UNIVERSITY OF KWAZULU-NATAL

A study of Non-Revenue Water Management in Lidgetton, uMgungundlovu District Municipality in KwaZulu-Natal.

By

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Abstract

Non-Revenue Water management is a global challenge affecting developing and developed countries and it is one of the vital elements of water management for any water service providers and Water boards. One of the communities affected by Non-Revenue Water is Lidgetton Township which is situated in UMgungundlovu District Municipality, KwaZulu-Natal Province. It is a complex task to quantify and characterize water losses. This study investigates possible methods that can be used in Lidgetton to manage Non-Revenue Water, and the state of readiness for the municipality in measuring and monitoring both aspects of water losses, real and apparent. In this study an attempt is made to identify the causes of high water consumption in Lidgetton Township by assessing the awareness level of municipal employees, and policies used by the municipality to manage Non-Revenue Water. Questionnaires were distributed to 115 municipal employees from different sections involved in Non-Revenue Water management, and only 110 were returned. Each questionnaire had 53 questions in total, and was divided into four sections. The data that was collected from respondents was analysed using SPSS version 22.0. A high percentage of respondents believed that water loss can be calculated in general. However, responses showed that few believed that the municipality has sufficient technical capacity to monitor water usage. Almost half of them respondents do not think that the municipality takes Non-Revenue Water management seriously. The results also show that more than half of respondents think that the municipality should focus on real losses in order to reduce NRW. It is therefore recommended that in order for the municipality to manage Non-Revenue Water it must acquire equipment that can detect leaks and also measure water usage vigorously. Policies addressing water losses and water usage should be promulgated, adopted by the full council and implemented consistently. It is also recommended that all municipal employees involved in Non-Revenue Water management related tasks be trained to manage Non-Revenue Water, regardless of their position and department they are in. Amongst the many methods of measuring Non-Revenue Water, there are some methods which are not suitable to be used in Lidgetton due to the type of existing water and sanitation infrastructure.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

This study examines methods of Non-Revenue Water (NRW) management used in the water sector industry and highlights those which may be suitable for use in Lidgetton, and also those which are not. It sought the views of uMgungundlovu District Municipal (uMDM) employees and analysed them using reliable data collection methods. Recommendations emanating from the research are then provided at the end of this study.

This chapter outlines the importance of the study, its focus and the questions that the study sought to answer. It also outlines what was done throughout the study in order to answer the research questions, and also highlight the limitations that were encountered.

1.2 Background

According to Walter, Kloos and Tsegai (2010) water is the most essential of all natural resources; it is indispensable for human beings, economic development and biological diversity. It is therefore necessary that water usage be investigated and calculated in all water supply schemes. Currently, there is no water management system that has been adopted and implemented by the uMgungundlovu District municipality that's addresses Non-Revenue Water (NRW). It is, however, clear that water wastage is high in Lidgetton. A policy position of the municipality has to be investigated and its effectiveness, as well as the capacity of the municipality in terms of technology, human resources and skills on NRW management.

1.3 Motivation of the study

This study attempts to assist uMgungundlovu District Municipality (uMDM) and Government at large to focus on the core aspects of Non-Revenue Water (NRW), and also encourage the uMgungundlovu District Municipality to reduce water loss in its Lidgetton water supply scheme and other water schemes within the municipality. Currently, the uMDM is speculating, because there is no study that has been conducted in the area that addresses water consumption and NRW. The uMDM should be able to focus its energies in solving NRW management issues based on informed research like this one carried out in this study.

Without proper research and guidance, the uMDM, Department of Water Affairs and community at large may find themselves wasting a lot of resources trying to rectify a problem that has not been well investigated.

1.4 Focus of the study

The focus of this study is Non-Revenue Water management in Lidgetton Township, in uMgungundlovu District Municipality in KwaZulu-Natal Province. This study investigates methods that can be used by municipal employees to manage NRW. There are several methods that can be used to investigate and calculate NRW. These methods are discussed in conjunction with the existing water and sanitation infrastructure at Lidgetton. The study involved municipal employees, who are involved in water and sanitation related activities.

This study excludes water quality and the intermittent supply of water in Lidgetton area. It also does not focus on the processing of water during the purification stages at the water treatment works; it only deals with water from the outlet at the water treatment works.

1.5 Problem statement

The World Bank estimates that in developing countries, water leakage is about 45 million cubic meters per day (m^3/day) (Kingdom, Liemberger, and Marin, 2006). Also, roughly 30 million m^3 of water per day is not paid for (Wyatt, 2010). The uMDM is not immune to this pandemic. According to the Note 21 of the audited financial statement, the municipality incurred water losses of up to 567 486 kilolitres of water valued at R1.8 Million during the 2008/2009 financial year (Auditor General, 2009). The Auditor General's (2009) report further states that the uMDM is consuming high volume of unaccounted for water, which also creates a negative impact for the municipality in obtaining a clean audit.

According to the Department of Water Affairs (DWA) design standards, Lidgetton Township should be consuming 25 litres of water per person per day, however currently the consumption is estimated at 46.32 litres of water per person per day, and this is higher than what the system was designed to produce.

This study also seeks to answer the question related to the commitment and capability of the municipality in trying to reduce NRW consumption in Lidgetton.

1.6 Objectives

The main objectives of this study are:

- To identify the current NRW assessment methods and management policies adopted by uMgungundlovu District Municipality
- To identify whether the uMDM is proactive or reactive towards NRW management in Lidgetton.
- To measure uMDM's employee's awareness of NRW from different sections that are involved in NRW management.
- To analyse the breakdown for NRW components (apparent losses, real losses, and unbilled authorized consumption) with respect to distribution system of Lidgetton Water Scheme.

Technical, social and financial aspects of the Lidgetton water scheme were investigated in trying to achieve these objectives. Finally, NRW components' prioritization and management recommendations are made at the end of the study.

1.7 Research Questions

There are four research questions that this study attempts to answer. The aim is to get an understanding of the current situation of NRW at Lidgetton, and proposals being made to reduce NRW. These questions are:

- What are NRW assessment methods and reduction policies adopted by the uMDM?
- What is the Infrastructure Leakage Index, of NRW in the distribution system of Lidgetton?
- At what level is the current awareness level of NRW issues of the employees of the NRW-related departments in the uMDM in its different managerial and operational levels?
- How does the uMDM determine NRW, apparent losses, real losses and unbilled authorised consumption of its water distribution network?

1.8 Justification of the study

As part of the overall Water Conservation/Water Demand Management (WC/WDM) strategy, the uMDM recognizes the need to focus on the reduction of NRW as well as its contribution towards the objectives of National Water Conservation/Water Demand Initiative (WC/WDM) initiative currently underway throughout South Africa in support of the protection of scarce water supply resource (Joat group, 2010).

It is therefore vital for the uMDM to implement a WC/WDM program in Lidgetton which has been identified as an area of concern with regards to the volume of water consumed on a daily basis. There is no official document that addresses NRW in Lidgetton. This necessitated a review of the existing literature to get a better understanding of challenges about NRW. It is vital to gather information on this issue in order to be able to assess the situation in Lidgetton more scientifically in line with approved international standards and principles.

The municipality will also use this study to do introspection in terms of the whole water supply chain process to their communities. In essence, through this study, the municipality will have a research document that may be used on a daily basis as a point of departure in dealing with water loss and NRW management.

This study also seeks to assist the uMDM authorities regarding the development and implementation of policies that attempt to address the NRW management. Each and every water supply scheme is unique; however, the findings and recommendations of this study may also prove crucial in addressing NRW management issues in the whole water distribution system within the uMDM.

1.9 Limitations of the study

Availability of technical data is limited and very difficult to get hold of. The area is not zoned; therefore it’s a challenge to use methods requiring District Metered Areas (DMA), and currently the equipment used to collect technical data required to monitor NRW is limited.

Communal standpipes are not metered, and therefore consumption can only be estimated in those areas using them. Lidgetton Town does not have a waste water treatment plant; they are using septic tanks to dispose of their sewerage. Therefore it was difficult to use the reverse approach equation to calculate leakage in the system, because this method requires volumes entering the sewerage in order to balance the equation.

Although meter readings are read and captured for the households, in some cases it was not done on a monthly bases, and in such cases the finance department estimates averages to calculate consumption.

1.10 Summary

It is vital that water services authorities and water boards be made aware of challenges s of managing NRW. A need to investigate NRW in Lidgetton was identified and there are methods that can be used to calculate and monitor NRW. The type of method used depends on the type of infrastructure amongst some of the requirements. These methods are discussed in the next chapter. The study will also investigate the current awareness level of municipal employees in relation to NRW management, and the level of commitment by senior management regarding approval and implementation of policies and by-laws. The municipality can also consider important views on NRW found in research that has been done by other experts discussed under literature review in the next chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter discusses the views of organisations and experts of NRW management nationally and internationally. It also looks at the set standards and norms that have been created and used to assist Water Service Authorities (WSA) in managing NRW effectively. The aim is to ascertain strategies that have been used y to tackle the issue of Non-Revenue Water (NRW) globally. The evaluation of strategies is part of the process to develop an effective plan to reduce water loss. Different types of approaches used to assess water losses have been revisited as well as the challenges to develop strategies identified in other studied cases.

2.2 Theoretical literature

A few years ago the NRW was not calculated in many organisations throughout the world. In developing countries where it was calculated, there was no standard procedure and terminology for it (Frauendorfer and Liemberger, 2010). This was up until the national associations adopted an International Water Association (IWA) standards and terminology (Frauendorfer and Liemberger, 2010).

Zaier (2010:27-28) argued that human factor and organisations play a major role in the NRW reduction and that failures are related to the following causes:

- Bureaucracy
- Inflexibility in the organisation
- No clear objectives
- Non rewarding of individual performance
- Insufficient staff training
- Lack of staff empowerment
- Lack of reporting

(Zaier, 2010) further explains the consequences of these deficiencies; they translate externally into customers being unsatisfied by the quality of service and an absence of motivation and interest in the work for the internal customers, and as a result human resources has to work through various control levers to ensure that there is a strong will of membership of the staff actions of progress.

The starting point in trying to curb water loss is to first measure it. In Algeria, city of Souk Ahras, for example, the water loss was reported to be at 55% (Sid, 2010). Sid (2010: 37) argued that due to a high volume of water loss, a serious intervention was needed in the city of Souk Ahras. His recommendations followed the trend by other writers who mainly focus on the system itself and not the other factors, like human factors and organisational situations as discussed by Zair Hocine above.

South Africa has 37% of Non-Revenue Water, which is well within the global average of 36.6% (Mckenzie, Siqalaba, and Wegelin, 2012). However, this global average is largely dominated by countries that are not water strained. Countries with scarce water resource like Australia have 10% of NRW (Mckenzie, Siqalaba, and Wegelin, 2012).

Previous research by Mckenzie, Siqalaba, and Wegelin (2012) showed that there is still high use of water per capita, which is estimated at 273 litres per person per day. This statement therefore backs the argument that the human factor can also play a critical role in the reduction of water loss and NRW.

Looking at what happened in Tampa Water Services Department in Washington DC, it is a good case study of the impact of human factor in the increase of water consumption. Their consumption of water increased to beyond 82 MGD which was their maximum limit to draw from the river abstraction. This was due to an increase in population which was estimated at 640 000 people in their area of service (Pickard, Vilagos, Nestel, Fernandez, Kuhr, and Lanning, 2008).

2.3 Strategy to reduce NRW

Real losses (physical losses) and apparent losses (commercial or administrative losses) have synergetic negative impacts on the overall performance of the Water Service Provider (WSP) (Ranhill Utilities Berhad and USAID, 2008). While real losses cause increase of the operating costs and larger investments, the commercial losses reduce the utility revenues, and this has been illustrated by Ranhill and USAID (2008) by drawing vicious and virtuous circles (Figure 2.1 and Figure 2.2 respectively).

Figure .2.1 Vicious NRW circle

Adapted from Ranhill Utilities Berhad and USAID. (2008). *The Manager's Non-Revenue Water Handbook.* Bangkok: United State Agency for International Development.

The vicious circle above in Figure 2.1 shows that increasing NRW level would lead to more production cost and simultaneously less revenues, and this, in turn; causes increased spending of the current budget to meet high demand on the cost of maintenance of the system (Ranhill Utilities Berhad and USAID, 2008). Improper maintenance causes NRW to increase and so forth; this remains a challenge for the WSP whose main purpose is to transform the vicious circle to the virtuous one (Ranhill Utilities Berhad and USAID, 2008).

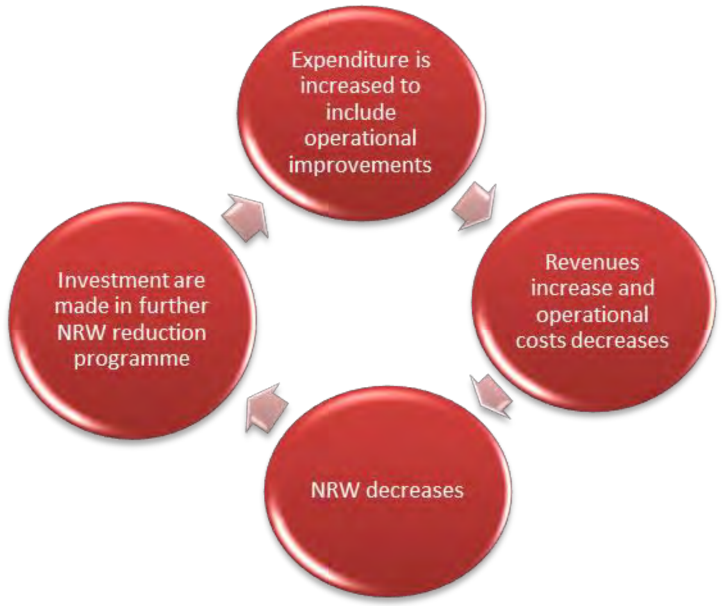

Figure .2.2 Virtuous NRW Circle

Adapted from Adapted from Ranhill Utilities Berhad and USAID. (2008). *The Manager's Non-Revenue Water Handbook.* Bangkok: United State Agency for International Development.

According to Dr (Abu-Zeid, 2000) a virtuous circle as shown in Figure 2.2 above may be realised where users pay for the services efficiently and accountably, and where they pay the costs of these services, in which investors place their money, and in which tax payers money is used primarily for public purposes. In order to help make a transaction from the vicious circle to virtuous circle, creativity will be essential, political commitment, and adaptation of local circumstances, as it was experienced by the city of Conakry in Guinea, it showed that a crucial element will be to use targeted, time-bound subsidies to attract first-class service providers who can be paid the costs of their services and can provide users with high-quality services (Abu-Zeid, 2000).

Research by the United State Agency for International Development, (2013) has shown that USAID is planning to tackle water global challenges in close cooperation with Non-Governmental and civil society organizations that assume the critical frontline obligation of developing and executing water programs.

This will involve forming a working relationship between advocacy groups that carry both knowledge and passion, (Marin, 2009) further argues that if a system is managed efficient and effectively, it improves services, leads to increased investments because customers will be more willing to pay for services and it becomes easier to raise tariffs and improve revenue collection if customers are convinced that their tax money and revenue collected from their bills is appropriately used, thus making it more feasible for the WSA to attract more investments (whether from Government, donors or banks) which, in turn increases the customer base and enhances cash flows.

2.4 Planning and implementing a Non-Revenue Water strategy

South Africa has developed one of the best complex water resource networks led by a progressive water resource planning department within the Department of Water Affairs (Mckenzie and Wegelin, 2008).

According to (Ranhill Utilities Berhad and USAID, 2008) WSP's should use a diagnostic approach, and this applies to all WSP's throughout the world, followed by implementing solutions that are feasible and attainable to decrease NRW by asking five relevant questions (as stated below and further explained in Figure 2.1) and also the understanding of the network system and operating practices. the five relevant questions to be asked in trying to understand the network are:

- How much water is being lost?
- Where are losses occurring?
- Why are losses occurring?
- What strategies can be introduced to reduce losses and improve performance?
- How can we maintain the strategy and sustain the achievements gained?

A summary of tasks required to address each question is illustrated in Table 2.1 below.

Table 2.1: The tasks and tools for developing a NRW reduction strategy

No.	QUESTION	TASK
1	HOW MUCH WATER IS BEING LOST? – Measure components	WATER BALANCE – Improved estimation/measurement techniques – Meter calibration policy – Meter checks – Identify improvements to recording procedures
2	WHERE IS IT BEING LOST FROM? – Quantify leakage – Quantify apparent losses	NETWORK AUDIT – Leakage studies (reservoirs, transmission mains, distribution network) – Operational/customer Investigations
3	WHY IS IT BEING LOST? – Conduct network and operational audit	REVIEW OF NETWORK OPERATING PRACTICES – Investigate: historical reasons ➢ poor practices ➢ quality management procedures ➢ poor materials/infrastructure ➢ local/political influences ➢ cultural/social/financial factors
4	HOW TO IMPROVE PERFORMANCE? – Design a strategy and action plans	UPGRADING AND STRATEGY DEVELOPMENT – Update records systems – Introduce zoning – Introduce leakage monitoring – Address causes of apparent losses – Initiate leak detection/repair policy – design short/medium/long term action plans
5	HOW TO MAINTAIN THE STRATEGY?	POLICY CHANGE, TRAINING AND O&M Training: – improve awareness – increase motivation – transfer skills – introduce best practice/technology O&M: – community involvement – water conservation and demand – management programmes – action plan recommendations – O & M procedures

Adapted from Farley, M. (2003). Non-Revenue water - International best practice for assessment, monitoring and control. 12th Annual CWWA Water, Wastewater and Solid Waste Conference (pp. 1-18). Bahamas: Malcolm Farley Associates.

Figure 2.1 above shows a guide that is used to develop NRW reduction strategy by aligning each question with a relevant task that can be used to answer the five questions.

2.4.1 Water balance: Amount of water lost

The IWA, through it task force has developed a standard method to be used throughout the world to do a water balance, and this answers our first question, which is; **"how much water is being lost"** as shown in Table 2.2 (Roland and Farley, n. d.). The development of a water balance is naturally based on a rough appreciation of the Apparent losses and a direct evaluation of Real Losses by measuring the minimum night flows (the top-down approach and the bottom up approach), this method normally produces good results if the information required is available to measure the minimum night flow (Vermersch and Rizzo, 2008).

Table 2.2: The IWA best practice standard water balance

System Input volume	Authorized Consumption	Billed Authorised Consumption	Billed Metered Consumption	Revenue water
			Billed Unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled metered consumption	Non-Revenue water
			Unbilled Unmetered consumption	
	Water Losses	Commercial losses	Unauthorized Consumption	
			Customer Meter Inaccuracies and data handling errors	
		Physical losses	Leakage on transmission and distribution mains	
			Leakage and overflows from the utilities storage tanks	
			Leakage on service connections up to the customer meter	

Adapted from United State Agency for International Development. (2013). *Water and Development Strategy.* Washington: USAID.

De Bruin, Meer, and Tilburg (2010) describes NRW as the amount of water that is produced and is “lost” somewhere in the system before it reaches its intended destination, in other words NRW is the difference between the volume of water that flows into a water distribution system and the portion that is billed to customers, NRW is made up of three components (real losses, apparent losses and unbilled authorised consumption) as shows in Table 2.2

NRW = System Input Volume - Billed Authorised Consumption

This equation assumes that:

- System input volume has been corrected for any known errors
- The billed metered consumption period for customer billing records are consistent with the System Input Volume period (Ranhill Utilities Berhad and USAID, 2008).

Water Service Authority (WSA) or technical managers should use the above water balance format to calculate each component and to determine where water losses are occurring from, as described in the next sections, (Ranhill Utilities Berhad and USAID, 2008). The task of managing NRW starts at the outlet meter at the water treatment works to a customer meter; therefore it is the task of everyone within the operations and maintenance team. They will be required to make necessary changes to the policies, and also implement those changes (Ranhill Utilities Berhad and USAID, 2008).

