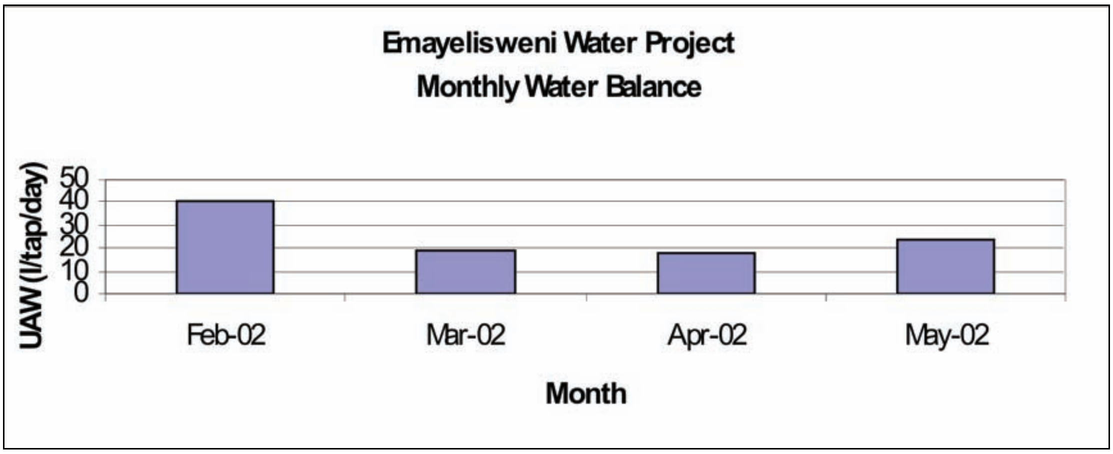


Figure 4.4 – KPI chart example

4.5.4 Mentoring

The time period allowed for mentoring will be specific to each project. If local people are used to carry out the UAW assessment strategy and then to develop and implement the UAW management programme then the level of further mentoring required can be assessed at an early stage. This involvement of local personnel should also reduce the need for further training.

The use of local personnel enhances the local understanding of the water system and the sense of ownership, which in turn increases the capacity of the water committees to be self-sustainable.

From the field studies it is generally expected that quite intensive mentoring will be required for the first two months of implementation of the UAW management programme. After this period any mentoring should be on an occasional level and will form part of the general project mentoring requirements.

As stated previously, the WSA has overall responsibility for UAW management and if mentoring is required the WSA must ensure that such support is provided and financed.

4.6 Summary

Management of rural UAW should be appropriate to all stakeholders, whether external or internal. Management of UAW will comprise a combination of proactive and reactive approaches depending on the financial loss due to UAW and the cost of reducing that UAW.

The appropriate level of technicality used to manage UAW will generally be low-cost and low-tech.

A needs assessment will determine the need for UAW management, the level of understanding of UAW issues and stakeholders' views on appropriate and sustainable management methods. This assessment will be specific to each project but the general strategy to follow is background information gathering, metering, field tests and system observations followed by workshops.

The UAW assessment strategy should be similar to the general UAW management strategy so that understanding of the programme can be developed through training at the assessment stage, minimising costs at the implementation stage.

Current international levels of acceptable UAW are not appropriate to rural situations. Levels will depend on the system infrastructure, catchment yield and financial situation of each project.

Although the WSA has overall responsibility for UAW management the implementation of the programme should be from the 'bottom-up'.

Monitoring, evaluation and mentoring of the UAW management programme should form part of the overall project monitoring, evaluation and mentoring procedures and KPIs are a useful tool that can be understood by all stakeholders. KPIs therefore help to involve both the committee and the WSA in the ongoing development and implementation of the management programme.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Very little research has previously been carried out on rural unaccounted-for water (UAW) management in South Africa or anywhere else in the world. Previous research on rural UAW and this research concludes that South African and international guidelines are not adequate or specific enough to cover rural UAW management. Current international levels of acceptable UAW are not appropriate to rural situations. Levels will depend on the system infrastructure, source yield and financial situation of each project.

