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**Evaluating Water Conservation and Water Demand Management
in an Industrialised City: A Case Study of the City of uMhlatuze
in Richards Bay**

By

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Abstract

The objective of this study was to evaluate water conservation and water demand management in an industrialised City of uMhlathuze in Richards Bay. The City of uMhlathuze Local Municipality is the third-largest municipality in KwaZulu Natal (KZN) and is strategically placed to continue attracting investment as an aspirant metropolis due to the newly established Industrial Development Zone (IDZ) and the country's largest deep-water port. As an industrialised city, uMhlathuze's demand for water is already increasing and with the establishment of the IDZ, it is expected that water demand will escalate even further once the IDZ is fully operational.

In line with the research question, this study has, therefore, sought to understand whether the industrialised City of uMhlathuze has developed and effectively implemented a water conservation and water demand management strategy and interventions in order to sustain water supply in anticipation of growing demand due to industrialisation and population growth. This objective was achieved by evaluating the city's current interventions and measures using a range of water conservation and water demand management solutions and guidelines.

During this study, it was evident that the greatest threat facing South Africa's ambitious future economic growth, poverty alleviation and government's transformation agenda was the inefficient and unbalanced use of available and limited water resources. Thus, in order to avoid this imminent threat, the country as a whole must continuously reduce water consumption and demand from various sectors. This goal can be achieved through sustainable and improved water conservation and water demand management interventions.

The study found that, in recent years, the issue of water scarcity had escalated in KZN. The province was in the grip of a drought, which was taking its toll on water supply in various municipalities around the province. The sparse rainfall in most parts of the province had caused the levels of rivers and dams to decrease to a point of crisis. Consequently, the KZN Provincial Government declared the province a disaster area in 2015. During the study, there was very little improvement as the City of uMhlathuze was still subjected to level 4 water restrictions. Evidently, the drought was intensifying the water problem in a municipality already grappling with poor and inadequate water infrastructure.

A review of international and local literature was undertaken to theoretically position the objective of the research. An evaluation of the City of uMhlathuze water conservation and water demand management strategy and interventions was conducted using a questionnaire

completed by city officials and part of the study included documentation review. This study investigated key elements of water conservation and demand management as well as interventions that were pertinent to achieving the desired outcome of efficient use of water. Respondents were required to answer questions focusing on several water conservation and water demand management related approaches and solutions.

During the study, it was identified that there were inconsistencies in the implementation of water conservation and water demand management interventions even though the City of uMhlathuze had already taken the important step of developing a water conservation and water demand management strategy. It was recognised, however, that water conservation and water demand management remained relatively new for most municipalities. Consequently, it would take time for municipalities, together with communities, to implement effective interventions. The focus needs to be on the establishment of a combined team of staff and stakeholders, set up to finding solutions and interventions designed to maximise the most sustainable and efficient use of water.

The conclusions drawn from this study and proposed recommendations indicated that wastewater reuse; pipe replacement; water pressure management; rainwater and stormwater harvesting; water sensitive urban design; leak detection and repair; joint planning and research team with the Industrial Development Zone; groundwater and aquifer recharge; stakeholder engagement, education and citizen awareness are feasible options for the City of uMhlathuze to consider in relation to water conservation and water demand management. These solutions should constitute the foundation of a revised and updated water conservation and water demand management strategy to be implemented incrementally with broad-based participation.

Table of Contents

Acknowledgements iii

Abstract iv

Table of Contents..... vi

List of Acronyms..... xi

Glossary xiii

List of Tables..... xvi

List of Figures xvii

Chapter One: Background..... 1

1.1 **Introduction** 1

1.2 **Problem Statement**..... 2

1.3 **Objectives of the Study**..... 4

1.4 **Overview of Chapters**..... 4

Chapter Two: Literature Review..... 6

2.1 **Introduction** 6

2.2 **South African Water in Context**..... 7

2.3 **Water Sensitive Urban Design (WSUD)**..... 10

2.3.1 Water Sensitive Urban Design (WSUD) principles..... 12

2.3.2 Ecologically sustainable development 13

2.3.3 Building community of practice for water sensitive strategy 14

2.4 **Sustainable Urban Drainage Systems (SuDS)**..... 15

2.5 **The Concept of Real Loss** 19

2.6 **Water Management Legislative and Policy Framework in South Africa**..... 20

2.6.1 Water Services Act..... 20

2.6.2 Water Services Act Regulations 21

2.6.3 National Water Resource Strategy 2nd (NWRS2)..... 22

2.7 **Water Conservation and Water Demand Management Practices and Solutions** 23

2.7.1 Water pressure management 23

2.7.2 Water conservation 26

2.7.3 Treated effluent and wastewater reuse..... 27

2.7.4	Rainwater and stormwater harvesting	30
2.7.5	Seawater desalination	33
2.7.6	Groundwater and recharge of aquifers	35
2.7.7	Pipe replacement and repair	36
2.7.8	Leak detection and repair	37
2.7.9	Greywater reuse.....	38
2.8	A Case Study of the Long-term Water Conservation and Water Demand Strategy (Cape Town).....	40
2.9	Department of Trade and Industry (DTI) Special Economic Zones driving Re-industrialisation in South Africa	42
2.10	Conclusion.....	44
Chapter Three: Research Methodology.....		46
3.1	Introduction	46
3.2	Research Methods	46
3.2.1	Case Study.....	46
3.3	Research Techniques	48
3.3.1	Questionnaires	48
3.3.2	Interviews and focus groups.....	48
3.3.3	Content analysis.....	49
3.4	Sampling	49
3.4.1	Random sampling	49
3.4.2	Systematic sampling	50
3.4.3	Stratified sampling.....	50
3.5	Method of Investigation, Case Study Identification and Evaluation	50
3.6	Research Question and Data Collection.....	58
3.7	Reliability, Validity and Limitations of the Study	59
3.8	Data Analysis.....	60
3.9	Conclusion.....	60
Chapter Four: Overview of City of uMhlathuze Municipality.....		61
4.1	Introduction	61
4.2	Population Distribution between Urban and Rural	62
4.3	The Effects of Drought on the uMhlathuze Water System.....	64
4.4	Reduction of Non-Revenue Water Project Analysis	68
4.5	Key System Information	70