2.4.2 Water balance component: sections that are losing water in the water distribution system

Abbreviated definitions of principal components of the IWA water balance are as follows:

- System Input Volume is the annual volume input to that part of the water supply system.
- Authorised Consumption is the annual volume of metered and/or non-metered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorised to do so. It includes water that is exported, and leaks and overflows after the point of customer metering.
- NRW is the difference between System Input Volume and Billed Authorised Consumption. NRW consists of:
  - Unbilled Authorised Consumption (usually a minor component of the Water Balance)
  - Water Losses
- Water Losses is the difference between System Input Volume and Authorised Consumption, and consists of Apparent Losses and Real Losses
- Apparent Losses consists of Unauthorised Consumption and all types of metering inaccuracies
- Real Losses are the annual volumes lost through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering (Roland Liemberger and Farley, n. d.).

2.4.3 Review of network operating practices: Reasons for losing water

Roland Liemberger and Farley (n. d.) Argues that the question "**why is water being lost**?" can be addressed by a review of the network and the way it is operated. This reflects the organisation's management of its network, and it can be appraised by carrying out a review of the physical characteristics of the network and the current operational practice. The aims of the review should be to show good practices, as well as the challenges caused by poor infrastructure and bad management practice (Roland Liemberger and Farley, n. d.).

According to Balkaran and Wyke (2003) there are several reasons for the loss of water in the case of Trinidad and Tobago, and these are described below:

- Illegal Connections – these are consumers that receive water from the water network illegally and do not pay for it, normally they are made of poor workmanship and they contribute significantly to apparent losses and revenue loss to the WSA

- Age of Pipe Network – about 40% of the infrastructure was laid 70 years ago, and it was in a dilapidating state due to operational measures, environmental conditions and general wear and tear and result in increased leakage in the network, and this include materials such cast iron, asbestos cement, galvanize wrought iron and steel pipes.
- Poor Maintenance of Network – this was resulting from lack of funding, poor workmanship on the service connections and the use of poor quality materials.
- Water Scheduling – the intermittent supply causing leakages in the system as a result of turning water supply on and off.
- Customer side Leakage – water lost inside properties due to lack of repairs of toilets, sinks, bath taps and fittings, although this might not be regarded as NRW, but it does contribute negatively to water loss.
- Absence of coherent strategy for Active Leakage Control – this resulted in NRW rising to 45%, regardless of the effort that the Water and Sewerage Authority had made.

Farley (2003) also argued that particular tasks should include;

a) Discussions with senior staff - that is, directors and senior managers on current management practice, perceptions, financial and political constraints and influences, and future planning

b) Discussions with operational staff on system features and practice, including

- physical data (population, demands, topography, supply arrangements, mains length, number of service connections, customer meter location, average pressure)
- drawings and records, billing data
- measurements or estimates of system input volumes
- estimates of authorised and unauthorised consumption estimates of non-revenue water components and performance indicators based on the IWA approach, with confidence limits
- current practice (staffing structure, staff numbers and skills)
- techniques and equipment
- repair programme

- economic data (cost of water etc.)

c) Field visits - to appraise current practice and skills

d) Selection of a suitable pilot area - for a future project to demonstrate techniques and equipment, gather results and show benefits, and to train staff.

2.4.4 Upgrading and strategy development

Leakage management should be seen as an overall strategy to manage the WSAs water distribution network, and it should not be treated as a separate activity (Parker, 2008). The section below seeks to address the question **'how to improve performance', and** Farley (2003) describes this stage as a strategy development phase where water loss reduction and improvements to the network performance is discussed. There are countries who are still struggling with satisfying their customer's basic needs of providing a constant supply of water to sustain health and life due to a network with collapsing infrastructure, very limited record keeping system, insufficient technical skills and technology, a revenue collection policy with inappropriate tariff structure, and a poor operation and maintenance policy.

2.4.4.1 Establishing NRW reduction strategy team

The NRW reduction strategy requires a diversified team to develop and implement. The NRW reduction strategy team's responsibility is to make sure that various components of NRW are looked into, and that the proposed strategy is feasible in terms of physical application and financial requirements (Ranhill Utilities Berhad and USAID, 2008).

Ranhill Utilities Berhad and USAID (2008) recommended that the team be formed by members from each operational department, including production, distribution, and customer service, and it may also include members from the finance, procurement, and human resource departments. It is vital to choose right representatives from various departments who are involved in the strategy implementation because this promotes ownership by various departments within the WSA or Municipality.

2.4.5 The zoning concept

Zoning is described by Ranhill Utilities Berhad and USAID (2008) as dividing a reticulation network into smaller and more manageable zones or district meter areas (DMAs) as it is now an internationally accepted best practice. This enables the WSA to get a better understanding of their water, and to more easily analyse pressure and flows in problematic areas. According to Ninham Shand (PTY)Ltd and UWP Consulting (PTY)Ltd (2007) the city of Cape Town was able to reduce their average water demand by 5.5 Mm^3/a, and also a reduction of sewer flows to the wastewater treatment works by approximately 43%, this was due to the use of the zoning concept which led into creation of 10 zones and and isolating them by installing bulk water meters and data loggers, in order to separately monitor water consumption for each zone. Establishing DMAs assist in pressure management, improving water quality, and in enabling continuous water supply. Figure 2.3 below shows the concept of zoning hierarchy, and the demarcation of smaller zones, and the positioning of bulk meters and flow meters.

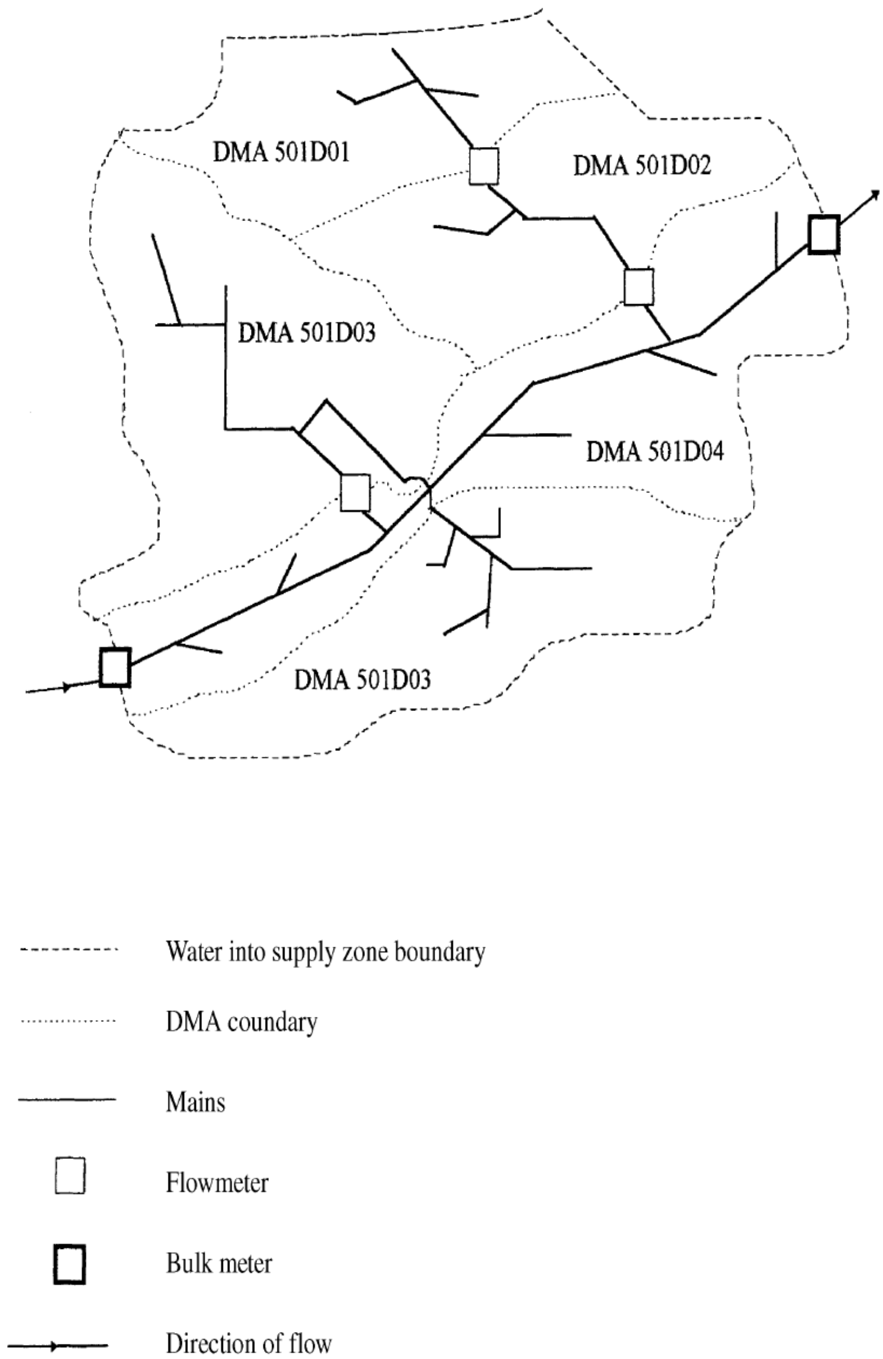

Figure .2.3 DMA types

Adapted from Roland Liemberger, and Farley, (n. d.). *Developing a Non-Revenue Water Reduction Strategy*. Part 1: Investigating and Assessing Water Losses.

According to Ranhill Utilities Berhad and USAID (2008), the criteria for demarcating the reticulation into DMAs as shown in Figure 2.3 above should include the size (or number of connections), number of valves that must be closed, flow meters, ground-level variations and visible topographic features that can serve as DMA boundaries. WSA managers use the minimum night flow (MNF) and legitimate night flow (LNF) to calculate the net night flow (NNF), along with commercial losses, to determine NRW in a DMA.

2.4.6 Flow metering

The U.S. Environmental Protection Agency describes water meters, both at the source and the service connection, as a vital aspect of water supply system and it makes accurate water auditing possible, and they make customer billing to be as per the customer's consumption. According to O'Mahony (2012) the installation of water meters is the only way of managing water supply service effectively and efficiently, meters play a significant role in the transformation of rural water service sector in terms of managing NRW.

In Yerevan Armenia the community was experiencing an intermittent supply of water and water wastage which was due to the absence of metering, water was supplied for about six hours a day, and Government had to embark in a campaign to secure funding and then engage a private service provider to implementation the installation of water meters for residential customers, repairs to plumbing system and network rehabilitation, and this increased the continuity of supply up to 18hrs per day, and 70% of the community enjoyed continuous supply (Marin, 2009).

In southern Asia in India the misuse of unmetered water had a negative impact in their water table which was dropped as a result of farmers digging wells without Government authorisation (Heymann, Lizio, and Siehlow, 2010).

The zoning hierarchy concept, and the creation of smaller zones, is illustrated below in Figure 2.4

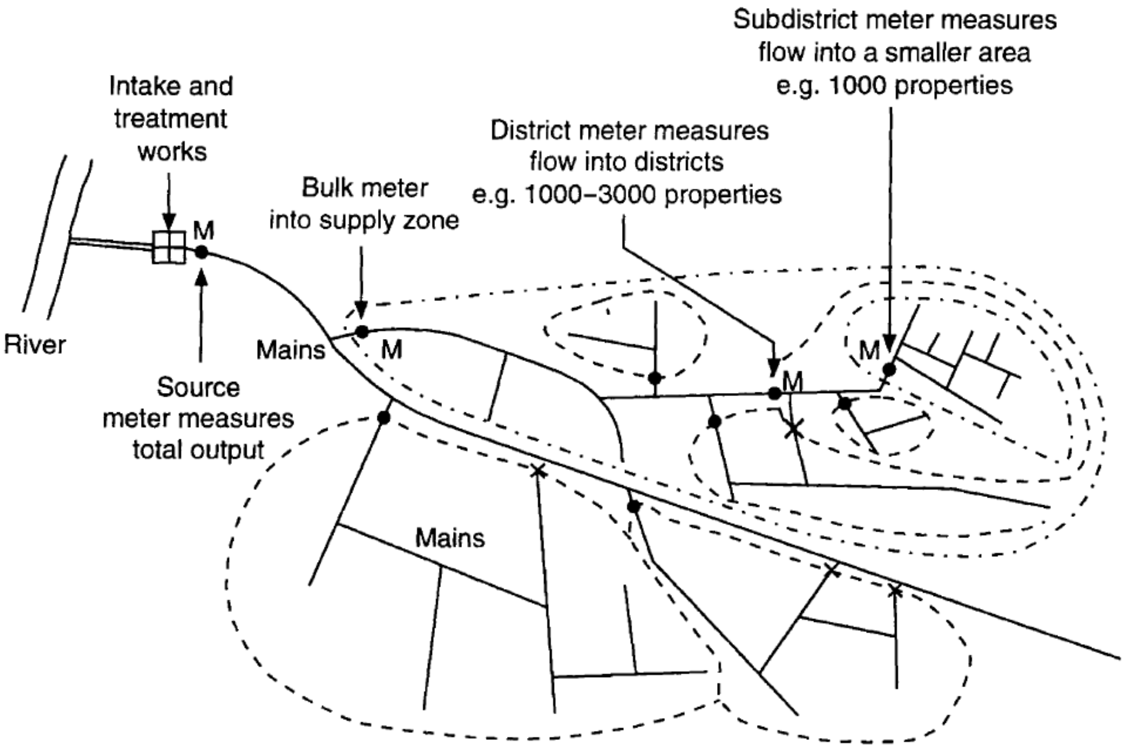

Figure .2.4 Metering hierarchy and DMA design

Figure 4: Metering hierarchy and DMA design options (from UKWIR "Managing Leakage") Adapted from Roland Liemberger, R., and Farley, M. (n. d.). *Developing a Non-Revenue Water Reduction Strategy*. Part 1: Investigating and Assessing Water Losses.

Effective metering is regarded as one of the essential features of network management, particularly for measuring flows into and out of each zone measured, to provide data for the water balance calculation. In some cases Water Authorities record flow data of meters into a central control station via telemetry (Roland Liemberger and Farley, n. d.).

2.4.7 Leakage management policies

2.4.7.1 Pressure management

U.S. Environmental Protection Agency (2009) describe pressure management as a tool to evaluate sections of water system with excessive pressure and then implements controls that reduce pressure to cut pressure-sensitive background leakage and reduce rupture rates. Rabe, Maree, Ramano, and Price (2012) argues that water lost in a system decreases exponentially as the pressure in a water system is reduced as illustrate in the diagram below in Figure 2.5, and therefore pressure management becomes a vital tool of reducing Non-Revenue Water that is attributed to leakages in a water supply system.

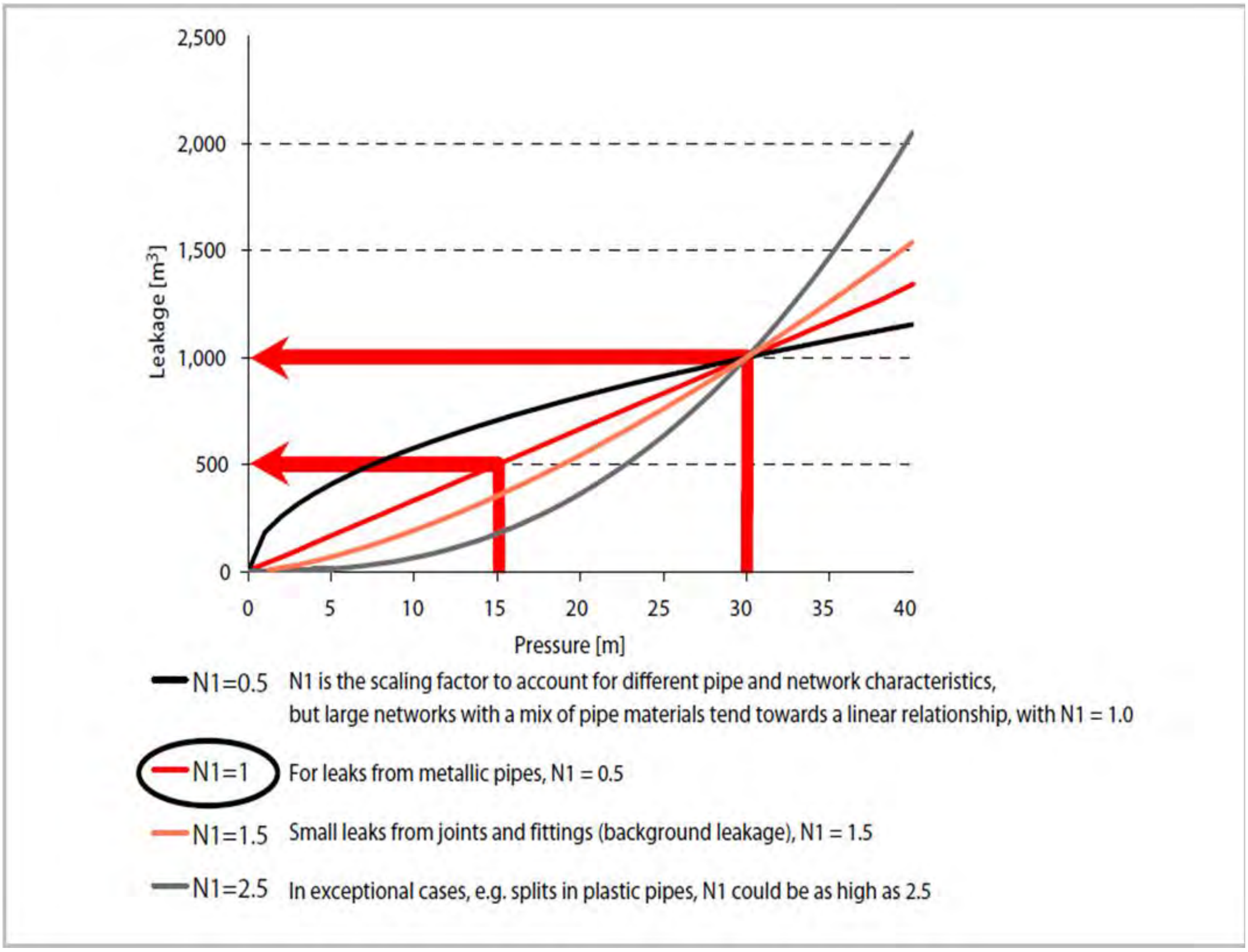

Figure .2.5 Pressure and leakage relationship

Adapted from the World Bank, cited from Ranhill Utilities Berhad and USAID. (2008). *The Manager's Non-Revenue Water Handbook.* Bangkok: United State Agency for International Development.

The relationship between pressure and leakages as shown in Figure 2.5 above is further described by Ranhill Utilities Berhad and USAID (2008) as follows:

- The higher or lower the pressure, the higher or lower the leakage

- The relationship is complex, but technical managers should initially assume a linear relationship (10% less pressure = 10% less leakage)
- Pressure level and pressure cycling strongly influence burst frequency

Khayelitsha was also experiencing water losses which was estimated at 70% to 80% of the water supplied in the area, in order to address this problem they needed to understand the nature of the problem they are facing, which led to the realisation that most water losses were occurring from internal leaks, and instead of the municipality doing repairs and replacement of taps and toilets, they decided to address the problem by reducing their operating pressure in their system by installing three PRV's horizontally, and the results indicated an estimated 40% saving translating to 9 million m3/hr of water originally supplied as shown in the (Mckenzie, Mostert, and de Jager, 2004).

