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Assessing the effectiveness of projects aimed at reducing water loss in Ekurhuleni Metropolitan Municipality.

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering

Johannesburg 2017

DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Science in Engineering to the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Salome Chiloane

16th day of October 2017

ABSTRACT

This research set out to investigate the effectiveness of water loss projects in Ekurhuleni Metropolitan Municipality. The study thus focused on water loss eradication programme in Ekurhuleni Metropolitan Municipality. The study was motivated by the fact that Ekurhuleni Metropolitan Municipality is facing a serious challenge of managing water loss. Thus, the objective of the study was to determine the effectiveness of projects which have been rolled out to minimise water loss. Information pertaining to the progress and performance of the twenty-three projects from Ekurhuleni Metropolitan Municipality was collected. The information which was collected was project reports, payments certificates as well as appointment letters.

Currently there is no study which has been done on the effectiveness of water loss projects in Metropolitan municipalities. However, literature on how water loss projects should be rolled out is available. Literature indicates that key areas need to be considered before embarking on a water loss reduction programme. The areas which need to be considered are system schematics, leak location and repair, pressure management, sectorising, logging and analysis of minimum night flow, bulk management meters, bulk consumer meters, domestic metering and billing, pipe replacement and repair, water balance as well as community awareness and education. Moreover, effectiveness measures of projects have been identified from literature.

The results of the study show that some projects are effective whilst others are not effective. The reason behind the non-effectiveness of the projects are as a results of contractors failing to execute the projects as per the contractual agreement. The other reasons which led to project non-effectiveness were contractors not adhering to project time which always affects the project cost. The findings of the study thus trigger the question on the criteria which are used to select contractors and consultants in Ekurhuleni Metropolitan Municipality. The manner into which the water loss projects have been rolled out, are in line with what literature suggest. However, consultants and contractors are failing the Metro.

The study recommends that focus should be made in developing municipal project managers to be able to conduct proper oversight on the contractors and consultants. Over and above that, the municipality should try to pay small contractors on time to prevent project delays. Focus should also be made by the municipality to blacklist service providers who do not deliver and also to have a system in place for recovering losses from contractors and consultants who do not render good services. A review on section 33 of the Municipal Finance Management Act (no 56 of 2003) may assist in improving project performance.

DEDICATION

I dedicate this report to my parents, Busetsang and Tsuki Chiloane for always believing in me and encouraging me to study further, may the Almighty God continue to bless them abundantly. I further dedicate this report to my kids, Koketso, Kgotso and Thato, for being such a wonderful inspiration to me.

ACKNOWLEDGEMENTS

This research would not have been successful without the help of the Water and Energy Oversight Committee and the Department of Water and Sanitation officials of Ekurhuleni Metropolitan Municipality. To my colleague, Dr. Zenzo Ndima, thank you for being the listening ear when I always needed someone to talk to and for all the support you have granted me. I would also like to acknowledge my supervisor, Professor Robert McCutcheon for his patience, wisdom and encouragement throughout the research study. And finally, to the love of my life, my husband, Emmanuel Nwabueze; thank you for your words of wisdom, encouragement, patience and support.

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NOMENCLATURES/LIST OF ACRONYMS

Acronym/ Nomenclature	Abbreviation
Ø	Diameter
@	At
/	Per
%	Percentage
AC	Asbestos Cement
AMR	Automatic Meter Reading
CBD	Central Business District
CCC	Customer Care Centers
CIDB	Construction Industry Development Board
CLO	Community Liaison Officer
CPO	Central Procurement Office
DMA	District Metering Areas
DWA	Department of Water Affairs
EMIS	Electronic Management Information System
EMM	Ekurhuleni Metropolitan Municipality
EPWP	Expanded Public Works Programme
FY	Financial Year
HDPE	High Density Polyethylene
IMQS	Infrastructure Management Query Software
IWA	International Water Association
KI	Kiloliter
M	Meter

M^3	Cubic Meter
MFMA	Municipal Finance Management Act (no 56 of 2003)
MM	Millimeter
MNF	Minimum Night Flow
NE	North East
NRW	Non-Revenue Water
NZWWA	New Zealand Water and Waste Association
PTY LTD	Proprietary Limited
QCO	Quality Control Officer
R	South African Rands
RE	Resident Engineer
SABS	South African Bureau of Standards
SW	South West
SMME	Small, Medium and Micro Enterprise
UARL	Unavoidable Annual Real Losses
UFW	Unaccounted for Water
US$	United States Dollars
VO	Variation Order
WC	Water Conservation
WDM	Water Demand Management
WEMMC	Water and Energy Meter Management Consultants
WSA	Water Services Authorities

DEFINITIONS OF TERMS

The definitions of these terms were taken from, (McKenzie, 2014)

Non-Revenue Water

Non-Revenue Water is becoming the standard term replacing unaccounted-for water (UFW) in many water balance calculations and is the term recommended by the International Water Association in preference to UFW. It is a term that can be clearly defined, unlike the unaccounted for water term which often represents different components to the various water suppliers. Non-Revenue Water incorporates the following items:

- Unbilled authorised consumption;
- Commercial Losses; and
- Physical Leakage.

Unbilled Authorised Consumption

The unbilled authorised consumption is the volume of authorised consumption that is not billed or paid for. The level of unbilled authorised consumption will vary from water services provider (WSP) to WSP and in some areas virtually all water is metered and billed in some manner with the result that the unbilled authorised consumption is zero.

Authorised Consumption

Authorised consumption is the volume of metered (authorised metered) and/or unmetered (Authorised unmetered) water taken by registered customers, the water supplier and others who are authorised to do so by the water supplier, for residential, commercial and industrial purposes. It should be noted that the authorised consumption also includes 'water exported' and, in some cases may include items such as fire-fighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, building water, etc. These may be billed or unbilled, metered or unmetered, according to local practice.

Billed Authorised Consumption

Billed authorised consumption is the volume of authorised consumption which is billed by the WSA and paid for by the customer. It is effectively the revenue water, which, in turn, comprises:

- Billed metered consumption;
- Billed unmetered consumption.

Commercial Losses

Commercial losses or Apparent Losses are made up from the unauthorised consumption (theft or illegal use) plus all technical and administrative inaccuracies associated with customer Metering or billing. While it should be noted that the commercial losses should not normally be a major component of the water balance in most developed countries, it can represent the major element of the total losses in many developing countries. A systematic estimate should be made from local

knowledge of the system and an analysis of technical and administrative aspects of the customer metering system.

Physical Leakage

Physical Leakage or Real losses represent the physical leakage from the pressurised system, up to the point of measurement of customer use. In most cases, the physical leakage represents the unknown component in the overall water balance and the purpose of most water balance models is therefore to estimate the magnitude of the leakage so that the Municipality can gauge whether or not it has a serious leakage problem. The physical leakage is generally calculated as the difference between the total losses and the estimated commercial losses.

System Input

The system input represents the volume input to the water supply system from the water services authorities (WSA) own sources allowing for all known errors (i.e. errors on bulk water meters) as well as any water imported from other sources – also corrected for known bulk metering errors.

Water Losses

Water losses are the sum of the physical leakage and the commercial losses and are calculated from the difference between the total system input and the authorised consumption. In most countries, the water losses are often referred to as the unaccounted-for water (UFW) although the exact definition of the UFW can vary from country to country.

Unavoidable Annual Real Losses (UARL)

The minimum level of real losses for a specific system that can be achieved under the most efficient operating conditions. It is an indication of the level of leakage that can theoretically be achieved if everything possible is done to minimise the leakage and is generally not an achievable target for most water suppliers since the UARL is normally well below the economic level of leakage

CHAPTER 1: INTRODUCTION

There is an increasing awareness around the world that water is becoming the critical issue of the twenty-first century (McKenzie, 2005). In some countries, measures are already in place to foster an approach of effective water utilization and reduction of wastage. Water lost from potable water distribution system remains one of the key problem issues facing not only developing countries but also developed countries throughout the world. South Africa is a water scarce country and its annual runoff is less than 13% of the world average (Wegelin *et al.* 2010). The country is ranked the 30th driest in the world in terms of water resources (Government of South Africa, 2015). The world's average rainfall is 985mm per year, and South Africa receives an annual rainfall of 492mm (Rand Water, 2006). South Africa is a semi-arid country faced with an uneven distribution of water resources and intermittent spells of droughts and floods. Its rainfall is below the world average (DWA, undated).

Though South Africa is a water scarce country, water losses in its water distribution systems remains one of its major problems. McKenzie (2014) has indicated that the average South African water loss is sitting at 31.8% and Non-Revenue Water is at 36.8%. The 36.8% is equivalent to 1 580million m^3/annum which is approximately one third of the total water supplied. This represents an annual loss of over R7 billion based on an average bulk water tariff of approximately R5/m^3.

According to Burn *et al*. (2000), water leakage is one of the major components of water loss in water distribution systems. Burn *et al*. (2000) stated that leakage problems do not only affect the cost factors, but also have an impact on the wastage of a scarce natural resource. The wastage of the natural resource also results in economic loss. The primary economic loss due to leakage is in terms of the raw water cost, its treatment and transportation. Without doubt leakage also results in secondary economic loss in the form of damage to the pipe network, e.g. erosion of pipe bedding and major pipe breaks, and in the form of damage to the foundation of roads and buildings (Burn *et al.* 2000).

Moreover, pipe leakages enable the entry of microbial contaminants into the distribution system which may in turn affect public health. Hence, water leakages raise serious concerns economically, in respect of public health and the need for water conservation. All of these factors motivate water services providers to implement leakage-control programs (Hunaidi, 2000). Leakage control programme is one of the interventions which can be implemented in reducing water loss. There are several programmes which can also be implemented which can assist in minimizing water loss.

The South African water law encourages water users to preserve, manage, conserve and protect water resources. This study assessed projects aimed at reducing water loss and recommended sustainable solutions for managing water loss projects at Ekurhuleni Metropolitan Municipality.

1.1 BACKGROUND

The study aims to assess the effectiveness of projects that are aimed at reducing water loss in Ekurhuleni Metropolitan Municipality. Ekurhuleni Metropolitan Municipality is located to the East of Johannesburg and was established in the year 2000 (City of Ekurhuleni, 2011). The Municipality covers an extensive geographical area which includes areas from Germiston in the west to Springs and Nigel in the east. The municipality was established as one of the six Metropolitan municipalities resulting from the restructuring of local government in 2000 (City of Ekurhuleni, 2011). Figure 1.1 depicts Ekurhuleni Metropolitan Municipality areas.



Figure 1.1: Ekurhuleni Metropolitan Municipality areas (adapted from: the local government handbook, 2016)

Ekurhuleni has a total surface area of about 2000km^2 with a population of about 2.8 million (City of Ekurhuleni, 2011). This constitutes about 5.6% of the national population and makes up to 28% of Gauteng's population (City of Ekurhuleni, 2011). The high percentage of population at Ekurhuleni requires services to be provided to all Ekurhuleni residents. The Metro has thus divided its areas into twenty customers care centers for ease of communication between customers and the Metro on service delivery issues. Figure 1.2 indicates key service delivery areas serviced to

Ekurhuleni residents by Ekurhuleni Metropolitan Municipality as per the Customer Care Centers (CCC):

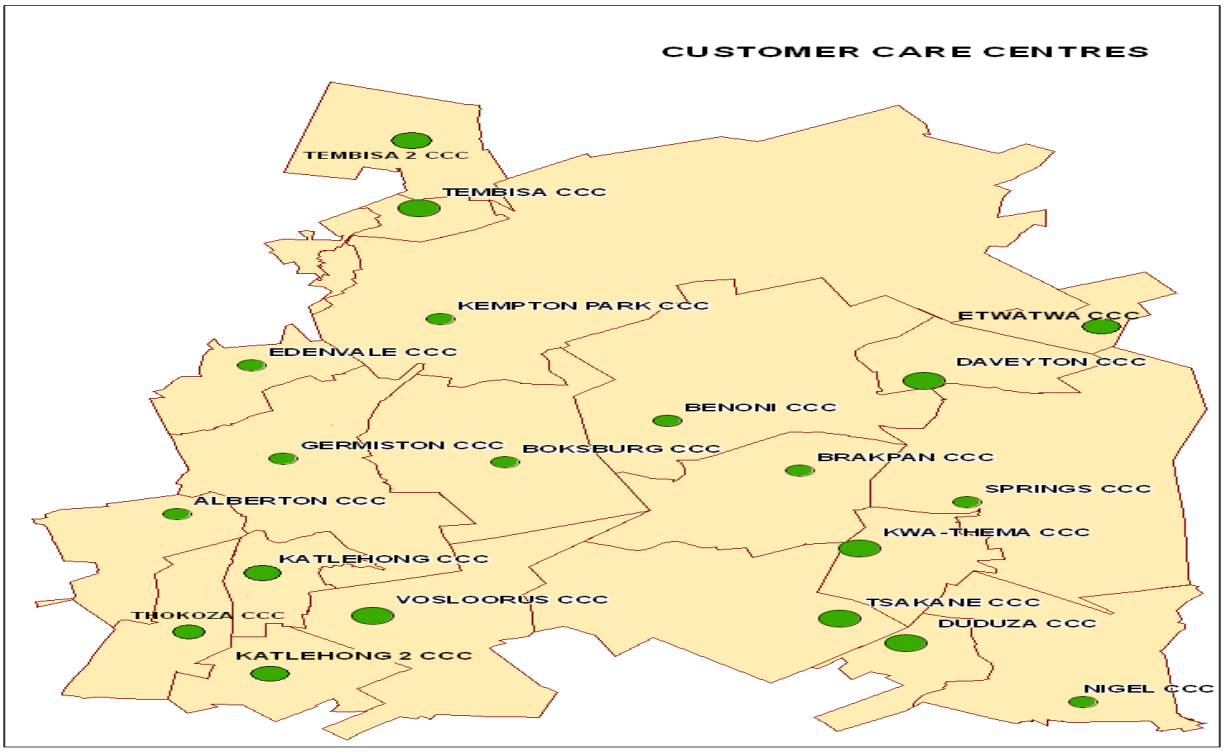

Figure 1.2: Ekurhuleni Metropolitan Municipality Twenty Customer Care Centers (from: City of Ekurhuleni, 2011)

One of the key basic services that need to be rendered to Ekurhuleni residents is the provision of a basic water supply. Whilst water services need to be provided, the Metro's water pipeline is estimated to be over 50 years old, and these thus make the infrastructure prone to leaks. Faure, Pandit and Spuhler *(*undated) stated that water leaks are the main factors of water loss in developing countries. Lahlou (2001) indicated that the generic or normal water loss that may occur in the water distribution system through pipe leaks should be between 10 and 20 percent. Any unaccounted for water above 20 percent of the distributed water is considered abnormal and requires priority attention and, therefore thorough maintenance, rehabilitation or repair must be undertaken.

In 2014, Ekurhuleni Metropolitan Municipality's non-revenue water figure was reported to be 39.3% (Ekurhuleni this week, 2014). This Non-Revenue Water (NRW) percentage was indicated to be equivalent to R600 million, amounting to monthly losses of R50 million, (Ekurhuleni this week, 2014). In 2012, the Metro's Non-Revenue Water and Water loss figure was 39.8% (McKenzie, Siqalo & Wegelin, 2012). The South African Non-Revenue Water figure is estimated to be 36.8% and is considered to be in line with the international NRW figure of 36.6% (McKenzie, Siqalo & Wegelin, 2012). Though the South African NRW percentage is in line with international

NRW figure, there is still room for improvement particularly since South Africa is a semi-arid country. In monetary terms, NRW in municipalities is estimated to be R7 billion per annum at a normal production cost of R5/m^3 (McKenzie, Siqalo & Wegelin, 2012).

As indicated above, any water losses above 20% encountered in the distribution systems are abnormal. Ekurhuleni Metropolitan Municipality has thus embarked on a number of projects which are aimed at reducing water loss since its water losses are above 20%. The study thus aims to assess the effectiveness of these projects in reducing water loss.

1.2 PROBLEM STATEMENT

The global volume of non-revenue water (NRW) and water loss is outrageous. It is estimated that on an annual basis, more than 32 billion m^3 of treated water is lost through leakage from the distribution network (Farley *et al*. 2008). An additional 16 billion m^3 per year is delivered to customers but not invoiced due to theft, poor metering, or corruption. According to Huinadi (2000), water leakages are a significant component of water losses. Lahlou (2001) has indicated that the generic or normal water loss that may occur in the distribution system through pipe leaks should be between 10 and 20 percent. As stated, any unaccounted for water above 20 percent of the distributed water is considered abnormal and requires priority attention and, therefore thorough maintenance, rehabilitation or repair must be undertaken (Lahlou, 2001).

Farley *et al*. (2008) has further indicated that it costs water utilities worldwide on an annual basis an estimated US$14 billion for non-revenue water (NRW). In other low income countries, the loss represents 50-60% of water supplied (Farley *et al*. 2008). At the end of June 2016, the percentage of non-revenue water at Ekurhuleni Metropolitan Municipality was 34.6% (Ekurhuleni Metropolitan Municipality, 2016). The financial amount equivalent to this percentage value can be used to develop other areas since Ekurhuleni has a high level of service delivery backlogs. The Non-Revenue Water figure is high and requires proper management in order to minimize the NRW figure. Any form of water loss should be corrected and prevented. Failure to prevent water loss may result in high water shortages since South Africa is already a water stressed country.

High levels of non-revenue water (NRW) reflect huge volumes of water being lost through leaks, not being invoiced to customers, or both (Kingdom, Liemberger & Marin, 2006). These high levels of non-revenue water seriously affect the financial viability of water utilities through lost revenues and increased operational costs (Kingdom, Liemberger & Marin, 2006). Water losses incorporates unbilled apparent losses and real losses as depicted in figure 2.1 below.

According to Kingdom, Liemberger and Marin (2006), a high NRW level is normally a surrogate for a poorly run water utility that lacks the governance, the autonomy, the accountability, and the technical and managerial skills necessary to provide reliable service to their population. South Africa is a water scarce country, water losses in the water distribution systems remains one of its major problem.

The country's water resources are under severe pressure, and South Africa is expected to suffer water shortages. In some areas of the South African municipal water works, water loss is extremely high and often exceeds the water used by the residents. This is unacceptable as the economy is also encountering high losses in terms of the raw water cost, treatment and transportation. It is therefore very important for the country and its water service providers/authorities to minimize any form of water loss throughout the water distribution system.

In an attempt to reduce its water losses, Ekurhuleni Metropolitan Municipality has embarked on a water loss eradication programme aimed at reducing the Metro's water loss and NRW. As mentioned above, in 2012 the Metro's Non-Revenue Water figure was sitting at 39.8%. Literature indicates that any water services provider which encounters an unaccounted for water above 20%, priority attention is required in order to minimize the losses. Thus, in an attempt to reduce the water loss, Ekurhuleni Metro has embarked on a robust water loss eradication programme in 2011/12 financial year. The water loss eradication programme aims to reduce the Metro's water losses.