4.6	Existing Water Resources and Utilisation	74
4.7	Richards Bay Industrial Development Zone	76
4.8	Conclusion	78
	Chapter Five: Research Findings and Data Analysis	79
5.1	Introduction	79
5.2	Results and Discussion	79
5.2.1	Statement: the City of uMhlathuze has developed and implemented a water conservation and water demand strategy	79
5.2.2	Statement: over a period of time, water conservation and water demand interventions have drastically reduced water losses in the city	80
5.2.3	Statement: the municipality allocates sufficient budget in each financial year for the implementation of WC and WDM projects such as pipe replacement, pressure management, water sensitive urban design, leaks monitoring and repairs, etc.	81
5.2.4	Statement: consumption based water tariffs are an effective method of reducing water demand	82
5.2.5	Statement: pipe replacement, leaks monitoring and repair, water use, rainwater harvesting, water sensitive urban design and water pressure are the main components of water conservation and water demand management	83
5.2.6	Statement: the municipality has sufficient water resources to support existing and new industries	84
5.2.7	Statement: investment in alternative water supply options such as seawater desalination, water reuse, stormwater and rainwater harvesting, ground water and recharge aquifers, etc. will provide long-term security of supply for businesses, industries and residents.....	85
5.2.8	Statement: the municipality has developed and implemented an effective and efficient water leaks detection and repair system.....	86
5.2.9	Statement: the residents, industries and businesses are adequately informed and empowered on water conservation and water demand management strategies	87
5.2.10	Statement: municipal elected political office bearers are leading and driving community based campaigns and projects focusing on water conservation and water demand management.....	88
5.3	Conclusion	89

Chapter Six: Conclusions and Recommendations	91
6.1 Conclusions	91
6.2 Key Findings	92
6.2.1 Statement: the City of uMhlathuze has developed and effectively implemented a water conservation and water demand management strategy.....	92
6.2.2 Statement: water conservation and water demand management interventions have drastically reduced water losses in the city over a period of time.....	92
6.2.3 Statement: the municipality allocates sufficient budget in each financial year for the implementation of WC and WDM projects.....	93
6.2.4 Statement: consumption based water tariffs are an effective method of reducing water demand.....	93
6.2.5 Statement: pipe replacement, leak monitoring and repair, water reuse, rainwater harvesting, sensitive urban design and water pressure management are considered the main components of water conservation and water demand management.....	94
6.2.6 Statement: the municipality has sufficient water sources to support existing and new industries.....	94
6.2.7 Statement: investment in alternative water supply options, such as seawater desalination, water reuse, stormwater and rainwater harvesting, groundwater and recharge aquifers, will provide long-term water security of supply for businesses, industries and residents.....	94
6.2.8 Statement: the municipality has developed and implemented an effective and efficient water leak detection and repair system.....	95
6.2.9 Statement: residents, industries and businesses are adequately informed and empowered on WC and WDM strategies.....	95
6.2.10 Statement: municipal elected political office bearers are leading community based campaigns and projects focusing on WC and WDM.....	95
6.3 Recommendations	96
6.3.1 Review of the Five Year Strategic Management Plan for WC and WDM.....	96
6.3.2 Rainwater and stormwater harvesting.....	97
6.3.3 Wastewater reuse.....	97
6.3.4 Water Sensitive Urban Design (WSUD).....	98
6.3.5 Water pressure management, leak detection and pipe replacement long-term project.....	99
6.3.6 Groundwater and aquifer recharge.....	99
6.3.7 Stakeholder engagement, education and awareness programme.....	100
6.3.8 Joint planning and research team with the Richards Bay Industrial Development Zone.....	100
6.3.9 Consumption based water tariffs study.....	100

6.4 Conclusion.....	101
References	102
Appendix A: Research Project Questionnaire	111
Appendix B: City of uMhluthuze Consumption-based Water Tariffs for Domestic Consumers, Businesses and Industries	117
Appendix C: Stage 4 Drought Tariffs.....	119
Appendix D: Consent Form.....	122
Appendix E: Ethics Approval	123

List of Acronyms

AFS	Annual Financial Statements
ALC	Active Leakage Control
AWWA	American Water Works Association
BAC	Billed Authorised Consumption
CBDs	Central Business Districts
CoCT	City of Cape Town
CoU	City of uMhlathuze
DMA	District Metered Area
DOH	Department of Health
DI&TS	Department of Infrastructure and Technical Services
DTI	Department of Trade and Industry
DWAF	Former Department of Water Affairs
DWS	Department of Water and Sanitation
ESD	Ecologically Sustainable Development
IDP	Integrated Development Plan
IDZ	Industrial Development Zone
IUWM	Integrated Urban Water Management
IWRM	Integrated Water Resource Management
KZN	KwaZulu-Natal
NDP	National Development Plan
NMA	National Water Act
NPC	National Planning Commission
NRV	Non-Revenue Water
NRW	Non-Revenue Water
NWRS	National Water Resource Strategy
O&M	Operation and Maintenance
PRV	Pressure Reducing Valves
PVR	Personal Video Recorder
RBIDZ	Richards Bay Industrial Development Zone
SA	South Africa
SDS	Sustainable Drainage System
SEZ	Special Economic Zone

SIUWM	Sustainable Integrated Urban Water Management
SIV	System Input Volume
STATS SA	Statistics South Africa
SuDS	Sustainable Urban Drainage System
UCT	University of Cape Town
UARL	Unavoidable Annual Real Losses
UN	United Nations
WC and WDM	Water Conservation and Water Demand Management
WDM	Water Demand Management
WDMS	Water Demand Management Strategy
WEF	World Economic Forum
WHO	World Health Organisation
WRC	Water Research Commission
WSDP	Water Services Development Plan
WSUD	Water Sensitive Urban Design
WSUM	Water Sensitive Urban Management
WSUP	Water Sensitive Urban Planning
WTW	Water Treatment Works

Glossary

Some of the standard definitions used in this research have been included below for ease of reference and understanding.

Disclaimer: Some definitions used here are the interpretation of the writer.

Abstraction

This is the water bought or taken from a water source (Fry, 2015).

Alternative water resources

These are water resources other than normal municipal treated tap water. These are usually decentralised sources and include rainwater, greywater, blackwater and groundwater (Viljoen, 2014).

Apparent losses

The losses consist of unauthorised consumption – theft or illegal use – and all types of inaccuracies associated with bulk and consumer metering. For example, under-registration of bulk meters and over-registration of consumer meters leads to under-estimation of losses. Conversely, over-registration of bulk meters and under-registration of consumer meters leads to over-estimation of real losses.

Aquifer

This is a saturated underground geological formation (Fry, 2015).

Authorised consumption

This is the volume of metered and/or unmetered water taken by registered consumers, the water supplier or others who are authorised to do so, for domestic, commercial and industrial purposes. Authorised consumption includes firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains and building water. These may be billed or unbilled, metered or unmetered according to local practice.

Blackwater

This is used water that has been excessively contaminated and consequently needs intensive treatment to ensure safe disposal or reuse. An example of blackwater is the wastewater from a toilet (Van der Walt, cited in Viljoen, 2014).