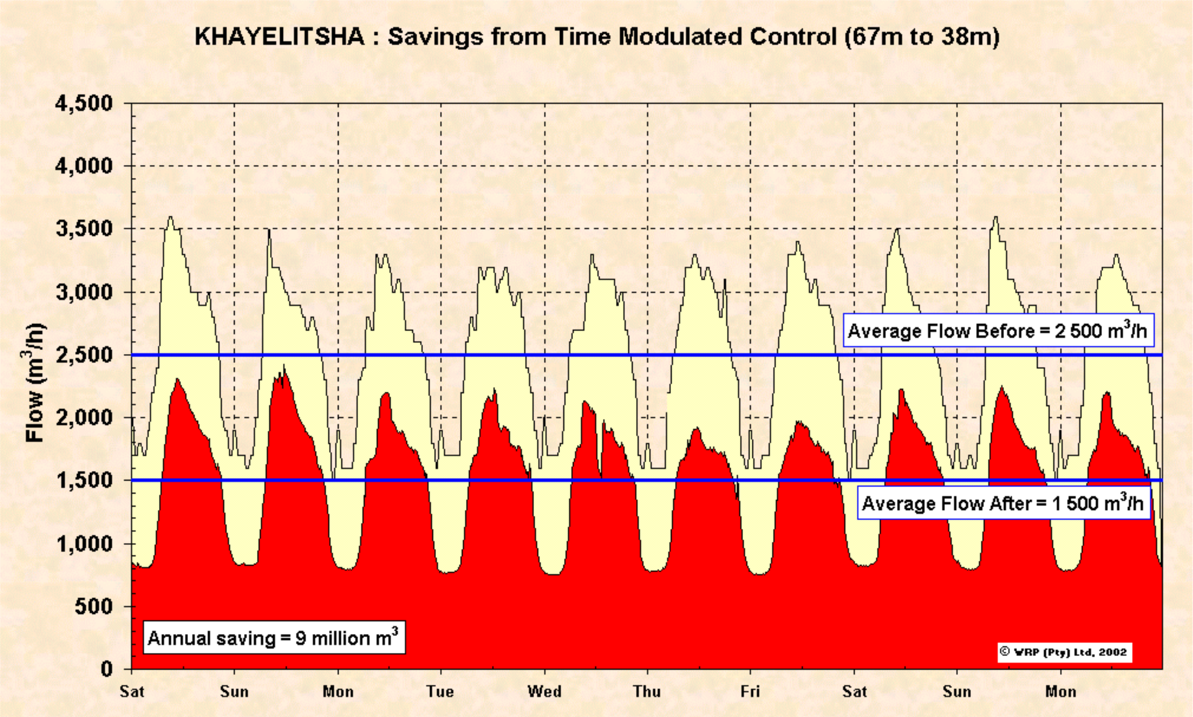

Figure .2.6 Savings achieved from the installation of PRV's

Adapted from Mckenzie, R. S., Mostert, H., and de Jager, T. (2004). Leakage reduction through pressure management in Khayelitsha: two years down the line. *Proceedings of the 2004 Water Institute of Southern Africa (WISA) Biennial Conference* (pp. 1096-1103). Cape Town: Water Institute of Southern Africa (WISA).

Figure 2.6 above shows that the minimum night flow was reduced to 750 m³/hr with the average daily flow dropping from 2 500 m³/hr to 1 500 m³/hr, which was due to the installation of PRV's that were equipped with electronic controllers termed Advanced Pressure Control to provide further pressure reduction low demand periods (Mckenzie, Mostert, and de Jager, 2004).

Babic, Dukic, and Stanic (2014) further argues that the reduction of excess pressure in order to reduce leakages in a distribution system is a basic concept controlling leakages in a water scheme, although the issue of excessive pressure is not easy to manage, various techniques and equipment has been created to assist in controlling the amount of pressure exerted in a system, thus reducing leakages, this pressure reduction may be achieved by the installation of pressure-reducing valves (PRVs) or installation of a variable speed drive in order to reduce pumping head.

The picture below in Figure 2.7 illustrate the installation set-up of a PRV which is installed strategically in a water network system to maintain or reduce network pressure at a set level, and its maintain that pre-set downstream pressure regardless of the upstream pressure or flow rate fluctuations.

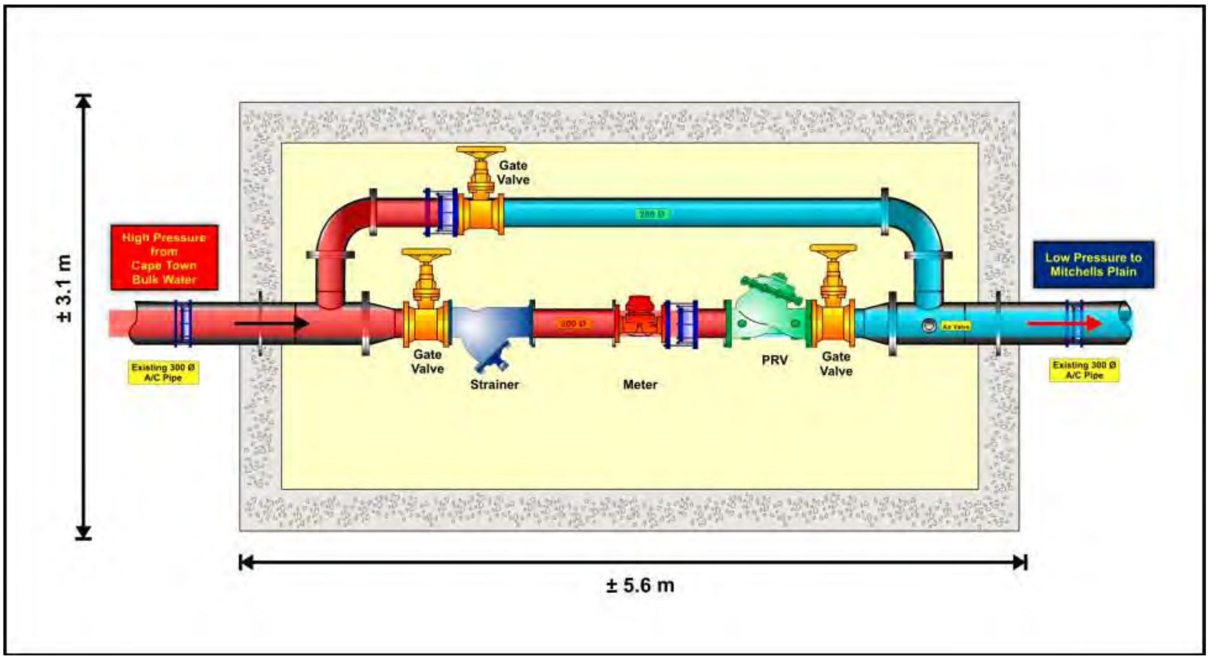

Figure .2.7 Schematic layout for the large pressure management chamber in Mitchells Plain on the 300mm diameter supply line

Adapted from Meyer, N., Engelbrecht, M., and Wright, D. M. (n.d.). Large scale pressure management implementation in the City of Cape Town. Cape Town: City of Cape Town.

Sometimes a PRV installation is incorporated into a flow meter installation (Roland Liemberger and Farley, n. d.). Maintaining sufficient pressure in a distribution network is vital in order to guard against contamination by the ingress of polluted seepage water, a minimum pressure of 5-10 mwc (metres of water column) in a small communal water scheme should be sufficient, and operating a water scheme at a pressure that is higher than 60 mwc is not recommended and should be avoided at all cost, as it may be a cause of increased leakages and burst pipes especially if the system is not maintained properly (Trifunovic, n. d.).

In any real loss analysis the average pressure is a key parameter, there must be sufficient work done in order to get detailed information to be used when estimating an average pressure, and this should be calculated as 24 hour average values (Roland Liemberger and Farley, n. d.).

Lack of understanding the system which is associated with staff turnover in municipalities may end up compromising zones which are demarcated according to pressure management strategy; low pressure problems in zones are improperly addressed by opening pressure-reducing valves, even though it may seem that the problem is linked to unauthorised closed valves (Wegelin and Jacobs, 2012).

2.4.7.2 Infrastructure management and repair policy

Infrastructure maintenance proved to be very effective in reducing Non-Revenue Water by 42% resulting in a €230 000 revenue increments in Cavan Ireland due to the implementation of a project for installation of bulk meters, repairing of leaks and replacement of bulk mains, this project also relieved a water treatment plant which was already operating at more than its maximum capacity by 17% (Brady and Gray, 2010).

Freshwater and Toxics Programme (2007) further argues that in order to keep the infrastructure intact there is a need for the WSA’s to invest in their infrastructure and continuously rehabilitate and replace the dilapidated assets, In Pakistan physical leakages in the water supply distribution network were high and they were estimated at 40% of SIV.

Rode (2010) further emphasise the importency of continuous water infrastructure management, however in other municipalities like Municipal Corporation in Maharashtra, the drinking water supply projects are highly capital intensive as they include building a dam, pipeline, storage and filtering system, water distribution system, metering and bill collection system, and other components, due to lack of revenue collection and low water tariffs, it is therefore unaffordable for the Municipal Corporation to implement new water supply projects, and the grant received from the central government.

According to Farley (2003) the amount of time taken to repair a leak will reduce the volume of leakage, and that for any distribution network there is a level of leakage below which is not cost effective to make further investment, or use additional resources, to drive leakage down further, and this point is known as economic level of leakage (ELL). Current research indicates that there are two groups of leakage management:

- passive (reactive) leakage control
- active leakage control (ALC)

2.4.7.3 Passive control

Farley (2003) describe passive control as the reaction to a drop in pressure or reported bursts, usually reported by consumers or noted by WSA's staff members while working on something else other than leak detection. This method is largely acceptable in areas with plentiful or low cost supplies, and it is normally practised in less developed supply systems where the rate of underground leaks is less well understood. It is the first step to improvement (that is, to make sure all visible leaks are repaired), except in exceptional circumstances where leakage will continue to rise under passive control.

2.4.7.4 Active leakage control (ALC)

In a situation of real loss management, the WSA normally implement active leakage control strategy, this means that the WSA will send specialised team in the field to physically search for leaks instead of waiting for leaks to be reported by communities or other pupil other than those who are in the specialised team, or instead of searching for leaks using a desktop monitoring and assessment methods to identify possible burst, and these leaks are then repaired instantly (Covas and Ramos, ND).

Figure 2.8 below is an illustration of a schematic diagram of a water distribution network showing all the meters which may be of interest when monitoring flow from the bulk supply into zones:

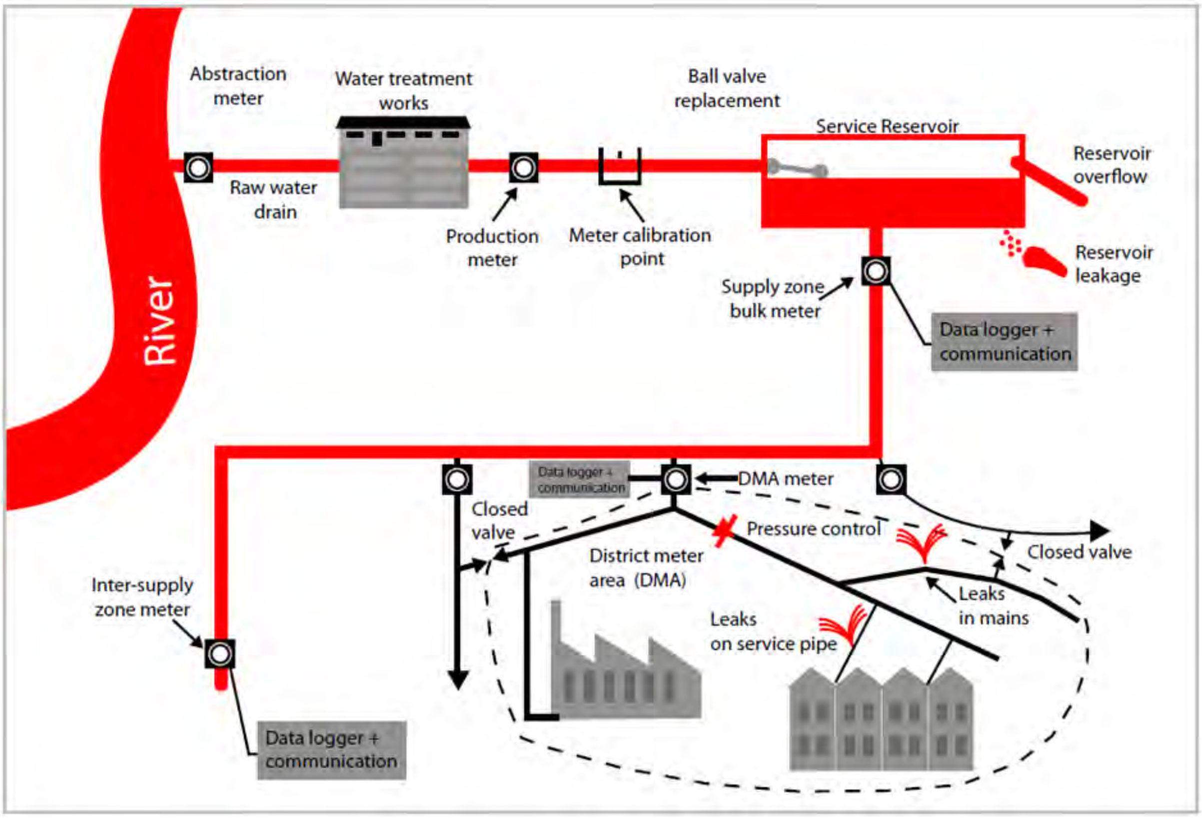

Figure .2.8 A typical distribution network

Adapted from Ranhill Utilities Berhad and USAID. (2008). *The Manager's Non-Revenue Water Handbook.* Bangkok: United State Agency for International Development.

Leakage monitoring is flow monitoring into DMAs or zones in order to quantify leakages and also to prioritise leak detection activities in a distribution system, and this is now one of the most cost effective (and the one most widely practised) to reduce real losses (Roland Liemberger and Farley, n. d.)

According to Dighade, Kadu, and Pande (2015) most WSA's in India do not apply the ALC method in their water schemes, if the time taken to repair leaks can be reduced this will reduce the amount of annual volume of real losses.

2.4.7.5 Regular survey

At times, leakage engineers or technicians would carry out door-to-door surveys checking for leaks from buried pipes in the water distribution network and consumer connections. According to Balkaran and Wyke (2003) in Trinidad and Tobago the surveys that were carried out yielded good result as they were able to locate and repair leaks, they used the most simple method which is listening to a sound via a listening stick and geophones by placing it on the valves, hydrants and water service connections in order to hear the noise that is coming from the leak in the system. The identification of leak positions by the use of this traditional method was a cost effective exercise with a reasonable success rate on metallic pipes with many "dry holes" or incorrectly sited excavations for alleged leaks on non-metallic pipes such as asbestos cement (Farley, 2003).

Hamilton and Hartley (2008) argue that the most basic principle and fundamental requirement of correlation is that the sound created by the leak must be transmitted to both sensors so that the leak can be located. Furthermore, Hamilton and Hartley (2008) argue that many engineers think that the acoustic leakage detection is the answer to their water loss problems and are convinced that by simply installing equipment the leak can be located regardless of pipe material, diameter, pressure or the distance between the fitments.

2.4.7.6 Leakage monitoring

Wyatt (2010) argues that the burst rate and leak flow rate will be influenced by the type of pipe material, age, system pressure, pressure variation, external loadings, and other variables. While significant strides made to collect data in the developed countries, only sporadic information is accessible on burst and flow rate, in terms of pressure from the developing countries. There are various possible sources of apparently high leakage levels where only a limited number of minor leaks can be identified (Wyatt, 2010). Upon confirmation of the DMA and the boundary been shown to be tight, then in essence there are two main components that could cause the problem:

- Error in the quantification of the leakage level;
- Error in the leakage location activity (Wyatt, 2010).

In the city of Kampala in Uganda, Mutikanga, Sharma, and Vairavamoorthy (2011) argued that the use of balancing bulk meters with domestic meters is the effective way of monitoring leaks in a system by taking weekly and monthly readings for the master meter and sub-meters, they had to perform this exercise for four months when they were doing their investigations in order to try and eliminate any leaks, illegal use and meter by-pass between the master meter and the sub-meter. Table 2.3 below shows some of the recommended actions to be taken when monitoring leakages:

Table 2.3: Actions to ensure that apparent leakage is real

Action	Comments
1. Check internal consistency of metering results	Check that the flows registered by the meter, and the flows used for leak calculation are the same. A simple way to do this would be to read the meter at least two times, say, 24 hours apart. The cumulative flow through the meter should then be compared to the total flow over the same period using the system by which DMA gets calculated (e.g. data logger). If these values disagree, the system by which data gets from the meter to the leakage calculation should be checked for an incorrect pulse unit multiplier etc. The method by which meter readings are added to give a total flow into the DMA should also be checked.
2. Check basic DMA data	The basic values used to calculate the leakage level should be checked. This includes all of the customer meter readings and allowances for household and non-household losses, the numbers of households and non-households, the exceptional users, and the data required for the background losses calculation.
3. Check leakage	Using the re-checked DMA data, and the re-checked night flow information,

calculation	the access night flow information, the access night flow calculation should be re-performed independently of the normal leakage calculation software or system.
4. Check on metering errors	If the DMA has several metered imports and exports then a calculation of the metering error would be useful. If the total metering error, using a ± 5% error, would account for the access leakage, then considerations should be given to either: redesign of the DMA in order to reduce the number of meters or: replacement of those meters where fairly small percent errors would give large errors in reported leaks.
5. Check boundary valves	Boundary valves should be checked in the same way as they would be checked when setting up a new DMA.
6. Perform pressure zero test	A pressure zero test should be performed to ensure that no connections exist that breach the DMA boundary.
7. Short interval flow logging	Use a short interval flow logging technique to calculate the time-variable night use. This may show that night use is higher (or lower) than assumed.
8. Verify meter accuracy	Some of the import or export meters to the DMA may have flows that are verifiable indirectly using other meters or combinations of meters. However, there may be others where no verification is possible. In this case some verification of flows should be carried out. Verification could consist of the replacement of the meter. After the meter is replaced, the new meter results should be used for a new leakage calculation. Another method may be the use of an insertion meter downstream of the existing meter, and comparing the flows recorded. Night-flow could be checked to ensure no mechanical meters stall at minimum flow. If a stalling meters is an export, this could lead to apparent high leakage. The installation could be checked against manufacturers' recommendations. This include the required length of straight pipe up and downstream, and situation where jetting could occur. The installation could also be checked for foreign bodies.
9. illegal use	If the DMA contains metered non-households, which could potentially use large volumes of water, a survey of these may find some illegal use.
10. Repairs	Check that repairs to reported leaks and bursts have been carried out.
11. Reconsider night	A list of un-metered non-household in the DMA should be examined to find

use allowances	large users, which might not have been metered. When these are found, a meter should be installed, if possible, a night use monitored. Similarly metered customers with potentially high use should have their night use monitored. A physical survey of the DMA may be useful to find households with large night use. This may be true if, for example, there is a large proportion of shift workers in the DMA, or many large gardens which are watered at night.

Adapted from water loss task force. (2004). *DMA guidance notes.* Cyprus: IWA.

Should it be found that the leakage level is correct; then there will be a necessity to assess the accuracy of the leakage location activity and to question specifically if it is possible that a leak was not located (Wyatt, 2010).

It is possible that the instrument may not detect the sound of the leak when using this acoustic method, and also non-metallic pipes and high background noise coupled to low operating pressures can dramatically affect the efficiency of the instruments as can erroneous maps or insufficient access points (Wyatt, 2010).

2.4.7.7 Selecting the most appropriate policy

According to Ranhill Utilities Berhad and USAID (2008), the most appropriate leakage control policy for a particular Water Services Authority is mainly determined by the characteristics of the distribution network and local conditions, which may also include financial constraints on the equipment and other resources, and in most developing countries the method of leakage control is usually inactive or low activity, repairing only visible leaks or conducting regular surveys of the distribution network with an acoustic or electric apparatus.