This research will assess the effectiveness of the water loss projects which are aimed at reducing water loss in Ekurhuleni Metropolitan Municipality. Currently there is no study which has been done on the effectiveness of water loss projects in Metropolitan municipalities. However, literature on how water loss projects should be implemented is available. Literature which is available on project effectiveness measures is on construction projects which focuses on other industry projects except on projects which are specifically aimed at minimising water loss. Thus, an assessment of the water loss projects will be based on project effectiveness measures which will be identified in literature. The project effectiveness measures will thus be put to test in measuring water loss projects of Ekurhuleni Metropolitan Municipality. The assessment will focus on analyzing the projects against the project effectiveness measures. Based on the findings, recommendations which will assist in managing non-revenue water and water losses in Ekurhuleni Metropolitan Municipality will be determined.

As indicated that the South African water law encourages water users to preserve, manage, conserve and protect water resources. The management of water loss is of fundamental importance to Ekurhuleni Metropolitan Municipality and also to South Africa. The study will thus assist Ekurhuleni Metropolitan Municipalities and other Metros to assess the effectiveness of their water loss projects. This study would further explore and suggest sustainable solutions for managing NRW and minimizing water loss throughout the water distribution system. In the context of this study, water loss is water which has been lost in the water distribution system and Ekurhuleni Metropolitan Municipality cannot account for that water. The unaccounted for water may be in the form of apparent losses or real losses (i.e. physical and commercial losses) as determined by the International Water Association water balance.

The study has assessed the effectiveness of the water loss eradication programme in Ekurhuleni Metropolitan Municipality. The projects which were assessed are from 2011/12 financial year to 2014/15 financial year. Based on the findings, recommendations were also drawn in an attempt to better manage water loss projects in Ekurhuleni Metropolitan Municipality.

1.3 RESEARCH OBJECTIVES

The primary aim of the study was to assess the effectiveness of projects that are aimed at reducing water loss in Ekurhuleni Metropolitan Municipality. The secondary objectives of the study are to:

- To determine criteria for measuring project effectiveness in literature in order to use empirical data to measure the water loss projects
- To determine criteria for rolling out water loss eradication projects in municipalities
- To assess the effectiveness of Ekurhuleni Metropolitan Municipality water loss projects in reducing water loss

1.4 RESEARCH QUESTIONS

- What are the criteria for measuring project effectiveness in the water industry?
- What are the criteria for rolling out water loss eradication projects in municipalities?
- Does the implementation of water loss projects in Ekurhuleni Metropolitan Municipality reduce water loss?

1.5 DELINEATIONS

This research focused on water loss projects which have been implemented in Ekurhuleni Metropolitan Municipality. Only Ekurhuleni Metropolitan Municipality water loss projects were assessed. Thus, the research does not include water loss projects that are carried out by other Metropolitan municipalities.

1.6 ASSUMPTIONS

Assumption 1
Proper planning, implementation and execution of water loss projects will reduce the water loss figure in Ekurhuleni Metropolitan Municipality.

Assumption 2
All contractors who are awarded or have been awarded contracts in Ekurhuleni Metropolitan Municipality for planning, implementing and executing water loss projects are registered with the Construction Industry Development Board (CIDB). The Construction Industry Development

Board Act no. 38 of 2000, requires that all public sector organs can only award contracts to contractors registered with the CIDB for construction projects (CIDB, 2011a).

1.7 RESEARCH STATEMENT

Research Statement
Proper planning, implementation and execution of Ekurhuleni Metropolitan Municipality water loss projects will greatly reduce water loss in the Metro.

1.8 IMPORTANCE OF THE STUDY

South Africa is currently experiencing a severe drought and is classified as a semi-arid country. This means that water is a very scarce resource in South Africa and thus any form of water losses should be corrected and prevented. Municipalities in particular losses an enormous amount of water in their water distribution systems. The study will assess the manner in which Ekurhuleni Metropolitan Municipality roll out their water loss projects. This will assist other municipality to use EMM as a benchmark when implementing water loss projects. Over and above that, Ekurhuleni Metropolitan Municipality will be able to put corrective and preventive measures in cases where they are needed in their project management of water loss programme.

1.9 REPORT STRUCTURE

Chapter 1: Introduction
This chapter outlines the problem statement, delineation, assumptions and hypotheses. It further includes the introduction and background of the research.
Chapter 2: Literature review
Inclusive in this chapter is the literature review. The literature review focusses on measures of project effectiveness as well the management of water loss.
Chapter 3: Methodology
The chapter focuses on the methodology followed in conducting the research as well as the process which was followed in gathering the empirical data.
Chapter 4: Results and analysis
The results and analysis of the empirical data are outlined in this chapter. The water loss projects are assessed based on project effectiveness measures.
Chapter 5: Summary, conclusion and recommendations
This chapter provides the summary of the research, conclusion as well as recommendations.

CHAPTER 2: LITERATURE REVIEW

There is currently little or no literature in measuring project effectiveness in water loss projects. However, many studies have been conducted in project effectiveness and project success in the construction industry. A preliminary literature survey was conducted with the aim of finding out what work has been done in the area of water loss and project effectiveness in the water industry. A full literature review was conducted on the study area with special attention drawn to the South African context. The literature was analysed in order to answer the first primary research question, which is: what are the criteria for measuring project effectiveness? The secondary objective is to determine the criteria which are used to roll out water loss eradication projects in municipalities. The literature review was also used to form a basis for the research methodology and give an idea of what methods are best suited for this study area.

2.1 MEASURING PROJECT EFFECTIVENESS

Within the field of project management, the concept of efficiency and effectiveness are commonly used but rarely defined (Sundqvist, Backlund & Chroneer, 2014). According to Takim, Akintoye and Kelly (2004) project efficiency and effectiveness measures are important to judge project performance and project success. Sundqvist, Backlund and Chroneer, (2014) indicate that researchers apply the concept of efficiency and effectiveness differently. Some researchers apply the concepts when describing how to improve some part of project management (Ward 1999 cited by Sundqvist, Backlund & Chroneer, 2014). Whilst other researchers apply the concepts when describing competencies for project execution (Lambel, 2001 cited by Sundqvist, Backlund & Chroneer, 2014).

According to Sundqvist, Backlund and Chroneer, (2014) the concepts of efficiency and effectiveness are thoroughly defined in the field of quality management. In quality management, efficiency means doing things right i.e. performance is done in a most suitable way given the available resources. Effectiveness means doing the right things i.e. selecting and focusing on producing an output that there is a demand for (Sundqvist, Backlund & Chroneer, 2014). Effectiveness looks at external project factors (such as client satisfaction, stakeholders etc.) and is long term whilst efficiency looks at internal project factors, such as cost, time and scope (i.e. short term).

Takim and Adnan (2008) elaborate that the identification of project effectiveness measures is associated with project '*results'* in terms of accomplishing core business and project objectives, users' satisfaction and the use of the project as identified by Pinto and Slevin, (1988; 1989) and Davies, (2002). In a study of analyzing the effectiveness measures of construction project success in Malaysia, Takim and Adnan (2008) have conducted a literature review to identify measures of project effectiveness. After an intensive literature review, it was found that ten criteria for

measuring project effectiveness were agreed upon by various researchers and authors. Thus, the ten project effectiveness measures as identified by Takim and Adnan (2008) are:

- Client satisfaction on service
- User satisfaction with product
- Level of effectiveness (i.e. achievement of outcomes)
- Project functionality
- Free from defects
- Value for money
- Profitability
- Absence of any legal claims and proceedings
- Learning and exploitation and,
- Generate positive reputation.

Literature search indicate that, the identification of project effectiveness measures is associated with project result in terms of accomplishing core business and project objectives, user's satisfaction and the use of the project (Pinto & Slevin (1988, 1989) and Cooke Davies, (2002)). According to Baccarini (1999) cited by Takim and Adnan (2008), a synonym for success is the degree of achievement of objectives. Takim and Adnan (2008) have further indicated that projects are formed to accomplish objectives and success is measured in terms of how well these objectives have been met. The overview of the ten effectiveness measures in the development of construction projects are reviewed.

2.2 PROJECT EFFECTIVENESS MEASURES

2.2.1 Client and User Satisfactions

According to Chan, Scott and Lam (2002) satisfaction describes the level of 'happiness' of people affected by a project. Bititici (1994) indicates that a client is satisfied when the project is delivered to quality, reliability, on-time deliveries, high service levels and minimum cost of ownership. Atkinson (1999) cited by Takim and Adnan (2008) indicate that two possible criteria which could be used to measure project success from effectiveness dimension are the resultant system (i.e. the product) which meets customers' satisfaction and benefits many stakeholders such as users. End-users will not be happy if the end product does not meet their requirements in terms of functionality and quality of service. Meanwhile, Liu and Walker (1998) consider client satisfaction as an attribute of project success. On the other hand, Torbica and Stroh (2001) cited by Takim and Adnan (2008), reckon that if end-users are satisfied, the project can be considered successfully completed in the long run.

2.2.2 Level of Effectiveness (achievement of outcomes)

Maloney (1990) explains that effectiveness encompasses the attainment of the organisation's objectives both at the corporate level and project level. It can be measured against the objectives earlier set by the client organisations (Abdel-Razek, 1997; Cameron & Whetten, 1983 cited by

Takim and Adnan (2008). According to Pinto and Slevin (1994), effectiveness measures refer to user satisfaction and the use of the project. Cameron and Whetten (1983) reckon that a system is effective if it achieves its objectives and since construction projects are directed towards client's objectives, an effective construction project is one that meets its objective.

2.2.3 Project Functionality and 'Fitness for Purpose'

Chan (2000) and Chan, Scott and Lam (2002) consider project 'functionality' as one of the success measures in the post-construction phase when the project is finished and delivered. According to them, project functionality correlates with expectations of project participant and can be best measured by the degree of conformance to all technical specifications. In addition, they further argue that both financial and technical aspects implemented to technical specifications should be considered, achieving the 'fitness for purpose' objective. Kometa, Olomolaiye and Harris (1995) regard client satisfaction in terms of the functionality of the finish product, meeting safety requirements, flexibility, time, and quality.

A study conducted by Chinyio, Olomolaiye and Corbett (1998) reckons project functionality as building to be operationally efficient with its intended purpose, durable building and keeping existing buildings operational during construction. They found that 73% of those who are interested in keeping existing facilities functional are clients whose works were mainly concerned with alterations and renovations. Hence, taking the points mentioned by those writers, it seems possible that project functionality and fitness for purpose could be associated with project effectiveness measures.

2.2.4 Free from Defects

Prahl (2002) defines construction defects as work performed that falls below the standard promised or expected by the client or purchaser of the work or services. According to Mazier (2001) construction defects is a broad term used for a wide range of conditions at a building such as leaky, improperly installed windows or the presence of so-called toxic mould. Atkinson (1999) divides the cause of building defects into lack of skill, lack of care and lack of knowledge of the site operative and difficult to build, low design and missing project information. It is a mixture of technical inadequacies, managerial inadequacies and operative's skills. In order to avoid construction defects, one way is to impose quality control during the construction process.

2.2.5 Value for Money

Value, a fundamental term in project management is a measure expressed in currency, effort, exchange, or on a comparative scale which reflects the desire to obtain or retain an item, services or ideal (Hamilton, 2002; Liu and Leung, 2002). Kloot and Martin (2000) define 'value for money' as the provision of adequate services without wasting limited resources and ensuring services are affordable. Typically, the analysis sees 'value' in which the 'benefits' to each party are perceived as value. Earlier work on 'value for money' equated value for money in terms of cost reduction

and higher quality thresholds, which lead to greater client satisfaction (Hamilton, 2002). Value for money is the optimum combination of whole life cost and project quality to meet a client's need and expectation, and value management aims to maximise the functional value of a construction facility to the clients. Value for money is an effectiveness measure of project success.

2.2.6 Profitability

Profitability measures the financial success of the project and a project must be properly managed to be profitable (Parfitt & Sanvido, 1993). Norris (1990) measures profit as the increment by which revenues exceed costs; that is, profitability is measured as the total net revenue (in dollars) over total costs (in dollar). Profitability is measured in the post-construction phase when the final account is settled and both the paying and the paid parties can be sure of the financial result (Chan, Scott and Lam, 2002), while Maloney (1990) regards profitability as revenues generated by firm exceeding the cost of producing the revenues.

2.2.7 Absence of any Legal Claims and Proceedings

Claims in construction can be based on the contract itself, a breach of contract, a breach of some other common law duty, a quasi-contractual assertion for reasonable (*quantum merit*) compensation, or extra *ex-gratia* settlement request. Some construction claims are unavoidable or necessary to contractually accommodate unforeseen changes in project conditions or unavoidable changes in client's priorities (Kumaraswamy, 1997). According to Sanvido *et al.* (1992), the absence of any claims or proceedings on projects is the major criterion to all parties (client, designer, and contractor) for measuring project success. Whenever a project is completed without using jurisdiction to settle conflict, the construction project can be considered efficient. Claims managers should focus not merely on the significant claims categories but also on the avoidable ones, so as to minimise the damaging effects on a given project. In certain cases, this variable could also be associated with project efficiency measures.

2.2.8 Learning and Exploitation

Learning addresses specific criteria in terms of organisational learning, changes in knowledge structure, on-going improvements and feedback (Vakola & Rezgui, 2000). According to Mooraj, Oyon and Hostettler (1999), the learning and growth perspective focuses on internal skills and capabilities, in order to align them to the strategic goals of the organisation. Learning and exploitation can be defined as the process of improving actions through better knowledge and understanding (Fiol and Lyles, 1985). In construction project development, the lessons learned in executing a project (whether the project is success or failure) could be applied to future projects. According to Dalgleish (2003), some developers believe that projects that were cancelled because they were late and over-budget could still be a success if they provided learning something that could be applied to future projects.

2.2.9 Generate Positive Reputation

In construction project development, project clients are more likely to have a favourable impression of a contractor's company if they have a positive experience in the services offered with a good quality finished product tailored to their initial needs and expectations (Cohen, 1993; Pete, 1987). In this respect, maintaining a company's positive image and reputation could be an effectiveness measure of project success to contractors and project consultants by creating good results in performance while implementing projects development. A positive reputation may be generated by working closely with construction project management, identifying opportunities for operational improvements, exploiting new technology, product or markets, identifying management information requirements, and resources constraints in offering well defined services and delivering an expected product that fits the client's business objectives.

2.3 TYPES OF WATER LOSSES

Water losses are sum of the physical losses and the commercial losses and are calculated from the difference between the total system input and the authorized consumption (McKenzie, Siqalo & Wegelin, 2012). Kingdom, Liemberger and Marin (2006) indicated that physical loss or real loss results from leaking and broken pipes and are mainly caused by poor operations and maintenance, aged infrastructure, lack of active leakage control and poor quality of underground assets. Physical losses comprise of all parts of the system and overflows at the utility's storage tanks (Kingdom, Liemberger & Marin, 2006).

Commercial losses or apparent losses are made of unauthorized consumption (i.e. theft/illegal use) and all technical and administrative inaccuracies associated with customer metering/billing (McKenzie, Siqalo & Wegelin, 2012). Kingdom, Liemberger and Marin (2006) emphasised that one of the major issues affecting water utilities in the developing world is the considerable difference between the amount of water put into the distribution system and the amount of water billed to consumers which is termed Non-Revenue Water (NRW).

High levels of non-revenue water (NRW) reflect huge volumes of water being lost through leaks, not being invoiced to customers, or both (Kingdom, Liemberger & Marin 2006). These high levels of non-revenue water seriously affect the financial viability of water utilities through lost revenues and increased operational costs (Kingdom, Liemberger & Marin 2006). Non-revenue water incorporates unbilled authorised consumption, commercial losses and physical leakages.

2.4 WATER BALANCE

In order for municipalities to have control over their water supply systems, a concept of water balance will need to be adopted. The International Water Associated (IWA) has helped to establish a standardized water balance throughout the world. However, in certain countries, the standardized water balance has to be modified to align it to the requirements of the country. McKenzie Siqalo and Wegelin (2012) has identified South African situation as one of the most difficult to address using a standard water balance format due to several factors. In South Africa, the most important issues that need to be incorporated in the water balance are the Free Basic Water as well as the Non-Recoverable Revenue Water as identified by Seago and McKenzie (2007).

Free Basic Water is relatively simple to address and the recommended approach is to consider it Revenue Water that is billed at a zero rate (McKenzie, Siqalo & Wegelin, 2012). McKenzie, Siqalo and Wegelin (2012) have further indicated that the current allocation of Free Basic Water by municipalities is not standardized and many municipalities now provide a volume, which can vary from the original 6 kl per household per month as stipulated by National Government.

The Non-Recoverable Revenue Water is water that has been metered and billed to consumers but consumers cannot afford to pay for the water services. This mainly results due to the fact that many households in South Africa experience high abnormal internal plumbing losses resulting in very high monthly water bills which the owner cannot afford pay (McKenzie, Siqalo & Wegelin, 2012). Technically, the water is considered to be Metered Billed Consumption and is therefore shown in a standard water balance as a Revenue Water (McKenzie, Siqalo & Wegelin, 2012).

In reality, the situation is the opposite as the consumer may never pay for this water and at some point the account may be written off. According to McKenzie, Siqalo and Wegelin (2012), the Non-Recoverable Revenue Water is important to be included in the water balance since it represents either leakage or inefficient use. Figure 2.1 depicts the modified IWA water balance to incorporate these two components (i.e. Free Basic Water and Non-Recoverable Revenue Water). McKenzie, Siqalo and Wegelin (2012) has also noted that in most South African municipalities, the water balance can only be completed using information provided by the Technical Department and the Finance Department. This is the case at Ekurhuleni Metropolitan Municipality as the Water and Sanitation Department is responsible for the provision of the water services whilst the Finance Department is responsible for billing of water services. Figure 2.1 indicates the modified International Water Association water balance.