Greywater

“This is water originating from a building which has been used for bathing, showering, bathroom basins or washing machines and is being reused for non-potable purposes such

as garden irrigation. Greywater is considered to be less contaminated than blackwater” (Viljoen, 2014).

Industrialisation

Generally, industrialisation can be defined as the process in which a society or country (or world) transforms itself from a primarily agricultural society into one based on the manufacturing of goods and services. O'Brien (cited in Naude, *et al.*, 2013: 3) defines industrialisation as a socio-economic process involving rapid transformation of manufacturing activity in relation to all other forms of production and work undertaken within national, regional or local economies.

Non-revenue water (NRW)

NRW is the difference between the System Input Volume and Billed Authorised Consumption.

Potable water

This is treated municipal (tap) water. This is water fit for human consumption purposes (Viljoen, 2014).

Rainwater harvesting

This is the capturing of water, usually from roof surfaces, storage and use of rainwater for any usage type (Van der Walt, cited in Viljoen, 2014).

Real losses

Losses are physical water losses from the distribution system, up to the point of consumer metering. The volume lost through all types of leaks, bursts and overflow depends on frequencies, flow rates and average durations of individual leaks.

Stormwater harvesting

This is the capturing, storage, treatment and use of stormwater runoff from urban impervious or pervious areas. It differs from rainwater harvesting, as the runoff is collected from land surface areas rather than roofs (Armitage, Vice & Fisher-Jeffes, cited in Viljoen, 2014).

System input volume (SIV)

SIV is the volume of water input to a distribution system.

Unauthorised consumption

This is generally associated with the misuse of fire hydrants and fire service connections, as well as illegal connections.

Water balance

This is the way of accounting for water entering an existing system.

Water conservation

Rabe *et al.* (2012) define “*water conservation as the minimisation of loss or waste of water, which includes preservation, care and protection of water resources plus the efficient and effective use of water. Water conservation is often associated with the curtailment of water use in times of drought when water is in short supply*”.

Water Demand Management (WDM)

Rabe *et al.* (2012) define Water Demand Management as the adaptation and implementation of a strategy such as policies and initiatives by a water institution or consumer. The purpose of this adaptation would be to influence water demand and usage in order to meet strategic objectives, such as economic efficiency; social development; social equity; environmental protection; sustainability of water supply and services, and political acceptability.

Water losses

Water losses of a system are calculated as system input volume, Authorised Consumption. Water losses can be considered as the total volume for the entire system, or for partial systems such as bulk or reticulation. In each case, the components of the calculation would be adjusted accordingly. Water losses consist of Real and Apparent losses and are effectively identical to Unaccounted-for Water.

Water scarcity

This is the shortage in the physical availability of clean water resources (Fry, 2015).

List of Tables

Table 2.1: Department of Water and Sanitation Water Conservation and Water Demand Management Strategy, 2013	9
Table 2.2: Summary of the current levels of wastewater discharge: Mhlathuze Water Board, 2001	30
Table 2.3: COCT WC and WDM strategy targets	41
Table 2.4: Richards Bay Industrial Development Zone Long Term Investment Book 2017.....	43
Table 4.1: City of uMhlathuze Water Restrictions Timetable 2016/17	66
Table 4.2: Water losses – City of uMhlathuze	68
Table 4.3: City of uMhlathuze – key system characteristics	70
Table 4.4: Existing water resources in the City of uMhlathuze 2017	75
Table 4.5: Percentage utilisation in Richards Bay system 2016	76
Table 5.1: CoU total water losses from 2013 to 2016.....	81

List of Figures

Figure 2.1: The integration of WSUD, WSUP and WSUM towards WSS.....	13
Figure 2.2: Interactions between WSUD, the built environment and the urban water cycle.....	14
Figure 2.3: The SuDS Treatment Train	17
Figure 2.4: Infiltration trench.....	17
Figure 2.5: Bio-retention.....	18
Figure 2.6: Green roof.....	18
Figure 2.7: Retention pond.....	18
Figure 2.8: Four component approach to the control of real losses: City of uMhlathuze Five Year Strategic Management Plan for Water Conservation, 2012.....	20
Figure 2.9: Typical pressure during peak demand periods	24
Figure 2.10: Underground leak at low and high pressure	25
Figure 2.11: Examples of water pressure management system in the City of Cape Town	26
Figure 2.12: United Nations World Water Development Report 2017	28
Figure 2.13: City of uMhlathuze yearly total rainfall from 1978 to 2017.....	32
Figure 2.14: Examples of pipe loss of physical integrity	37
Figure 2.15: Leak detection using sounding equipment	38
Figure 2.16: Major greywater reuse applications.....	39
Figure 4.1: City of uMhlathuze spatial structuring elements	62
Figure 4.2: Illustration of population distribution.....	63
Figure 4.3: City of uMhlathuze households with no access to water in 2017	64
Figure 4.4: Goedertrouw Dam levels	65
Figure 4.5: Save water campaign.....	66
Figure 4.6: The river system during good times in 2012 and bad times in 2015/16	67
Figure 4.7: City of uMhlathuze 5 Year WC and WDM Strategic Management Framework 2012.....	69
Figure 4.8: Richards Bay supply system zone water balance	71
Figure 4.9: Esikhaleni supply system zone water balance	72
Figure 4.10: Empangeni supply system zone water balance.....	72
Figure 4.11: Selected regional, national and international comparison of NRW by volume 2012	73

Figure 4.12: KwaZulu Nata NRW figures for 2014/2015 financial year	74
Figure 5.1: CoU WC and WDM strategy statement	79
Figure 5.2: Water losses statement	80
Figure 5.3: WC and WDM budget statement	81
Figure 5.4: Consumption based water tariffs statement	82
Figure 5.5: Main components of WC and WDM statement.....	83
Figure 5.6: Water sources statement.....	84
Figure 5.7: Alternative water supply options statement.....	85
Figure 5.8: Water leaks detection and repair system	86
Figure 5.9: Information dissemination statement.....	87
Figure 5.10: Municipal elected office bearers statement.....	88
Figure 5.11: Summary of overall respondents.....	89

Chapter One: Background

1.1 Introduction

Effective and efficient water management in the South African context is crucial for future development, poverty alleviation, job creation and addressing inequalities in society. Water scarcity could be a limiting factor to growth and development. In South Africa, the freshwater resources are being over-exploited, thus water could be a major constraint on the implementation of the National Development Plan 2030¹, which emphasises the need for accelerated economic growth, transformation and investment (Hedden & Cilliers, 2014: 1a).