The geological factor of the area also plays a role in identifying a policy to be used by the WSA. According to Farley (2003), if the geology of the area allows a major fraction of the leaks to be visible at the surface (for example, parts of the Middle East and Australia), a policy of regular survey followed by rapid repair may be sufficient, where some leaks are not identifiable at the surface, a more intensive policy of leakage monitoring will be required.

If a more stringent leakage control policy is adopted by the WSA, this will result in a temporary backlog of repairs (Wyatt, 2010). Management of pressure is a key factor in an effective leakage management policy (Water Loss Task Force, 2004).

McKenzie, Buckle, Wegelin, and Meyer (2002) highlighted that if a water distribution network is well maintained, a pipe replacement policy, where at least 1% of the capital value of the whole distribution infrastructure is replaced annually, is imperative.

2.4.7.8 Finding the leaks

Once the leaks have been discovered they must be repaired, and proper date and time of the repair should be documented, and that repair should be seen so that a gross estimate of the magnitude of the leak can be made (Wyatt A. S., 2010).

There are benefits to water utilities for engaging in a leak detection and repair program, and these include:

- More efficient utilisation of existing water supply
- Reduced carbon footprint
- Improved water conservation measures, environmental quality and and public relations;
- Increased system operational efficiency, integrity reliability, performance and firefighting capacity;
- Extended useful life of existing facilities and an ability to extend supply to new developments;
- Enhanced knowledge of the distribution system; and
- Delayed expansion of treatment plant capacity, and construction of new sources of water supply (Boulos and Aboujaoude, 2011).

2.4.7.9 Measuring Performance

Farley (2003) noted that most people use percentages to measure NRW including the media and the non-specialists, as they believed that this was the best way to measure performance. However, some specialists see this as a discrimination against the WSA that produce low consumption (low system loading), higher than average operating pressures (due to topography), and NRW which includes leakage on customers' private pipes.

Depending upon the consumer's consumption per service connection, the same volume of real losses could, in percentage terms, be anything from 44% to 2.4% (Farley, 2003). Thus, countries with relatively low consumption, such as Malta, England/Wales, and many developing countries, can appear to have high losses when expressed in percentage terms; in contrast, percentage losses for urban areas in developed countries with high consumption can be equally misleading (Farley, 2003).

When consumption decreases, seasonally or annually, or due to demand management measures, the percentage of real losses increases even if the volume of real losses remains unchanged, and when consumption increases, the opposite effect occurs (Farley, 2003).

These four components can be considered as constraints, which prevent the Annual Real Losses from increasing as shown in Figure 2.9.

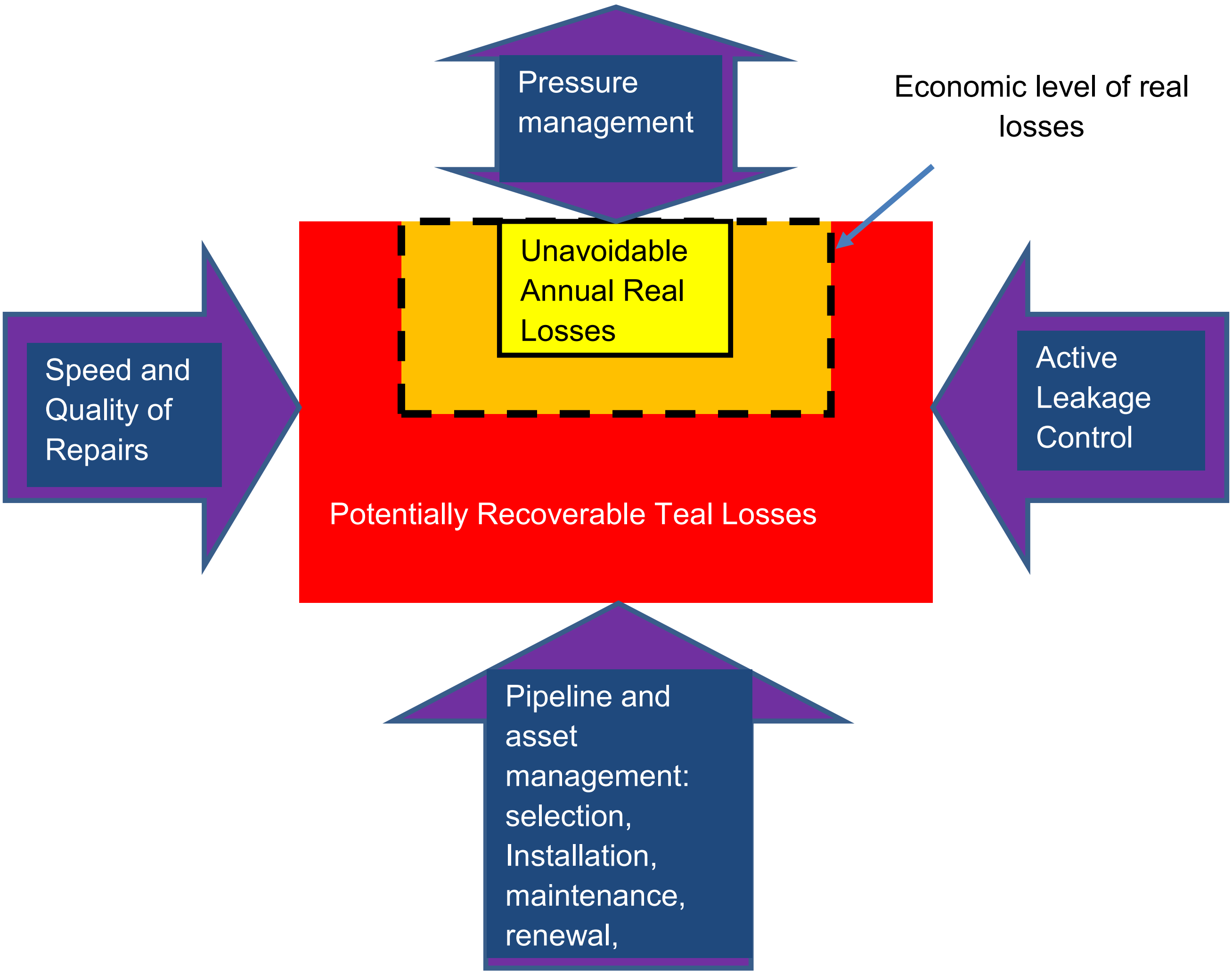

Figure .2.9 Four Basic Methods of Managing Real Losses

Adapted from Ranhill Utilities Berhad and USAID. (2008). *The Manager's Non-Revenue Water Handbook.* Bangkok: United State Agency for International Development.

McKenzie, Buckle, Wegelin, and Meyer (2002) established that there are four key influencing factors, and if these are identified and quantified, predictions can then be made regarding the likely influences of the different leakage reduction activities. Below are the most important influencing system leakage factors:

- Speed and quality of repairs;
- Pipeline and assets management, selection, installation, maintenance, renewal and replacement;
- Active leakage control; and
- Pressure management.

Farley (2003) argues that Figure 2.8 above demonstrates the outcome of operating practices on real losses, which will decrease when more efficient operating practices are implemented, and this is the basis for developing leakage management strategy, and that the difference between the Unavoidable Real Losses (UARL) in the small rectangle and the Current Annual Real Losses (CARL) in the biger rectangle is the potentially recoverable Real Losses.

McKenzie, Buckle, Wegelin, and Meyer (2002) established a system of performance comparison which can be used by WSAs to measure its own success following the outlining of a leakage strategy, and it also allows inter-company and inter-country comparisons. This performance measure is called international leakage index (ILI), and is calculated using the ratio of current annual real losses to unavoidable annual real losses.

2.4.8 Maintaining the strategy

This section addresses the question **"how to maintain the strategy?"** and how to maintain the improvements gained from it. Maintaining the strategy may require that certain policies be reviewed, and probably an operations and maintenance program be introduced. All WSAs might be compelled to examine their policies for producing and delivering water (Farley, 2003).

Research has shown that when WSAs attempt to reduce NRW they normally do not look at providing incentives for management and staff within the WSA. This is one of the reasons why NRW strategies fail, particularly in the developing countries, and it becomes difficult for them to improve their performance (Kingdom, Liemberger, and Marin, 2006).

Farley (2003) established that the increase in demand from water consumers versus new resources is causing an increase in environmental risk, and policies need to cater for such observations, including:

- demand management and water conservation
- regulatory and legal frameworks
- customer metering policy, tariff structures, and revenue collection

2.4.8.1 Customer metering policy

Farley (2003) established that most countries are using some form of household metering or other charging structure for their consumers, but with the developing countries, most of them set low tariffs or flat rates to cater for low income earners or indigent consumers in order to maintain health and hygiene. However, it does seem to become the expected trend and it is much politicised, especially during local elections.

In the Middle East and North Africa their tariff structure was structured in such a way that commercial customers pay less for fresh water which made it difficult for the water utility to persuade them from coming with other alternatives, and they recommended an increase in the tariffs in order to reduce the use of fresh water, and this would make irrigation with recycled wastewater more economically attractive (Abu-Madi & Al-Sa'ed, 2009).

According to Farley (2003:17) there are major dissadvantages for the WSAs that allow a zero or lower tariff structure while not charging an economic rate for water, that is:

- "it does not encourage sensible use
- it does not encourage the mending of customer leaks
- the company has no incentive to install an active metering and meter replacement policy
- insufficient revenue is generated to provide a sustainable operation, maintenance and repair programme often, even on low tariffs, customers (both household and non-household) will vandalise or by-pass meters to save paying. Usually a review of a company's customer metering policy and tariff structure is included in the strategy development procedure. Correcting the metering policy and tariff structure policy, in conjunction with other water conservation initiatives, is a major step towards reducing customer demand. To overcome adverse reaction from customers and to assuage political sensitivities, a pilot study could be designed within a water loss study programme. The study would include reading a sample of customer meters to check:
    - how many meters are working and how many have stopped

- which of those not working are due to meter malfunction, deliberate vandalism, or bypassed (illegal connection)
- how accurate they are (under-registration)”.

The accuracy of readings is normally verified by installing a “check” meter downstream of the main meter, and it is recommended that a class C or D meters be installed in order to meet the international standards and to maintain the high accuracy of readings, even in very low flows circumstances (Farley, 2003).

An infrastructure replacement program should be implemented regularly for the non-household customers to encourage water conservation practices, continuous revenue enhancement, and it is worth noting that some organisations even have a policy where bulk meters are changed every five years (Farley, 2003).

2.4.8.2 Technology transfer and training

In order for the leak management strategy to be sustainable, employees need to be trained, motivated, skilled on techniques and technology of leakage management and in operating and maintaining the whole water distribution network (Farley, 2003). There is a need for an emphasis to be made on the introduction of leakage management programme at all levels in an organisation to address the structure of the programme, the steps in its design and implementation, and the support should be from the senior management to the operating level (Farley, 2003).

Farley (2003) argues that a sustainable training programme should include the following;

- awareness seminars for senior staff and decision makers (and also to raise public awareness)
- training workshops for engineering and technical staff
- continuous practical training for operations staff.

2.4.8.3 Operation and Maintenance

Operations and Maintenance (O & M) is very critical in every water distribution network, borehole, hand pumps, technological equipment, infrastructure and institutional development, in order to maintain the sustainability of the network system, O & M requires forward planning and transfer of technology in all the stages from installation of plant and equipment, during the training of operators and handing over phase, to routine operation and upkeep (Farley, 2003).

The main concern for Doyle, Hennelly, and McEntee (2003) in his argument is that maintenance is a long term function and responsibility for municipalities and they become reluctant to take over the maintenance long term commitment. The O & M processes should be discussed and finalised during the installation phase, and the selection of equipment, spares purchasing and repair procedures should be formalised, and an operating manual created based on the best practices in operating and maintaining the system (Farley, 2003).

2.4.9 NRW assessment methods

The first point to be noted is that the NRW assessment methods that are proposed in any given scenario are not always applicable, and in some cases the accuracy of the apportionment of loss is very questionable (Vermersch and Rizzo, 2008). However (Cong Thanh, nd) argues that it is necessary to apply the nowadays available methods and tools to the NRW assessment in order to establish the first baseline.

2.4.9.1 Top down approach

This method provide a good basis for analysis, but it requires that the data be refined regularly and water audits to be done continuously (Pickard et al., 2008).

Below are the main steps that are taken when performing the top-down audit (Charalambous and Hamilton, 2011):

- Determining the volume of water put into the distribution network
- Obtaining authorised consumption (billed + unbilled) from records
- Calculating water loss (water loss=system input - authorised consumption)
- Estimating apparent losses (theft + meter error + billing errors and adjustments)
- Calculating real losses (real loss = water loss – apparent loss)

This audit rely more on the information that is readily available from the records of the municipality.

2.4.9.2 Bottom up approach

This procedure is used when the water authorities have confirmed that the data that was used in the top-down portion includes every aspect of the utility's operation: billing records, distribution system and accounting principles (Puust, Kapelan, and Koppel, 2010). The main purpose of this audit is to assess the efficiency of water distribution system and the interventions required to achieve the targeted results. The most accurate and up to date data is required in order to achieve reasonable results (Puust, Kapelan, and Koppel, 2010)

Puust, et al. (2010), in their review paper, argue that the bottom-up real loss assessment can be done in two different ways: (a) 24 Hour Zone Measurement (HZM) or (b) Minimum Night Flow (MNF) analysis. HZM require District Metered Areas (DMA) to be zoned in a distribution system from one or two inflow points only, and then those areas with a 24-h inflow measurements shall always be logged along with pressure measurements (Puust, Kapelan, and Koppel, 2010). The DMA needs to be properly done because this method also relies on it, mostly when calculating the minimum night flows (Charalambous and Hamilton, 2011).

2.4.9.3 Component based analysis

The main purpose of a component based analysis is to determine the portion of real losses which is in 'excess' of all other leakage components, because the amount of excess losses represents the volume of water that is lost due to leaks that are not detected and repaired with the current leakage control policy (Cong Thanh, nd).

2.4.9.4 The reverse approach equation

In this methodology a distinguish is made by separating the apparent losses and real losses by considering the fact that apparent losses flows into the wastewater treatment works and real losses do not. Hence, the quantification of apparent losses is done by monitoring the volumes of the inflow at the waste water treatment works inlet or a bulk meter at the outlet of the DMA. In this case, the apparent losses could be estimated by using Equation 3.5 which is derived from the following equation:

$NRW = \text{Apprent Losses} + \text{Uubilled Authorized Consumption}$	Eq 3.1
$NRW = \text{produced water} - \text{Billed water Consumption}$	Eq 3.2
Produced Water = Real Losses + Outdoor use consumption + Waste Plant Flow + Sewers Exfiltration – Sewers Infiltration	Eq 3.3
When applying 3 into 2 NRW = Real Losses + Outdoor Use consumption + Waste Water Plant Inflow + Sewers Exfiltration – Sewers Infiltration – Billed Water Consumption	Eq 3.4
With applying 1 into 4 Apparent Losses = WWTP Inflow – Billed Water Consumption – Unbilled Authorised Consumption + Outdoor Use Consumption + Exfiltration – Infiltration	Eq 3.5a
OR $Qa = Qww - Qbw - Quac + Qout + Qex - Qin$	Eq 3.5b
Quac: Unbilled authorised consumption: metered consumption which is unbilled as well as any kind of authorised consumption that is neither billed or metered **Qout:** Outdoor use consumption: water used for lawn irrigation or watering of plants, car washing, house cleaning, and refilling of ornament fountains, ponds and surface lagoons (Nunez, et.al ., 2010) **Qex:** Exfiltration: wastewater flow the exfiltrates out of the sewers **Qin:** Infiltration: groundwater that enters the sewer system **Qa:** Apparent Losses **Qww:** Inflow of wastewater treatment plant or the flow into the sewers' outlet of DMA **Qbw:** Billed water consumption: all metered water consumption which is billed	

2.5 Summary

NRW is a global challenge that prompted IWA to come up with technical interventions in order to try and reduce NRW. The NRW water management methods are chosen based on the characteristics of the water scheme.

The methods that were adopted by IWA which are used to calculate and distinguish commercial losses from physical losses have also played a major role in guiding the industry regarding measuring and monitoring water losses and authorised consumption as stipulated in the IWA best practice standard water balance. All these methods form part of the NRW management strategy which should be adopted by municipalities and water boards. The strategy also suggests that there should be leakage management policies in place to monitor and address water losses. Leakage management programmes are implemented in the distribution network as part of the effort to reduce NRW. The next chapter discusses the capabilities of municipal employees and the method that the municipality used to manage NRW.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

As mentioned in the previous chapter, there are various methods used to manage NRW. These, however, depend on the water scheme that is being studied. As a result, the research methodology used in this study is also informed by the availability of information and the type of water scheme that was constructed for the Lidgetton community. This chapter discusses the method that was used to carry out research, based on the research objectives and research questions that are stated in the introduction chapter. The location of the study and its participants is discussed, including the sample size. The methods of data collection and preparation are also discussed. Water produced monthly and monthly consumption was discussed with a view of using it to evaluate water losses.

3.2 Aims and objectives of the study

The following are objectives of this study:

- To identify the current NRW assessment methods and management policies adopted by uMgungundlovu District Municipality
- To identify whether the uMDM is proactive or reactive towards NRW management in Lidgetton.
- To measure uMDM's employee's awareness of NRW from different sections that are involved in NRW management.
- To analyse the breakdown for NRW components (apparent losses, real losses, and unbilled authorized consumption) with respect to distribution system of Lidgetton Water Scheme.

3.3 Participation and location of the study

This study was conducted with the uMgungundlovu District Municipal employees from various departments as participants. The uMDM has five inter departments; namely: technical finance, community, corporate, and the office of the municipal manager. Only municipal employees doing water related activities participated in the study. Managers and supervisors from the technical and finance department, as well as civil engineer, plumbers and process controllers from water and sanitation division also took part in the study.

NRW can be regarded as a specialised field, therefore participants in the study were carefully selected to include employees who are familiar with the environment of water service provision. Most participants were employees who sometimes interact with customers in one way or another, because these are employees fully informed about the customer relationship within the municipality.

The study was conducted in Lidgetton township, from the water treatment works up to the consumer outlets. It was also done from uMDM head offices situated in the city of Pietermaritzburg.

3.4 The Sample

In total, 115 questionnaires were despatched and 110 were returned which gave a 95.7% response rate. The population size is made up of 133 municipal employees which include field workers and office bound employees, and it is made up of staff members from the participating inter departments.

3.5 Data collection strategy

Non-Revenue Water management is a cross cutting function which requires various departments within the municipality to be involved, and therefore data was collected in all relevant departments. The data, analysed in Chapter 4, was collected using questionnaires, they were distributed and collected from employees who are working in different departments of the municipality.

Drawings were collected from uMDM's technical department head office. Supporting data for the reticulation and meter positioning was collected from the GIS section. Burst pipe and incident register was collected from water and sanitation technicians in the Operations and Maintenance section of the Lidgetton area. Meter readings, number of metered households, numbers of billed consumers, monthly consumption per household, non-metered consumers and inactive meters were received from revenue collection section.

Information obtained from the Auditor General's report was also collected from finance department. Non-revenue water assessment report was also used to collect data. Field visits were done to collect information from water pumps at water treatment works and at the main reservoir.

Getting information was not easy because it was not readily available; it had to be downloaded in various computer systems such as, GIS, Microsoft Excel, Microsoft Word, Municipal Billing and Pastel Evolution. There was also a waiting period due to the fact that some departments are short-staffed and there was no one available to provide the information timeously. In some cases, there is no employee who acts as the direct custodian of specific information, and the required information was processed by whoever was available at that present moment.

3.6 Research design and methods

3.6.1 Description and purpose

The Institute of Lifelong Learning (2009) describe research design as the study of materials, sources and data in order to get conclusions, it also provide the structure of the research and the type of method to be used.