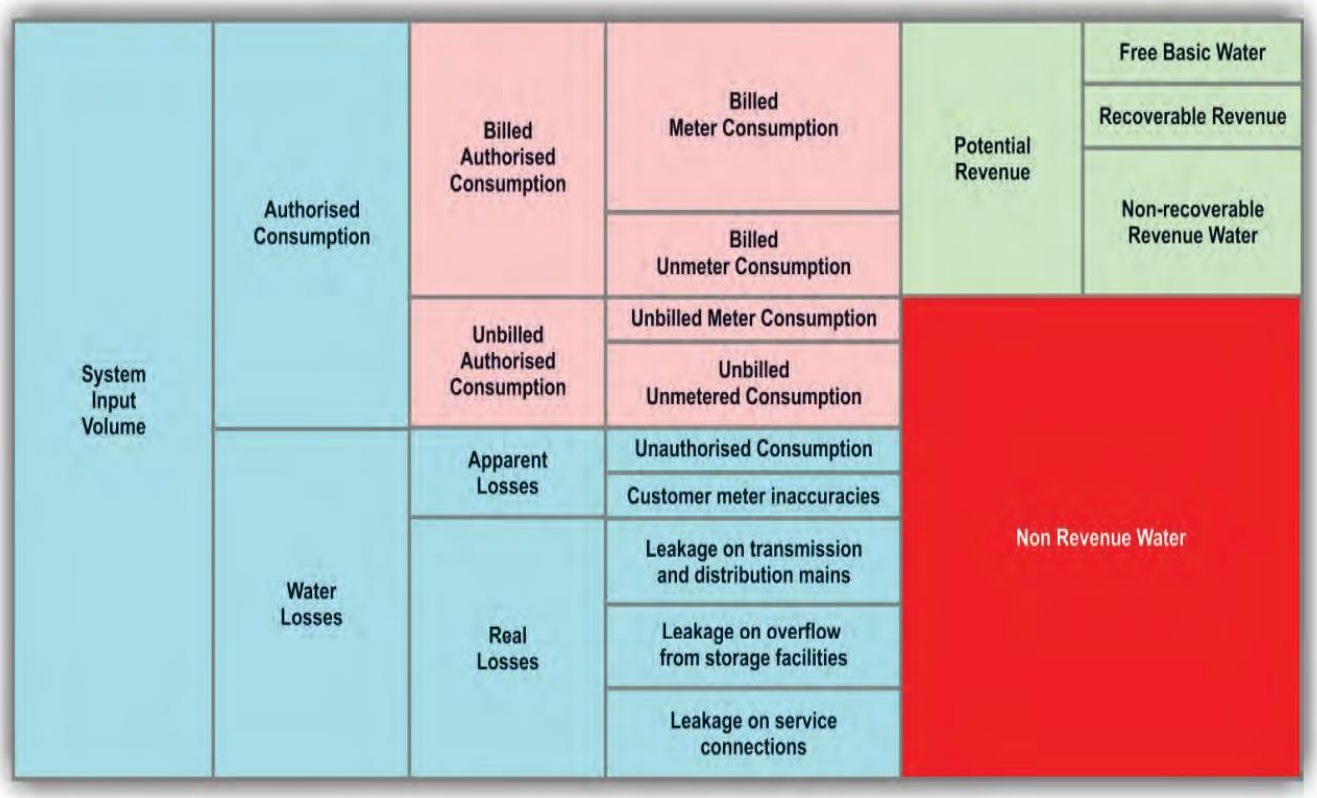

Figure 2.1: Modified IWA Water Balance (from: Seago and McKenzie, 2007 cited by McKenzie Siqalo & Wegelin, 2012)

As depicted in Figure 2.1, the IWA water balance is colour coded in blocks according to the areas of responsibility. As illustrated, the input volume, authorised consumption and water losses in the form of apparent and real losses are under the jurisdiction of the technical department, which is responsible for the physical operation, and maintenance of water reticulation systems (McKenzie Siqalo & Wegelin, 2012). The metering of consumers is usually the responsibility of the technical departments which is the case in Ekurhuleni Metropolitan Municipality. However, the billing of consumers is typically under the authority of the finance department which is also the case in Ekurhuleni Metropolitan Municipality. The overall Water Balance therefore bridges both the Technical and Financial Departments within a Municipality and such joint responsibility often results in some form of discrepancy (McKenzie, Siqalo & Wegelin, 2012).

The billed and unbilled components of the water balance fall under the responsibility of the finance department and this is the case at Ekurhuleni Metropolitan Municipality. The study will focus on assessing the effectiveness of projects which the Metro has implemented to reduce water loss (i.e. real and apparent losses) and ultimately decrease Non-Revenue Water. As indicated above that water loss is a component of the technical department, the study will thus determine whether the

projects implemented are effective in reducing water loss. Based on the findings, recommended strategic ways on implementing and managing water loss were determined.

2.5 HOW WATER LOSS REDUCTION PROJECTS SHOULD BE IMPLEMENTED

McKenzie (2014) emphasized that in reality reducing water loss in a municipal water distribution system is not a difficult task, it only requires a dedicated and methodical approach if real and sustainable savings are to be achieved. In many cases, water loss reduction interventions are introduced which are inappropriate to the problems experienced in the reticulation system. If a municipality intends to embark on a water loss project, it is important that it select an intervention which will address most serious problems experienced in a specific area in order to have a chance of success (McKenzie, 2014). In a municipal setting, the interventions may vary from one municipality to another municipality. The possible water demand management interventions and issues are depicted in figure 2.2:

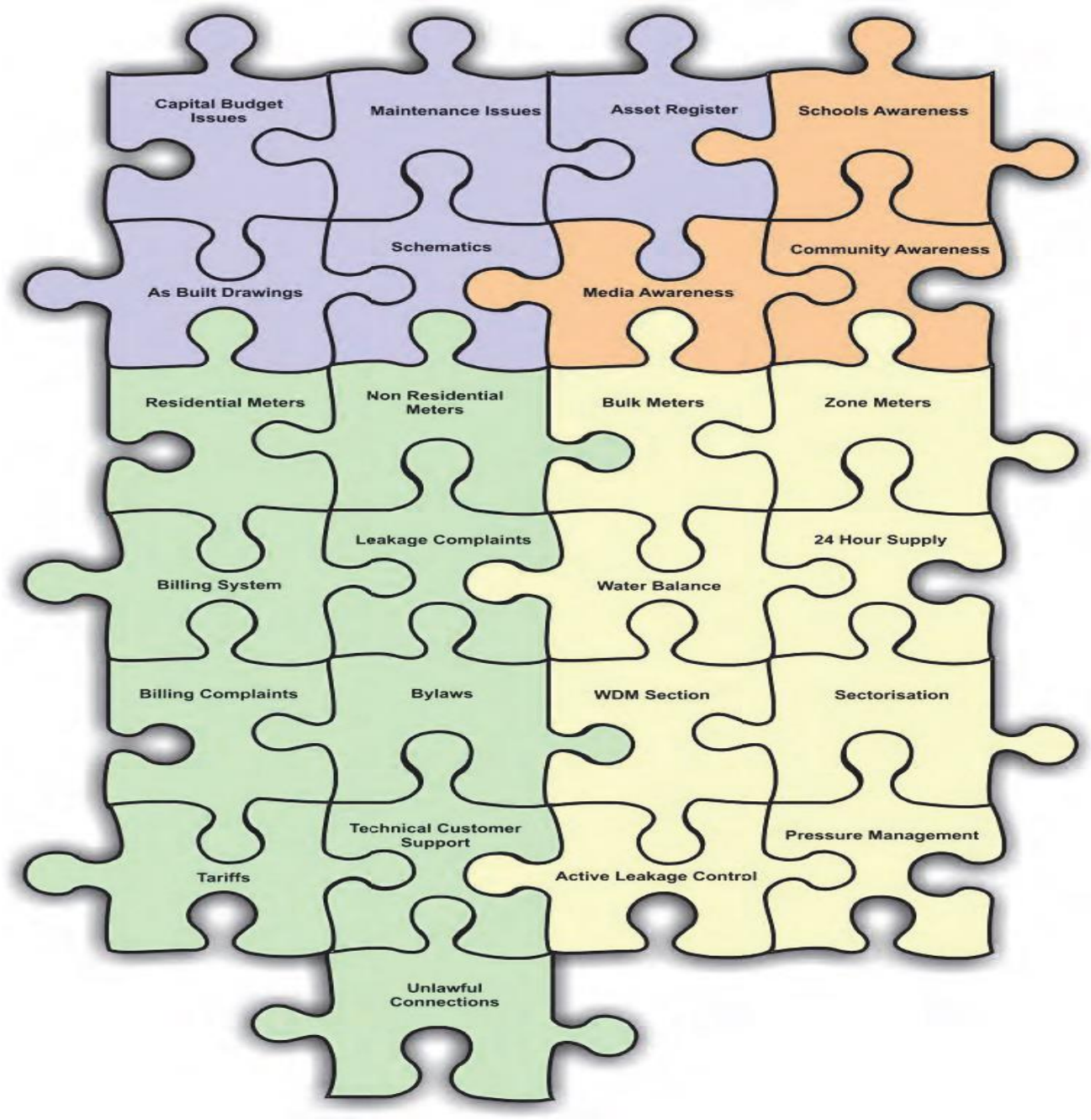

Figure 2.2: Some possible WDM Intervention and issues (From McKenzie, 2014)

The key issue is to decide which intervention will be more effective in reducing water loss. McKenzie (2014) further indicated that the most common mistake, which is made by many municipalities in the globe, is to believe that water loss reduction is achieved through only by leak detection and repair. In such cases, more money is spent on purchasing expensive hi-tech equipment's. If high levels of water loss are due to inaccurate metering or water theft, the intervention in leak detection and repair will yield negative results on water loss reduction. It is thus vital for municipalities to first conduct an analysis of water loss in the system in order to come

up with interventions that will address the problem. Identifying the root cause of water loss is a very critical phase if water loss reduction is to be achieved. Once the problems have been identified, the solutions are often obvious and the way forward become clear (McKenzie, 2014).

McKenzie (2014) has identified the following key areas which a municipality needs to consider before embarking on a water loss reduction programme:

- System schematics
- Leak location and repair
- Pressure management
- Sectorising
- Logging and analysis of minimum night flow
- Bulk management meters
- Bulk consumer meters
- Domestic metering and billing
- Pipe replacement and repair
- Water balance
- Community awareness and education

System schematic

McKenzie (2014) emphasis that before any work can be considered in a water supply network, it is important to understand the basic layout of the network. Understanding how the network system operates will assist in identifying key components such as master meters, reservoirs, purification plants etc. This will also assist in identifying were possible water loss problems may occur.

Leak location and repair

Repairing visible and reported leaks (preferably within 24 hours of being reported) is without doubt one of the most obvious and basic intervention that should be implemented as a top priority. However, this is not always possible due to lack of adequate leak fixing staff in many municipalities. No municipality can expect its customers to save water if it leaves visible leaks unrepaired or rather unattended for days or months. Repairing visible and reported leaks is the most basic and obvious water loss reduction intervention that can be implemented (McKenzie, 2014).

Active leakage controls involve spending time trying to detect leaks in the network by using leak sounding equipment. The process assists in identifying leaks which are not visible and a well experience leak detector with a basic listening rod will often find more leaks than a poorly trained leak detector with the most expensive equipment.

Pressure management

According to McKenzie (2014), pressure management is one of the most important water demand management interventions that should be considered. Pressure management is one of the most cost-effective measures to reduce leakage and wastage that can be considered. McKenzie (2014) indicated that many of South African municipal water systems are operated at an unusual high pressures and can be implemented as one of the most important WDM intervention. In order to reduce leakage through pressure management it is necessary to reduce the water pressure without compromising the level of service with regard to the consumers and fire-fighting.

Sectorising

Sectorising is the process of cutting a big area into smaller manageable areas which will enable the person responsible for the areas to easily identify problem areas (McKenzie, 2014). It is however important for water utilities to have a smaller number of larger zones that can be properly maintained rather than too many small zones that are not maintained. The process of sectorising is well known as a critical element of any water loss reduction programme.

Logging and analysis of minimum night flow

After zones have been established, the flows and pressures can be monitored in order to identify specific problem areas.

Bulk management meters

Bulk management meters assist water managers to monitor and understand the flows in the water supply network. McKenzie (2014) indicates that bulk meter management is essential for the proper operation and management of any reliable and well managed water supply network.

Bulk consumer meters

Industries pay for their water supply and do not expect to receive free water from municipalities but they expect to receive a reliable water supply. Having bulk meters to big consumers like industries assists in monitoring the supply of water easily and this in turn enables water managers to know how much water is being utilized where and when.

Domestic metering and billing

Domestic metering and billing plays a vital role in water loss reduction. Responsible consumers who are paying for their water services will ensure that any visible leakage in their plumbing or street is urgently reported to the municipality to prevent high water bills. However, consumers who do not pay their bills are very much likely to be careless with leaks at their homes and their water usage is excessive creating a vicious cycle where high water consumption leads to high water bills that cannot be paid since many of the consumers are unemployed and cannot afford to pay for their water use.

If the municipality intends to meter households particularly with new technology such as smart meters, it is important to get a "buy in" from community members before implementation. If a buy in is acquired and consumers are made aware and educated about the importance, scarcity, conservation and payment of water, consumers are likely to pay for their services as they would understand the reasons for metering projects and paying for water services.

Pipe replacement and repair

Many water managers currently struggle with resolving when to repair or replace pipes. Pipe replacement is one of the most expensive water loss intervention methods and it should be considered as the action of the last resort after other options including pressure management and leak repair have been exhausted. McKenzie (2014) states that there are two schools of thoughts which exist in pipe replacement. The first approach which was implemented in eThekwini Metro was the blanked replacement where all pipes of a certain types and age were replaced. An alternate approach to "blanket replacement" which was introduced in Tshwane Metro in which certain types and age of pipes are replaced according to the incidence of burst pipes as recorded and monitored on the municipality's management information system.

In cases were finances are a constraint, the option of selective replacement will most likely be the appropriate route.

Water balance

It is important to grasp the concept of water balance in order to be able to fully account for the systems input. Though the concept of water balance will assist in accounting for all the systems input, water experts around the world agree that there is no system that can ever be completely free from leakage, no matter how new or well managed (McKenzie, 2014). The concept of unavoidable annual real losses (UARL) was developed based on the fact that there is no system which can be entirely free from leakage and that every system will have some level of leakage which cannot be reduced any further (McKenzie, 2014).

- **Infrastructure leak index**

  According to McKenzie (2014), the infrastructure leak index is now widely used throughout the world as an indicator of physical leakage from a water supply system. A value of 1.0 indicates that the actual level of leakage is equal to minimum level of leakage that can in theory be achieved in the specific zone whilst a value of 10 or above usually suggest that there is a very serious leakage problem.

Community awareness and education

Community awareness and education plays an important role as a water loss reduction intervention (McKenzie, 2014). If communities can work with municipalities in conserving water and also assist by reporting leaks and paying for their water services, municipalities can encounter a greater reduction in water loss. It is thus important for municipalities to engage communities in all water

projects and also provide education and awareness to enhance community member's knowledge and understanding in the importance of water conservation.

2.5.1 International best practices on implementation of water loss reduction projects

Everywhere in the world, the annual volume of treated water leaking from a distribution system is an important indicator of the evolution of water distribution efficiency, in individual years and as a trend over a period of years. High and increasing annual volumes of leakage indicate ineffective planning and construction, and low operational maintenance activities. With the increasing international trend towards sustainability, economic efficiency and environmental protection, the topic of water supply system leakage is high-profile. This is especially so during times of water scarcity or drought, when consumers are asked to reduce their own consumption of water in order to maintain continuity of supply. Failure to quickly repair visible leaks is highly damaging to a Utility's reputation (European Union, 2015).

According to Pierderideapa (2015), Germany is the country with the lowest water losses (under 10%), having therefore the most effective ways to manage the water losses. The strength of the water supply system in Germany is the infrastructure. For example, the water supply system in Munich consist for the most part of metal pipes as well as taps that are all in steel. Most pipes are positioned in the pavements. The water meters are located in the basement. The network pressure is 6 bar, with pressure reducers on connections. Water meters are read once a year in the self-reading system, the monthly bill is based on estimated consumption.

The network is provided with underground and surface hydrants, buried valves concession taps; all fittings are easily identified by standard plates. The distance between hydrants is between 80 and 100 m. The maintenance of the fittings is required annually and all the problems require to be rectified. The Water Company is required by the community to submit all efforts to reduce water losses. There is a German Standard, W-392, where it is stated that all networks should be checked. Therefore, all water companies comply with that and check their entire network.

In Germany, the city of Munich is divided into 12 zones. The whole network is inspected once a year. Water loss detection teams are equipped with a test van with flow meter and pressure sensor connected to a laptop, correlator, ground microphone, fitting microphone, trails locator and a metal locator. Each team receives a map of the area to be checked. On the map is marked the duct portion to be verified. Verification is made by bridging, listening valves or flow measurement. Defects are classified in three categories:

- Category A: these are defects that must be repaired immediately,
- Category B: these are defects which are hidden and must be remedied within a week (most common),
- Category C: these are defects which are hidden that need to be rectified within 30 days.

A report is made on the verified streets, lengths and identified defects. The identified defects are marked with blue. Repairing the defects is done by private companies (Pierderideapa, 2015). The manner into which water losses are managed in Germany is efficient and the country's best infrastructure makes it possible. In South Africa, the majority of the cities/metros are still struggling with replacing aged infrastructure. Ekurhuleni Metropolitan Municipality is one of those Metro's which is replacing its aged infrastructure. The replacement of this infrastructure ussually requires more capital which is ussually not available. It thus becomes difficult to manage water losses when the infrastructure is not functioning optimally.

New Zealand is another countries which has good practices in terms of efficient water loss management. In 1999/2000, recommendations for a best practice Water Balance and associated Performance Indicators were published by the Water Loss Task Force of the International Water Association (IWA). New Zealand was one of the first countries to adopt these recommendations, when in 2002 Water New Zealand (previously known as the New Zealand Water and Waste Association (NZWWA)) commissioned and published the BenchlossNZ software and associated User Manual. These provided a standard annual water balance for bulk metering, consumption and water loss calculations, and recommended performance indicators for Non-Revenue Water and real (physical) losses, all based on international best practice (Lambert & Taylor, 2010).

In order for cities to be sustainable in terms of managing its water loss, best practices need to be developed. Engel *et al.* (2011) indicated that sustainability goes beyond physical engineering and manipulation of water flows. Urban water management must integrate a larger proportion of solutions like raising awareness to reduce consumption, law enforcement and controls, reuse and recycling of storm-and wastewater, corporate water stewardship, economic and fiscal incentives and instruments, cost recovery, integrated river basin management, payment for environmental services, and climate change adaptation. Thus, the efficient and effective management of water loss requires various experts to play a critical role if success is to be achieved.

2.6 SUMMARY OF LITERATURE REVIEW

It is evident from the literature review that efficiency and effectiveness are important in project management. Whilst efficient is associated with internal factors (i.e. time, cost and quality), effectiveness is very broad as it puts emphasis on external factors (i.e. client and user satisfaction, level of effectiveness, project functionality and fitness for purpose, free from defects, value for money, profitability, absence of any legal claims and proceedings, learning and exploitation and general positive reputation).

In planning, implementing and executing water loss projects, a methodical approach need to be followed in order to achieve the desired outcomes. Literature indicates that before municipalities can embark on a water loss eradication programme, they should ensure that a thorough assessment of the entire water distribution network is done. The assessment will enable municipalities to know what the municipality and the network systems suffers from in order to address the key problems. Every municipality has its own water loss problems, thus water loss eradication programmes should be designed to meet the needs of each municipality.

In implementing water loss reduction projects, municipalities should ensure that they consider system schematics, leak location and repair, pressure management, sectorising, logging and analysis of minimum night flow, bulk management meters, bulk consumer meters, domestic metering and billing, pipe replacement and repair, water balance, as well as community awareness and education. Germany and New Zealand two countries which have best practices in water loss management. Both countries have best infrastructure which enables them to plan, implement and execute water loss management projects efficiently and effectively. Even though these countries are good in water loss management, both countries have made an extensive investment in terms putting systems and processes in place which enables its objections in relation to water loss management to be achievable.