According to Hedden and Cilliers (2014: 2b), water crises are emerging worldwide at various different levels due to a scarcity of water and high demand by people, farmers and industries. This demand requires alternative approaches to water provision and demand management solutions. These crises occur nationally and across different regions worldwide. The nature of crisis differs from country to country, depending on the severity of the water scarcity and constrained supply. According to the World Economic Forum (WEF) Global Risks Report released in 2017, water scarcity ranks as the third most concerning top five (5) global risks in terms of impact (World Economic Forum Global Risk, 2017).

As noted by the National Planning Commission (NPC) (2012), South Africa is a water scarce country. Food, fuel and water are interconnected, particularly in the context of climate change. Their impact on one another, together with water scarcity, could derail the elimination of poverty and the envisaged reduction of inequalities by 2030.

Furthermore, according to the National Water Resource Strategy 2nd (2013), South Africa is a water-stressed country and it is facing a number of water challenges and concerns, including security of supply, environmental degradation and resource pollution. The nature of South Africa's water scarcity requires urgent intervention as the country has limited water resources. Consequently, the limited water resources require careful management to enable the provision of basic water services to every citizen, while meeting the needs of economic growth without posing a threat to water resources. It is estimated that the sustainability of the country's fresh water resources has reached a critical point and its associated management is now at a crossroads, unless urgent steps are taken to preserve existing water resources

¹The National Development Plan 2030 (NDP) offers a long-term perspective as it defines a desired destination and identifies the role different sectors of society need to play in reaching the anticipated goal. The NDP aims to eliminate poverty and reduce inequality by 2030 and according to the plan, South Africa can realise its goal by drawing on the energies of its people, growing an inclusive economy, building capabilities, enhancing the capacity of the state, and promoting leadership and partnerships throughout society (National Development Plan, 2012).

and introduce water conservation and water demand management initiatives (National Water Resource Strategy 2nd, 2013).

Notably, no socio-economic development can take place without water. South Africa's water resources are indeed scarce. The situation is worsened by the occurrence of droughts and the increasing demand associated with population growth, coupled with a rapidly developing economy. There is a need therefore for a strategic change in the supply, use and conservation of water reserves.

In respect of the South African industrialisation agenda, the Department of Trade and Industry (DTI) has introduced a strategic approach to the identification and promulgation of Special Economic Zones (SEZ)². According to the DTI (2014), the special economic zone aims to attract foreign direct investment and export of value-added commodities.

A special economic zone is defined as a geographically designated area of a country set aside for specific targeted economic activities. These activities are then supported through special arrangements and support systems to promote industrial development (DTI Special Economic Zones Tax Incentive Guide, 2014).

Accordingly, the SEZ is a tool used by many economies to promote trade, economic growth and industrialisation. Richards Bay, which is one of the strategic Central Business Districts (CBDs) of the City of uMhlathuze, is one of these designated SEZs in South Africa. Beyond the SEZ, the city hosts a number of large industries who use the Port of Richards Bay for importing and exporting raw materials as well as finished products and goods.

This study then attempts to assess and evaluate water conservation and water demand management from the Office of the City Manager's perspective based on insights and experiences at non-technical level without going into technical details.

1.2 Problem Statement

Municipalities are mandated by legislation to supply water to their customers. In the South African context, access to water is a constitutional right entrenched in the Constitution of the Republic of South Africa. Most cities in South Africa are economic hubs with various industries located in many of these cities. These industries require water for their current

²The SEZs act as a magnet for investment and industrial capability development and desirable activities in specially designated areas by providing quality infrastructure complemented by an attractive incentives package, business support services, cluster development and minimal red tape. They promote industrial agglomeration and cluster development which is important for creating economies of scale. Furthermore, SEZs facilitate coordinated planning and implementation as the various agencies and systems directly and indirectly supporting industrial development must act together to achieve common objectives (DTI, 2014).

operations and future growth. This has a direct impact on development, job creation and economic growth.

In this regard, security of water supply is crucial for investments to take place as well as protection of existing industrial investments and possible business expansion. It is common knowledge that water supply is not only limited to industries, but is required for domestic use as well. This is particularly important in South Africa where historically, under the apartheid system³ of government, the majority of black South Africans did not have access to water. As a result, the water services sector is still characterised by skewed water distribution patterns emanating from the apartheid era, albeit the picture is changing gradually (Department of Water Affairs and Forestry Water Conservation and Water Demand Management Strategy for the Water Services Sector, 2004).

According to the Department of Water Affairs (2004), the water services providers are expected to initiate and implement interventions and measures aimed at efficiency of water use. In this regard, the Water Services Act (No 108 of 1997) and the National Water Act (No. 36 of 1998)⁴ provide the basis for the legislative framework within which water supply, sanitation services, water resource management and water use need to take place.

In respect of the City of uMhlathuze, the promulgation of the new Industrial Development Zone in an area with an existing number of industries requires the municipality to implement effective water conservation and water demand management interventions to curtail potential water shortages. This should be accomplished in order to continue to guarantee security of supply to businesses, industries and residents without depleting existing water sources. Evidently, the City of uMhlathuze is already facing water shortages as its current water supply cannot meet the growing demand as the main bulk water supply dam⁵ is currently at 33.20% full (Department of Water and Sanitation KwaZulu-Natal Dam Levels Report, September 2017). This problem of water scarcity is further compounded by continual drought and poor implementation of WC and WDM interventions.

³Apartheid was a political and social system in South Africa while it was under white minority rule. Apartheid was in force from 1948 to 1994. Racial segregation had been used for centuries but the new policy started in 1948 was stricter and more systematic and restricted the provision of services, particularly for the black majority (www.gov.za).

⁴The National Water Act (Act 36 of 1998) aims to achieve the desired balance between the development, use, protection, conservation, management and control of water resources. The National Water Act also recognises the pivotal role that WCWDM plays in water resource management with the objective of reconciling water supply and demand; and to enable all user sectors to gain equitable access to the desired quantity and reliability of water supply (National Water Resource Strategy 2, 2013).

⁵Goedertrouw Dam is the main source of water supply for the City of uMhlathuze (CoU Integrated Development Plan, 2016/17).

1.3 Objectives of the Study

This study attempted to do the following:

- Assess whether the industrialised City of uMhlathuze has developed a water conservation and water demand management strategy.
- Evaluate how the water conservation and water demand management interventions have been implemented.
- Report on key recommendations that will improve water conservation and water demand management in the City of uMhlathuze.

The City of uMhlathuze, like other water services authority/provider municipalities, is expected to develop and implement a water conservation and water demand management strategy and interventions in order to provide water supply services in an efficient, equitable and sustainable manner taking into consideration the growing demand due to industrialisation and population growth.

1.4 Overview of Chapters

This section gives a brief overview of the contents of each chapter of the research report.