According to Sekaran and Bougie (2013: 96) studies are classified into three types of groups, and choosing a right type depends on the advancement of stages of knowledge available for that particular study, these three types of studies are:

- **Exploratory** study – it is when attempts are made to explore new business research, and to find solutions to similar challenges which have not been solved in the past.
- **Descriptive** study – descriptive study is either quantitative or qualitative in nature, in most cases they are designed to collect data that describes characteristics events, persons or situations.
- **Causal** study – this is more of a scientific approach to research, and in this type the researcher is more interested in researching about the impact of a certain variable to another variable, and the relationship between two variables.

In the case of Lidgetton the appropriate type is the causal study, because the study is researching about variables that are causing a problem and in this case that problem is NRW.

Due to the nature of the study that is conducted, a quantitative research was used. According to the Institute of Lifelong Learning (2009) Quantitative research is influenced by the empiricist paradigm, which means that it is concerned with cause and effect of social phenomena and uses the data which is based on empirical observation and their critical interpretation.

3.6.1.1 Construction of the instrument

Questionnaires were used as research instruments, and this research instrument consisted of 53 questions, with a level of measurement at a nominal or an ordinal level. The questionnaire was divided into 4 sections which measured various themes as illustrated below:

Section 1	Personal data
Section 2	Water management
Section 3	Finance questionnaire
Section 4	Social Questionnaire

3.6.1.2 Recruitment of study participants

Upon receipt of a gate keeper's letter, a permission to visit employees at their work stations was requested and granted. The technical department produced a list of all employees who are deemed to be relevant for the study, and that list was used to recruit participants. The list also included individuals from other departments. Questionnaires were distributed together with a consent letter, and a gate keeper's letter was also produced prior to the distribution of questionnaires to respondents.

3.6.2 Pretesting and validation

In order to do pretesting and validation of the questionnaires, the questionnaires were distributed to four Budget Officers from finance department and Senior Technicians from the technical department. An expert in statistics was also consulted to verify the correctness and effectiveness of the questionnaire. Concerns raised by these parties were considered prior to finalising the questionnaires for distribution to all participants.

3.6.3 Administration of the questionnaire

Municipal employees were grouped together for the ease of distributing and collecting data, and questionnaires were personally distributed to them and collected at the same time. This was a preferred method compared to the mailing of questionnaires, due to the fact that most respondents do not have access to computers and emails.

Sekaran and Bougie (2013: 147) argues that administering a questionnaire to a group of respondants personally is much cheaper and time saving, and if respondents have any doubt they can be addressed on the spot, and the reseacher can also motivate respondents to give their honest answers, however, there is also a disadvantage of administering questionnaires personally, because the researcher may introduce a bias by explaining questions differently to different people.

3.7 Reliability Statistics

The two most important aspects of precision are **reliability** and **validity**. Reliability is computed by taking several measurements on the same subjects. A reliability coefficient of 0.70 or higher is considered as “acceptable”.

The table below reflects the Cronbach’s alpha score for all the items that constituted the questionnaire.

Table 3.1: Cronbach's alpha score table for the whole questionnaire

		No of Items	Cronbach's Alpha
Section 2.1	Water management	11 of 11	.866
Section 4.1	Customers level of satisfaction for water service	10 of 10	.872
Section 4.2	Water is a scarce source	6 of 6	.513
Overall		27 of 27	.892

The overall reliability score for the ordinal data was 0.892, which is greater than the recommended value of 0.700. This implies that overall; the respondents were consistent in the manner of their responses.

One section did, however, have a score that was (slightly) below the acceptable standard. These scores were affected by various factors. Primarily, the construct is newly developed. Some of the sections had a small number of items and in some instances, interpretation may have been a problem.

3.8 Analysis of the data

According to Sekaran and Bougie (2013: 276), the next step after data collection is to analyse the data to test the research hypothesis, but before it is analysed it has to be tested for accuracy, completeness and suitability as mentioned above. The data was then coded using numbers that corresponded with responses from respondents. Non responses were also coded in a similar way. In order to check for coding accuracy in the coded questionare, at least 10% of the data should be checked (Sekaran and Bougie, 2013: 278).

The data was then entered into a Statistical Package for Social Sciences (SPSS). The SPSS then generated graphs, charts, histogram, pie charts and tables, which were used to present the data that is analysed in different forms.

3.9 Summary

The research methodology used in this study allowed the municipal employees involved in water related activities to contribute in the study by responding to the questionnaire that was provided to them. The inputs that were provided during the pretesting phase assisted in creating a questionnaire that is user friendly, easy to understand and analyse. The idea of engaging with municipal employees in groups yielded positive results in terms of managing time for distribution and collection of data. The analysis of data, which is discussed in Chapter 4, was then carried out using data that was reliable.

CHAPTER 4: PRESENTATION OF RESULTS

4.1 Introduction

This chapter presents the results from the questionnaires of this study. The questionnaire was the primary tool that was used to collect data and was distributed to employees at the uMgungundlovu District Municipality in KwaZulu-Natal. The data collected from the responses was analysed with SPSS version 22.0.The results present the descriptive statistics in the form of bar chats, cross tabulations and other figures for the qualitative data that was collected. Inferential techniques include the use of correlations and chi square test values; which are interpreted using the p-values. The importance of using factor analysis will also be discussed.

4.2 Factor Analysis

The general purpose of factor analysis technique is to summarise data in such a way that relationships and patterns are easily interpreted and understood, and it is normally used as a tool for regrouping variables into a limited set of clusters based on shared variance, hence it helps to isolate constructs and concepts (Yong and Pearce, 2013).

Ramdass (2012) further argues that a typical use of factor analysis technique is when a researcher is conducting a survey research and the aim of that particular research is to represent a number of questions with a small number of hypothetical factors, for example, as part of a national survey on political opinions, participants may answer three separate questions regarding environmental policy, reflecting issues at the local, state and national level. Ramdass (2012) further explain that each question, by itself, would be an inadequate measure of attitude towards environmental policy, but *together* they may provide a better measure of the attitude.

According to Warne and Larsen (2014), factor analysis can be used to establish whether the three measures do, in fact, measure the same thing. If so, they can then be combined to create a new variable, a factor score variable that contains a score for each respondent on the factor. Factor techniques are applicable to a variety of situations.

In order to perform a factor analysis a researcher need to believe that factors actually exists, but in practice the factors are usually interpreted, given names, and spoken of as real things.

4.3 The KMO and Bartletts's Test tables, and Rotated Component Matrix table

The matrix tables (Table 4.2, Table 4.4 and Table 4.6) are preceded by tables (Table 4.1, Table 4.3 and Table 4.5) that reflects the results of KMO and Bartlett's Test. The requirement is that Kaiser-Meyer-Olkin Measure of Sampling Adequacy should be greater than 0.50 and Bartlett's Test of Sphericity less than 0.05. It is noted that the conditions are satisfactory which allows for the factor analysis procedure. Certain components are divided into finer components. This is explained below in the rotated component matrix tables.

4.3.1 Water Management

Table 4.1: KMO and Bartlett's Test table

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.842
Bartlett's Test of Sphericity	Approx. Chi-Square	416.105
	df	55
	Sig.	.000

Table 4.2: Rotated Component Matrix table

	Component		
	1	2	3
Water loss can be calculated	-.072	-.002	.666
Water balancing is done monthly	-.139	.746	.340
The infrastructure is in working condition	.393	.678	.070
Water meters are working properly	.487	.657	-.104

All consumers are metered	.739	.349	.046
Water supply scheme is zoned	.679	-.035	.465
As built drawings are available for your water scheme	.788	.231	.145
Monitoring equipment is used to monitor water usage	.423	.178	.620
Monitoring equipment for water usage is useful	.193	.337	.749
There is technical capacity to monitor water usage	.453	.245	.643
The municipality take Non-Revenue Water monitoring seriously	.330	.737	.292
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 11 iterations.			

The principle component analysis was used as the extraction method, and the rotation method was Varimax with Kaiser Normalization. This is an orthogonal rotation method that minimizes the number of variables that have high loadings on each factor. It simplifies the interpretation of the factors.

4.3.2 Customer Level of Satisfaction

Table 4.3: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.867
Bartlett's Test of Sphericity	Approx. Chi-Square	412.861
	Df	45
	Sig.	.000

Table 4.4: Rotated component Matrix table

	Component	
	1	2
Amount of water supplied	.229	.581
Quality of water supplied	.063	.802
Time taken to attend to faults	.194	.785
Customer service from municipal employees	.464	.505
Water charges	.819	.148
Meter readings	.864	.199
Water billing	.865	.224
Accessibility to municipal offices	.535	.298
Quality of work done by municipal employees	.392	.656
Response time by the municipality to attend to queries	.535	.499
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

Factor analysis/loading shows inter-correlations between variables. Items of questions that loaded similarly imply measurement along a similar factor. An examination of the content of items loading at or above 0.5 (and using the higher or highest loading in instances where items cross-loaded at greater than this value) effectively measured along the various components.

It is noted that all of the sections split along two or three components. Respondents identified certain aspects of the sub-themes as belonging to other sub-sections.

4.4 Personal data

This section describes the demographic characteristics of the respondents.

4.5 Age and gender analysis

The gender of the respondents is described by age in Table 4.7 below.

Table 4.5: Age versus Gender Comparison table

			Gender		Total
			Male	Female	
Age group	18 – 34	Count	26	10	36
		% within Age group	72.2%	27.8%	100.0%
		% within Gender	29.5%	45.5%	32.7%
		% of Total	23.6%	9.1%	32.7%
	35 – 44	Count	27	9	36
		% within Age group	75.0%	25.0%	100.0%
		% within Gender	30.7%	40.9%	32.7%
		% of Total	24.5%	8.2%	32.7%
	45 – 54	Count	19	3	22
		% within Age group	86.4%	13.6%	100.0%
		% within Gender	21.6%	13.6%	20.0%
		% of Total	17.3%	2.7%	20.0%
	55 – 65	Count	16	0	16
		% within Age group	100.0%	0.0%	100.0%
		% within Gender	18.2%	0.0%	14.5%

		% of Total	14.5%	0.0%	14.5%
Total		Count	88	22	110
		% within Age group	80.0%	20.0%	100.0%
		% within Gender	100.0%	100.0%	100.0%
		% of Total	80.0%	20.0%	100.0%

The ratio of males to females is approximately 8:2 (80.0%:20.0%). Within the age category of 35 to 44 years, 75.0% were male. Within the category of males (only), 30.7% were between the ages of 35 to 44 years. This category of males between the ages of 35 to 44 years formed 24.5% of the total sample.

Within the age category of 18 to 34 years, 27.8% were females. Within the category of females (only), 45.5% were between the ages of 18 to 34 years. This category of females between the ages of 18 to 34 years formed 9.1% of the total sample.

4.6 Qualification breakdown

The figure below illustrates the qualifications of the respondents.

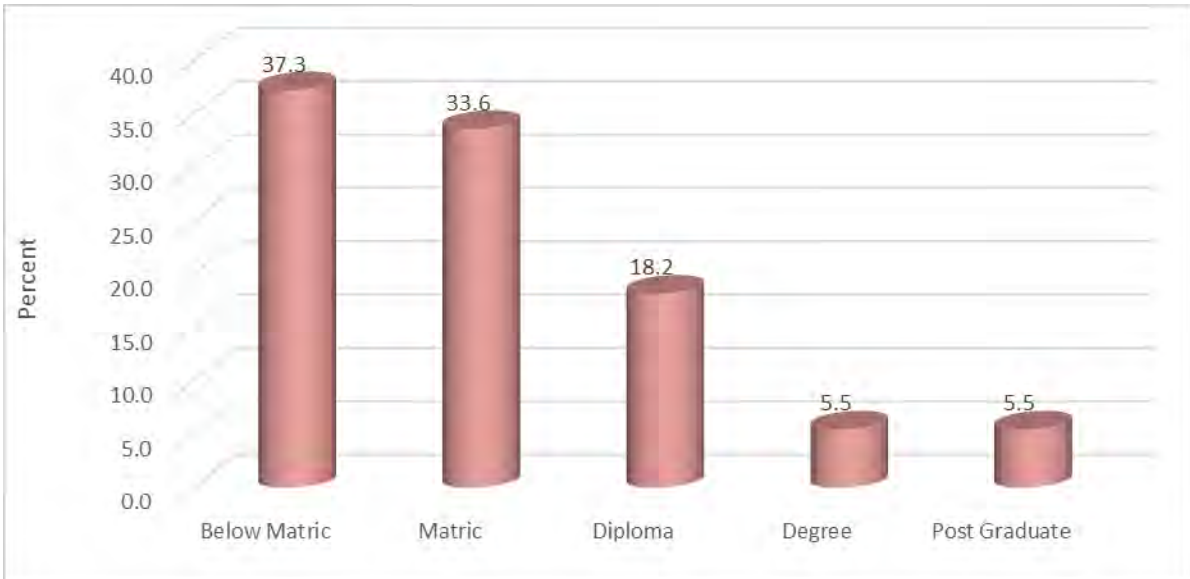

Figure 4.1 Level of education for respondents

Approximately 71% of the respondents had no more than a school qualification. A tenth of the respondents had a degree qualification (11%). Approximately 29.2 are in a possession of a post matric qualification. As the level of education increases, the number of qualified respondents decreases, from 37.3% to 5.5%.

4.7 Racial analyses

The racial composition of the sample is shown below in Figure 2.

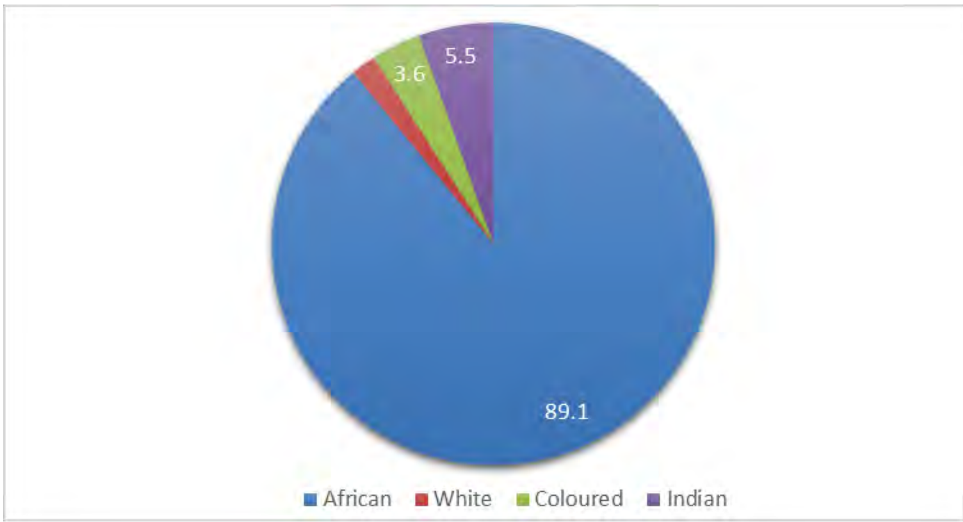

Figure 4.2 Racial representations of respondents

The majority of respondents were African (89.1%). The other slice of a pie chart was shared by Indians (5.5%), coloured (3.6%) and whites (1.8%).

4.8 Section Analysis

The section below analyses the scoring patterns of the respondents per variable per section. Results are analysed according to the importance of the statements.

4.8.1 Water management scoring patterns

This section looks at water management scoring patterns, and infrastructure management.

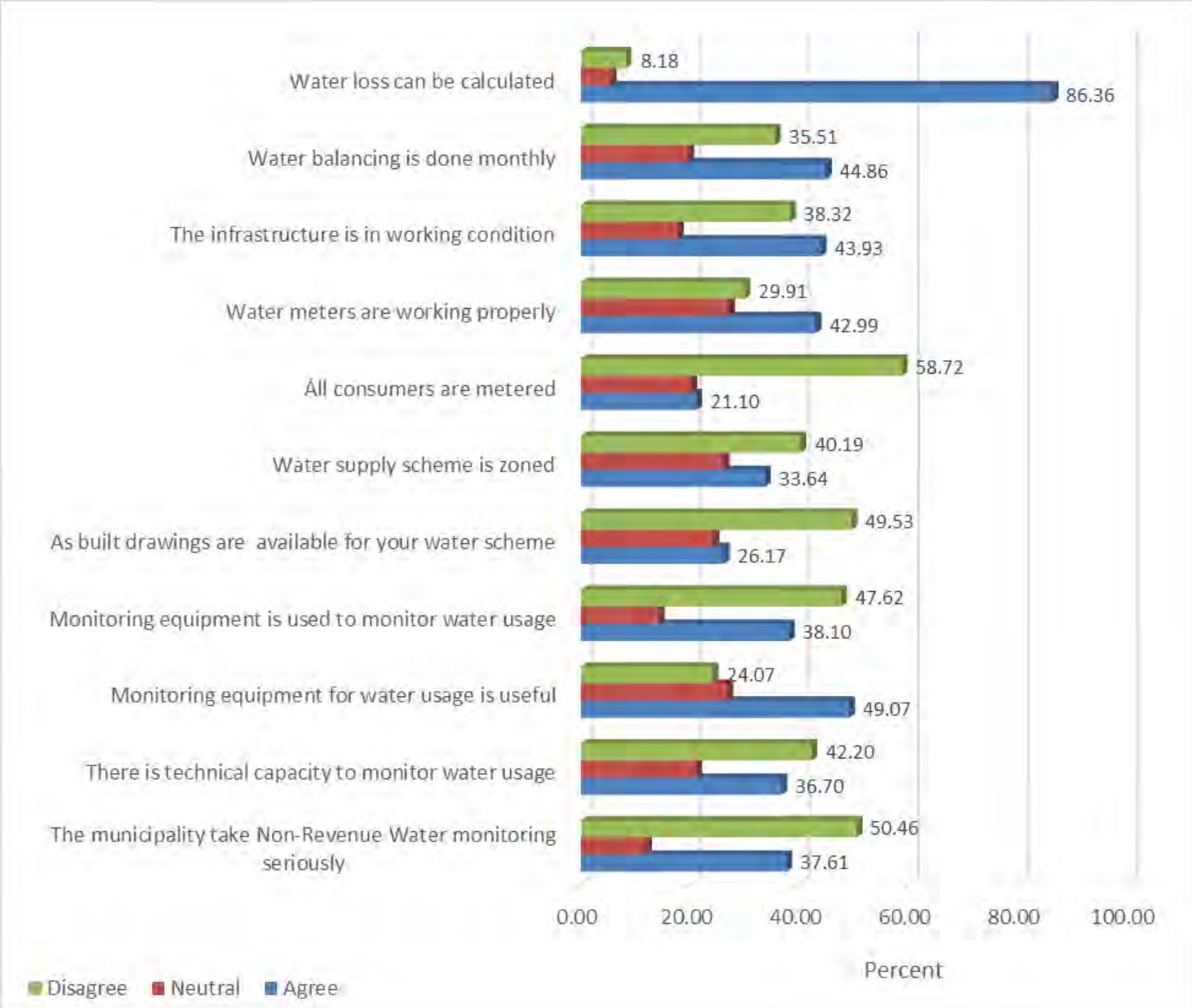

Figure 4.3 Infrastructure Management Bar Chat

Figure 4.3 above shows that there are differences in the scoring patterns.

4.8.1.1 Illustration of significances in scoring patterns

To determine whether the differences per option per statement were significant, a chi-square test was performed. The significance of these differences was tested using the chi-square test for a single variable as shown on Table 4.8 below.

These tests determine whether the scoring patterns across the options were similar or not.