CHAPTER 3: METHODOLOGY

It can be argued from the studies that have been conducted on the subject of project effectiveness that there is little literature available on project effectiveness in the water industry. Several studies that have been conducted are on project effectiveness in the construction industry (i.e. building, roads etc.). This study was done to assess the effectiveness of water loss projects in Ekurhuleni Metropolitan Municipality. The method followed in any study is informed by aspects such as, the nature of the phenomenon under study, the research questions being asked and the problem that set off the enquiry. The research tradition followed in this study is a case study using Ekurhuleni Metro as a model to assess the effectiveness of projects that are aimed at reducing water loss both in terms of scale and impact. According to Baxter and Jack (2008), a case study is an intensive analysis of a single unit.

In this study, Ekurhuleni Metro is used as a unit to assess the Metro's water projects in reducing water loss. Ekurhuleni Metro is used as a case study because it is a second largest Metro in South Africa and, it is South Africa's highly industrialized powerhouse and therefore attracts many people. When many people migrate into a finite space with limited resources, there are bound to be survival mechanisms in the struggle for such resources as water, housing and electricity. The situation in Ekurhuleni Metropolitan Municipality is therefore assumed to be adequate enough to assess the phenomenon under study.

A literature review was done in order to firstly determine how water loss projects should be rolled out. Secondly, the literature review was conducted in order to determine project effectiveness measures which will be applied when analyzing the empirical data.

A positivist philosophy was used for this research and focused on the project effectiveness in water loss project in Ekurhuleni Metropolitan Municipality. Thus, the study was based on facts from the body of knowledge and from the empirical data that was collected. The research statements propose that if water loss projects are carried out effectively, water loss will be greatly reduced. A qualitative approach was used for the collection of data in order to study the effectiveness of water loss projects in Ekurhuleni Metropolitan Municipality.

According to Myers and Avison (1997), qualitative data sources include observation and participant observation (fieldwork), interviews and questionnaires, documents and texts, and the researcher's impressions and reactions. Purposive sampling was to use to select the sample for the study. According to Bryman and Bell (2014), purposive sampling is a non-probability form of sampling which aims to sample cases/participants in a strategic way, so that those sampled are relevant to the research questions. The Department of Water and Sanitation in EMM was chosen to conduct the study because the department is responsible for rolling out water loss projects.

A literature study was used as the first part of the qualitative data in order to achieve the following objectives:

- Determine how water loss projects should be planned, implemented and executed.
- To determine measures of project effectiveness in the water industry.
- To identify previous research and gaps or limitations that may need to be addressed or supported by the empirical data.

Project information pertaining to the water loss eradication programme was collected and analysed in order to test the research statements and address any limitations in literature. The empirical data was also used to confirm and support the literature study. Figure 3.1 shows the methodology followed for the research from problem identification, literature survey to the finalization of the research report.

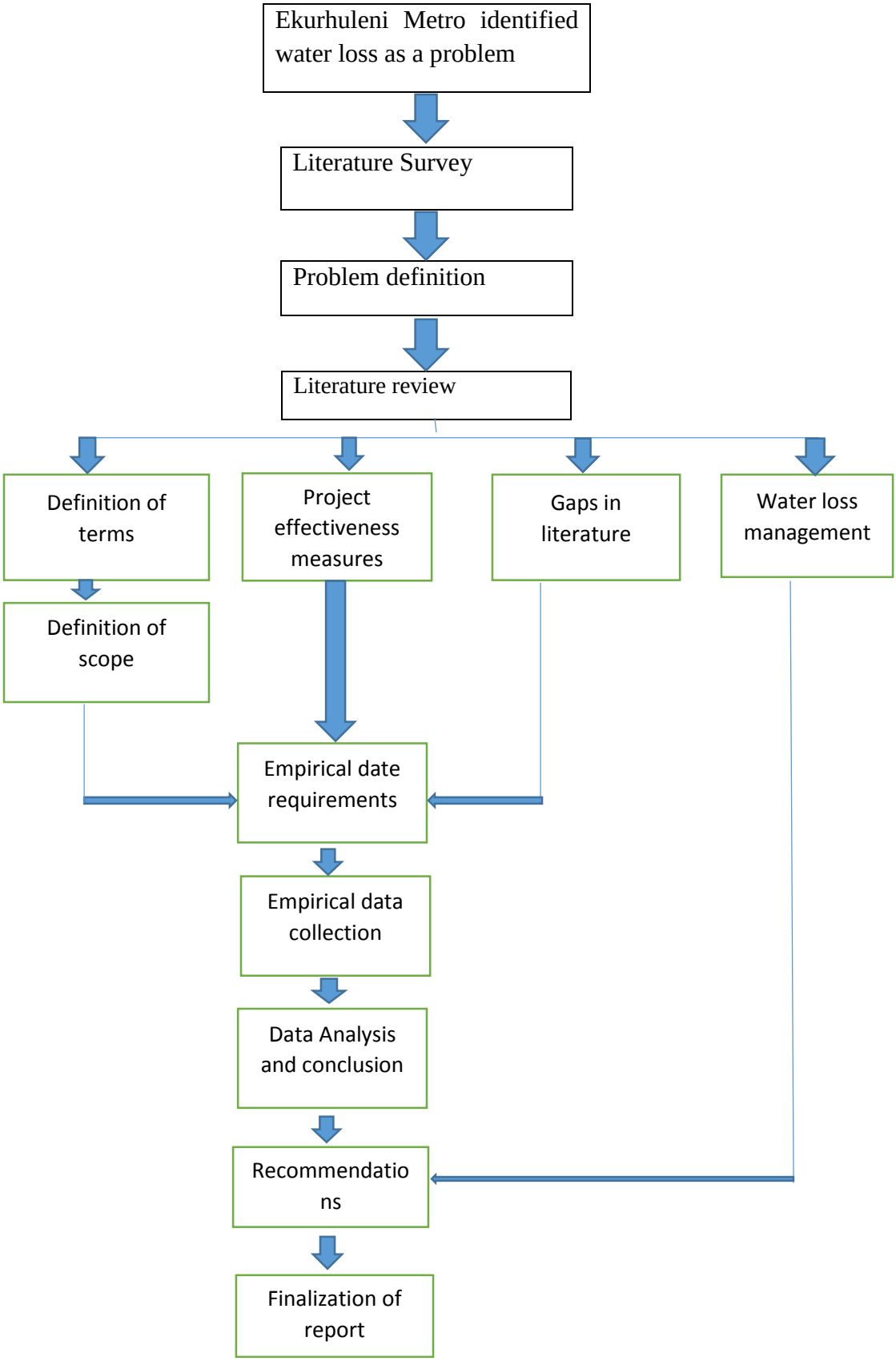
Ekurhuleni Metro identified water loss as a problem
Literature Survey
Problem definition
Literature review
Definition of terms
Project effectiveness measures
Gaps in literature
Water loss management
Definition of scope
Empirical date requirements
Empirical data collection
Data Analysis and conclusion
Recommendations
Finalization of report

Figure 3.1: Research Methodology and process diagram

As mentioned above, the projects were analysed based on the ten effectiveness project measures which were compiled and reviewed by Takim and Adnan (2008). The results were then analysed in order to develop recommendations to address the water loss problem. The empirical data and results were represented both quantitatively and qualitatively for analysis. Thereafter, drawing of conclusions and formulation of recommendations followed.

3.1 RESEARCH EXECUTION PLAN

The research execution plan was divided into two phases. The first phase incorporated literature study which included literature on project effectiveness measures as well as water loss management. The second phase incorporated scope definition and collection of data. The primary data comprised of water loss projects from Ekurhuleni Metropolitan Municipality. Site visit were secondary data and they were conducted to independently verify project reports information.

3.2 EQUIPMENT AND RESOURCES

In conducting the study, the following resources were used for completion of the research. The empirical data collection along with the respective sources are included.

3.2.1 Data collection

The data was collected from Ekurhuleni Metropolitan Municipality from the Department of Water and Sanitation. Site visits to the respective projects areas were also conducted for independent verification. The primary data which was collected were as follows:

- Project reports
- Payments certificates
- Appointment letters

Whilst the secondary data collection consisted of project site observations. Pictures of project sites were also taken during the site visits. In collecting the data for the study, the EMM Department of Water and Sanitation was informed of the study and requested to submit the project reports on the water loss eradication programme. Thus, the method employed in analyzing the data was document analysis. The secondary method of analysis was observation which was done through site visits. The site visits were done after the project reports were received in order to independently verify information contained in the project reports.

3.2.2 Reliability and validity

This section indicates how the factors of reliability and validity of the research and the research instruments were taken into consideration.

3.2.2.1 Reliability

According to Bryman and Bell (2014), reliability is concerned with the question of whether the results of a study are repeatable. Joppe (2000) cited by Golafshani (2003) defines reliability as the extent to which results are consistent over time and an accurate representation of the total population under study and if the results of a study can be reproduced under a similar methodology‖. The research was based on empirical data that was collected from Ekurhuleni Metropolitan Municipality (i.e. Department of Water and Sanitation). The empirical data collected is kept by the Department of Water and Sanitation.

Further and above that, site visits were conducted to the respective projects sites in order to verify the authenticity of the information. Thus, the same conclusion will be reached if the study was to be conducted in a similar environment.

3.2.2.2 Validity

According to Joppe (2000) cited by Golafshani (2003) validity is a measure of how truthful the research results are or if the research instrument measured what it was intended to measure. Bryman and Bell (2014), indicates that validity is concerned with the integrity of the conclusion that are generated from a piece of research. When considering the definition put forward by Joppe (2000) cited by Golafshani (2003) and Bryman and Bell (2014), it can be said that the research instrument was internally valid as the empirical data that was collected was used to analyse whether the water loss projects in Ekurhuleni Metropolitan Municipality are effective or not, which was achieved (see Chapter 4 and Chapter 5).

However, the result may not necessarily be externally valid as the size of the sample was small. Only twenty-three (23) projects were evaluated, some of which were conducted by the same contractors, and only concentrated on one Metropolitan municipality in Gauteng. Because the study focused only on Ekurhuleni Metropolitan Municipality, it can thus be said that the results are not generalizable. In order to achieve generalisability for the South African Metropolitan municipalities, a bigger sample must be used over the country.

3.2.3 Ethical considerations

For the sake of confidentiality purposes of the contractors and consultants used for the study; the names or company names of the contractors and consultants as well as contact details were not included on the report. This information was used solely for the analysis.

At the time of this research, the author was employed by Ekurhuleni Metropolitan Municipality as a Researcher for Water and Energy. However, the author has maintained objectivity in analyzing the empirical data in order to ensure that bias is eliminated.

CHAPTER 4: RESULTS AND ANALYSIS

4.1 DESCRIPTION OF DATA

In assessing the effectiveness of projects which are aimed at reducing water loss in Ekurhuleni Metropolitan Municipality, a water loss eradication programme was selected as a case study for this research. Ward (2009) indicates that a project has a defined start and end point and specific objectives that, when attained, signify completion. Whilst a programme, on the other hand, is defined as a group of related projects managed in a coordinated way to obtain benefits not available from managing the projects individually (Ward, 2009). Ward (2009) further indicates that a programme is comprised of multiple projects and is created to obtain broad organizational or technical objectives. The Ekurhuleni water loss eradication programme is designed to obtain the broader organizational goal which is to minimise water losses. The water loss eradication programme consists of the following sub-programmes:

- Leak fixing and meter installation project in Tsakane
- Consolidation and replacement of all large water meters
- Metering of all informal settlement
- Metering of Council properties
- Metering school's properties
- Domestic and bulk metering
- Pipeline and valve assessment and replacement
- Replacement of mid-block pipelines

Each sub-programme has projects which are implemented with an attempt to ultimately reduce water loss. Thus, twenty-three (23) projects were analysed from the various sub-programmes. Data on a total of twenty-three (23) projects was collected and analysed. The projects in the case study were implemented and executed from July 2011 until June 2015. An email was sent to the Department of Water and Sanitation Head of Department requesting completed project reports of the water eradication programme. Twenty-three (23) project reports were then submitted for the study. The completed projects reports are from projects which have been implemented under the water loss eradication programme. Different projects have been implemented on the different sub-programmes. Table 4.1 indicates the number of projects which have been analysed per sub-programme programme.

Water loss eradication programme	**Number of projects analysed**
Leak fixing and meter installation project in Tsakane	1
Consolidation and replacement of all large water consumer meters	2
Metering of all informal settlement	1
Metering of Council properties	1
Metering of schools properties	1
Domestic and bulk metering	10
Pipeline and valve assessment and replacement	1
Replacement of mid-block pipelines	6
Total	**23**

Table 4.1: Number of projects analysed per water loss programme

The study has thus assessed the twenty-three (23) projects which have been implemented by the Department of Water and Sanitation in an attempt to reduce the Metro's water loss.

4.2 Assessing the effectiveness of Ekurhuleni Metropolitan Municipality's water loss projects.

In assessing their effectiveness, the projects were measured against the ten project effectiveness criteria which were compiled and reviewed by Takim and Adnan (2008).

4.2.1 Tsakane "War on Leaks" project

The Tsakane "War on Leaks" project was a large scale leak repair project implemented by the Ekurhuleni Metropolitan Municipality (EMM) in an attempt to increase the percentage of revenue water in the areas of Tsakane, Langaville and Geluksdal. After conducting a Water Demand Management task in which the EMM management area was subdivided into 87 District Metering Areas (DMAs), it was found that upon analysis of the water balances of the 87 DMAs, the Tsakane/Langaville/Geluksdal DMA had the highest percentage of Non-Revenue Water (NRW) and water losses. In an attempt to address the NRW and water loss issues, Ekurhuleni Metropolitan Municipality embarked on a war on leaks project in Tsakane.

The project entailed retrofitting of houses and meter installations in Tsakane. The name, war on leaks meant that the contractor will fix any leaks found in all the properties which were identified.

The project has been planned in three phases which are located in ward 82, 83 and 84. The overall project cost in phase 1 was R28 million and pilot phase amounted to R10 million. The projects (i.e. both the pilot phase and phase 1) were carried out from September 2013 to March 2015. Takim and Adnan (2008) indicated that projects which are considered effective should meet client satisfaction on service, user satisfaction with product, project effectiveness, project functionality, fitness for purpose, free from defects, value for money, profitability, absence of any legal claims and proceedings, learning and exploitation and generate positive reputation. The Tsakane "War on Leaks" project was assessed based on the ten project effectiveness criteria as stipulated by Takim and Adnan (2008).

Client and User Satisfactions

Contractor A was appointed to do the retrofitting of houses and meter installation. The contractor further appointed 15 local Small, Medium and Micro Enterprises (SMMEs) to conduct the retrofitting and meter installations. In total, the contractor retrofitted 11 100 stands and metered 11 468 households. The retrofitting that was done consisted of plastic cistern, porcelain cistern, plastic flush mechanism, porcelain flush mechanism, pans, flush pipe, flexible supply connection, rubber cone, brass bip-tap, mixer, ball valve and copper pipe. Figure 4.1 and 4.2 depicts the installation of outside toilet and two adjacent meters at the project site (i.e. Tsakane).



Figure 4.1: Retrofitting of an outside toilet on adjacent properties (pictures taken from: EMM, 2015).



Figure 4.2: The labour team in the process of installing two meters

The contractor had 11 quality control officers who were responsible for checking the quality of work done and sign off completed work in households. Community Liaison Officers were responsible for ensuring that household owners sign off happy letters (attached as Annexure A) once the house is leak free. The happy letter means that the owner of the household is happy with the work done and that the house is leak free. Based on client and user satisfaction, Ekurhuleni Metropolitan Municipality (client) is satisfied with the work done by Contractor A and users (households) are also satisfied with the work done in their households as happy letters were signed off by household owners to all the retrofitted 11 100 stands and 11 468 metered households.

Level of effectiveness (achievement of outcomes)

According to Maloney (1990), level of effectiveness is measured based on the attainment of objectives both at the corporate level and project level. The Tsakane project objectives were as follows:

- **To drastically reduce the high levels of Water Losses in EMM by means of a large scale Leak Fixing Project in the area with the highest NRW / Water Losses (88% in Tsakane) in Ekurhuleni.**

According to a detailed analysis which was conducted in 2010/11 financial year by Consultants A, Tsakane was considered to be one of the areas with high NRW and water losses. A detailed analysis of the water distribution system was conducted in which flow and pressure logging was included. The logging results were then used as the pre-intervention logging for Phase 1 of the Tsakane "War on Leaks" Project.

Phase 1 of the Tsakane "War on Leaks" Project covered Ward 82, 83 and 84 which fall under Tsakane East. The pressure logging results for Tsakane East indicated that the water was supplied at a pressure in the range of 280kPa – 330kPa (EMM, 2015). The minimum zone pressure was 150kPa and most of the pressure recorded in the system was consistent with normal operation. The flow logging results for Tsakane East showed that the average daily demand was 1 212kl/hr. with the Minimum Night Flow (MNF) being 895kl/hr. (EMM, 2015).

It was thus noted that implementing Phase 1 of the project in the area will be very beneficial in reducing wastage on a larger scale. An average wastage of 76% is extremely high and the logging results exposed this fact to the Metro, as well as the urgent need for a leak repair project in the Tsakane/Langaville/Geluksdal DMA. This objective was thus met, as Tsakane East was the area with the highest NRW / Water Losses and priority was given to the area.

- **To implement the Project utilizing best practice Water Demand Management (WDM) and Water Conservation (WC) principles.**

This objective was also met as priority was given to Tsakane East which is the area with the highest water loss and NRW.

- **Creating much needed job opportunities utilising labour-intensive construction methods in line with EPWP principles. (There are currently only a few types of these projects in EMM compared to other Metropolitan Municipalities hence this project can help in this regard.)**

This objective was achieved as the project has managed to employ over 173 people, divided amongst the SMMEs, Quality Control Officers (QCOs), Community Liaison Officers (CLOs), Community Facilitators and the staff required on site. Most people worked on the project between 3 – 5 months and the people employed on the project ranged from 18 years old to 72 years old.

- **Maximise the utilization of Local SMMEs, Plumbers and other Labour, CLOs and Community Facilitators, who are temporarily employed in terms of the scope of work. (The project incorporates the "Management Contractor Contracting Model" in which the Main Contractor only brings some key staff to Site.)**

This objective was also achieved as indicated above that the project has managed to employ over 173 people, divided amongst the 11 SMMEs, QCOs, CLOs, Community Facilitators and the staff required on site.

- **Empowerment of the Community by providing Technical Training, Skills Development, Mentoring and Coaching.**

Labourers were provided with a training on plumbing. The training for the plumbers was two-fold; the one being the theory aspect and the other being the practical aspect

- **Training and Development of SMME Companies (to efficiently run their businesses, i.e. small contractor development).**

11 SMMEs were sub-contracted by Contractors A. Contractor A was further responsible for training and development of the sub-contractors and also to ensure that the work done by the sub-contractors is of good quality as per the contractual agreement.