Chapter 2

Chapter 2 is a literature review that was done to gain relevant knowledge on the subject matter. It looks at the literature and theoretical framework supporting water conservation and water demand management. Furthermore, a review of the City of Cape Town WC/WDM strategy was conducted with a view to underlining the importance and relevance of water conservation and water demand management in the South African context, with specific focus on municipalities. The themes reviewed include *inter alia* Water Sensitive Urban Design, Sustainable Drainage System, Water Pressure Management, Treated Effluent and Waste Water Reuse, Rainwater and Stormwater Harvesting and Seawater Desalination. A literature review summary is provided.

Chapter 3

This chapter explains the research methodology followed and utilised for this research project. It reviews various research techniques, provides an in-depth analysis of the research methodology, points out the limitations of the study and explains how the research was conducted. It describes the method used for information gathering, data interpretation and sampling.

Chapter 4

Chapter 4 presents an overview of the City of uMhlathuze Municipality. This chapter details the state of water conservation and management in the city. It outlines the population distribution, the effects of drought on the uMhlathuze Water System, water restrictions, existing water resources, water utilisation and the impact of the IDZ.

Chapter 5

Chapter 5 provides the results of the research and gives an analysis of the questionnaires completed by respondents. This chapter concludes with an analysis of the results and a discussion summary.

Chapter 6

Chapter 6 draws conclusions about the state of water conservation and demand management in the City of uMhlathuze. It evaluates the outcome of the research against the research question and makes recommendations on the possible solutions to further enhance water conservation and demand management in the city.

In conclusion, the development of a water conservation and demand management strategy and implementation of interventions offer a viable option for municipalities and water services providers in order to create required efficiencies among existing users. Water demand management is even more critical in highly industrialised cities where the demand for water for production purposes is much higher compared to less industrialised cities. Industrialisation requires security of supply in terms of water and energy. As a result, it is important for industrialised cities, like the City of uMhlathuze, to develop and implement effective and efficient water conservation and water demand management strategies and interventions in order to continue attracting investors and ensure security of supply.

Chapter Two: Literature Review

2.1 Introduction

According to the Department of Water Affairs (DWA) Strategic Overview of the Water Sector in South Africa (2013), South Africa is ranked as the 30th driest country in the world. The country is semi-arid with rainfall varying from less than 100 mm per annum in the west to over 1500 mm per annum in the east. Average rainfall is 450 mm per annum which is well below the world average of 860 mm per annum. Climate change predictions are for a drier western half of the country and for far more variability with more extreme events to the east (Department of Water Affairs National Water Resource Strategy 2nd, 2013).

Butler and Fayyaz (2006: 23) stated that “*world-wide, a common characteristic of water demand management in urban areas is its relentless rise with projections of continuous growth over several decades*”. There are a number of factors influencing the increase in water demand such as population growth, changes in lifestyles influenced by growth of the middle class, demographic structure and the possible effects of climate change. This is compounded by rapid urban development fuelled by urbanisation and migration, rising standards of living and expectation by the population of improved access to basic services such as water (Butler & Fayyaz, 2006: 23).

The authors further argued that there are typically two potential responses to water demand management: on the supply side - meeting the demand with new sources of water supply; or on the demand side - managing the consumptive demand itself by limiting use, wastage and loss of water in the system (Butler & Fayyaz, 2006: 23). In this regard, a Water Demand Management Strategy (WDMS) should involve a wide range of demand management measures for it to be effective.

These measures include *inter alia*:

- Cost reflective pricing for the project;
- Customer metering to determine consumption levels;
- Reticulation leakage detection, repair programmes and pressure reduction to reduce water losses;
- Community education campaigns to build social capital and awareness;
- Retrofitting of water efficient equipment to minimise equipment deficiencies;
- Reduction of water use through rationalisation to restrict over consumption and introduce restrictions; and

- Regulation of efficiency of water use, especially in new buildings by introducing solutions such as rainwater harvesting and greywater reuse.

Taking the foregoing into consideration, Herbertson and Tate (2001: 6) emphasised that traditional thinking around water supply based on abundance should be discouraged and there is a need for a paradigm shift in terms of mind-set, use of technology and more focus on sustainable water conservation as well as demand management due to water scarcity and the impact of climate change. This approach is essential for the sustainability of water resources and the environment, and for economic efficiency and social development (Herbertson & Tate, 2001: 6).

Again, Herbertson and Tate (2001: 6) stated that *“there is a need to foster a culture of caring for the resource, of knowing how to save water and to realise that water can play an essential role in developing a country”*. Accordingly, the paradigm shift in water resources management requires an integrated approach to water management and commitment by all key players. This is essential in order to maintain the momentum, save water and effect a period of culture change in the way water resources are managed and utilised.

2.2 South African Water in Context

According to Rabe, *et al.* (2012: 3), water is crucial for the prosperity and growth of any country, especially the underdeveloped countries that are still seeking investment and economic growth opportunities. In the context of South Africa as a developing country which faces multiple challenges of unemployment, poverty and inequality, water supply and access remain a challenge especially in the rural areas and informal settlements. The current problems include poor town planning, water stress, growing and urbanising populations, socio-economic imbalances of the past, poor maintenance of infrastructure, ageing infrastructure and skills shortages at government level (Rabe, *et al.*, 2012).

According to Rabe, *et al.* (2012: 3), there is also spatial inequality as a result of the geography of apartheid, changing weather patterns and persistent drought in many parts of the country. In South Africa, the challenge of ensuring a sustainable water supply for all is exacerbated by the following:

- Usually dry climate with precipitation levels lower than the average compared to many other developed or developing countries;
- A rapidly urbanising population putting pressure on cities;
- High evaporation levels due to changing weather patterns;

- Skewed development and economic centres located far from water resources as a result of apartheid spatial planning;
- An ageing water supply infrastructure and failure by authorities to adequately maintain the infrastructure;
- A focus on expansion of the water distribution network due to growing demand and underserved areas at the sacrifice of improved bulk treatment and pumping infrastructure;
- Improving socio-economic wellbeing of a large segment of the population in order to address past imbalances, thus leading to increased water demand and consumption;
- Technical skills shortages and expertise at all levels of government; and
- Focus on reindustrialisation of the South African economy.

Otieno and Ochieng (2004: 120) argued that:

“South Africa, currently categorised as a water stressed country, is forecasted to experience physical water scarcity by the year 2025 with an annual freshwater availability of less than 1000 m³ per capita. With the trends in population growth and its attributes and continuous pollution of the available water sources, there is bound to be increased pressure on the available water probably resulting in increased conflict over its allocation and a further stress on this resource leading to scarcity.”