Table 4.6: Chi-square test result

	Chi-Square	df	Asymp. Sig.
Water loss can be calculated	139.327	2	.000
Water balancing is done monthly	10.449	2	.005
The infrastructure is in working condition	12.187	2	.002
Water meters are working properly	4.617	2	.099
All consumers are metered	31.615	2	.000
Water supply scheme is zoned	3.159	2	.206
As built drawings are available for your water scheme	12.692	2	.002
Monitoring equipment is used to monitor water usage	18.571	2	.000
Monitoring equipment for water usage is useful	12.167	2	.002
There is technical capacity to monitor water usage	7.835	2	.020
The municipality take Non-Revenue Water monitoring seriously	25.174	2	.000

Since all but 2 of the p-values are less than the level of significance of 0.05, it implies that differences observed were significant. That is, the scoring patterns were quite different. An examination of the frequencies (graph or table), does indicate this.

4.8.2 Financial management

4.8.2.1 Summary of financial responses

The table below is a summary of the finance related questions.

Table 4.7: Break down for finance response

	Yes	No
Do you know the actual number of consumers in Lidgetton?	18.2	81.8
Are their water meters read monthly?	50.9	49.1
Are meter readings reliable?	31.5	68.5
Is Lidgetton water scheme generating sufficient revenue for the municipality?	35.8	64.2

Table 4.9 above shows that there were as many respondents who agreed compared to those who disagreed regarding the meters being read monthly. In all other instances, there are higher levels of negative responses.

4.8.2.2 Significance testing

The significances of the differences were tested using the chi square test.

Table 4.8: Chi-square test results

	Do you know the actual number of consumers in Lidgetton?	Are their water meters read monthly?	Are meter readings reliable?	Is Lidgetton water scheme generating sufficient revenue for the municipality?
Chi-Square	44.545[a]	.037[b]	14.815[b]	8.817[c]
df	1	1	1	1
Asymp. Sig.	.000	.847	.000	.003
a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 55.0.				
b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 54.0.				
c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 54.5.				

The chi square tests confirm that the differences observed were significant.

4.8.2.3 Water expenditure savings

The table below shows how the respondents compare the importance of apparent losses versus real losses

Table 4.9: Apparent losses versus Real losses

	Frequency	Percent
Apparent losses	35	32.4
Real losses	73	67.6
Total	108	100.0

Two-thirds (67.6%) of the respondents suggested that the municipality focus on the issue of real water loss.

4.8.3 Social Questionnaire

This section deals with the way municipal employees view their standard of services that they themselves are providing to the consumers. It also investigates the level of knowledge that the municipal employees have on the NRW management and matters that affect consumers on a daily basis.

4.8.3.1 Customers level of satisfaction for water service

The following Table 4.10 illustrates the level of satisfaction of the municipal employees about their capabilities in meeting consumers' expectations.

Table 4.10: Level of satisfaction for services rendered

	Satisfied	Neutral	Not satisfied
Amount of water supplied	49.07	16.67	34.26
Quality of water supplied	72.22	16.67	11.11

Time taken to attend to faults	61.47	19.27	19.27
Customer service from municipal employees	58.33	20.37	21.30
Water charges	22.43	26.17	51.40
Meter readings	19.63	26.17	54.21
Water billing	16.98	25.47	57.55
Accessibility to municipal offices	64.22	14.68	21.10
Quality of work done by municipal employees	66.67	23.15	10.19
Response time by the municipality to attend to queries	54.21	25.23	20.56

Table 4.10 above shows that an average of 21.38% is neutral, and the highest level of dissatisfaction is on meter readings, while the highest satisfaction is on the quality of water supplied.

4.8.3.2 Chi square testing results

The chi square table below tests whether the differences per statement per option are different.

Table 4.11: Chi-square results

	Chi-Square	df	Asymp. Sig.
Amount of water supplied	17.056	2	.000
Quality of water supplied	74	2	.000
Time taken to attend to faults	38.826	2	.000
Customer service from municipal employees	30.389	2	.000
Water charges	15.944	2	.000

Meter readings	21.664	2	.000
Water billing	29.113	2	.000
Accessibility to municipal offices	47.468	2	.000
Quality of work done by municipal employees	56.722	2	.000
Response time by the municipality to attend to queries	21.327	2	.000

Table 4.11 above shows that all of the values are less than 0.05 implying that the differences are significant.

4.8.3.3 Water conservation management

This table below illustrate the level of awareness of the municipal employees in relation to the municipal commitment in conserving water.

Table 4.12: Water conservation rating table

	Agree	Neutral	Disagree
Water is a scarce resource	79.82	8.26	11.93
Water usage is high amongst residents	77.57	10.28	12.15
Consumers monitor their monthly consumption	20.37	31.48	48.15
The municipality informs consumers on how to save water	30.91	19.09	50.00
If consumers are taught, they apply what they were taught by the municipality	37.61	26.61	35.78
Community awareness campaigns are effective	48.62	17.43	33.94

As shown in the Table 4.12 above, consumers do not seem to monitor their monthly water consumption, and also the municipality does not seem to be effective enough in informing them on how to save water. Both these items were scored lower than the rest.

4.8.3.4 Chi-square test for water conservation

Below are the results for the chi-square test on water conservation. The chi square test is given below in Table 4.15.

Table 4.13: Chi-square test results

	Chi-Square	df	Asymp. Sig.
Water is a scarce resource	106.202	2	0.000
Water usage is high amongst residents	94.28	2	.000
Consumers monitor their monthly consumption	12.667	2	.002
The municipality informs consumers on how to save water	16.055	2	.000
If consumers are taught, they apply what they were taught by the municipality	2.275	2	.321
Community awareness campaigns are effective	15.927	2	.000

Table 4.13 above shows that all differences are significant except for “If consumers are taught, they apply what they were taught by the municipality”
(χ^2 = p-value = .321).

4.8.3.5 Legality of Water Usage

The following section shows the level of illegal water use in Lidgetton.

Table 4.14: Level of illegal water connections

	Very high	High	Low	Very low
How is the illegal water use in Lidgetton?	0.00	50.46	39.45	10.09

There were as many respondents who indicated a high level of illegal use (50.46%) compared to those who felt it was low (49.54%).

4.8.3.6 Illegal water users

Table 4.15 below shows the municipal employees level of awareness regarding illegal water users.

Table 4.15: Awareness on illegal water users

	Frequency	Percent
No	55	50.5
Yes	54	49.5
Total	109	100.0

There was almost an equal split amongst the respondents in terms of whether they knew of illegal connections.

4.8.3.7 Who does illegal water connections?

This section shows the parties that are responsible for illegal connections according to the municipal employees understanding.

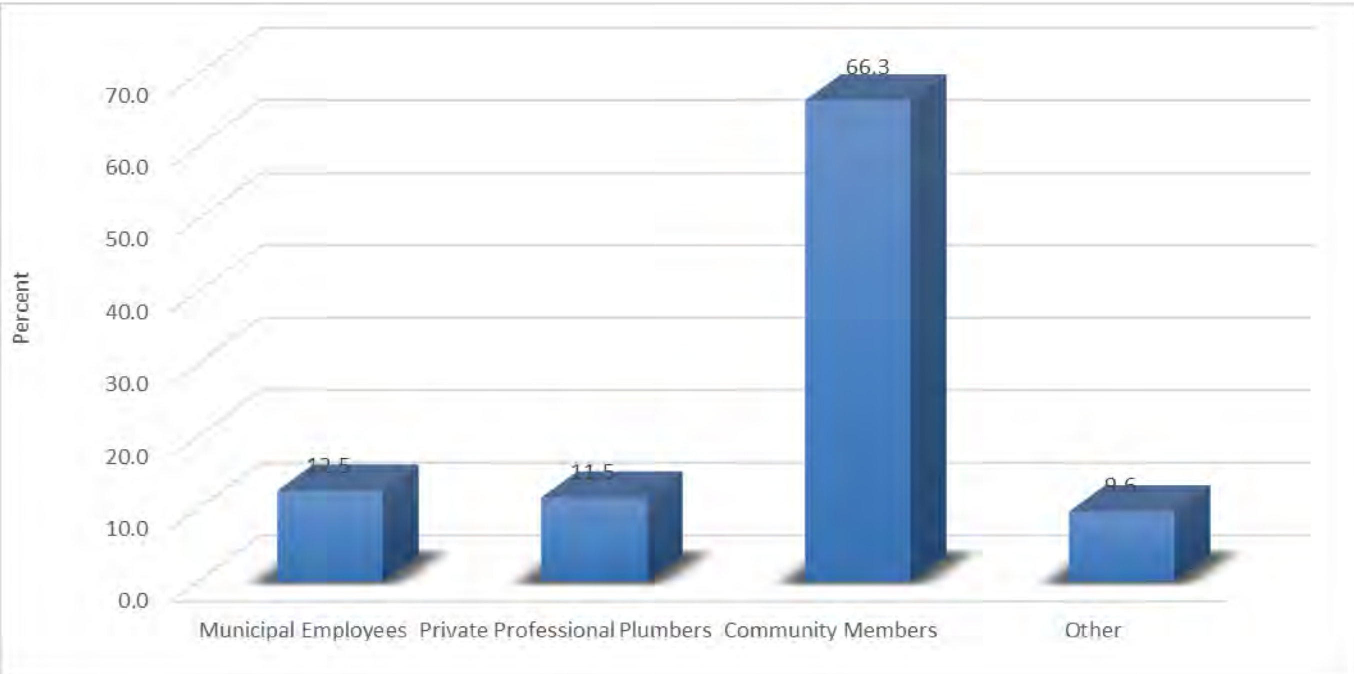

Figure 4.4 People responsible for illegal connections

Of the respondents who knew of illegal connections, approximately two-thirds (66.3%) identified community members as being responsible for doing the connections.

4.8.3.8 Reasons residents resort to illegal water consumption

Table 4.16: Reasons for doing illegal connections

	Percent
Consumers not being aware of application process	17.3
Complicated application process for new house connections	17.3
Weak monitoring and inspection procedures	20.0
Delays in requested house connections	22.7
Water charges	36.4
Connection fee	39.1
The belief that water should be free of charge	41.8

The above Table 4.16 shows that the three highest rated items ranging between 36.4% to 41.8% are all related to money paid by consumers. At the lowest ranking are two items, each ranking at 17.3% and both are related to application process.

4.9 Reaction of Municipal employees to Municipal policies

The table below presents the way municipal employees view their policies in respect to provision of water supply services.

Table 4.17: Views on the municipal policies

	Yes	No
Is 6000 litre free monthly basic water enough?	67.0	33.0
The municipality should disconnect water supply where there are illegal connections	79.2	20.8
The municipality must reduce water supply where there is perceived water wastage	81.9	18.1
The municipality must restrict water supply to customers in arrears	83.0	17.0
Do consumers use more than 6000 litre per month?	84.3	15.7
The municipality must impose a penalty on illegal water users	89.5	10.5

Table 4.17 above shows that municipal employees who are in agreement in their answers on ways related to water wastage and solutions, ranging from 67% to 89.5% in their agreements. It is also worth noting that the highest rated item is "the municipality must impose a penalty on illegal water users" at 89.5%.

4.10 Hypothesis Testing

The traditional approach to reporting a result requires a statement of statistical significance. A **p-value** is generated from a **test statistic.** A significant result is indicated with "$p < 0.05$". These values are highlighted with a *. The Chi square test was performed to determine whether there was a statistically significant relationship between the variables (rows versus columns). The null hypothesis states that there is no association between the two. The alternate hypothesis indicates that there is an association. The results of the chi-square tests are summarised and presented in a table format.

Table 4.18: Pearson Chi-square test results for water management

Pearson Chi-Square Tests						
		Gender	Age group	Race	Highest level of qualification	Municipal employee working for
Water balancing is done monthly	Chi-square	8.864	6.269	6.142	21.033	4.007
	df	2	6	6	8	6
	Sig.	.012*	0.394	0.407	.007*	0.676
Water meters are working properly	Chi-square	4.552	9.709	6.940	17.008	5.560
	df	2	6	6	8	6
	Sig.	.103	0.137	0.326	.030*	0.474
There is technical capacity to monitor water usage	Chi-square	15.126	9.415	5.539	9.688	7.219
	df	2	6	6	8	6
	Sig.	.001*	0.152	0.477	0.288	0.301
The municipality take Non-Revenue Water monitoring seriously	Chi-square	2.115	8.534	8.811	15.895	5.361
	df	2	6	6	8	6
	Sig.	.347	0.202	0.184	.044*	0.498

Table 4.18 above shows that the p-value between "Gender" and "Water balancing is done monthly" is 0.012 which is less than the significance value of 0.05. This means that there is a significant relationship between the variables. That is, the gender of a respondent does play a role in terms of how they perceive water balancing is done.

The p-value between "highest level of qualification" and "water meters working properly" is 0.030, and this is less than the significance value of 0.05.

The level of qualification possessed by the municipal employees has got a significant relation to their understanding of the working conditions of meters. There is a significant relationship between the two variables which are, “there is technical capacity to monitor water usage” and “gender”. The p-value is 0.001between the two variables and it is less than 0.05 which is the significance value.

Table 4.18 above also shows a significant relationship between “The municipality take Non-Revenue Water monitoring seriously” and “Highest level of qualification”. The p-value for these two variables is 0.044, and this figure is less than 0.05 which is the significant value.

The results below in Table 4.19 are based on the chi-square results for the financial section. A relationship between the horizontal and vertical variables will be presented in Table 4.19 below.

Table 4.19 Pearson Chi-square test results for financial related responses

Pearson Chi-Square Tests						
		Gender	Age group	Race	Highest level of qualification	Municipal employee working for
Do you know the actual number of consumers in Lidgetton?	Chi-square	0.000	3.034	9.944	2.901	1.375
	df	1	3	3	4	3
	Sig.	1	0.386	.019*	0.574	0.711
Is Lidgetton water scheme generating sufficient revenue for the municipality?	Chi-square	.868	9.574	4.783	12.328	4.063
	df	1	3	3	4	3
	Sig.	.351	.023*	0.188	.015*	0.255
Where should the municipality focus on in order to reduce Non-Revenue Water?	Chi-square	4.748	7.958	1.527	1.472	.491
	df	1	3	3	4	3
	Sig.	.029*	.047*	0.676	0.832	0.921

There seem to be a significant relationship between “Race” and “Do you know the actual number of consumers in Lidgetton?” The p-value is 0.019 which is less than the significance value of 0.05. The relationship between these two variables shows that being in a certain race influences how you identify the number of consumers in Lidgetton.

Table 4.20 presented below will present results for the relationship between “gender: and the two variables which are, “time taken to attend to faults” and “how is illegal water use in Lidgetton”.

Table 4.20 Pearson Chi-square test results for social related responses

Pearson Chi-Square Tests						
		Gender	Age group	Race	Highest level of qualification	Municipal employee working for
Time taken to attend to faults	Chi-square	8.614	10.513	7.918	5.586	9.917
	df	2	6	6	8	6
	Sig.	.013*	0.105	0.244	0.694	0.128
How is the illegal water use in Lidgetton?	Chi-square	10.707	4.223	6.704	6.331	3.666
	df	2	6	6	8	6
	Sig.	.005*	0.646	0.349	0.61	0.722

There is a significant relationship between “gender” and “time taken to attend to faults”. The p-value is 0.013 for these two variables and it is less than the significant value of 0.05. The other variables that have a significant relationship are “how is the illegal water use in Lidgetton” and “gender”. These two variables have a significant relationship with a p-value of 0.005, which is also less than 0.05.All values without an * (or p-values more than 0.05) do not have a significant relationship.

4.11 Correlations

Bivariate correlation was also performed on the data, and the results indicate the following patterns:

Positive values indicate a directly proportional relationship between the variables and a negative value indicates an inverse relationship. All significant relationships are indicated by a * or **. For example, the correlation value between “All consumers are metered” and “Water supply scheme is zoned” is 0.378. This is a directly related proportionality. Respondents agree that the more supply is zoned, the more likely the houses would be metered, and vice versa.

There is a directly proportional relationship between the variable “water balancing is done monthly” and “all consumers are metered”, the correlation value is 0.316. This means that the more consumers are metered the more likely that balancing will be done monthly.

There is an inverse relationship between the variables “water billing” and “water loss calculation”. This means that if the municipality focuses more on increasing and improving water billing, water loss will decrease.

4.12 Summary

The results presented above were generated from the questionnaires which were distributed to uMDM employees. There were significant issues that were discovered during the data analyses stage, and some of these issues are suggesting some trends regarding the Non-Revenue Water management. The respondents were dominated by Africans (89.1%), followed by Indians at 5.5%. The respondents were dominated by males at 80% and females at 20%; this is due to the nature of the work done by water departments. The questionnaires also consisted of a social section. This section was answered by the municipal employees and not the community. The municipal employees are in contact on a daily basis with communities and therefore they are a reliable source of social information. The tables and data that were presented above will further be discussed in Chapter 5, where the interpretation of the data will be done.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter discusses findings for the results obtained from the study. The chapter also compares the results with case studies, official reports and available research on similar studies. The objectives of this study will be further discussed in comparison to the data that was collected throughout the study, and they will also be discussed independently. The results discussed are those obtained from the questionnaires which were distributed to uMDM employees.

It should also be noted that in some sections, negative levels were grouped together, and the positive ones also grouped together; this meant that there will only be a negative, neutral and a positive response category. These responses were not discarded, but they are combined to make the analysis more manageable.

5.2 Responses according to departments

There was a positive feedback from respondents as it can be seen in Table 5.1 below. The divisions in which the respondents worked are given in the Table 1.

Table 5.1: Respondents allocation by department

	Frequency	Percent
Technical Department	102	93.6
Finance Department	3	2.8
Water Services Authority	3	2.8
Community Services	1	.9
Total	109	100.0

The overwhelming majority of respondents (93.6%) belonged to the Technical Department. Almost everyone within the technical department is somehow linked to NRW management, and that is why the majority of the respondents are from that department. In other departments, very few employees are exposed to NRW management, hence the small percentage of respondents from those sections.

5.3 Discussion by objectives

5.3.1 Objective 1

To identify the current NRW assessment methods and management policies adopted by uMgungundlovu District Municipality.

Table 5.2 below shows how the municipal employees view the assessment methods that are used to measure and monitor Non-Revenue Water within uMDM.

Table 5.2: Water management

	Agree	Neutral	Disagree
Water loss can be calculated	86.36	5.45	8.18
Water balancing is done monthly	44.86	19.63	35.51
The infrastructure is in working condition	43.93	17.76	38.32
Water meters are working properly	42.99	27.10	29.91
All consumers are metered	21.10	20.18	58.72
Water supply scheme is zoned	33.64	26.17	40.19
As built drawings are available for your water scheme	26.17	24.30	49.53
Monitoring equipment is used to monitor water usage	38.10	14.29	47.62
Monitoring equipment for water usage is useful	49.07	26.85	24.07
There is technical capacity to monitor water usage	36.70	21.10	42.20
The municipality take Non-Revenue Water monitoring seriously	37.61	11.93	50.46

A large number of respondents believe that water loss can be calculated (86.36%). There is a lot of technicality when doing NRW management which involves mostly technical services employees. To back the view that is shared by this majority (86.36%) refer to the IWA water balance components.

The trend in the above results is that employees agree that water balancing can be done. However, when it comes to the components building up to a proper water balancing system, they are rating every item below 50%. Even the most important items like “All consumers are metered”, it was rated at 21.1%, and “There is technical capacity to monitor water usage” was rated at 36.7%. In order to try and account for every drop of water produced, according to Gopalakrishnan (2005) countries like Egypt formulated several policies that were to be used as a tool to manage their water resources; these policies included Water Policy, Egyptian Water Master Plan, Water Security Project and The National Water Resources Policy.

The results in the above table shows that 42.99% agree that water meters are not working properly and 47.6% disagree that there is monitoring equipment used by the municipality to monitor water. What was even more alarming was that 50.46% of respondents did not think that the municipality takes NRW management seriously. Only 43.93% of respondents agree that the infrastructure is in good working condition, this means that monitoring water usage is not done properly. This differed to what the study on the City of Tshwane Metropolitan Municipality (CTMM). The study by Rabe, Maree, Ramano, and Price(2012) revealed that the CTMM takes NRW management seriously to the extent of metering all their own buildings and parks, as they believe that these areas might be a source of high water loss if they are not monitored properly.