- **Eradicating the backlog of unmetered areas in EMM. (This Project will meter 43 000 out of the 70 000 unmetered stands in EMM.)**

At the end of the project, 11468 households were metered in phase 1. The remaining 31 532 meters should be metered in phase 2 and phase 3.

- **Public Education and Awareness Raising Campaign.**

Public education and awareness campaign were done in Tsakane. The targeted stakeholders for the education and awareness campaign were:

  - Ward Councillors
  - Customer Care Area Managers
  - Communities
  - Affected Households
  - Relevant Officials in the Water & Sanitation Department

- **Enhanced Service Delivery in the targeted project area.**

Service delivery has been enhanced in Tsakane East, as water service is supplied efficiently without experiencing the high levels of water losses and NRW. Both the corporate and project objectives have also been met as the project has managed to reduce water losses and households are now leak free.

Project Functionality and 'Fitness for Purpose'

Ekurhuleni Metropolitan Municipality (client) was satisfied with the work done by Contractor A as the project has been concluded and signed off. This means that the project is functional and fit for use as per the contractual agreement/technical specifications. Users (households) were also satisfied with the work done in their households as happy letters were signed off by household owners to all the retrofitted 11 100 stands and 11 468 metered households.

Free from defects

Quality control was done during the implementation process. The contractor had 11 quality control officers who were responsible for checking the quality of work done and sign off completed work in households. All households work done was checked and signed off by Quality Control Officers (QCO). Community Liaison Officers (CLO) were responsible for ensuring that household owners sign off happy letter once the house is leak free. Household's owners signed off the happy letters indicating that the work had no obvious/visible defects.

Value for money and profitability

Table four depicts the projects value for money based on the projects reduction in water losses and return on investments.

Project Type	**Pilot Phase**	**Phase 1**
Reduction in water losses:		
Number of Stands	2573	11468
kl/month/stand	23	31.6
kl/month	59 179	362 388.8
Savings/month (@R6/kl)	R 355 074	R 2 174 333
Savings/annum (@R6/kl)	R 4 260 888	R 26 091 994
Return on Investment		
Project Cost	R 10 000 000	R 28 000 000
Recovery Months	28	13

Table 4.2: Pilot phase and phase 1 project costs (adapted from: EMM, 2015)

The Metro has indicated that the pilot phase saved EMM approximately R4.3 million/annum while phase 1 saved EMM approximately R26 million/annum. Comparing the number of stands completed for both projects, the properties of the pilot phase comprise of 22% of the number of properties completed in phase 1. Using this concept for the annual savings, the savings for the pilot phase comprise approximately 17% of the savings achieved for phase 1. This was to be expected considering that phase 1 achieved savings of 31.6 kl/month/stand while the pilot phase achieved savings of 23 kl/month/stand.

Absence of any legal claims and proceedings

There were no legal claims and proceedings from the Contractor and the client (EMM). Both parties were satisfied with each other's work.

Learning and exploitation

The project had its challenges which were faced during project implementation. The project challenges which were faced during the implementation process will be used as lesson learned when implementing other similar projects. The challenges which were experienced during the implementation process were as follows and the resolutions are also outlined:

- **The residents of Extension 17 preventing the project team from working in their area**

A meeting was held with the CLOs, the Site Manager, the Consultant Representative and the Ward Councillor at the beginning of the project. The Ward Councillor advised the project team to employ people from Extension 17 and this was done. However, the residents were not satisfied with this and still prevented the project team from working in the area. Therefore, it was decided to exclude Extension 17 from the project area.

- **Lack of Quality Control Officers – 3 QCOs for 11 SMMEs**

The ratio of 3 QCOs to the 11 SMMEs was delaying the project in the sense that completed properties were not being signed off by the QCOs quickly enough. It was decided that 8 more QCOs be employed, therefore creating a 1:1 ratio of QCOs to SMMEs and thus increasing productivity.

- **Issues with the leak free test rate, the yard connection rate and the concrete slab rate**.

The SMMEs argued that they would like to get the contractor's rate for the Leak Free Test (R40). The issue was discussed and the SMMEs agreed to the R25 rate that the contractor was offering. The SMMEs also had an issue with the yard connection rate being R5 per meter of piping. They suggested that the rate be changed to R50 for the entire stand and this was accepted by the contractor. The SMMEs felt that the Concrete Slab rate was too low and therefore the contractor agreed to increase the rate by R5 back-dated to the project start date.

General positive reputation

There is a good relationship between Contractor A and Ekurhuleni Metropolitan Municipality as the Contractor has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor in full.

Overall assessment based on the ten effectiveness criteria's for Tsakane "War on Leaks" project

The assessment based on the ten effectiveness criteria indicate that the Tsakane "War on Leaks" projects was effective. As Tsakane was considered the area with the highest water losses, it was thus prioritized as the first project for implementation. This means that the principles of water demand and conservation management were considered in the planning process. The project was efficient as the project cost, time and scope was adhered leading to project effectiveness. Other measures of the effectiveness criterions were also met; the project can thus be considered effective.

4.2.2 Consolidation and replacement of all large water consumer meters

Under the sub-programme of consolidation and replacement of large consumer meters, Ekurhuleni Metropolitan Municipality has implemented two key projects. The first project was the top 500 bulk meter management project which aimed at consolidating meters for the top 500 consumers in the Metro. The second project was the consolidation of meters in Wadeville and adjacent industrial areas. Consultants B, C and D were used for design and implementation whilst Contractor B and C were also used to carry out the project.

4.2.2.1 Top 500 bulk meter management project

A bulk meter is used to measure the volume of water used by residential and commercial buildings that are supplied with water by Ekurhuleni Metropolitan Municipality. Any meter which is greater than or equals to 25mm is considered a bulk meter in the Metro. Ekurhuleni Metropolitan Municipality is an industrial powerhouse of Gauteng Province and houses some of the largest industrial areas in South Africa (McKenzie, 2014). It also houses many other bulk water users such as academic and medical institutions, large residential complexes, large retail complexes and municipal facilities. The focus areas for the work undertaken on this project were limited to bulk consumers in Springs, Germiston, Benoni and Edenvale**.** According to McKenzie (2014), most of the water connections to the bulk consumers in these areas were constructed many years ago and have not been replaced or upgraded since installation.

As a result, numerous below ground meters are no longer operational and some have been buried for years and do not appear on the billing system. A large number of the meter chambers have been filled with debris and there are no records of fire supply connections to some bulk consumers which are therefore not metered. Over several decades, some of these "mislaid' connections have Inadvertently or deliberately been used to supply domestic and, in some instances, process water. Some fire reticulation systems have developed leaks, but without metering of the fire connection in place, these leaks have gone un-noticed for years. As a result, the status of the metering infrastructure to many of the large consumers has been poor and subsequently it has been difficult for Ekurhuleni Metropolitan municipality to bill these consumers accurately for their water consumption.

Ekurhuleni Metropolitan Municipality has in the past provided new connections to large consumers as and when requested. This has led to a situation where a large consumer may have up to 20 connections to a single industrial site. The municipality is then required to maintain and read all of these supplies which invariably lead to mistakes. In many cases meters are simply not included in the billing process. This results in high levels of "commercial losses" in these heavily industrialised areas. These "losses" represent water that may be used for legitimate purposes, but is not being recorded in the billing system and therefore bypasses the accounting systems completely.

As a result of such losses, the municipality loses hundreds of millions in unclaimed revenues annually. If it is assumed that the commercial and physical losses are of similar magnitude in Ekurhuleni Metropolitan Municipality, it is estimated that the value of the commercial losses based on the current industrial water tariff of approximately R10/m^3 is in the order of R700 million annually. It is this component of the water losses that Ekurhuleni Metropolitan municipality is targeting through the bulk meter audits of all large industrial users since the return on the project costs will generally be between 6 and 24 months. Consultants B, C and D as well as Contractor B and Q were used to implement and execute the project. The Top 500 bulk meter project is assessed based on the ten project effectiveness criterions as stipulated by Takim and Adnan (2008).

Client and User Satisfaction

The project has been carried out successfully and customers were willing to work with the municipality. The municipality has replaced and upgraded 458 water meters to various customers in the municipality. The areas were replacement and upgrades took placed are as follows:

Area	**Total**
Benoni	63
Boksburg	151
Brakpan	49
Springs	57
Edenvale	16
Germiston	10
Kempton Park	104
Nigel	8
Total	458

Table 4.3: Number of bulk meters installed in the various areas of the Metro

On completion of the construction, the project team inspected the site accompanied by the consumer to confirm that all water infrastructure was re-pressurised. The consumer was requested to sign a "Consumer Acceptance Form" (Attached as Annexure B) for the work undertaken on their premises. A completion report was prepared for each site detailing all work undertaken and

submitted to Council as a formal record of all work undertaken at each large consumer. Full details of all meters removed together with serial numbers and meter readings were captured in the completion reports. Details of all new meters installed with serial numbers and meter readings were also documented. "As-built" drawings were prepared for all properties where sufficient work was undertaken to require an as-built drawing.

Courtesy visit and full report

A final courtesy visit was made several months after the installation has been completed and a copy of the final report was presented to the consumer. The process involved the following;

• Assessing the correctness of metering & billing information on consumers account;
• Determining if the consumer had any complaints or concerns;
• Assessing the correct operation of the new meters;
• Repeat drawdown test to confirm all water supplied passed through meter installation;
• Cleaning the strainer on the meter installation if needed

Level of effectiveness (achievement of outcomes)

The objectives of the project were to:

- Improve meter management
- Improve meter reading
- Curb water losses
- Maintain a reliable level of service
- Ensure accurate billing
- Apply proper water demand management

The key objective of the project was to reduce non-revenue water and specifically the commercial losses, by addressing metering problems at the top 500 consumers within EMM. Most of these water connections for bulk consumers had been constructed many years ago, and in some cases decades ago, and had never been replaced or upgraded since they were installed. As a result, numerous of the existing below ground meters were no longer operational and some had been buried for years with the result that the meter chambers have become full of debris which must be removed before the meters can again be included in the billing process. Some of the typical problems encountered during the investigations are shown in Figure 4.3 to Figure 4.6.



Figure 4.3: Buried and broken meters



Figure 4.4: Cleaning rubbish from chamber



Figure 4.5: Meter buried in ground



Figure 4.6: Non-functional and old meter

Another key issue that is relevant in many parts of South Africa concerns the fire connections which were previously never metered. As a result, there are many thousands of unmetered fire connections throughout most parts of South Africa. Over time, some of these connections have inadvertently been tapped into for domestic or process water supply, with the result that such water use is not recorded and is therefore part of the "commercial losses". Many industries that are using water through unmetered fire connections are completely unaware that they are doing so illegally, and are very happy when such use is identified and brought to their attention.

Others may not be so happy and in such cases, they generally know what is going on with their water supply. In both cases, the problems must be addressed and corrected so that all water being used by every industry is properly measured and properly billed. Many of the older unmetered fire reticulation systems have developed leaks over a period of years, and without proper metering in place, these leaks remain undetected and can often result in significant water losses. In the case of Ekurhuleni, the situation was aggravated by the fact that the current Metro comprises a number of

previously autonomous municipalities, each of which had its own system for managing the metering and billing and in some cases; the systems used were totally inadequate.

Project functionality and fitness for purpose

All work was carried out by contractors and inspected by consultants. On completion of work done per property, a completion report of each consumer were completed consisting of the following information:

- Consumer information (i.e. Name, erf number, account number, meter number and position, contact person, street name)
- Basic sketch that shows the meter and connection found on site
- Sketch proposing the design of consolidation
- Meter sizing calculation sheet
- Pressure test and flow test performed on EMM system to give indication of actual pressures and flows available
- Letters to consumers affected and sharing information on the exercise
- Existing meter information (captured and photos)
- New meter installed information.

Free from defects

Quality control was done by the consultants during the implementation process. Thus, all consumers signed the consumer acceptance form.

Value for money and profitability

The project was funded entirely by Ekurhuleni Metropolitan municipality at a total cost of R21, 887,235.78 million. The municipality benefited from the reduction of "commercial losses" which appeared as additional water sales to most of the consumers. In some instances, the increases in "billed consumption" were more than expected due to the location of buried meters which were ultimately brought into the consolidated supplies. Based on the metered and billed consumption during the first year after completion of the project, it was estimated that the increase in billed consumption to the municipality was in the order of R43 million/year. This represents a pay-back on the original investment of approximately 6 months.

This project led directly to the creation of approximately 20 full-time jobs for a period of two years, creating more than 4 500 man-days of employment. In addition to the decrease in non-revenue water and job creation achieved through this project, a number of additional benefits were achieved which are worthy of mention, namely:

Absence of any legal claim and proceedings

There were no legal claims from the contractor and the client (EMM). Both parties were satisfied with each other's work.

Learning and exploitation

The project had several challenges which it encountered during implementation and the challenges will be used as lessons learned in planning for the implementation of the remaining 24500 bulk consumers. The challenges experienced are as follows:

- Availability of funding
- Time consuming field work and negotiations with customers
- Appointment of suitable consultant to assist with project
- Materials availability from suppliers
- Shut down for drop test- consumers are water production dependent (Hospitals)
- Fire design risk taken over from consumer
- Meter data in the field does not correspond with financial data
- Meters damaged beyond reconditioning
- Meters buried underground
- Existing infrastructure failures, cannot close down network as to malfunction of network valves.
- Time delay with large companies due to safety inductions and occupational health and safety
- Obtaining of way leaves from all service providers

Generate positive reputation

There is a good relationship between the Consultant and Ekurhuleni Metropolitan Municipality as both the contractor and the consultant has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor and consultant in full and sub-contractors were also paid by the contractor.

4.2.2.2 Analyzing the effectiveness of the project installation and repair of bulk water meters and related work to consolidate water connections to consumers in Wadeville and adjacent industrial areas on an-as and when required basis from August 2012 to June 2015 based on the effectiveness measures.

The project involved investigating and consolidating the water supply connections to over 450 non-domestic water consumers in Wadeville over a 3-year project period (i.e. from August 2012-June 2015). In addition to consumer meter consolidation the network was assessed for operation and maintenance, faulty isolating valves were identified and replaced, leaks were identified and repaired (Water and Energy Oversight Committee: 2016). Meter consolidations were undertaken using the following methodology;

- Identify consumers
- Investigate and document supplies
- Conduct zero pressure tests

- Design the consolidation of multiple supplies into a single connection
- Co-ordinate and supervise construction (undertaken by contractor)
- Document all work undertaken and prepare completion reports for each consumer
- Submit documentation to EMM Finance Department and update the municipal billing system
- Undertake courtesy visit six months after consolidation at each property
- Generate full reports for each property

Consultants A and E were used for design and implementation whilst Contractor B was also used to carry out the project.

Client and User Satisfactions

Before the commencement of the project, a design letter describing details of the work to be undertaken at each consumer property was prepared and issued to each consumer prior to undertaking work at each property. Consumers who had concerns on certain issues or aspects, additional consultation was undertaken to gain approval from these consumers prior to proceeding with the works. Six months after work was completed, a courtesy visit was done to confirm that meters are operational and that consumer's account is accurate. The project was successfully completed as the client (Ekurhuleni Metropolitan Municipality) was satisfied as well as the 469 consumers.

Level of effectiveness (i.e. achievement of outcomes)

Level of achievement measures the attainment of the organization's objectives both at corporate and at project level. At corporate level the objectives were met as reduction in physical and commercial losses were achieved. Over and above that, improved metering, improved consumer meter infrastructure and billing and fewer consumer meters per property were achieved.

Project functionality and fitness for purpose

The consultants were supervising the construction process and maintained communications with the consumer and the contractor during implementation. The consultant confirmed that the work was implemented to specifications and that the correct materials and workmanship were applied. Financial and technical aspects of the project is considered crucial in order to deem the project fit for purpose. In terms of financial aspects, the project has cost the municipality R38, 042, 784.15.

Free from defects

The contractor was responsible for the quality of work while ad-hock inspection was conducted by the consulting engineers. All work undertaken on consumer properties were approved by consumers through signing off consolidation approval documents. Six months after project completion, a courtesy visit was made to confirm that new meters are operational and that the consumer account is correct. The shutdown process was repeated and the strainer was inspected and cleaned during the courtesy visit.

Value for money and profitability

The average metered consumption at each property was calculated prior to the commencement of the project and after project intervention. The calculations were done on all properties. Table 4.4 depicts the summary of project payback for 469 properties completed.

Monthly increase in water sales (469 properties)	R581 889.23
Monthly increase in sanitation charges (469 properties)	R194 487.56
Monthly increase in water and sanitation sales (469 properties)	**R776 376.79**
Consulting Engineers cost for 469 properties	R12 000 980.00
Contract cost (for 469 properties)	R7 109 434.94
Material cost (for 469 properties)	R3 503 760.29
Total cost for 469 properties	R22 614 175.23
Project payback in months	29 months

Table 4.4: Wadeville Project payback period

Absence of any legal claims and proceedings

There were no penalties which were imposed on the contractor. Also, there were no claims lodged by the contractor.

Learning and exploitation

Since Ekurhuleni Metropolitan Municipality has over 25 000 industries, the learning which was accumulated in executing the 469 bulk metering project, will be applied when implementing similar projects.

General positive reputation

There is a good relationship between the Contractor, Consulting Engineers and Ekurhuleni Metropolitan Municipality as the contractor has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor in full.

Overall assessment based on the ten effectiveness criteria for top 500 consumers and Wadeville project

The analysis based on the ten effectiveness criteria indicates that the top 500 consumer and Wadeville projects was effective. The projects however were not completed on time, this is mainly due to the fact that in the planning phase the client and consultant were not sure of the intensity of the problem. Prioritizing bulk consumers meant that the Metro would save more water in terms of commercial losses. The project was efficient as the project cost and scope was adhered to although

there were some delays on time. Other measures of the effectiveness criteria were also met. The project can thus be considered effective.

4.2.3 Analyzing the effectiveness of metering informal settlements project.

Ekurhuleni Metropolitan Municipality has 119 informal settlements. Previously, all of the informal settlements were not metered. Lack of metering the Metro's informal settlement resulted in the Metro's water been unaccounted for, increasing the Non-Revenue Water figure. In 2013/14 financial year the Metro has managed to meter 86 informal settlements, 23 informal settlements were metered in 2014/15 financial year. The remaining 10 informal settlements are receiving water through mobile tankers within EMM and therefore do not need metering. Consultants E and D were used for design and implementation whilst Contractor D was also used to carry out the project.

Client and user satisfaction

The project has been carried out successfully as all the informal settlements have been metered enabling the Metro to account for all the water consumption. The municipality which is the client and user of the bulk water meter were satisfied with work of the contractors.