The units of measurement primarily used in rural UAW management should be l/tap/day, which can easily be converted to l/km/hr, the specific loss rate, for use by Water Services Authorities (WSAs).

International guidelines and the South African Code of Practice recommend that systems be fully metered. These guidelines are not specific to rural situations.

The South African Code of Practice outlines the responsibility of the WSA to manage and reduce UAW in all situations, as UAW is a financial and conservation issue.

The Free Basic Water policy is likely to diminish motivation to reduce UAW. As the Free Basic Water policy has not yet been implemented in many rural areas, there is still a need to manage UAW in order that the water supply projects continue to be financially viable.

The management of UAW should involve all stakeholders but should be carried out by the community who would then report to the WSA through simple Key Performance Indicators (KPIs). The WSA should support the community in the implementation and continuous development of the management programme. KPIs should be time based and graphic for easy and quick understanding and reporting.

Management of UAW will comprise a combination of proactive and reactive approaches that will generally be low-cost and low-tech.

An initial assessment of the needs and capabilities of each project is required prior to development of the UAW management programme. The research carried out on the two case studies showed that varying institutional, social, technical and financial needs and capabilities make each project unique. Institutional support is crucial to the success of an UAW management procedure. Local understanding of UAW may initially be low to non-existent. UAW may best be understood by the local people if explained in financial terms.

Systems should be metered, as far as capital finances allow, though not all rural systems are currently fully metered. Where systems are metered, meter readings will form a part of the general project management procedure and can easily be expanded to include UAW management. One person within the community, possibly the project administrator, should be made responsible for collating meter readings and carrying out the necessary calculations.

The UAW at Emayelisweni and Montebello was mostly due to leakage from poor joints exacerbated by high pressures. Domestic meters were accurate, with the exception of a few non-recording meters, and there was little evidence of illegal connections though there were problems with a small proportion of unbilled meters. There were occasional problems from neglected maintenance and this should be addressed through ongoing training. If UAW is to be reduced, pressure must be kept to a suggested maximum of 50 m, and this should form part of the initial project design. Communities need an adequate technical support structure and an understanding of the need for urgency in reporting and fixing problems.

Interactive workshops are a useful tool in involving all stakeholders in the development of the UAW management procedure.

Training required for implementation of the UAW management procedure can be minimised if local people are involved in the initial assessment of UAW. Ongoing external support is required in monitoring and evaluating the procedure but this can be part of the general mentoring process.

For future projects, the UAW management procedure should be developed during the planning phase, as part of the overall project management procedure.

This research project has achieved all its objectives and has resulted in an UAW assessment strategy and UAW management programme that can easily be adapted to other rural water projects. The primary lesson learnt from the two case studies was that utilising local people as much as possible improves their sense of ownership, the sustainability and the success of the UAW management programme, even though implementation of that programme may take longer due to necessary training and mentoring.

5.2 Recommendations for Further Study

It is recommended that Montebello and Emayelisweni water projects be evaluated after one year of implementation of the UAW management programme to assess the effect of the programme on UAW levels and on the projects generally.

It is further recommended that the UAW assessment strategy and UAW management programme shown in Figures 4.1 and 4.2 be applied to other rural water projects primarily within the KwaZulu-Natal region, and after further review and necessary improvement, to other rural water projects outside this region.

It is also recommended that the possible use of schools as a link between the community and the local water committees be developed as a separate research project.

6 REFERENCES

Cairncross S, I Carruthers, D Curtis, R Feachem, D Bradley and G Baldwin. 1980. *Evaluation for Village Water Supply Planning*. WHO. The Hague, Netherlands.

Churchill AA. 1987. *Rural Water Supply and Sanitation – Time for a Change*. World Bank. Washington.