To further show that the CTMM is serious about NRW management and keeping their infrastructure in good working condition, they instituted a water meter audit to investigate the meter positions, audit and verify the status of the meters, whether there was a meter at all, road island and parks that were irrigated by the CTMM, and also to verify if the water used is accounted for and billed correctly by the CTMM (Rabe, Maree, Ramano, and Price, 2012).

The municipality has policies in place in pursuit of creating sound water management practices. The Figure below illustrates the effectiveness of these policies and activities that may be improved and adopted as municipal policies.

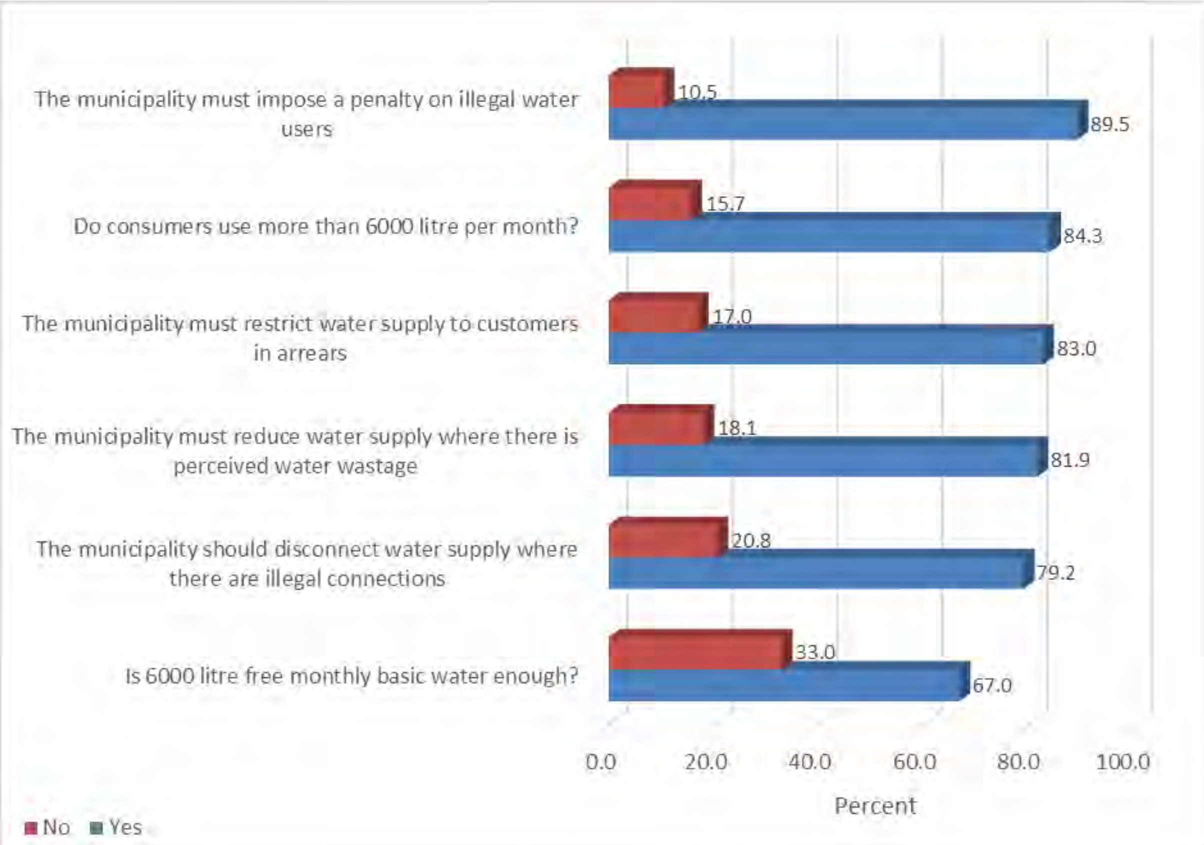

Figure 5.1 Reactions to municipal policies

The pattern observed in Figure 5.1 above shows that the respondents agree on the implementation of policies in an attempt to monitor the use of water, and which endeavour to curb water losses. The result shows that 89.5% of the respondents agree that the municipality must impose penalties on illegal water users. Also 84.3% of respondents agree that consumers are using more than free basic 6000 litres of water and 67% of respondents think that the 6000 litres is not enough.

Research by Rabe, Maree, Ramano, and Price (2012) established that even the Ethekwini municipality, in their service level standards policy which takes into cognisance Water Conservation and Water Demand Management (WC/WDM), is more focused with maintaining and containing volumes supplied to customers. The Ethekwini policy also specifies that:

- All standpipes must be metered
- Full pressure supply systems must have a water management device installed, and
- Tariffs are to be charged on all metered connections for consumption over a Free Basic Water volume of 6kl per property per month

The way the EThekwini municipality structured their policy concurs with the result of the study in that it also aims to reduce water losses while ensuring that they meet public expectations and assist consumers to manage their water supply effectively.

5.3.2 Objective 2

To identify whether the uMDM is proactive or reactive towards NRW management in Lidgetton.

In order for the municipality to be regarded as proactive it will mean that all the systems are in place regarding NRW management. It will also mean that there is relevant equipment, human resources and skills to be used in NRW management. Chapter 3 elaborated on the methods of monitoring and calculating NRW, all of them proved to be of no use in the case of Lidgetton due to reasons discussed in chapter 3. According to De Bruin, Meer and Tilburg (2010) the lack of understanding of the magnitude, sources and costs of NRW is one of the main reasons for insufficient NRW reduction efforts, to be proactive municipalities need to be able to quantify NRW and its components.

The Figure below shows some of the items that the respondents should agree on in order to be capable of calculating NRW.

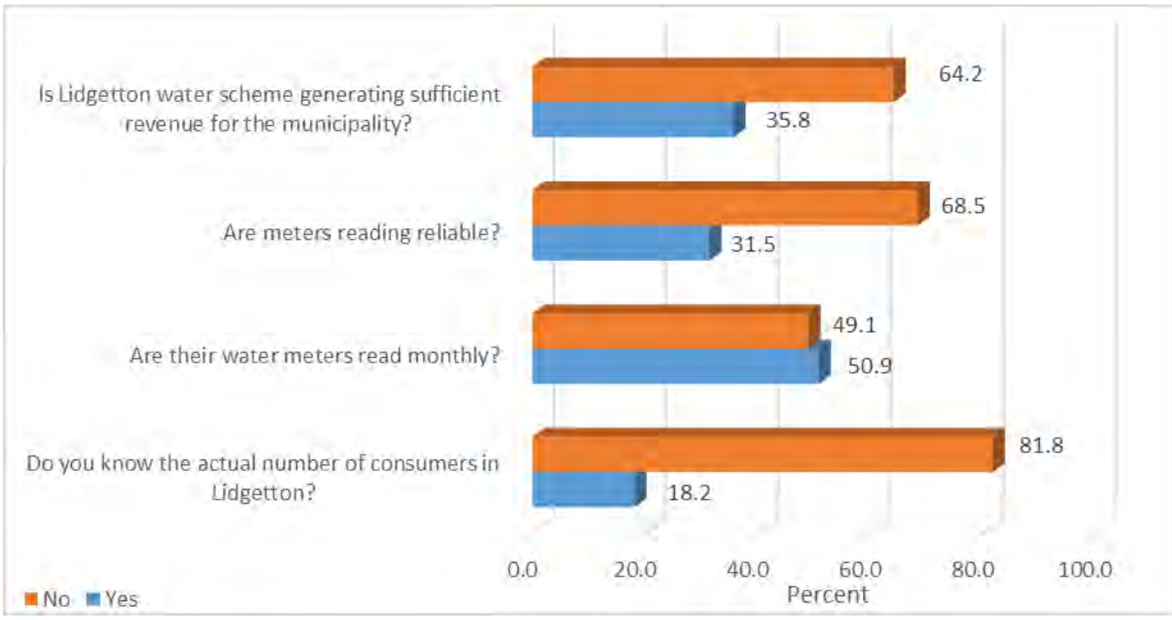

Figure 5.2 Revenue generation through metering

Figure 5.2 above shows that 64.2% of respondents believe that the Lidgetton water scheme is not generating sufficient revenue for the municipality. Presumably, reasons for the lack of revenue are depicted by the percentage (68.5%) of the respondents who believe that meter readings for Lidgetton are not reliable. Even though 50.9% believe that meter readings are done monthly, it is immaterial due the 81.8% of respondents who do not know the number of consumers in Lidgetton.

It is highly unlikely that the municipality can be proactive in monitoring NRW in Lidgetton if the majority of respondents do not even know the number of consumers in their water distribution system. Having a reliable data is one of the basics in monitoring NRW, but this is not the case with Lidgetton. Having unreliable data will result in unreliable results which will not assist the municipality in managing NRW. According to Ministry of Water and Livestock Development (2002), the Government of Tanzania has tried to be proactive in their approach even though they are having challenges with high rate of urbanization, increase of industrial activities and significant unaccounted for water that includes pipe leaks, illegal connections and wastage, the steps that they have taken in order to be proactive in reducing their NRW are:

- Measures on proper tariff setting (at an economic cost), metering, rationing, leakage control and mass education on frugal use of water and conservation.
- Regulations on efficient use of water by using low capacity cisterns.

5.3.3 Objective 3

Seeks to measure uMDM's employee's awareness of NRW from different sections that are involved in NRW management, as well as investigating the level at which the municipal employees are aware of NRW management.

NRW management is not only about managing systems, but according to a study done by Mbombela local municipality it is better managed in a form of a Public Private Partnership, hence their engagement with Sembcorp Silulumanzi in 1999, formerly known as Greater Nelspruit Utility Company (GNUC). According to the report from Mbombela Local Municipality some of the achievements for this PPP were:

- The establishment of satellite offices in areas where they are supplying water, in order to provide improved customer services such as payment kiosk, raising of queries and reporting leaks/water supply problems
- Getting rid of illegal connections and repairing of household leaks through implementation of a pilot project
- Provision of training to both staff members and communities in water matters including the importance of water supply and the management thereof
- Extension of infrastructure to meet the growing population demand
- Developing an asset register that is linked to a GIS system and fault reporting/repair system, which is also linked to customer billing and service level data (Rabe, Maree, Ramano, and Price, 2012).

The probability that the employees are aware of NRW management is high if the municipality takes the above mentioned approach. The figure below indicates the items that were rated by the respondents in trying to find out their level of knowledge with regards to some of the NRW management components and the level of satisfaction for the services they are providing to consumers.

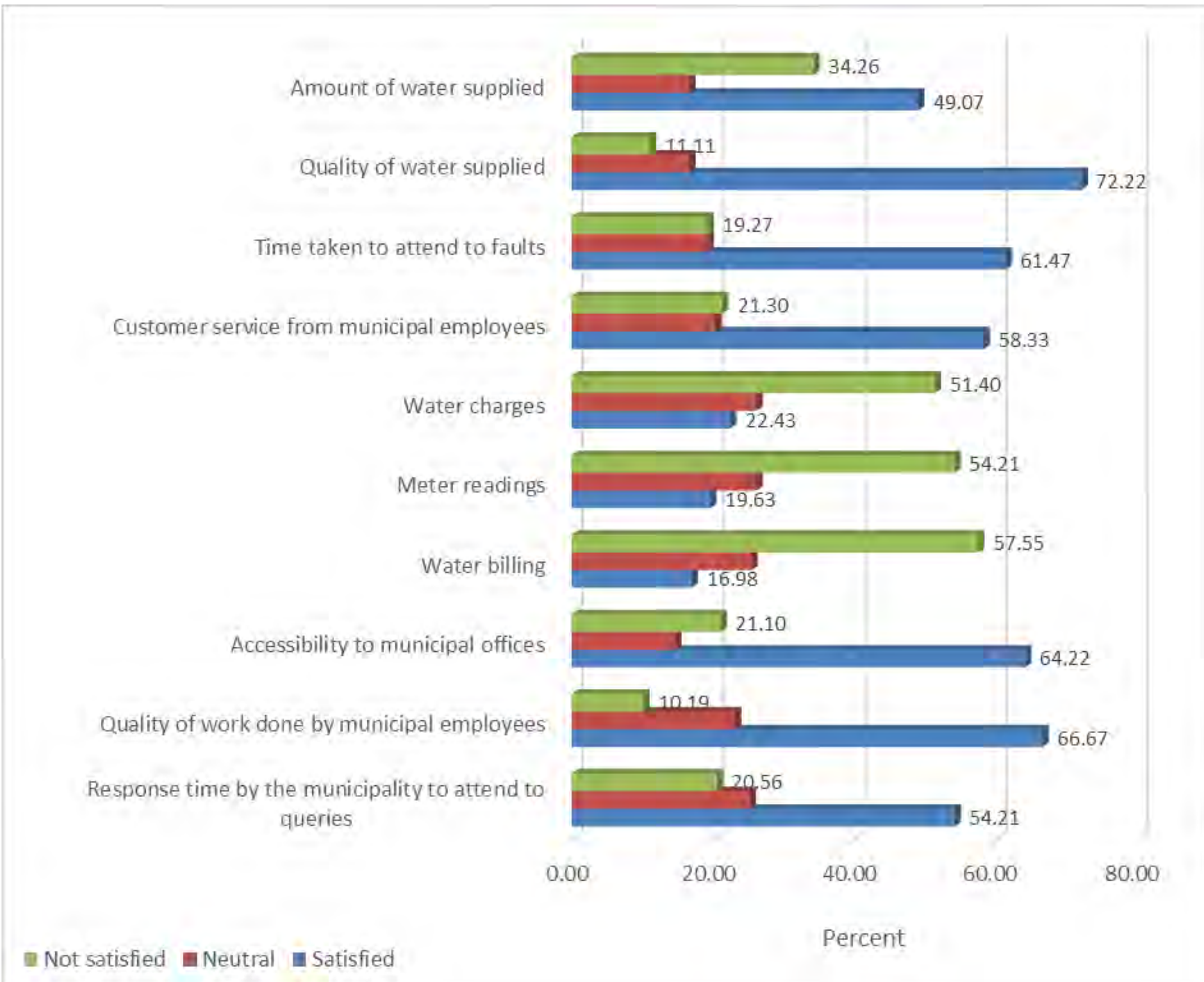

Figure 5.3 Municipal services satisfaction level

The results in Figure 5.3 above show that there is a positive trend regarding the work done by the municipality towards their consumers. The highest percentage of 72.22% was scored on the satisfaction about the quality of water supplied. Also at 66.67% is the satisfaction of the quality of work done by the municipal employees, and 61.47% is satisfied with the time taken by municipal employees to attend to infrastructure faults after being reported.

While the level of dissatisfaction ranges from 51% to 58% for the three items, “Water charges”, “meter readings” and “water billing” the level of satisfaction ranges from 16% to 23%. The noticeable trend looking at Figure 3 and Figure 2 is that the employees are not satisfied with water meter related issues, and this is alarming because water meters are a fundamental tool used to monitor and manage NRW.

These results also shows a high satisfaction when it comes to consumer relationship. At 64.22% there is a high level of satisfaction regarding access to municipal offices, and 58.33% on level of satisfaction on customer service.

Cosgrove and Rijsberman (2000) argues that community empowerment should be at the center of planning for municipalities in order to encourage a sense of ownership for the developments taking place in their areas, and this will also empower man and woman and it will improve sustainable living conditions for everyone, particularly women and children.

5.3.4 Objective 4

To analyse the breakdown for NRW components (apparent losses, real losses, and unbilled authorized consumption) with respect to distribution system of Lidgetton Water Scheme.

As discussed in the above section and in Chapter 3, the calculation of NRW components requires intense monitoring and a continuous records keeping system. Charalambous (2010) established that it is important for the strategy of NRW to be continuous, be based on a long term strategy, and it must be integrated to the vision of the municipality.

5.3.4.1 Apparent losses

Apparent losses emanate from consumer meters which are not functioning properly, errors caused by handling of data and water stolen in various forms (Fanner and Thornton, 2005). In the case of Lidgetton, apparent losses could not be quantified because of lack of information and its reliability.

However, the respondents provided some information which seeks to give an indication regarding the status of apparent losses in Lidgetton in the Figure below. Figure 2 will give us an indication for the main causes of illegal connections.

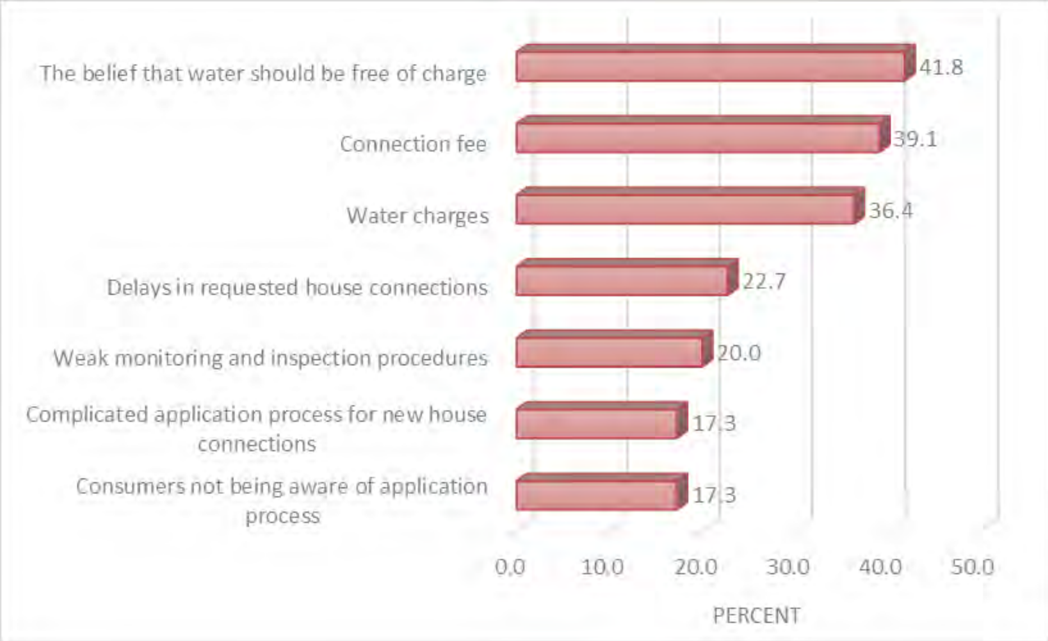

Figure 5.4 Reasons for illegal connections

Figure 5.4 above shows that there is water that is not accounted for from the Lidgetton distribution system that is affecting apparent losses. It then shows the three highly rated reasons for the misuse of water, and these are “the belief that water should be free of charge” at 41.8%, “connection fee” at 39.1%, and “water charges” at 36.4%. The two lowest ranked items at 17.3% are “complicated application process for new house connections” and “consumers not being aware of application process”. This means very few illegal connections are as a result of application processes.

20% of the respondents believe that illegal connections are as a result of “weak monitoring and inspection procedures’, while 22.7% believe that it is because of “delays in requested house connections”. The reasons why the first three items got high percentage might be that at Lidgetton, it is an existing supply with very few requests for new connections, and these are more focused on the payment and charges of water service.

5.3.4.2 Real losses

Real losses are made up of leakages in the distribution system, overflows of reservoirs, poor operations and maintenance, lack of active leakage control and poor infrastructure quality (Fanner and Thornton, 2005). The Table below shows how respondents compare the importance of real losses to apparent losses.

Table 5.3: Apparent losses versus real losses

	Frequency	Percent
Apparent losses	35	32.4
Real losses	73	67.6
Total	108	100.0

In Table 5.3 above respondents were asked “where should the municipality focus on in order to reduce Non-Revenue Water?” 67.65% of the respondents believe that the municipality must focus on real losses in order to reduce NRW.