Level of effectiveness (achievement of outcomes)

The project aim was to provide water meters to existing connections and replacement of non-functional existing water meters for bulk and domestic consumers at informal settlements in Ekurhuleni Metropolitan Municipality. The objectives of the project at corporate level was to ensure that all informal settlements are metered in order to account for water. At project level, the objectives were to install bulk meters to all the municipal informal settlement and these was also met. This has been done from the year 2012 to 2015.

Project functionality and fitness for purpose.

All 119 informal settlements are now verified and metered. This was done by:

- Identifying all informal settlements
- Conducting desktop analysis of metered connections
- Onsite investigation and drop test
- Creation of accounts
- Installing and replacing meters and uploading of information to Venus

Courtesy visit was done after six months to ensure that the bulk meter is operational. During the courtesy visit, the strainer was also washed.

Free from defects
The contractor was responsible for the quality of work while ad-hock inspection was conducted by the consulting engineers.

Learning and exploitation
Should it happen that other informal settlements be formed, the municipality has experience in metering informal settlements? This means that the municipality will not suffer as results of Non-Revenue Water as metering will be immediately done.

Value for money and profitability
The majority of the metering of informal settlement were done during 2013/14 financial year as a sub-project under the refurbishment, replacement and installation of meters as it was mainly replacement and installation of meters. The overall costs for the last phase was R722 000. There are costs which needs to be recovered as water consumptions in the informal settlements are treated as free basic water supply. Free basic water supply is treated as revenue water according to the International Water Association water balance.

Absence of any legal claims and proceedings
There were no penalties which were imposed on the contractor. Also, there were no claims lodged by the contractor.

General positive reputation
There is a good relationship between the contractors, consultants and Ekurhuleni Metropolitan Municipality as the contractor has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor and consultants in full.

Overall assessment based on the ten effectiveness criteria for informal settlement project
The assessment based on the ten effectiveness criterions indicates that metering of informal settlements projects was effective.

4.2.4 Analyzing the effectiveness of metering Council properties project.
The project entails the auditing and metering of all unmetered Council properties. The intent of this project was to consolidate multiple water connections to a single above ground water connection per property and also to reduce non-revenue by improving meter management and ensuring accurate billing. Properties classified herein include:

- Council buildings
- Parks and recreational facilities
- Cemeteries
- Taxi ranks
- Clinics

- Churches

A total number of 2427 properties were audited as received from finance department. All properties ring-fenced in all EMM areas were listed for possible water supply consolidations into a single supply.

The following were encompassed:

- Identification of all active meters per consumer on the Venus system.
- Physical inspection on the stand to locate all meters, those that are showing as active as well as other connections found, whether metered or not.
- Conducting a "drop test" to ensure all feeds into a specific stand has been located.
- The purpose was to combine all feeds found as far as possible into a single feed with one above ground combination meter installation (the current adopted standard).

Of the 2427 audited properties in the area, a total of 255 were concluded with single meters installed and 1065 were open stands where there is no need for water connections and 1107 properties were outstanding. Consultants F was used for design and implementation whilst contractor E, F and G were also used to carry out the project.

Client and user satisfaction

The project was carried out successfully as most of the Council properties were metered enabling the Metro to account for all the water consumption. The municipality which is the client and user of the bulk water metering are satisfied with work of the contractors thus far.

Level of effectiveness

The project's objectives were to meter all properties of the Metro. Further and above that, the objectives were to:

- Meter all domestic and fire properties
- Ensure that meters are accessible (i.e. install meters above ground and parallel to the property boundary)
- Ensure that water meters are appropriately sized for accurate measurements
- Ensure that water meters are in good working conditions, visible for reading
- Water meter database correctly records meter installation details
- Water meters are to be suitable for automatic meter reading (AMR)

Project functionality and fitness for purpose.

All the metered stands can now be accounted for by the Metro in terms of water consumption.

Free from defects

The contractor was responsible for the quality of work while ad-hock inspection was conducted by the consulting engineers.

Value for money and profitability
The overall project cost has amounted to R5, 059,625.49. The Metro is now able to account for the water in the metered Council properties.

Absence of any legal claims and proceedings
There were no penalties which were imposed on the contractor. Also, there were no claims lodged by the contractor.

General positive reputation
There is a good relationship between contractors, consultants and Ekurhuleni Metropolitan Municipality as the contractor has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor and consultants in full.

Overall assessment based on the ten effectiveness criteria for Council properties project
The assessment based on the ten effectiveness criteria indicates that metering of Council properties projects was effective. However, the project is still ongoing as not all Council properties have yet been metered.

4.2.5 Analyzing the effectiveness of metering schools properties project.

The metering of schools enabled EMM to adequately bill the relevant department and to also assist schools with water conservation measures. This project realised the benefits of reduced Non-Revenue Water as most technical losses are within school properties. All consumption prior to and after metering were recorded so as to determine the impact that the project had in terms of the return on investment, Non-Revenue Water and water losses encountered over the years.

Project status quo

A total number of 550 schools were identified in the Metro. All schools ring-fenced in all EMM areas were listed for possible water supply consolidations into a single supply.

The following were encompassed:

- Identification of all active meters per consumer on the Venus system.
- Physical inspection on the stand to locate all meters, those that are showing as active as well as other connections found, whether metered or not.
- Conducting a "drop test" to ensure all feeds into a specific stand has been located.

The purpose was to combine all feeds found as far as possible into a single feed with one above ground combination meter installation (the current adopted standard). Of the 550 identified schools, a total of 382 were concluded with single meters installed and 168 is outstanding and it is planned to be metered during the 2015/2016 financial year. Consultants F was used for design and implementation whilst contractor E, F and G were also used to carry out the project.

Client and user satisfaction

The project has been carried out successfully as most of the schools have been metered enabling the Metro to account for all the water consumption. The municipality which is the client and user of the bulk water meter are satisfied with work of the contractors thus far. The municipality is anticipating to conclude on metering all the 55 schools by the end of June 2016.

Level of effectiveness

The overall project objectives were to meter all schools of the Metro. Further and above that, the objectives were to install and repair bulk meters and related work to consolidate water connections to school on an as and when required basis from the date of award until June 2015.

Project functionality and fitness for purpose.

All quality work was done under the supervision of the consulting engineers and a quality assessment was done as per the contract. This means that the technical specifications were met, however financial budgeting were exceeded by R2, 735,105.59.

Free from defects

The contractor was responsible for the quality of work while ad-hock inspection was conducted by the consulting engineers.

Value for money and profitability

All the metered stands can now be accounted for by the Metro in terms of water consumption. The metered schools are now being billed, thus water consumption is accounted for.

Absence of any legal claims and proceedings

There were no penalties which were imposed on the contractor. Also, there were no claims lodged by the contractor.

Learning and exploitation

The project had encountered challenges during the implementation period. There were delays in expenditure from Central Procurement Office (CPO) in terms of acquiring orders as well as service providers at the beginning of the financial year. The contract was awarded on an as and when basis until the end of June 2015. Project was halted in January 2015 as a results of the enforcement of the “capping” principle. The capping principle does not allow projects to spend over the cost of the project. This has thus forced the municipality to request the accounting officer to ratify the contract in terms of the supply chain management policy. The Metro has learned from this experience that when implementing as and when contracts, the CPO procure orders and service providers on time to avoid over expenditures.

General positive reputation

There is a good relationship between contractors, consultants and Ekurhuleni Metropolitan Municipality as the contractor has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor and consultants in full.

Overall assessment based on the ten effectiveness criterions for school's properties project

The assessment based on the ten effectiveness criterions indicates that metering of Schools properties projects was effective. However, there was an over expenditure on the budget and the project is still ongoing as not all Schools properties have been metered yet.

4.2.6 Analyzing the effectiveness of domestic and bulk metering projects.

Ekurhuleni Metropolitan Municipality has a number of metering programmes. The metering programmes which the Metro has are as follows:

- Metering of unmetered properties
- Replacement and maintenance of meters
- Metering of informal settlements
- Bulk metering of commercial properties: consolidation of connections
- Metering of Council properties
- Metering schools
- Metering of properties within proclaimed township

Metering of unmetered properties

The metering project of unmetered properties is an on-going project which the Metro implements on a financial year to financial year basis depending on the availability of funds. Ekurhuleni Metropolitan Municipality (EMM) conducted a desktop study in 2011 and found that the Metro had 92 023 unmetered stands (EMM, 2015). In 2013/14 financial year, the Metro planned to install 24 000 meters and the actual target was 22 092. In 2014/15 financial year, the Metro's planned target was 15 000 and the actual target was 16 672. The target for 2015/16 financial year was 10 000, the actual target was 1988. The revised target going forward if the metering of 10 000 stands was achieved in 2015/16 financial year would have been 43 259. The target will be revised given the fact that the target for 2015/16 financial year was not met.

Metering of properties within un-proclaimed townships

Although some areas may have been zoned as residential, records show that they have not been legally proclaimed. This means that there are no individual registered stands both on the EMM as well as the Deeds office database. In these circumstances, a user account cannot be created as registered property details are not available yet for account purposes. The Venus finance system always requires that such details be available to ensure the creation of a user account. In such instances, where no official proclamation is registered; a bulk meter is installed for the purposes

of being able to measure what is supplied into the township and record such into the water balance for accounting purposes.

Suppliers estimate that mechanical components of domestic water meters have a service life of approximately 7-10 years for domestic meters and 5-7 years for bulk meters (EMM, 2015). Based on the analysis which Ekurhuleni Metro conducted in 2013, It is estimated that 180 000 domestic meters are older than 15 years. Meters which are old have a tendency of under reading consumption which affect the Metro's revenue and the NRW figure. The project of replacement and maintenance of meters is thus implemented subject to budget. Meters which are prioritized are meters which are older than 20 years which are estimated to be 80 000. In 2013/14 financial year the Metro has managed to install 5 054 whilst in 2014/15 financial year 31 957 meters were installed and the anticipated target for 2015/16 financial year is 50 000. If the Department of Water and Sanitation manages to achieve the planned target of 50 000 by the end of the 2015/16 financial year, the revised target for replacement and maintenance of meters will be 92,989.

There are different contractors and consultants which were used for different regions and financial years. Table 4.5 depicts the summary of projects which were conducted for domestic and bulk metering from 2012/13 financial year to 2014/15 financial year.

Project name	**Project Methodology**	**Consultants and Contractors**	**Project Achievement**	**Project cost**	**Payback Period**
1. Replacement of water meters North East (NE) Region in 2012/13 financial year (FY)	EMIS (i.e. call center system which is used to log complaints) complaints as well as analysis and inspections which require replacement.	Consultants D-Water and Energy Meter Management Consultants (WEMMC) and Contractor B	6808 domestic meters replaced and 174 bulk meter replaced	Budget for 2012/13 FY is R20,000,000 R 6,499,519- Contractor and R3, 647,354- Material Supply. **Total Expenditure: R10,146,872** Consultants fee: R158, 226, 476 (3-year contract from 7 December 2011 to 30 June 2014)	53.2 months for 20kl monthly consumption at 10%

2. Replacement of water meters South West (SW) Region in 2012/13 FY	EMIS complaints as well as analysis and inspections which require replacement. New application for domestic meter (15mm) and bulk meter (>=25mm).	Contractor D (for domestic meters) and Contractor A (for bulk meters) and Consulting Engineers E (WEMMC)	6124 domestic and bulk meters replaced. 1410 new connections for domestic and bulk meters	R 3,721,892- Contractor and R1, 857,209- Material Supply. **Total Expenditure: R5,579,101** Consultants fee: R170, 297, 780 (3-year contract)	53.2 months for 20kl monthly consumption at 10%
3. Replacement of water meters NE Region in 2013/14 FY	EMIS complaints as well as analysis and inspections which require replacement. New application for domestic meter (15mm) and bulk meter (>=25mm). Metering of unmetered stands	Consultants D-Water and Energy Meter Management Consultants (WEMMC) and Contractor B	20 449 domestic water meters were either replaced or new connections installed or unmetered areas attended at various stands	Budget for 2013/14 FY is R52,918,790 R 12,179,851.63- Contractor and R12, 794,037.91- Material Supply. **Total Expenditure: R24,973,889.54** Consultants fee: R158, 226, 476 (3-year contract)	3.5 to 6 months for consumers using 20kl-30kl monthly consumption
4. Replacement of water meters SW Region in 2013/14 FY	EMIS complaints as well as analysis and inspections	Contractor D (for domestic meters) and Contractor A (for bulk meters) and	12 368 domestic meters replaced 385 bulk meters replaced 1441 new domestic water	R 26,014,312- Domestic meter contractor; R2, 931,835- Bulk meter contractor and	3.5 to 6 months for consumers using 20kl-30kl

	which require replacement. New application for domestic meter (15mm) and bulk meter (>=25mm). Metering of unmetered stands	Consulting Engineers E (WEMMC)	connections were made 210 new bulk meter connections 4521 aged meters older than 25 years were replaced 10439 unmetered stands were metered Total installed/replaced meters are 29 364	R24, 917,931 Material Supply. **Total Expenditure: R53,864,078** Consultants fee: R170, 297, 780 (3-year contract) **Over-expenditure: R25,919,173.54**	monthly consumption
5. Refurbishment, new connections & replacement of bulk and domestic water meters for NE Region in 2014/15 FY	Replacement of meter: EMIS complaints as well as analysis and inspections which require replacement. New application for domestic meter (15mm) and bulk meter (>=25mm).	Consultants D, (Pty) Ltd-Water and Energy Meter Management Consultants (WEMMC) Contractor B	New connections: Domestic-1183 and Bulk-53 Replacements: Domestic-13 551 and bulk-85 Total meters installed/replaced-14787	Available budget is R14,103,187.55 R 5,001,909-Contractor and R7, 613,319-Material Supply. **Total Expenditure: R12,615,228** Consultants fee: R158, 226, 476 (3-year contract)	10.4 to 18.3 months for consumers using 20kl-30kl monthly consumption
6. Refurbishment, new connections & replacement of bulk and domestic water meters for SW	Replacement of meter: EMIS complaints as well as analysis and inspections	Contractor D (for domestic meters) and Contractor A (for bulk meters) and Consulting	11 297 domestic meters replaced 110 bulk meters replaced 749 new domestic water connections were made	Available budget is R26,459,395 R 6,446,162-Domestic meter contractor; R3, 577,575-Bulk meter	10.4 to 18.3 months for consumers using 20kl-30kl monthly consumption

	Region in 2014/15 FY	which require replacement. New application for domestic meter (15mm) and bulk meter (>=25mm).	Engineers E (WEMMC)	18 new bulk meter connections Total installed/replaced meters are 12144	contractor and R8, 988,996 Material Supply. **Total Expenditure: R19,012,733** Consultants fee: R170, 297, 780 (3-year contract)	
7.	Installation of water meters on unmetered stands for NE Region in 2014/15 FY	Metering of unmetered stands	Consultants D-Water and Energy Meter Management Consultants (WEMMC) and Contractor B	2619 domestic meters installed at unmetered stands	Available budget is R3,594,659 R1,100,182.31- Contractor and R2, 094,660- Material Supply. **Total Expenditure: R3,194,842.31** Consultants fee: R158, 226, 476 (3-year contract)	1.9 to 3.2 months for consumers using 20kl-30kl monthly consumption
8.	Installation of water meters on unmetered stands for SW Region in 2014/15 FY	Metering of unmetered stands	Contractor D (for domestic meters) and Consulting Engineers E (WEMMC)	2857 domestic meters installed at unmetered stands	Available budget is R6,000,000 R3,249,154- Contractor and R2, 421,900- Material Supply. **Total Expenditure: R5,671,054**	3.5 to 6 months for consumers using 20kl-30kl monthly consumption
9.	Replacement of aged domestic water meters for NE Region in 2014/15 FY	Replacing aged domestic water meters	Consultants D-Water and Energy Meter Management Consultants (WEMMC) and Contractor B	3619 aged domestic meters were replaced in various regions	Available budget is R10,176,851.56 R1,984,931.83- Contractor and R4, 117,635- Material Supply. **Total**	16.1 to 28.4 months for consumers using 20kl-30kl monthly consumption

				Expenditure: R6,102,566.83	
10. Replacement of aged domestic water meters for SW Region in 2014/15 FY	Replacing aged domestic water meters	Contractor D (for domestic meters) and Consulting Engineers E (WEMMC)	5324 aged domestic meters were replaced in various regions	Available budget is R9,649,999 R3,986,870- Contractor and R2, 959,750- Material Supply. **Total Expenditure: R6,946,620**	16.1 to 28.4 months for consumers using 20kl-30kl monthly consumption
Total			**91375 meters installed and replaced**	**R148,106,987.70**	

Table 4.5: Summary of domestic and bulk metering projects

Client and user satisfaction

Consulting Engineers D and E were appointed to do design for domestic and bulk meter installation and replacement. The Consultants were also responsible for supervision and quality assessment on each meter installation. Contractor B and F were also appointed to do meter replacement and installation. In total, the contractors have installed/replaced 91375 meters in the areas of Brakpan, Kempton Park, Kwa-Thema, Tembisa, Nigel, Duduza, and Springs (North East Region) as well as Alberton, Boksburg, Edenvale, Germiston, Katlehong, Thokoza and Vosloorus (South West Region). There were no subcontractors which were used to implement the projects.

The project has been carried out successfully as meters which were installed or replaced have been uploaded in Venus system (i.e. system used to bill consumers). The metering projects have thus enabled the Metro to account for all the water consumption in the metered areas. The municipality which is the client and the user of the bulk water meters were satisfied with the work of the contractors and consultants.

Level of effectiveness

The project objectives were to meter areas of the Metro whilst the corporate objectives were to reduce Non-Revenue Water. These objectives have been met as meters have been installed in various areas resulting in a decrease in Non-Revenue Water.

Project functionality and fitness for purpose.

All quality work was done under the supervision of the consulting engineers and a quality assessment was done as per the contract. The Consultants quality assured 100% of installation on receipt of completed job card from the contractor. Thereafter, the Consultants will then upload the

new meter information to workflow. Ekurhuleni Metropolitan Municipality Finance Department verify installation into the Venus billing system after which the meter was read and consumption billed by Finance Department.

The Department of Water and Sanitation Revenue Division Area Engineer will then generate a random 10% sample and inspect all aspects of compliance. This means that the technical specifications were met as the randomly selected samples had to defects. However, financial budgeting was exceeded by R R25, 919,173.54 in 2013/14 financial year.

Free from defects

The Consulting Engineers were responsible for the quality of work and supervision of all meter installations and replacement. The Department of Water and Sanitation Revenue Division Area Engineer will then generate a random 10% sample and inspect all aspects of compliance. There were are no reported defects in the project reports, however Contractor D were imposed penalties amounting to R214 990 due to quality of work and late completion of work.

Value for money and profitability

The Metro has embarked on the robust metering project over the years. All the metered stands can now be accounted for by the Metro in terms of water consumption. The metered areas are now being billed, thus water consumption is accounted for.