Cyllok M. 2000. *Water Loss Management: Benchmarking the Performance of Rural Water Supply Schemes in South Africa on Water Loss Management*. Pietermaritzburg. Republic of South Africa.

De Vallier W. 1997. *Unaccounted-for Water: Guidelines for the Formulation of a Policy and Implementation of Practical Methods for the Control Thereof*. Report 489/2/97. WRC. Pretoria. Republic of South Africa.

De Vallier W and DW Broadhurst. 1997. *The Development of Procedures for the Control of Unaccounted-for Water in Water Distribution Systems and for the Reduction of Water Loss*. Report 489/1/97. WRC. Pretoria. Republic of South Africa.

DWAF. 1997a. *RDP Rural Water Supply Design Criteria Guidelines – First Edition*. Pretoria. Republic of South Africa.

DWAF. 1997b. *Water Services Act (No. 108 of 1997)*. Republic of South Africa.

DWAF. 2000. *Water Resources Availability and Utilisation in South Africa*. Republic of South Africa.

DWAF. 2001a. *Our Vision, Our Mission, Our Values*. http://www-dwaf.pwv.gov.za/mission.htm#Our%20Vision

DWAF. 2001b. *Press Release of 14th Feb 2001*. http://www-dwaf.pwv.gov.za/Water%20Services/Tarifftool/html/MinPressRelease14thFeb2001.htm

Fortmann L. 1983. *Managing Seasonal Man-made Water Sources: Lessons from Botswana*. Waterlines Vol. 1 No. 4, April 1983.

Guardian. 1999. *Those Winds of Change - South Africa Needs Justice*. Guardian Newspaper Article Jan 9th 1999. Manchester. United Kingdom.

ITDG. 1980. *Guidelines on Planning and Management of Rural Water Supplies in Developing Countries*. Appropriate Technology Vol. 7 No. 3 December 1980. The ITDG Water Panel.

Jeffcoate P and A Saravanapan. 1987. *The Reduction and Control of Unaccounted for Water – Working Guidelines*. World Bank Technical Paper Number 72. Washington.

Lambert A, TG Brown, M Takizawa and D Weimer. 1999. *A Review of Performance Indicators for Real Losses from Water Supply Systems.* AQUA.

Lambert A and W Hirner. 2000. *Losses from Water Supply Systems: Standard Terminology and Recommended Performance Measures*. International Water Association.

McKenzie RS and Lambert A. 2002. *Benchleak User Guide Version 1.1. Development of a simple and pragmatic approach to benchmark real losses in potable water distribution systems in South Africa*. Water Research Commission.

Netshiswinzhe B and A Potter. 2000. *Developing Community-based Monitoring and Evaluation Tools for Rural Water and Sanitation Projects*. Mvula Trust. Braamfontein. Republic of South Africa.

Pearson I. 2000. *Rural Water Supply Projects – Check List No. 4 – Operation and Mentorship Stage*. Draft Report 3. Johannesburg. Republic of South Africa.

SABS. 1999. *South African Standard Code of Practice. The Management of Potable Water in Distribution Systems*. Pretoria. Republic of South Africa.

Saunders RJ and JJ Warford. 1976. *Village Water Supply, Economics and Policy in the Developing World.* World Bank. Washington.

Shepherd M. 2001. *Free Water – Necessity is the Mother of Innovation*. Civil Engineering – June 2001. Republic of South Africa.

Stephen DA and DA Still. 2000. *Performance Indicators used for a Rural Water Supply Scheme in KwaZulu Natal, South Africa - A Case Study*. Umgeni Water and Partners in Development. Republic of South Africa.

Still DA. 2001. *Free Basic Water in Rural Areas: Is it Feasible? – A Perspective from KwaZulu Natal*. Presented at a WISA Seminar, March 8 2001. Republic of South Africa.

Twort AC, DD Ratnayaka and MJ Brandt. 2000. *Water Supply 5th Ed*. Arnold. London.