Clearly, there is an urgent need for water conservation and demand management interventions in order to prevent the forecasted physical water scarcity by the year 2025 (National Water Resource Strategy 2nd, 2013). Consequently, such interventions must effectively reduce physical losses in water networks; artificial demand at the end-user level created through leakages, apparent losses, water wastage, illegal connections and lack of water reuse.

McKenzie (2014: 2) argues that *“there is no single water demand management intervention that will always provide the best savings at the least cost. Every water-supply system is unique in some way and will have its own specific problems that set it apart from other systems”*.

In 2013, the Department of Water and Sanitation approved a Water Conservation and Water Demand Management (WC and WDM) Strategy, which aims to promote water use efficiency and is consistent with the National Water Act (Act 36 of 1998), which emphasises effective management of water resources. The objectives of the WC and WDM Strategy are summarised in Table 2.1.

Table 2.1: Department of Water and Sanitation Water Conservation and Water Demand Management Strategy, 2013

Objective	Description
Objective 1	To facilitate and ensure the role of WC/WDM in achieving sustainable, efficient and affordable management of water resources and water services
Objective 2	To contribute to the protection of the environment, ecology and water resources
Objective 3	To create a culture of WC/WDM within all water management and water services institutions
Objective 4	To create a culture of WC/WDM for all consumers and users
Objective 5	To support water management and water services institutions to implement WC/WDM
Objective 6	To promote the allocation of adequate capacity and resources by water institutions for WC/WDM
Objective 7	To enable water management and water services institutions to adopt integrated planning
Objective 8	To promote international co-operation and participate with other Southern African countries, particularly basin-sharing countries, in developing joint WC/WDM strategies

Similarly, the National Water Resources Strategy 2nd focuses on equitable and sustainable access and use of water by all South Africans while sustaining the water resource. Equity and redistribution can be achieved through the authorisation process and other mechanisms and programmes such as water allocation reform, financial support to emerging farmers and support to urban and rural local economic development initiatives (Department of Water and Sanitation, National Water Resource Strategy 2nd, 2013).

In this regard, Rabe *et al.* (2012: 4) emphasised that many authorities throughout the world are increasingly focusing on water use efficiency, water loss and water demand management. The implementation of water conservation and demand management interventions offer a viable option for municipalities and water services providers to create required efficiencies among existing users. This also ensures that there is capacity for new water users and demand is minimised as far as possible. Where there is a limited supply of available surface water, water demand management represents an effective strategy for creating efficiencies using the resource more effectively as well as avoiding water wastage and water loss. This allows for the extension of supply to new consumers (Rabe *et al.*, 2012: 4).

Water demand management is even more important in highly industrialised cities where the demand for water for production purposes is much higher compared to less industrialised cities. Industrialisation requires security of supply in terms of water and energy.

2.3 Water Sensitive Urban Design (WSUD)

Wong (2006) (cited in Armitage *et al.*, 2014) indicated that the term Water Sensitive Urban Design (WSUD) reflects a new paradigm shift in the planning and design of urban environments that are sensitive to the issues of water sustainability, environmental protection and preservation. WSUD can contribute to water conservation and water demand management in order to address water scarcity, environmental challenges and improve sustainable urban planning.

“Water Sensitive Urban Design has the potential to: mitigate the negative effects of water scarcity; manage and reverse water pollution; develop social and intergenerational equity; increase sustainability; and develop resilience within water systems in RSA. In particular, it could transform the extremely divided settlements that are so typical of the country into ones where water can be used to connect disparate communities and bring about significant change.” (Armitage et al., 2014: 2).

The term Water Sensitive Urban Design comprises two parts, which are, 'Water Sensitive' and 'Urban Design'. Accordingly, it brings 'sensitivity to water' in relation to urban design principles by ensuring that urban design takes into consideration the importance of water as part of urban design processes in order to ensure sustainable urban morphology. The integration of engineering and environmental sciences in WSUD is critical for the realisation of integrated urban water cycle management for sustainable water provision.

Armitage *et al.* (2014: 10) argued that the adoption of WSUD requires a proactive and holistic approach that is able to comprehend the consequences of such a transition and thereby to help overcome socio-economic barriers while simultaneously producing sustainable and equitable economic growth, and protecting scarce natural resources. Thus, creating a balance between economic growth and environmental protection is imperative. This balanced approach will ensure sustainable use of natural resources while progressively driving inclusive economic growth.

According to Armitage *et al.* (2014: 10), implementing WSUD in RSA requires consideration of a number of issues such as those listed below.

- a) **Institutional structures:** Fragmented organisational structures at municipal level create silo-management of different aspects of the urban water cycle. Different

departments deal with different aspects of water management and generally there is no point of integration, resulting in poor communication and lack of coherent approach. WSUD requires integrated and coherent institutional arrangements for effective implementation and impact.

- b) **Champions:** WSUD cannot succeed without the appointment of strategic champions within the organisation to lead in ensuring that the principles and approaches to WSUD are embedded in the planning processes and operations of the organisation. It is important for these champions to occupy positions of authority in order to effectively manage and champion WSUD, including driving and mobilising support of key stakeholders. Ongoing interface with key stakeholders inside and outside the organisation is vital for the success of WSUD.
- c) **Equity:** Addressing past imbalances, the legacy of apartheid in terms of service delivery, and the creation of sustainable communities are important for WSUD to succeed. It is practically impossible to introduce initiatives such as WSUD when there are still challenges in the delivery of basic services to the previously disadvantaged communities. The issues of access, equity and ownership remain a challenge for government to address so that an environment that is conducive is created for WSUD to be successful and have impact.
- d) **Health aspects:** Potential health risks must be taken into account, particularly in respect of the creation of different pathways (mainly waterborne) for spreading disease. WSUD cannot be implemented in isolation without consideration of potential waterborne health risks. This further emphasises the importance of an integrated and coherent approach.
- e) **Adaptability and uncertainty:** Technical capacity and skills constraints at various levels of government remain serious challenges. Uncertainties relating to the impacts of climate change, politics, demographics and resulting water demand patterns also result in policy makers being risk-averse. Implementation of climate change adaptation initiatives across all spheres of government will provide certainty and necessary mitigations.
- f) **Mitigation:** South Africa needs to manage its environmental impacts, particularly in terms of CO₂ outputs resulting from energy usage (i.e. adopting WSUD to avoid desalination). The use of coal powered stations for the generation of power is still a

serious threat to the environment. South Africa has to strike a balance between its industrialisation ambitions and environmental protection.

- g) **Ecosystem Goods and Services (EGS):** While the economic valuation of ecosystem services is recognised worldwide as a means of motivating for the adoption of the WSUD approach, it is unlikely to have as much impact in South Africa, given the widespread poverty and inequality in the country.