Absence of any legal claims and proceedings

There were no penalties which were imposed on the client. There were however penalties which were imposed to the contractor in 2013/14 financial year. Penalties were imposed to Contractor D amounting to R214 990 due to quality of work and late completion of work. Over and above that, there were R51 200 of penalties which were levied to Consultants D for an administrator error. However, there were no claims lodged by the contractor or consultants to the clients and vice versa.

Learning and exploitation

The project had encountered challenges during the implementation period. The following were the challenges which were encountered:

- Newly developed townships/subdivision were not always uploaded into the engineering system such as IMQS
- Meters were previously removed/replaced without updating the financial system of the municipality
- Access to a number of properties was a challenge due to locked gates
- Incorrect information supplied by the water meter reading contractor
- Water supply shut offs to replace bulk water meters created delays to the contractor

- The contract for the meter contractor and supplier of the water consumption meters were terminated in September 2012 and no work was possible until January 2013 when appointment of a new contractor was made.

Financial challenges

- Late payments from EMM to contractors
- Payment of invoices sometimes got lost in the administration which impacts the smaller contractors.
- Payments not done within 30 days as per contractual agreement
- Late payments affected contractors to secure material for the project and also pay wages to employees on time.

General positive reputation

There is a good relationship between contractors, consultants and Ekurhuleni Metropolitan Municipality as the contractor has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor and consultants in full. Even

Overall assessment based on the ten effectiveness criteria for metering project

The assessment based on the ten effectiveness criteria indicates that metering of projects was partially effective. The partial effectiveness is as a results of the claim lodged to Contractor D and the over expenditure of R25 million. The project is still ongoing as not all properties have been metered yet.

4.2.7 Pipeline and Valve assessment and replacement

Analyzing the effectiveness of upgrading and construction of water network on an as and when required basis from date of award until June 2016: Bulk water supply to Zincor Mine in Selcourt Springs

Ekurhuleni Metropolitan Municipality's objective was to supply and isolate the Zincor Mine from the bulk line through a 355mm diameter pipeline. Initially the system was designed in such a way that the Mine, Struisbult informal settlement and Struisbult extension 01 are all fed from one bulk line. The objective of the project was also to reduce water losses as the existing infrastructure (Ø300mm steel pipe) had reached its life cycle period. The project also aimed at increasing the capacity of the mine as the mine was bought by new shareholders who are aiming at resuscitating operations of the Mine. The new line now run from North side of Selcourt and connect into an existing Manhole inside the Mine.

Site camp was located along Springs Struisbult, Plover Street, Stand No: 542. Consultants B was used for design, management and implementation whilst contractor H, I and J were also used to carry out the project. Contractor I was appointed to conduct and compile an Environmental

Management Plan for Ekurhuleni Metropolitan Municipality (EMM). Whilst Contractor J was appointed to conduct geotechnical investigations at the site. Contractor K was used as the testing laboratory consultants.

Client and user satisfaction

The project has been carried out successfully as the pipeline has been replaced with 355mm HDPE class 12 pipes connected to a 400mm supply line and ending at Zincor mine with a 200mm Isolating valve as per the design. Setting out of the line was done by a professional land surveyor, with 2m the road reserve from the existing tarred road along Plover Street crossing Eend and Kwartel streets. The municipality which is the client and owner of the pipelines was satisfied with the work of the contractors thus far.

Level of effectiveness

A total of 1 665m of HDPE 355mm including five air-valve chambers as well as a scour chamber, supply chamber and connection chamber were laid and constructed. Thus the overall project objectives were met as the pipeline has been successfully laid and it operates well.

Project functionality and fitness for purpose.

Quality was fully complied to; compaction test was done from bedding to main fills as well as pressure testing. Contractor K was used as the testing laboratory consultants. This means that the technical specifications were met. The contract amounted to R14, 012,544, there was an over-expenditure of R314, 790 due to the project being completed two months after the anticipated time-frame.

Free from defects

The contractor was responsible for the quality of work while ad-hock inspection was conducted by the consulting engineers. The project was thus free from defects as everything was done as per the agreed specifications.

Value for money and profitability

The project has prevented possible leaks and pipe burst as the pipeline had reached its life cycle. The capacity of the mine was also increased.

Absence of any legal claims and proceedings

There was a claim for extension of time due to the following:

- Manufacturing of changed special fittings delays,
- Additional by-pass line to Zincor mine, (Existing AC Pipe),
- EMM delays on securing a shutdown date as clients could not accept cutting of water on some days.
- Delays on way-leaves approvals.

The required extension of time was granted thus moving our completion date forward from 22 November 2014 to 30th January 2015. The extension was with cost on P&G's (i.e. Preliminary and general budget for the Metro) at R314, 790.00

Learning and exploitation

Construction started off slow but was accelerated after issues of some way-leaves were sorted. The specials and fittings were ordered well in advance but due to scarcity from the industry manufacturing only started in October with a time frame of 6 to 10 weeks' delivery on site. In addition to the late delivery of specials and fittings to site, the supplier did not adhere to the delivery dates therefore causing delays with testing. Additional works were done whilst awaiting delivery.

Overall the construction of the new Bulk Water Supply line to Zincor Mine was done and completed without any major damage to existing services and within the approved budget. The overall performance of the contractor H was good. Their quality of work was on standard and complied to detailed design specifications and of satisfaction with EMM standards. EMM Project Manager, was at times challenged as he had to monitor the project in an absence of Consultant' and the project had some design' shortcomings.

General positive reputation

There is a good relationship between contractors, consultants and Ekurhuleni Metropolitan Municipality as the contractor has delivered a good quality work as per the contractual agreement. The client (EMM) has also paid the contractor and consultants in full.

Overall assessment based on the ten effectiveness criteria for replacement of pipe in Zincor mine project

The assessment based on the ten effectiveness criteria indicate that the projects was effective. Even though the project time was extended with a cost, the project end results were satisfactory.

4.2.8 Analyzing the effectiveness of midblock water replacement projects

The "Midblock Water Pipe Replacement" project is a large scale infrastructure upgrade project implemented by the Ekurhuleni Metropolitan Municipality (EMM) in an attempt to reduce Non-Revenue Water (NRW). The NRW was reduced by minimizing the water losses which results due to pipe bursts inside properties. The NRW was also reduced by billing all consumers as the Metro was unable to bill accurately as water meters were located inside the properties. Thus, the Midblock Water Pipe Replacement project was implemented in Vosloorus, Thokoza, Daveyton, Phomolong and Kwa-Thema. The frequency of pipe breakage in these areas was on the increase due to the age of the pipes. The project also envisaged to simplify the maintenance of the network.

The contract period for the "Midblock Water Pipe Replacement" project in this areas was from July 2013 till the end of June 2015. The "Midblock Water Pipe Replacement" project, eliminated approximately 6965 properties from midblock water pipes. The project also envisaged to install new 'road reserve' water meters. A total of 6965 water meters were replaced and moved to the road

reserve in the various areas. Different contractors were appointed to do the pipe replacements and meter replacements/installations. Properties which were eliminated from midblock pipe replacement project are as follows:

Area	**No of properties done**	**Properties with midblock water supply**	**Contractor**	**Consultant**	**Project Value**	**Cost per stand**
Phomolong (Tembisa)	1460	11400	Contractor L	Consultants B and Consultants G (Consultants G appointed from October 2014 till June 2015)	R8, 400, 000	R13,120
Tembisa 1	Unknown	30 000	Contractor L	Consultants B and Consultants G (Consultants G appointed from October 2014 till June 2015)	R8,100,000	Unknown
Kwa-Thema	889	2000	Contractor L	Consultants B and Consultants G (Consultants G appointed from October 2014 till June 2015)	R11,050, 000	R12,500
Vosloorus	1645		Contractor N	Consultants B and Consultants G (Consultants G appointed from October 2014 till June 2015)	R24,052,946	R14,605.44
Thokoza	1511		Contractor N	Consultants B and Consultants G (Consultants G appointed from October 2014 till June 2015)	R18,745,958	R12,406

Daveyton	1460	4000	Contractor O	Consultants B and Consultants G (Consultants G appointed from October 2014 till June 2015)	R24, 600, 000	R16,800
Total	6965				R94,948,904	

Table 4.6: Midblock project summary in different areas

As depicted in table 4.6, Consultants B and G were the consultant appointed for overseeing the projects in all areas. Contractors appointed local SMMEs to do reinstatement of walkways and road crossings. In line with the EPWP Principles, the Contractor, with the help of the Ward Councillors appointed 315 people (27 Phomolong, 41 Kwa-Thema, 147 Vosloorus, 73 Thokoza, and 27 Daveyton), Community Liaison Officers (CLOs) and other labourers all of whom reside in the project areas. The CLOs were responsible for communicating project matters to the community and relaying any issues that the community had to the project managers. The Community Facilitators were responsible for getting the residents to sign "Happy Letters" after all work on the property was concluded and the property was declared leak free.

The network completed comprised of installation of pipes ranging from 20 mmØ to 400 mmØ. The Contractor was responsible for health and safety on site. Weekly Toolbox Talks were held during which a range of issues were discussed such as hazardous substances that can be encountered on site, electrical safety, etc., as well as safety meetings were held every fortnight. The project employed over 315 people, divided amongst the SMMEs, CLOs and labourers. Public awareness of the project was the responsibility of the CLOs who were assisted by the Community Facilitators. Communication media such as leaflets, pamphlets, etc. were distributed to the community and meetings were held with the Ward Councillors to ensure that the community was aware of the project and to assist with any questions that the community had regarding the project.

Project Objectives

The objective of the project was to relocate midblock water lines to the road reserve. This assisted in accessing the water infrastructure for planned and emergency maintenance and to access the water meters for billing. The access to the meters improved the accuracy of billing and enhanced revenue. Midblock project was one of the programmes / interventions aimed at reducing water losses. Mid-block mains remain a problem, and are one of the biggest contributors towards water losses. Accessibility to repair leaks will be improved, metering efficiency improved and illegal connections reduced.

At the end of June 2016, Ekurhuleni Metropolitan Municipality Non-Revenue Water (NRW) percentage was 34.6. In terms of the International Water Association (IWA) best practice

guidelines, a Metro (large city) should aspire towards a NRW figure of 20%. EMM's Non-Revenue Water figure currently sits at 34.6% (June 2016) requiring a 14.6% reduction to fall into the good category band in terms of the IWA best practice template. To achieve this target requires a multi-disciplinary approach to include all facets of Municipal Departments such as Revenue, Finance, Operations, Planning, and Communications is important. Political impetus is also important in order to achieve the desired outcome.

In line with Water Demand Management principles, EMM has decided that all midblock water pipes must be replaced with water pipes in the streets. A major concern is also that the majority of these pipes are Asbestos Cement (AC) pipes. Cement pipe containing asbestos was first used in the United States and Canada in 1931, primarily in western states (Mesothelioma Cancer Alliance, 2016). This kind of concrete pipe was made from a mixture of Portland cement and asbestos fiber; the addition of asbestos made the pipes very durable and resistant to corrosion. By 1953, the American Water Works Association had put standards into place governing the use of asbestos cement pipe in municipal water systems throughout the country.

The expected service life of these asbestos cement pipes was originally expected to be approximately seventy years (Mesothelioma Cancer Alliance, 2016). The main risk from asbestos cement pipes comes from the possibility of ingesting water contaminated with loose fibers. Individuals who lived in areas where AC pipes were used in the water system may be at enhanced risk of developing peritoneal mesothelioma from the ingestion of asbestos material. Peritoneal mesothelioma is known only to be caused by exposure to asbestos, a microscopic natural fiber that was used heavily in industry (Mesothelioma Cancer Alliance, 2016). Asbestos is said to reach the abdominal wall by one of the two methods. The first is through ingested asbestos fibers which are processed through digestion and become lodged in the peritoneum. The other method is through the lungs and lymph nodes by inhaled asbestos fibers (Mesothelioma Cancer Alliance, 2016). It is thus one of the reasons which the Metro want to replace AC pipes due to the associated health hazards.

Client and user satisfaction

Consultants B and G were appointed to do design of the midblock pipe replacements. Contractors were also appointed to do pipe replacement and meter replacement/installation. In total, the contractors have worked on 6965 properties in the areas of Thokoza, Daveyton, Kwa-Thema, Vosloorus and Daveyton. The contractors appointed quality control officers who were responsible for checking the quality of work done and sign off completed work in households. Community Liaison Officers were responsible for ensuring that household owners sign off happy letter. The happy letter meant that the owner of the household is happy with the work done and that the house is leak free and there are no visible defects.

Local labourers were also appointed to do plumbing, pipe replacement, meter installation and replacement. Based on client and user satisfaction, Ekurhuleni Metropolitan Municipality (client) is not satisfied with the work done by the consultants and the contractor. The reason been that the consultants who are responsible for the site monitoring did not do a good job since they have allowed contractors to proceed with the installation of pipes without pipe-jacking of road crossings. This has thus resulted in misaligned pipe joints. Numerous leaking joints were the result of this practice. Because of this practice, the new lines in Daveyton and Tembisa/Phomolong which are supposed to replace the midblock pipeline are not operational.

This has thus defeated the purpose of reducing water losses and replacing the health hazardous Asbestos Cement pipes. Also some users (households) are not satisfied with the work done in their households as not all happy letters were signed off by household owners. The reason for the user dissatisfaction was that some users did not want their meters to be removed from their properties as they have connected illegally. Some users did not sign the happy letters in Vosloorus because the Community Liaison Officer resigned whilst the project was still running. A new Community Liaison Officer could then be not appointed as the project was closer to completion. This has resulted in some household owners not signing their happy letters as they are used to communicating with the Community Liaison Officer not an official from the municipality. Also, in areas like Daveyton and Phomolong/Tembisa, happy letters are not signed as the new pipeline and meters are not operational.

Level of effectiveness

The "Midblock Water Pipe Replacement" Project Objectives were as follows:

- **To drastically reduce the high levels of Water Losses in EMM by means of a large scale pipe replacement in in Ekurhuleni.**

The water losses have not been drastically reduced as the contractors installed pipes without the pipe-jacking of road crossings in some areas (i.e. Daveyton and Phomolong). This has thus resulted in misaligned pipe joints. Numerous leaking joints were the result of this practice. Because of this practice, the new lines in Daveyton and Tembisa/Phomolong which is supposed to replace the midblock pipeline is not operational. This means that household which did not have meters are still being billed on a flat rate. Also, water pipe leaking due to the aged pipelines is also still occurring.

- **To implement the Project utilizing best practice Water Demand Management (WDM) and Water Conservation (WC) principles.**

The manner into which the project was implemented in Daveyton and Phomolong is not in line with water demand management and conservation principles. The methodology which was employed as elaborated above, did not take into consideration the principles of WDM and WC during project planning and implementation.

- **Creating much needed job opportunities utilising labour-intensive construction methods in line with EPWP principles. (There are currently only a few types of these projects in EMM compared to other Metropolitan Municipalities hence this project can help in this regard.)**

This objective was achieved as the project has managed to employ over 315 people, divided amongst the SMMEs, QCOs, CLOs, Community Facilitators and the staff required on site. Most people worked on the project between 9 – 12 months and the people employed on the project ranged from 18 years old to 72 years old. Even though, the contractor and the consultant did not deliver good services, the project has however employed and paid its labourers.

- **Maximise the utilization of Local SMMEs, Plumbers and other Labour, CLOs and Community Facilitators, who are temporarily employed in terms of the scope of work. (The project incorporates the "Management Contractor Contracting Model" in which the Main Contractor only brings some key staff to Site.)**

This objective was also achieved as indicated above that the project has managed to employ over 315 people, divided amongst the 11 SMMEs, QCOs, CLOs, Community Facilitators and the staff required on site.

- **Empowerment of the Community by providing Technical Training, Skills Development, Mentoring and Coaching.**

Labourers were provided a training on plumbing. The training for the plumbers was two-fold; the one being the theory aspect and the other being the practical aspect

- **Public Education and Awareness Raising Campaign.**

Public education and awareness campaign were done in the project areas. The targeted stakeholders for the education and awareness campaign were:

  - Ward Councillors
  - Customer Care Area Managers
  - Communities
  - Affected Households
  - Relevant Officials in the Water & Sanitation Department

- **Enhanced Service Delivery in the targeted project area.**

Service delivery has been enhanced in Thokoza, Kwa-Thema and Vosloorus but not in Daveyton and Phomolong/Tembisa. In the areas of Thokoza, Kwa-Thema and Vosloorus water service is supplied efficiently without experiencing the high levels of water losses and NRW whilst in Daveyton and Phomolong/Tembisa areas high level of water losses and NRW are still experienced. Both the corporate and project objectives have been partially met as the project did not manage to reduce water losses and NRW to all the areas.

Project functionality and fitness for purpose.

- **Network Piping**

In terms of network piping, the contractor installed the new network according to the approved construction drawings, designed by Consultant B. The construction staff were provided with plans for the replacement of the water mains. It was indicated that a disorganized construction management policy was followed. The contractor installed pipes without pipe-jacking of road crossings. This resulted in misaligned pipe joints. Numerous leaking joints were the result of this practice. Because of this practice, the new lines in Kwa-Thema and Tembisa/Phomolong which are supposed to replace the midblock pipelines are not operational. This has thus defeated the purpose of reducing water losses and replacing the health hazardous asbestos cement pipes as the project is not fully functional. The project was an as and when required, meaning that the contractors would implement the project as and when the finances becomes available. This thus makes it difficult to price the whole project as contractors are only required to price the project whenever funding is available.

All the pipes were pressure tested to the required pressure and approved. However, Consultants B did not come up with a decommissioning design which posed a problem as the contractors did not know where to decommission and also to check whether households are not affected negatively.

- **Meter Installations**

The meters installed on residential properties were the 15mm Sensus meters. The meter box had a closable opening on the top where the meter serial number and meter reading can be seen. The meter box was approximately 0.6m in length and has a lining midway of the length. This lining indicates the level at which the meter must be buried. Therefore, a good installation is where the meter is buried to that level. Some properties were found to already have meters installed.

The types of meters which were found in the household were not ideal for the municipality as they are built into the property wall and therefore they cannot easily be read by the meter readers as they may not be able to gain access to the property. Properties on which these meters were found, were also installed with new meters. Even though meters were installed to all properties which the pipeline replacement was done, new installed meters in Daveyton and Phomolong/Tembisa are not operational as the new network line is not working. This thus defeats the financial value for the projects as some parts of the project areas were not functional.

Free from defects

Consultant B was responsible for the site monitoring from the start of the project until May 2014. Thereafter, the Vosloorus and Thokoza project was operating without a Consultant and it was managed internally by EMM Project Manager. Whilst Phomolong, Daveyton and Kwa-Thema were managed by Consultants G which were appointed from October 2014. Daveyton and Tembisa/Phomolong new network lines were not operational due to lack of pipe-jacking of road

crossings. As indicated above, this practice has resulted in misaligned pipe joints and numerous leaking joints were the result of this practice. This has thus led to Daveyton and Phomolong/Tembisa areas to be dysfunctional. The project thus had defects which required to be fixed at another cost.