Umgeni. 2001. Umgeni Water South Africa – *Our Operations*.
http://www.umgeni.co.za/operations/index.html

Welton RJ and SJ Goodwin. 1984. *The Accuracy of Small Revenue Meters*. Report TR 221. WRc. United Kingdom.

Water Supply and Sanitation Collaborative Council (WSSCC). 2000. *Vision 21 in Brief – The People's Route to Water, Sanitation and Hygiene for All*. WHO. Geneva. Switzerland.

Wyatt A. 1991. *Water Loss in Rural Water Systems in Developing Countries*. WASH Field Report No. 341. Washington DC. United States of America.

Appendix A

Unaccounted-for Water Management Programme Development

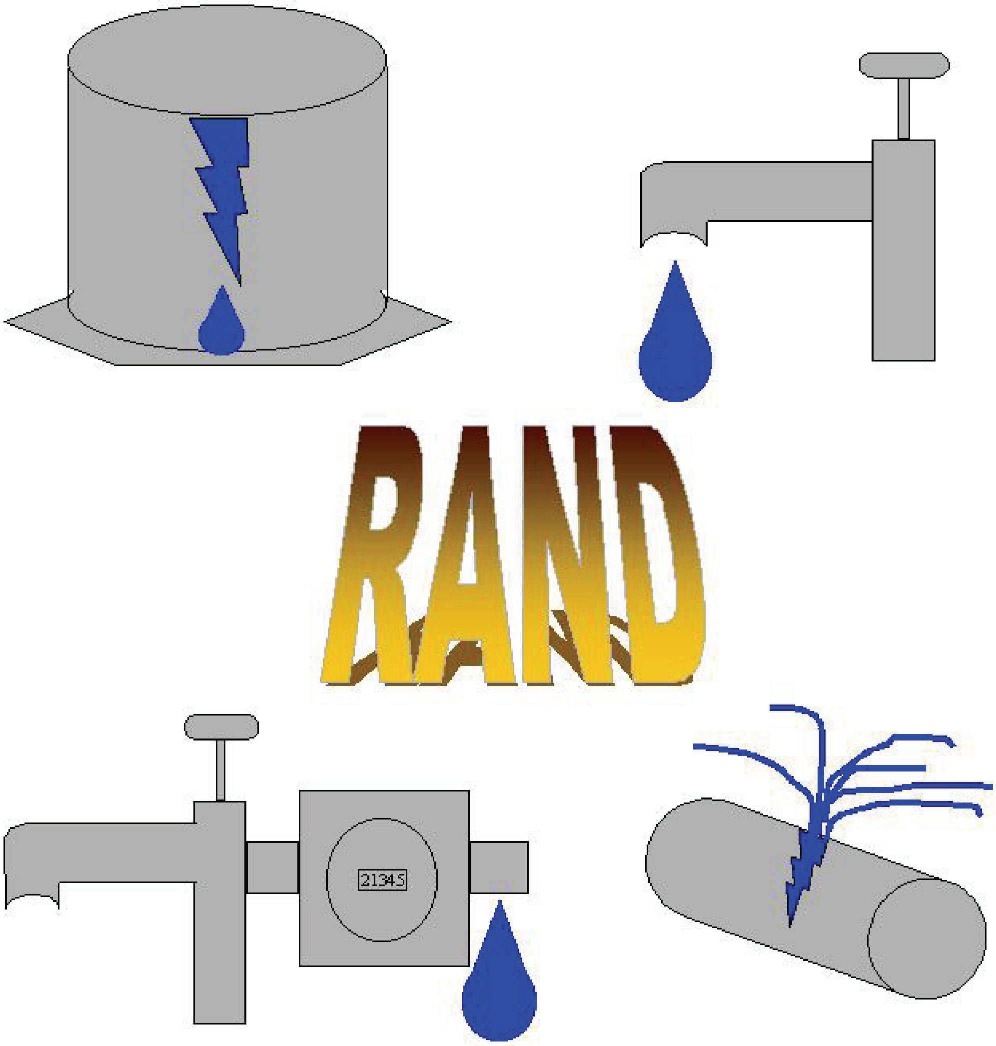
Workshop Agenda

Water Loss Management

Agenda

1. Why Reduce Losses?
2. Who Lives Where?
3. Where Does the Water Go?
4. What Can We Do?
5. How We Will Manage Losses.
6. How We Will Pay for Management.