Unbilled authorised consumption

Unbilled authorised consumption include water that is used by the WSA for operational purposes, water used by fire fighters and water that is provided by the WSA for free to a certain group of consumers (Fanner and Thornton, 2005).

The International Water Association’s performance indicators are used as a tool for benchmarking the WSA’s performance and to setup targets for improved performance (Fanner and Thornton, 2005). The most commonly used method requires volume of losses per connection per day and the infrastructure leakage Index (Fanner and Thornton, 2005). In the case of Lidgetton, there are no records for data that is required for unbilled authorised consumption. However, Figure 18 below shows how respondents perceive matters related to water usage that may impact on unbilled authorised consumption volumes.

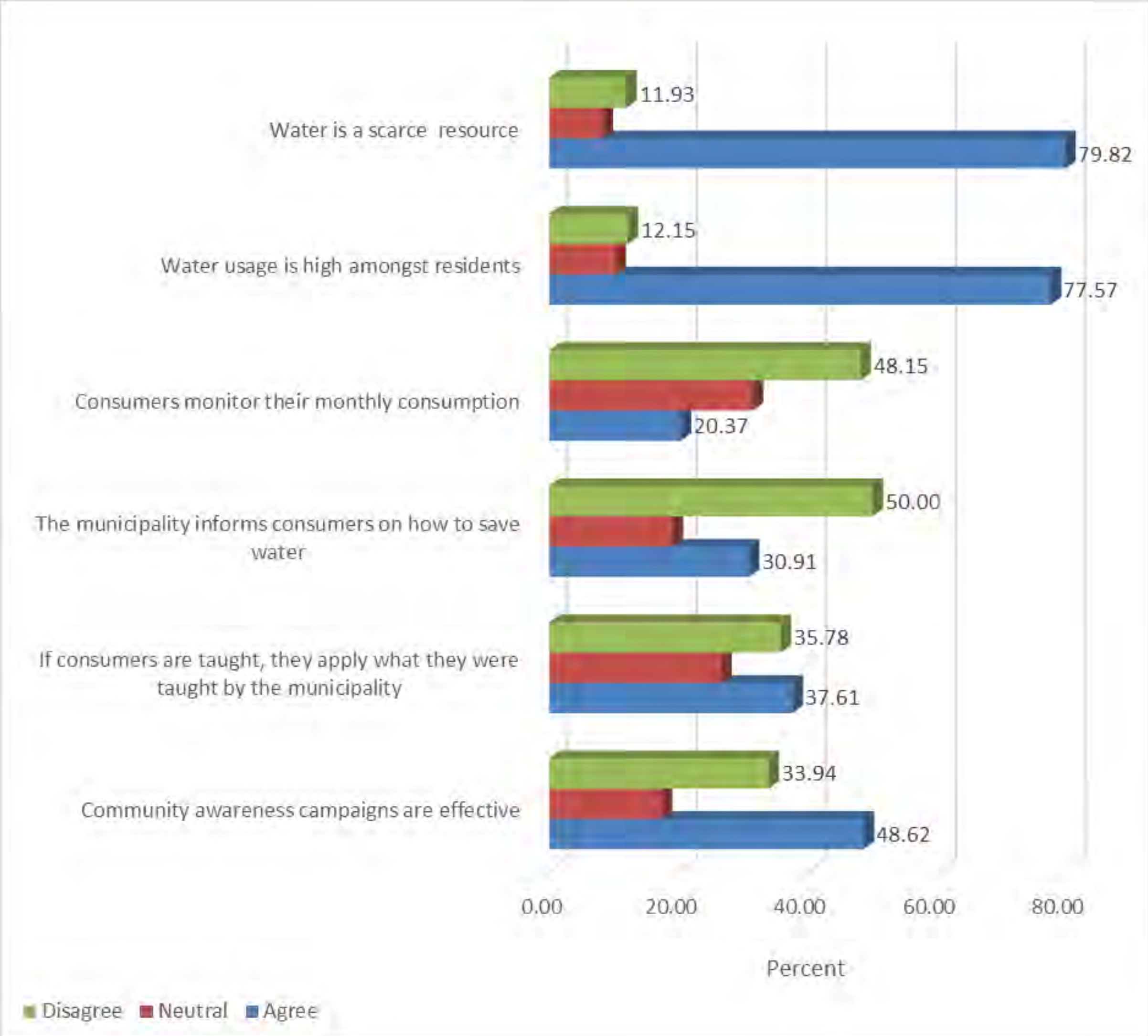

Figure 5.5 Water usage

Figure 5.5 above shows that respondents who believe that “water is a scarce resource” are 79.82%, and those who believe that “water usage is high amongst residents” are 77.57%. The low rated percentage of consumer awareness campaigns (33.94%), and 35.78% on “if consumers are taught, they will apply what they were taught by the municipality” seem to be the cause for high water usage amongst residents. This also means that the municipality does not inform consumers thoroughly on how to save water hence the 50% on “the municipality informs consumers on how to save water”; as a result the unbilled authorised consumption will be high.

5.4 Summary

The respondents agree that NRW can be calculated. However, it will need to be taken seriously at management level first by making sure that there are policies in place which are developed and that there is a NRW strategy in place to be implemented by all relevant internal departments, including other external stakeholders. The municipality will also need to invest in skilled human resources and equipment so that the required data can be collected continuously and monitored effectively. The results also show that the municipality need to repair and upgrade their infrastructure where necessary and make sure that all consumers are metered and their meters are working properly.

Having all the necessities in place will assist the municipality to become proactive in NRW management rather than being reactive as it is the case currently at Lidgetton. The trend shows that meter readings and billing information needs to be monitored closely so that the information received can be regarded as credible and sufficient. This will then assist in the compilation of NRW components figures for water balance as developed by IWA. Based on these results there are recommendations that were made which are discussed in the next chapter.

CHAPTER 6: RECOMMENDATIONS AND CONCLUSIONS

6.1 Introduction

This study on the Non-Revenue Water management, carried out in Lidgetton, came out with findings which were discussed in the previous chapter. This section discusses the recommendations arising from the results of the study, the implications of the study and discusses whether the problem can be solved or not.

6.2 Has the problem been solved?

The previous sections addressed and discussed the objectives of the study at length. These objectives were as follows:

- To identify the current NRW assessment methods and management policies adopted by uMgungundlovu District Municipality
- To identify whether the uMDM is proactive or reactive towards NRW management in Lidgetton.
- To measure uMDM's employee's awareness of NRW from different sections that are involved in NRW management.
- To analyse the breakdown for NRW components (apparent losses, real losses, and unbilled authorized consumption) with respect to distribution system of Lidgetton Water Scheme.

The problem has not been solved due to non-availability of NRW assessment methods within the uMDM that are used currently. There also no policies in place currently which specifically deal with NRW management.

6.3 Findings

The findings of the current research work suggest that all is not well in Lidgetton water scheme regarding NRW management. The study revealed that there is no NRW assessment done in Lidgetton water distribution network. However, the study discussed various methods that may be used to assess NRW. The existing policies do not address the management and assessment of NRW extensively. Even the policies that are in existence are not implemented completely and consistently in such a way that they can make an impact in the management of NRW.

The study also revealed that the issue of creating, adopting and implementation of policies still remains a challenge that has to be addressed by the senior management. The municipality is not proactive in managing NRW in Lidgetton; it is more of a reaction organisation that only acts on what has been reported by the community, community representative and municipal employees.

The study revealed that uMDM employees are not fully aware of the NRW management and its impact in the organisation. The employees are only aware of some of the items which form part of measuring NRW. The problem of identifying NRW components as identified by IWA and discussed in previous chapters was not resolved due to a lack of data that is required to calculate these essential components.

6.4 Implications of this research

This study will assist other municipalities which are in a situation similar to that of the Lidgetton area. It will also assist the uMDM to manage NRW in its other water schemes. This study pointed out vital elements that need to be considered when crafting a strategy for NRW management. This strategy may not necessarily be for Lidgetton only, but it can be a broad strategy that will cover the whole municipal area of supply.

The findings of this study exposed some of the things that the municipality need to be aware of, and these will benefit the municipality in many ways. These are:

- the non-existence of data for calculating water loss;
- unavailability of equipment to monitor and measure NRW
- the level of service provided by municipal employees to the communities
- the perceived quality of work done by municipal employees
- the deteriorating conditions of water infrastructure
- lack of revenue collection

The above mentioned findings will benefit the municipality when attempting to reduce NRW and in putting permanent systems in place as required by the provincial water and sanitation department and other interest groups. The provincial Department of Water and Sanitation provide funding for municipalities in order to reduce NRW. The

information available in this study can assist the provincial department when crafting a business plan and assessing the need for funding the Lidgetton water scheme.
The community will benefit from this study in that it creates an awareness of the issues that might affect their constant water supply.

According to Every and Foley (2006) community benefits are more visible if there is tolerance between government and other stakeholders, and as a results findings and programs involving communities are most likely to promote water efficiency.

6.5 Recommendations to solve the problem

Recommendations were formulated based on the findings of the study and they are linked to the objectives of the study. The first objective is; “to identify the current NRW assessment methods and management policies adopted by uMgungundlovu District Municipality”. It is recommended that a NRW management strategy for Lidgetton water scheme be developed and senior management to have a buy in on the strategy. Policies should be promulgated, adopted and implemented fully and consistently by the municipality. Policies for metering of all consumers should be advocated, and meter readings should be done monthly and where there are discrepancies, to be verified and rectified timely. Metering policy should also encourage bulk meters to be installed and read daily in all inlets and outlets of bulk pipeline.

For the second objective which is; ‘to identify whether the uMDM is proactive or reactive towards NRW management in Lidgetton“. It is recommended that the municipality should source any recognised equipment for monitoring and measuring NRW. It is recommended that the municipality should be pro-active when dealing with NRW, it is further recommended that the municipality should establish a NRW section with its own NRW manager that will proactively plan, organise and monitor all NRW management related activities. This manager will also co-ordinate work done by other department, because NRW management cuts across various departments.

The third objective is; “to measure uMDM’s employee’s awareness of NRW from different sections that are involved in NRW management”. All employees working with NRW related tasks should be trained in NRW management regardless of the department they come from and the position they occupy. Consumer awareness campaigns should be intensified and be carried out continuously. It is also recommended that infrastructure be repaired regularly and managed properly, and where operations and maintenance employees has done repairs or replacement of fittings and parts within the system to keep records of all work done in the distribution system. GIS, operations and maintenance and asset register should also be updated regularly and be interlinked

The recommendations for the fourth objective which is; “to analyse the breakdown for NRW components (apparent losses, real losses, and unbilled authorized consumption) with respect to distribution system of Lidgetton Water Scheme”. For this objective it is recommended that illegal connections should be investigated and corrected, and it is recommended that transgressors be warned and educated about the consequences of illegal connections, then after they can be punished if they continue to do them. The municipality should adopt and implement an active leak detection method as discussed in previous chapters. Therefore the distribution system should be zoned properly, and pressure management equipment and methods to be used in the distribution system.

According to Wyatt (2010) there are several possible outcomes to a leakage location and repair programme, and these are shown below in Table 2.4

Table 6.1 Outcome from leak repair

Outcome	Further actions
1. leaks detected and repaired: night-flow drops after repair by same amount as step	No further action necessary
2. Leaks detected and repaired: night flow drops but by smaller amount then expected	Further investigation of night use in step, investigate pressure reduction possibilities
3. leaks detected and repaired: night flow drop but rises again	Look for new leak in DMA investigate pressure reduction consider service and/or mains replacement
4. leaks detected and repaired: night flow drops but rises again	Look for new leak in DMA, investigate pressure reduction consider service and/or mains replacement
5. leaks not detected	Further investigation of night use

Adapted from Water Loss Task Force. (2004). *DMA guidance notes.* Cyprus: IWA.
The fluctuation of inflow into the DMA and the minimum night-flow before and after the repair should also be captured (Wyatt, 2010).

The above recommendations are practical and they are addressing the issues affecting NRW management in Lidgetton, implementing them will be of great benefit to the municipality and it will save cost for the municipality. The municipality does not have to implement all of the above mentioned recommendations at once; these can be done in phases depending on the availability of funds. It is advisable that the municipality budget for these activities as they appear above.

6.6 Limitations and area for future studies

During the distribution and filling in of questionnaires it was noted that some key personnel in NRW management do not have sufficient formal education and good writing skills. Most employees do not have the necessary skills and knowledge required to measure and monitor NRW. It is therefore recommended that a skills audit be done in future for the municipality in order to identify the actual capacity of the municipality with regards to NRW management.

During this study the reliability of the infrastructure was seen to be one of the vital elements of NRW management, and this study could not investigate it. It is therefore recommended that a future study be done to investigate the condition of the existing infrastructure for the Lidgetton distribution system.

The study also established that NRW management is not only about the measurement and calculations that require technical knowledge, but it also require other stakeholders to be involved and trained on the impact of NRW management in the municipality and in the community. This study did not cover these stakeholders, namely:

- Community members
- Community leaders
- Senior management of the municipality
- Political leadership of the municipality
- Municipal customers

It is therefore recommended that the above mentioned stakeholders be involved from the beginning till the end of any NRW management studies to be done in future. It is also recommended that more field work be done in future studies to collect all the information that may be required in assisting the municipality to manage NRW effectively.

6.7 Summary

The research questions were designed in such a way that they address the challenges facing the municipality regarding NRW management related matters. The questionnaires were used as a tool to answer the research questions. Findings were made based on research that was conducted with municipal employees by answering the questionnaires. There is an opportunity that has been identified for future research. It was also revealed that the municipality is not well prepared to manage NRW, and as a result the research problem has not been solved. As mentioned previously, most of the technical information required could not be received from the municipality. The information that could be used comfortably was the information collected from questionnaires. The data that was collected from questionnaires was used to address some of the issues emanating from the research question, but they could not solve the problem on their own without the technical data and the rest of the information that was not available from the municipality.

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Appendix

Appendix A: Introductory letter

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

Dear Respondent,

MBA Research Project
Researcher: Buhle Msomi - 033 897 6888/082 909 0758
Supervisor: Christopher Chikandiwa – 031260 8882
Research Office: Ms P Ximba 031-2603587

I Buhlebakhe Msomi an MBA student, at the Graduate School of Business and Leadership, of the University of KwaZulu Natal. You are invited to participate in a research project entitled "A study of Non-Revenue Water Management in Lidgetton, uMgungundlovu District Municipality in KwaZulu-Natal". The aims of this study are to: Identify the methods used by the uMDM to assess NRW, and to identify the status quo and whether the uMDM is pro-active or reactive when dealing with NRW.

Through your participation I hope to understand the contributing factors in the amount of water that is consumed in Lidgetton. The results of the focus group are intended to contribute to development of a model that may be used in future to study and curb water losses in other areas within uMDM, and even in other municipalities outside uMDM. Both technical and financial disciplines of the water scheme will be investigated in trying to achieve objectives of the study.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey/focus group. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN.

If you have any questions or concerns about completing the questionnaire or about participating in this study, you may contact me or my supervisor at the numbers listed above.

The survey should take you about 10 minutes to complete. I hope you will take the time to complete this survey.

Sincerely

Investigator's signature____________________________________ Date_________________

This page is to be retained by participant

Appendix B: Letter of informed consent

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

MBA Research Project
Researcher: Name (Telephone number)
Supervisor: Name (Office Telephone number)
Research Office: Ms P Ximba 031-2603587

CONSENT

I……………………………………………………………………………(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT DATE

……………………………………………………………………………………………………

This page is to be retained by researcher

Appendix C: Questionnaire

INSTRUCTIONS

- Please read each question carefully
- Please answer questions as honestly as possible

A study of Non-Revenue Water Management in Lidgetton, uMgungundlovu District Municipality in KwaZulu-Natal.

Section 1. Personal data

1.1 Gender

Male	Female

1.2 Age group

18-34	35-44	45-54	55-65	Above 65

1.3 Race

Black	White	Coloured	Indian	Other

1.4 Highest level of qualification

Below matric	Matric	Diploma	Degree	Post grad

1.5 Please tick the appropriate box and state your position:

Municipal employee working for:				
Technical Department	Finance Department	Water Services Authority	Corporate Services	Community Services
Position:	Position:	Position:	Position:	Position:

Section 2 Water management

2.1 Please tick the appropriate box

No.	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Water loss can be calculated					
2	Water balancing is done monthly					
3	The infrastructure is in working condition					
4	Water meters are working properly					
5	All consumers are metered					
6	Water supply scheme is zoned					
7	As built drawings are available for your water scheme					
8	Monitoring equipment is used to monitor water usage					
a	If yes: the monitoring equipment is useful					
b	If no: the monitoring equipment is needed					
9	There is technical capacity to monitor water usage					
10	The municipality take Non-Revenue Water monitoring seriously					

Section 3 Finance questionnaire

3.1 Please tick the appropriate box

No	Question	Yes	No
1	Do you know the actual number of consumers in Lidgetton?		
2	Are their water meters read monthly?		
3	Are meters reading reliable?		
4	Is Lidgetton water scheme generating sufficient revenue for the municipality?		
5	How often do you do consumer meter readings?		

3.2 Please tick the appropriate box

No.	Question	Apparent losses	real losses
1	Where should the municipality focus on in order to reduce Non-Revenue Water?		

Section 4 Social Questionnaire

Part 1

4.1 Customers level of satisfaction for water service

No.	Question: are you satisfied with the following?	Strongly satisfied	Satisfied	Neutral	Not satisfied	Strongly dissatisfied
1	Amount of water supplied					
2	Quality of water supplied					
3	Time taken to attend to faults					
4	Customer service from municipal employees					
5	Water charges					
6	Meter readings					
7	Water billing					
8	Accessibility to municipal offices					
9	Quality of work done by municipal employees					
10	Response time by the municipality to attend to queries					

Part 2

4.2 Please tick the appropriate box

No.	Question: In your opinion,	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Water is a scarce resource					
2	Water usage is high amongst residents					
3	Consumers monitor their monthly consumption					
4 (a)	The municipality informs consumers on how to save water					
(b)	If consumers are taught, they apply what they were taught by the municipality					
5	Community awareness campaigns are effective					

4.3 Questions for illegal water use

No.	Question: In your opinion,	Very high	High	Low	Very low
1	How is the illegal water use in Lidgetton?				

4.4 Questions for illegal water use

No.	Question	No	Yes	How many
1	Are you aware of illegal water users?			

4.5 Please tick the appropriate box

No	Question	Municipal employees	Private professional plumbers	Community members	Other
1	Who does the illegal connections in Lidgetton?				

4.6 In your opinion, residents resort to illegal water consumption because of:

No.	Options	Select
1	Water charges	
2	Connection fee	
3	Delays in requested house connections	
4	The belief that water should be free of charge	
5	Weak monitoring and inspection procedures	
6	Consumers not being aware of application process	
7	Complicated application process for new house connections	

4.7 Customer reaction to Municipal policies: (Please tick the appropriate box)

No.	Question: In your opinion	Yes	No
1	The municipality must impose a penalty on illegal water users		
2	Is 6000 litre free monthly basic water enough?		
3	Do consumers use more than 6000 litre per month?		
4	The municipality should disconnect water supply where there are illegal connections		
5	The municipality must restrict water supply to customers in arrears		
6	The municipality must reduce water supply where there is perceived water wastage		

Appendix D: Ethical clearance approval letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

10 November 2014

Mr Buhlebakhe Msomi 212549611
Graduate School of Business and Leadership
Westville Campus

Dear Mr Msomi

Protocol reference number: HSS/1419/014M
Project title: A study of Non-Revenue Water Management in Lidgetton, uMgungundlovu District Municipality in Kwa-Zulu Natal

Full Approval – Expedited Application

In response to your application received 23 October 2014, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Christopher Chikandiwa
Cc Academic Leader Research: Dr E Munapo
Cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
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1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood, Howard College, Medical School, Pietermaritzburg, Westville