Value for money and profitability

Since the amount of water lost in those areas through pipe leaks and illegal water connections were not known (i.e. calculated before project implementation), this thus makes it difficult to know the exact profits which are been yield and the return on investments. This means that the project is not fully profitable and the municipality ran at a loss as not all households are being properly billed due to the lack of meters. Over and above this, pipe leakages are still occurring due to the aged pipelines.

Absence of any legal claims and proceedings

Since Ekurhuleni Metropolitan Municipality was not happy with the work of the contractor and consultants in Daveyton, Phomolong and Tembisa, the municipality held ten percent project amount which it will only be released as soon as the project is functional. There were no claims lodged by the contractor as well as the consultants.

Learning and exploitation

The project had encountered challenges during the implementation period. The change of consultants during a mid-construction period is a very unhealthy situation. All quantities needed to be re-measured, which was a very time consuming exercise. Quality of concealed work could not be verified. Responsibility concerning professional indemnity insurance also remained problematic as the designs were done by one firm which implemented seventy-five percent of the project work and the second consultant finished the project.

The contractor also uses the consultant change as an excuse for additional time, monetary claim and so-called approved work. Table 4.7 depicts issues which have been encountered during the midblock water pipe replacement project:

Issue	**Resolution**
The workers/residents preventing the contractor from working in their area	Late payment of workers created major unhappiness. This was however resolved with the intervention of the consultants.
Workers strike at the site camp	Late payment of workers created major unhappiness.
Lack of decommissioning design	The lack of a decommissioning design created a problem with the operation section. Consultants were forced to produce a design in

	a very short period for this and issued VO's to ensure that the old network is terminated.
Illegal connections created a situation where outbuildings did not have water.	House owners installed T connections between the mainline and the meter. With the new connection from the street to the meter these connections were cut off. This created major unhappiness. The consultants insisted that this is a private matter and the owners had to employ private plumbers to rectify.
Reinstatement of erf connection	Unreasonable requirements from owners was resolved by the intervention of the RE.

Table 4.7: Issues encountered during the midblock water pipe replacement project

General positive reputation

There is a no good relationship between the contractors, consultants and Ekurhuleni Metropolitan Municipality as the contractors did not deliver a good quality work as per the contractual agreement. However, EMM (i.e. client) has paid the contractor and consultants in full.

Overall assessment based on the ten effectiveness criteria for metering project

The assessment based on the ten effectiveness criteria indicates that the project was partially effective. Only one project was fully functional and monies were paid to the respective contractors and consultants whilst the projects were not operational. The municipality did not obtain value for money in this project.

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

In order to summarise this research, the objectives of the study were revisited and the findings are indicated according to each objective. The factors used to measure project effectiveness were determined through the literature review. Different researchers and authors agree that the factors for measuring project effectiveness are client and user satisfaction, project effectiveness (i.e. achievement of outcomes), project functionality and fitness for purpose, value for money and profitability, absence of any legal claims and proceedings, free from defects, learning and exploitation as well as general positive reputation. This factors were used to assess the effectiveness of the water loss projects under study during the analysis of the empirical data.

To determine criteria for measuring project effectiveness in literature in order to use empirical data to measure the water loss projects

The factors used to measure project effectiveness were investigated. Literature indicates that in measuring project effectiveness, ten criteria's can be used. The criterions are client and user satisfaction, project effectiveness (i.e. achievement of outcomes), project functionality and fitness for purpose, value for money and profitability, absence of any legal claims and proceedings, free from defects, learning and exploitation as well as general positive reputation. All the factors for project effectiveness were relevant in measuring the Ekurhuleni Metropolitan Municipality water loss projects.

In measuring the project effectiveness using the empirical data, the results indicate that some projects are effective except for three projects under the midblock pipe replacement project. Also, the pipe replacement project in Zincor mine did not meet all the effectiveness measures criteria. There was a claim which was made to the preliminary and general budget (P&G) as a results of the request for project extension. The required extension of time was granted, thus moving project completion date forward from 22 November 2014 to 30th January 2015. The extension was with cost on P&G's at R314, 790.00. This thus makes the project to be partially effective, even though the project objectives were fully met.

Also, three of the midblock project that were implemented in Daveyton, Phomolong (Tembisa) and Tembisa one (01) are not effective. The reasons for these three projects to be not effective is that the contractors did not conduct their work properly. That is, the contractor proceeded with the installation of pipes without pipe-jacking of road crossing. This practice has thus led to misaligned and leaking pipe joints rendering the project defective. Tembisa one (01) area was the one with the highest failure rate, as meters were not installed. Also, road crossing and the interconnection of pipes were still outstanding. The contractor also skipped rocky areas. Further and above this, the contractor nor the consultants did not know the number of stands which have been piped. It was thus difficult to measure this project in terms of all the project effectiveness criterions as none

of them are met. What is fascinating though is that, the project has cost R8.1 million and the contractor was paid. The project is thus not effective. Similar circumstances were also experienced in Phomolong (Tembisa) as the same contractor who was used to implement the project in Tembisa was also implementing the project in Tembisa one. The difference however was that in Phomolong, some houses had meters installed whilst others did not have meters installed. For an example, one house would have a meter whilst the next house might not have a meter.

This thus raised the question on how the contractors and consultants were selected as they demonstrated a lack of knowledge in terms of the work which needed to be done from the contractor who was implementing the project. A point to note is that, a contractor cannot take the blame for the project failure alone. A consultant was appointed to oversee the work of the contractor and also to ensure that the quality of work was in line with the agreed specifications. Thus, in this case a contractor's failure was also the consultant's failure to execute the project. As both parties needed to work hand in hand in order to obtain project success.

In Daveyton, a similar case was also observed, however, a different contractor was used. Whilst both the contractor and the consultants have been paid, the Metro is still not making use of their project work. Thus, the three projects in Tembisa 1, Phomolong and Daveyton were ineffective as they did not adhere to the ten criterions of the project effectiveness measures.

It was also noted that some households in Thokoza and Vosloorus were not being billed using the new meters installed. The reasons behind this was that the process of shutting the valves in order to allow the new line to be operational would affect many houses. Meaning that the houses which were to be affected would be without water for few days as some old lines did not have a shut-off valves and some shut-off valves were not operational anymore. These two areas can thus be classified as partially effective as the project is not fully operational, thus the project functionality and purpose for use as well value for money and profitability criteria's are negatively affected. The only project which was fully effective in the mid-block pipeline replacement project was the Kwa-Thema project.

On the domestic and bulk metering project, there were no reported defects in the project reports, however Contractor D had an imposed penalties amounting to R214 990 due to quality of work and late completion of work. The penalties were imposed whilst the contractor was working under the installation/replacement of water meters in South West Region in 2013/14 financial year. This thus affect the aspect of project functionality and fitness for purpose, leading to the project been partially ineffective. The metering of school's properties has also experienced an over expenditure of R2, 735,105.59. This thus render the project partially effective due to the unexplained over expenditure.

To determine criteria for rolling out water loss eradication projects in municipalities

The criteria for rolling out water loss eradication projects has been determined through literature review. Literature indicates that key areas need to be considered before embarking on a water loss reduction programme. The areas which need to be considered are system schematics, leak location and repair, pressure management, sectorising, logging and analysis of minimum night flow, bulk management meters, bulk consumer meters, domestic metering and billing, pipe replacement and repair, water balance as well as community awareness and education.

In Ekurhuleni Metropolitan Municipality the manner in which the water loss reduction projects are rolled out is in line with what literature suggest. However, the problem is with hiring of incompetent contractors who are supposed to be implementing and executing the water loss projects. Some contractors lack the technical knowledge of planning, implementing and executing water loss projects. This thus affects the Metro as some contractors who have been awarded the water loss contracts are unable to deliver.

Over and above that, consultants who were meant to be checking the quality of work done by the contractors and also sharing knowledge with the Metro's Project Managers are mostly given more contract work with the Metro. This resulted in lack of adequate time from the consultants to oversee the work done by the contractors and also to share in-depth knowledge with the Metro's Project Managers.

Also, it will be important for the Metro to strengthen its role in implementing community awareness and education programmes. Community awareness and education programmes will assist the Metro to work hand in hand with the people. In Germany, the water loss management programmes are partly successful due to the involvement of community members. The involvement of the community members is so intense such that water companies are required by the community to submit all efforts to reduce water losses. Thus, the involvement of community members should not be taken lightly by the Metro as they play a critical role in water loss management.

To assess the effectiveness of Ekurhuleni Metropolitan Municipality water loss projects in reducing water loss

In 2012, the Metro's Non-Revenue Water figure was 39.8%. At the end of June 2016 the Metro reported a Non-Revenue Water figure of 34.6% (EMM Council Agenda, 2016). The manner which the projects were implemented are in line with the principles of rolling out water loss eradication programmes as described by McKenzie (2014). The project effectiveness measures have been put to test in assessing Ekurhuleni Metropolitan Municipality water loss eradication programme. In assessing whether the projects are effective or not in reducing water loss based on the project effectiveness measures, it was found that out of all the projects which were rolled out; three

programmes were not fully effective. A project is rendered not fully effective if it did not adhere to the ten criteria for project effectiveness measures.

The programmes which were not fully effective is the replacement of mid-block pipelines and one project under the install, replace and maintenance of water meters programmes which was implemented and executed in 2013/14 financial year. The pipeline and valve assessment which is the bulk water supply to Zincor Mine in Selcourt Springs and the metering of school's properties projects were also not fully effective. Table 5.1 depicts the number of projects done per water loss programme and the project effectiveness results.

Water loss eradication programme	**Number of projects analysed**	**Project effective or not**
Leak fixing and meter installation project in Tsakane	1	Effective
Consolidation and replacement of all large water consumer meters	2	Effective
Metering of all informal settlement	1	Effective
Metering of Council properties	1	Effective
Metering of schools properties	1	Partially effective
Domestic and bulk metering	10	9 projects effective, 1 project Partially effective
Pipeline and valve assessment and replacement	1	Partially effective
Replacement of mid-block pipelines	6	5 projects Partially effective, 1 project effective
Total	**23**	

Table 5.1: Number of projects done per water loss programme and project effectiveness results

As depicted in table 5.1, out of the eight programmes, four programmes were not fully effective. A point to note though about the effectiveness of this projects is that, it was difficult to analyse all the projects in terms of project costs and time as almost all the water loss eradication projects are done on an "as and when" basis. As and when basis are projects which are rolled out based on the availability of funds. The municipality usually appoints a contractor and a consultants based on the available funds to do work which the municipality only has the budget. The problem with as and when contracts particularly in water loss projects is that they are difficult to manage in terms of time and cost.

For an example, a contractor may be appointed to meter houses at the cost of R3 million. The contractor will then estimate the number of houses which the cost will meter as well as the timeframe. During the implementation of the metering project, the municipality may have another R3 million which the metro intend to add to the already existing funds of R3 million. The contractor in this case will have to extend the scope of work and timeframe. This thus makes it difficult to make a thorough assessment on these two key factors. However, other factors of project effectives were thoroughly assessed.

The water loss figure since the implementation of the water loss eradication programme from 2011 to 2016 has greatly reduced. This thus indicates that the water loss eradication programme is effective. Even though some projects are still ineffective due to contractor's incompetence and lack of adequate skills to do the work, the effective projects have shown a positive outcome in terms of reducing the Metro's water loss.

5.2 CONCLUSION

In view of the increasing water loss in the water distribution system of Ekurhuleni Metropolitan Municipality, the management of water loss still needs a greater development. The factors which were used to measure project effectiveness were investigated and put to test in measuring water loss projects. All the ten criteria which were used to measure project effectiveness as prescribed by the body of knowledge were all relevant in assessing water loss projects.

The water loss figure has been greatly reduced since 2011 to 2016. This means that the water loss eradication programme is effective. However, the municipality did not implement pressure management projects. It was indicated that an assessment of the municipal pressure management valves still needs to be conducted. According to McKenzie (2014), pressure management is one of the most important water demand management interventions that should be considered. McKenzie (2014) has reiterated that pressure management is one of the most cost-effective measures to reduce leakage and wastage that can be considered. He has further indicated that many of the South African municipal water systems are operated at an unusual high pressures and can be implemented as one of the most important WDM intervention.

It will thus be important for the municipality to implement pressure management projects as this will greatly assist in reducing leakage which will in turn reduce the water loss. Also, the element of community awareness and education is not properly conducted by the Metro. Education and awareness to communities should form part and parcel of the Department of Water and Sanitation's service delivery and budget implementation plan (SDBIP). It should not be done on an as and when there is a project or on an as and when a need arises. It should be continuously done until communities acquire an in-depth understanding about the importance of conserving water, reporting leaks to the Metro on time, careers in water management etc.

The manner into which consultants and contractors were appointed need to be reviewed, as there seems to be an imbalance in terms of the appointment of consultants and contractors. Consultants

were awarded too many contracts at the Metro and this thus affect the project results as it becomes difficult for consultants to oversee many projects at the same time.

5.3 RECOMMENDATIONS

5.3.1 Review of section 33 of the MFMA is needed

Section 33 of the Municipal Finance Management Act (MFMA), (no 56 of 2003) states *that "a municipality may enter into a contract which will impose financial obligations on the municipality beyond a financial year, but if the contract will impose financial obligation on the municipality beyond the three years covered in the annual budget for that financial year, it may do so only if the municipal manager, at least 60 days before the meeting of the municipal council at which the contract is to be approved".* This create a problem to projects as the municipality do not start in time to secure other contractors or consultants. This thus affect the quality of projects particularly when consultants who are meant to also conduct site inspection and quality work contract comes to an end at the middle of project due to the automatic termination of a contract as a results of the requirements of section 33 of MFMA.

Ideally, Ekurhuleni Metropolitan Municipality project managers are supposed to conduct site inspection and quality work when the consultant's contract expire before an appointment of new consultant is made. As part and parcel of consultant's work is to impart knowledge and skills to the municipality's officials who are involved in the project management. However, it becomes difficult to do so as most of the municipality's project managers lack adequate technical background to be able to conduct a thorough site inspection and quality work. Over and above that, some consultants do not have adequate time to train the municipal Project Managers when they are on site as much attention is given to the over sighting of the contractors not on training and developing the Metro's Project Managers.

5.3.2 Developing Project Managers

Project Managers at the municipality need to be skilled in order to be able to do their work efficiently and effectively. A robust training and development programmes for Project Managers is needed. Relying on the consultants to train the project managers only is not adequate, a formal training is needed. Training and developing the municipal's Project Managers will enable the municipal's projects to implemented and executed efficiently and effectively.

5.3.3 Payment of small contractors on time

The municipality need to pay contractors on time. Not paying small contractors on time delays the implementation of projects. Often small contractors do not have adequate capital to carry out projects when not paid on time. The municipality thus need to strengthen their financial administration system particularly on paying contractors.

5.3.4 Legal system for retrieving money

A legal system need to be put in place and into practice for retrieving monies from service providers who do not perform as per the contractual agreement. The municipality has lost money in the midblock pipe replacement project as some contractor did not implement and execute the project as per their contractual obligation. The municipality has however not yet retrieved the monies from those contractors. Thus a system needs to be put in place and the municipal project managers need to be educated on how to follow due processes in cases where contractors or service providers did not deliver as per the agreement.

5.3.5 System for managing awarding of contracts

A Contractor or a Consultant cannot be given too many contracts at the same time as this affects their ability to provide good services. A central system needs to be put in place which will enable the Metro to know Contractors and Consultants who already have been granted contracts at any of the Metro's departments. This will enable the Metro to better manage the awarding of contracts to various Consultants and Contractors.

5.3.6 Blacklisting of service providers

Contractors or service providers who do not perform need to be blacklisted. Service providers cannot be granted other contracts whilst they have failed to deliver on their previous work. Contractors and Consultants who have failed to deliver as per the contractual agreement in the water loss eradication programme have not been blacklisted. Chances are, they may still be awarded other projects in the municipality or in another municipality.

5.3.7 Recommendation for further studies

The study did not establish whether there is a relationship between the contractors and consultants technical background, experience and project performance. Further studies on establishing the relationship would be recommended in order to cement the findings of the study. The municipality mostly implement their contracts on an "as and when" basis. The efficiency or rather the sustainability of this as and when basis need to be established from the project management point of view and also for the financial viability of the Metro.

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Annexure A (Happy Letter)

Ekurhuleni
METROPOLITAN MUNICIPALITY

To: **Stand Owner**

Name & Surname: _____

Contact Details: _____

Stand Number: _____

Street Name: _____

Water and Sanitation Department
Springs Civic Centre
Cnr Main Reef and
Plantation Road

P O Box 45
SPRINGS
1560

Website :
www.ekurhuleni.gov.za

Our ref: 1615
Enquiries: Mr Hennie Snyman
Consultant: Luleka Consulting Engineers
Te;: +(278) 569 1837

CONTRACT: (WS) 05/2013: CONSTRUCTION AND INSTALLATION OF WATER AND SEWER AND TOILET STRUCTURES- MASETJHABA VIEW EXT4 : HAPPY LETTER

Please comment on this letter whether you are satisfied / not satisfied with the equality of the construction work done in and around your property. Please tick the relevant block and comment below.

☐ Satisfied _____ METER NUMBER

☐ Not-satisfied _____READING _____DATE

_____

_____

_____

_____

_____

_____ _____

Stand Owners Signature **Date**

Annexure B (Consumer Acceptance Form)

Our Ref : *PS – WS 26 - 2014*
WLE133E

Your Ref :

Date : 14/10/2015

№ 0025

Ekurhuleni
METROPOLITAN MUNICIPALITY

Water and Sanitation Department
Water Revenue Management

Company: MAIZEY ENGINEERING

Address: Cnr BARRACUDA AND LANTERN ROAD
GERMISTON

P O Box 215
BOKSBURG
1460

Tel: (011) 999-5355
Fax: (011) 999-5524
E-mail : andries.kruger@ekurhuleni.gov.za
Web address: www.ekurhuleni.com

Sir / Madam

EKURHULENI METROPOLITAN MUNICIPALITY: CONSUMER METER CONSOLIDATION PROJECT CONSOLIDATION APPROVAL

Ekurhuleni Metropolitan Municipality (EMM) has recently completed the consolidation of water supplies to your property. The contractor and consultant are required to confirm together with the consumer that all water infrastructure on the site is pressurised prior to leaving the site on the day of consolidation.
Please sign the approval below to acknowledge that the work has been undertaken and that all fire and other infrastructure is pressurised following the consolidation exercise.

I André Muller (Name of consumer representative) acknowledge modifications made to the water infrastructure at MAIZEY ENGINEERING. (Name of consumer). I hereby acknowledge that all water infrastructure, including all fire infrastructure, on the property is pressurised following the consolidation exercise which took place on 12 (day) OCTOBER (month) 2015 (year)

Signed for Consumer:

Signed for Consultant:

Signed for Contractor:

Yours faithfully

DB MABUZA (PR. TECH ENG)
DIVISIONAL HEAD: WATER REVENUE MANAGEMENT
WATER & SANITATION DEPARTMENT