Why Reduce Water Losses?

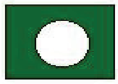


Who Lives Where?

Draw a map of Emayelisweni

Mark/show on it the following:

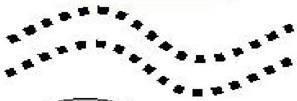
Emayelisweni bulk meter



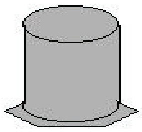
Emayelisweni school

Water Office

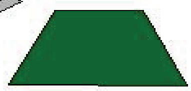
Main roads



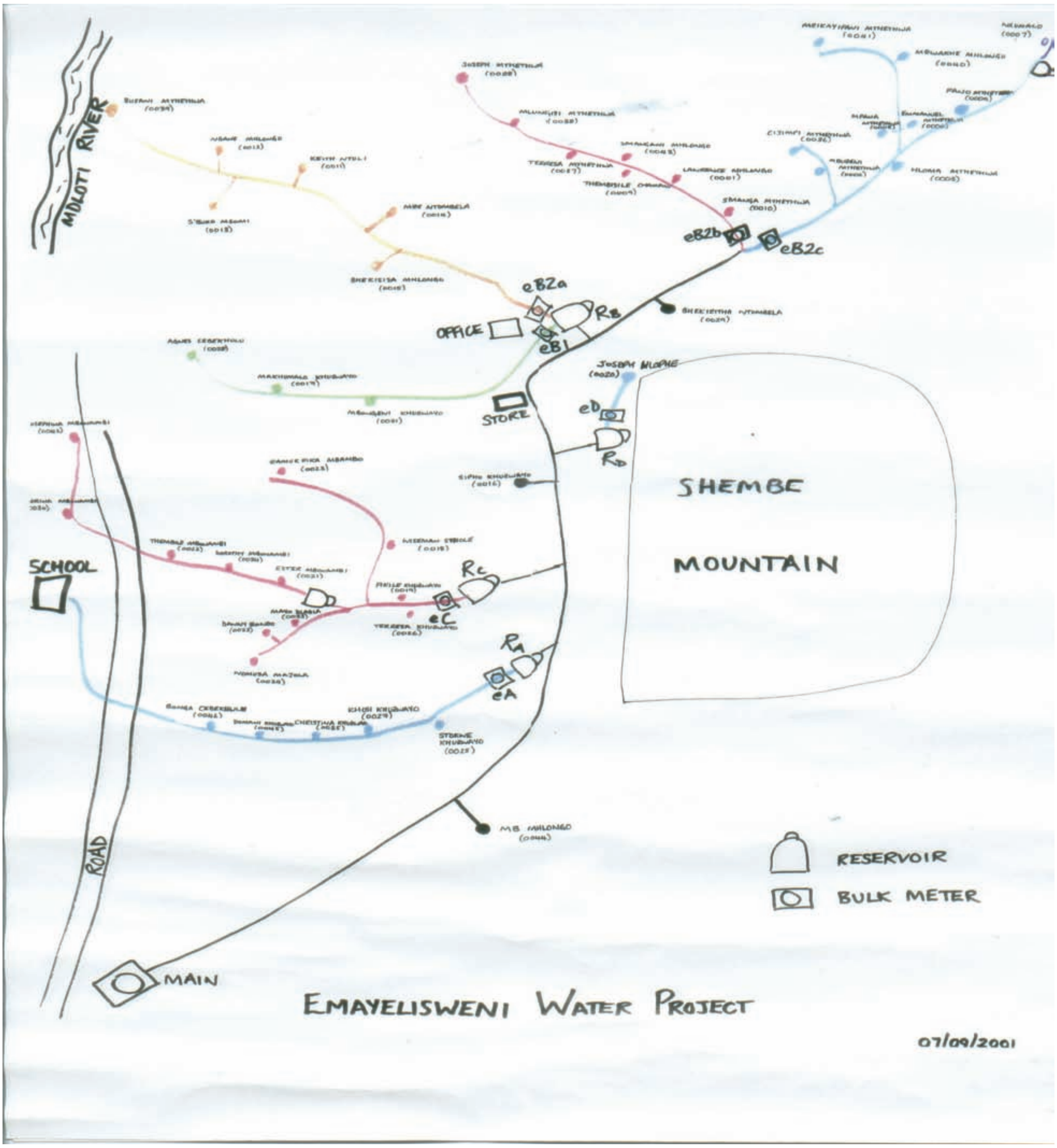
Reservoir Tanks



Shembe Hill

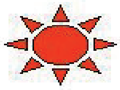


Houses with taps
(show project account number)

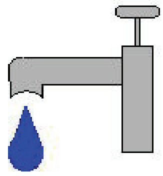


MDLOTI RIVER
ROAD
SCHOOL
OFFICE
STORE
SHEMBE
MOUNTAIN
eB2a
eB2b
eB2c
eB1
eD
eC
eA
MAIN
RESERVOIR
BULK METER
EMAYELISWENI WATER PROJECT
07/09/2001

Where Does all the Water Go?

Each day: 

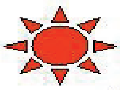
Each house: 

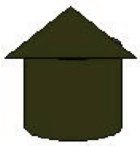


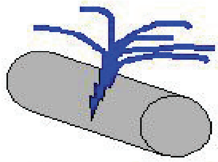
Uses, on average:

25l	25l	25l	25l	25l

125l

Each day: 

Each house: 

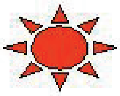


Loses, on average:

25l	25l	25l	25l	25l	25l	25l	25l	25l	25l
25l	25l	25l	25l	25l	25l	25l	25l	25l	

475l

Where Does all the Water Go?

Each day: 

The Project makes	+	R20
but spends	-	R40
= Overall loss per day of	-	R20

This means:

R600

PER MONTH

LOSS

What Can We Do?

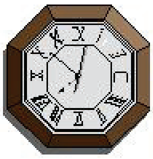
We need to:

1. **Increase Income**

2. **Reduce Unnecessary Expenditure**

What Can We Do?

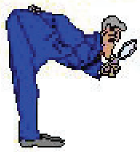
1. **Night Flow Readings**