2.3.1 Water Sensitive Urban Design (WSUD) principles

According to Armitage *et al.* (2014: 19), the WSUD principles can be summarised as follows.

- **Sustainable water supply:** Sustainable water supply focuses on water conservation, demand management, alternative water sources such as rainwater/stormwater harvesting, ground water and aquifer storage.
- **Wastewater minimisations:** Wastewater minimisation, as a process of limiting wastewater disposal, focuses on water recycling, use of treated wastewater, quality improvement, greywater recycling and industrial effluent reuse.
- **Stormwater management:** Sustainable stormwater management requires sustainable urban drainage systems (SuDS), use of nature and the environment, enhancement of amenity and biodiversity, urban management and urban planning.
- **Blue-green infrastructure:** Blue-green infrastructure promotes green buildings programmes, sustainable infrastructure development, institutional capacity and the creation of social capital in support of water sensitive urban design.

Accordingly, Armitage *et al.* (2014: 20) emphasised that the integration of Water Sensitive Design (WSUD), Water Sensitive Urban Planning (WSUP) and Water Sensitive Urban Management (WSUM) is critical for the achievement of Water Sensitive Settlements (WSS).

These three components are explained in detail below.

- **Water Sensitive Urban Design (WSUD):** WSUD connects the concepts of water sensitivity and urban design together thus ensuring that urban design is undertaken in a water sensitive manner. In this regard, the urban design process of giving form, shape and character to groups of buildings, neighbourhoods and the city takes into consideration the importance of water management.
- **Water Sensitive Urban Planning (WSUP):** WSUP focuses on urban planning and governance principles which recognise the importance of water sensitive urban

planning. In the context of current water and environmental crises, water planning needs to be undertaken at the highest level. The term WSUP brings together two components, namely: Water Sensitive and Urban Planning thus ensuring that the process of development and use of land, planning permission, protection and use of the environment, and the design of the urban environment take into consideration the treatment of water sensitively.

- **Water Sensitive Urban Management (WSUM):** Urban management seeks to redress all the malfunctions that may occur in the use of public and private environments, causing potential threat to the quality of life, liveability and making the city less attractive to investment (competitiveness). Adequate management of the urban environment post-construction is vital. Sustainable urban management should be implemented in a manner that is sensitive to the ecosystem and to the needs of affected individuals.

Figure 2.1 depicts the integration of WSUD, WSUP and WSUM towards WSS.

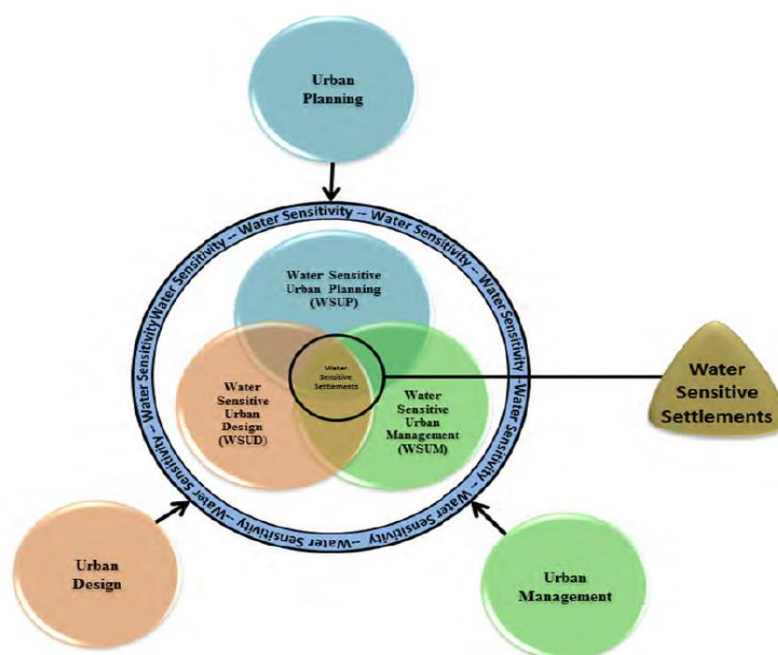


Figure 2.1: The integration of WSUD, WSUP and WSUM towards WSS
(Adapted from Armitage *et al.*, 2014)

2.3.2 Ecologically sustainable development

Armitage *et al.* (2014) argued that all aspects of the water cycle and their interaction with urban design must be considered and that WSUD aims to be the medium through which

sustainable development can be achieved. It should be noted, however, that in order to achieve Ecologically Sustainable Development (ESD), it is critical that WSUD is set as an over-arching planning process, encompassing the desired environmental preservation and ESD objectives upfront (Armitage *et al.*, 2014).

WSUD as a multi-disciplined approach to urban water management should consider various aspects of environmental, social and economic consequences of water management infrastructure in order to ensure sustainability of design and interventions (Wong & Eddie, 2000 cited in Armitage *et al.*, 2014).

Figure 2.2 depicts interactions between WSUD, the built environment, and the urban water cycle.

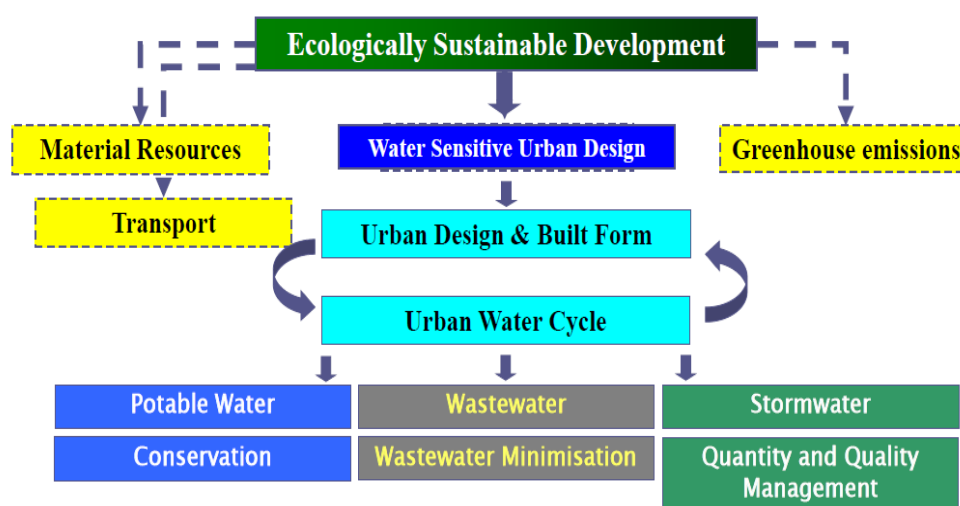


Figure 2.2: Interactions between WSUD, the built environment and the urban water cycle
(Adapted from Hoban & Wong, 2006)

2.3.3 Building community of practice for water sensitive strategy

According to Carden (2015: 5), developing a strategy in terms of water sensitivity is core to the future sustainability of water resources because water is a fundamental enabler of all life and primary catalyst for human development. Increasing urbanisation and extension of services to underserved areas provide an opportunity to plan and manage water differently.