Most people do not use water during hours of darkness, therefore,
Read bulk meters at sunset and then at sunrise the following day, difference in readings is night flow.

2. **Walk Pipeline Routes**

Where we know that a pipeline has a high loss, we can check that pipeline for leaks on:



- Taps
- Meters
- Valves
- Pipe itself (possible damp patches on ground)

Where leaks are found they should be fixed as quickly as possible.

3. **Domestic Meter Readings and Bulk Meter Readings**

The difference in bulk consumption from the bulk meter readings and the domestic consumption from the domestic readings is the amount of water loss (unaccounted-for water) on that section of pipeline.

4. **Calculations**

Steps 1 and 3 require calculations to be done.
It is not possible to reduce all water losses, so we must know if the amount of water lost is above or below an acceptable level.

5. **Call Experts**

Where leaks are found but cannot be fixed, it is important to call someone who can fix the problem as soon as possible.
Where a pipe is known to have a leak but the leak cannot be found, it is important to call someone who can find the leak as soon as possible.

How We Will Manage Losses

How We Will Pay for Management

Possible Options:

1. Increase tariff
2. Encourage more domestic consumption
3. Increase number of connections
4. Introduce fines for late payment of water bill
5. Review wages, e.g. plumber costs
6. Reduce transport, stationery costs