In this regard, a water sensitive strategy should be linked to WSUD as it integrates water cycle management with the present built environment through urban planning, urban design

and urban management. This provides multiple benefits and opportunities to overcome the challenges of water management. WSUD can help with the following:

- Building flexibility and adaptability into city water sources as well as water supply catchments;
- Building flexibility and adaptability into sanitation ensuring healthy cities;
- Blue-green infrastructure with cities providing ecosystem services;
- Building social and institutional capital in cities supporting water educated communities (Carden, 2015: 6).

Carden (2015: 6) emphasised that better urban water management provides the core for multi-value, multifunctional urban spaces fit to cope with future challenges, and that building a community of practice aims to create strategic learning alliances so that stakeholders can engage in collective sense-making and vision-building, while placing strong emphasis on community participation and the creation of social capital and human development.

Carden (2015: 17) explained that:

“The development and management of a Water Sensitive Design Community of Practice programme aims to strengthen the researcher/stakeholder and the implementer interface. This would assist in leveraging partnerships and facilitate, manage and document technology, thus transferring opportunities from the planning and design phases through to the piloting (adapting) and implementation phases.”

The author proposed the following strategies for community of practice.

- Enabling environment through social learning by empowering communities and community based solutions.
- Shared interest, joint activities and discussion in order to create understanding and social capital for better community involvement.
- Enhanced generation of knowledge through collaborative learning processes, knowledge management and exchange.
- Adaptive management embedded in social learning processes by creating an environment that supports adaptation and systematic learning and growth.

2.4 Sustainable Urban Drainage Systems (SuDS)

Armitage *et al.* (2013: 1) emphasised that Sustainable Urban Drainage Systems (SuDS) are designed to reduce the potential impact of new and existing developments with respect to

surface water drainage discharges. In this regard, drainage systems can contribute to sustainable development and improve urban design by balancing the various issues influencing the development of communities, urban planning and water management. SuDS are designed to reduce water flow, use the natural environment to channel water and systematically slow water down before it enters streams, rivers and other watercourses, thus preventing environmental degradation and improving natural filtration.

In taking the above into consideration, SuDS need to be integrated into other water management systems for effectiveness and different options should be applied based on the nature of development and environmental considerations. SuDS should be an integral part of urban planning and design in order to promote integration.

Armitage *et al.* (2013:5) outlined the four components of a good SuDS treatment train as outlined below.

- I. **Good housekeeping** intervention point aims to ensure that the possible release of pollutants is prevented. The common pollutants include *inter alia*: litter, environmentally unfriendly fertiliser and pesticides. Interventions such as management of sedimentation, comprehensive public education and removal of particulates are critical in ensuring that pollutants are not transported by stormwater.
- II. **Source controls** intervention point involves management of stormwater runoff as close to its source as possible, preferably on site. The available options in this regard include green roofs, rainwater harvesting reuse soak ways and permeable pavements.
- III. **Local controls** intervention point involves localised management of stormwater runoff in a local area. Examples of area based stormwater runoff management include infiltration trenches, bio-retention, sand filters and swales. These can be managed in a controlled local environment.
- IV. **Regional controls** intervention point involves management of stormwater runoff from several sources and developments in a bigger area. Regional controls include options such as detention ponds, retention ponds and constructed wetlands.

Figure 2.3 summarises the SuDS treatment train.

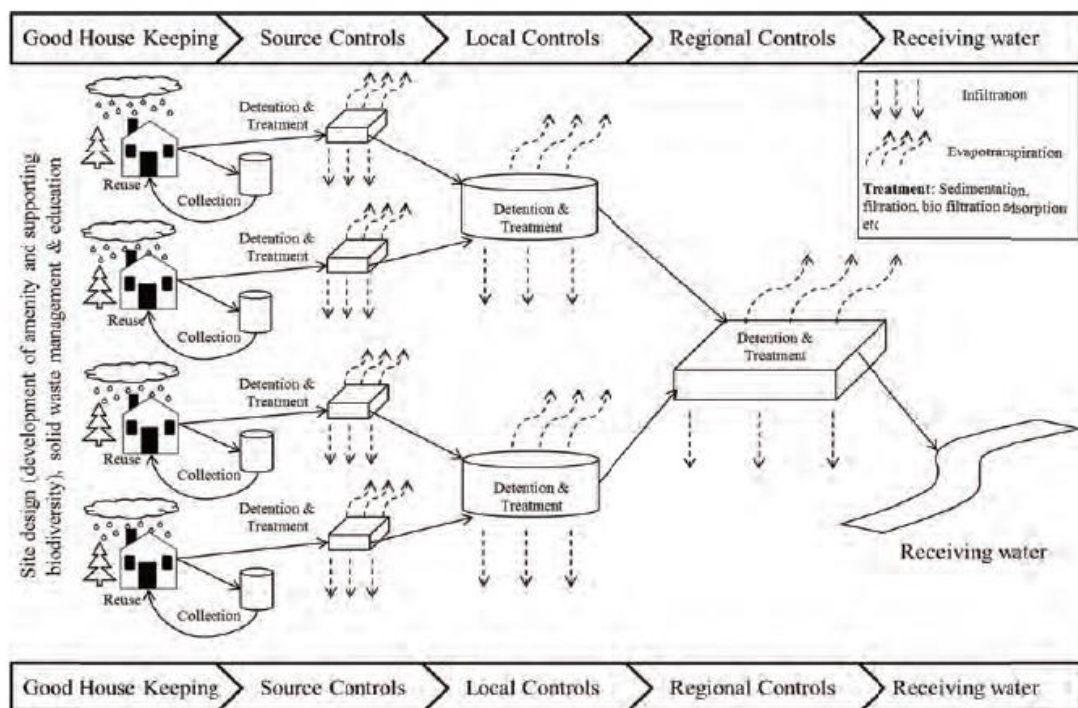


Figure 2.3: The SuDS Treatment Train
(Armitage *et al.*, 2013 adapted from Woods-Ballards *et al.*, 2007)

Figure 2.3 outlines the relationship between the four SuDS interventions starting with good housekeeping, source controls and local controls up to receiving water. These interventions have been explained above. To further illustrate different types of SuDS, Figures 2.4 to 2.7 adapted from Armitage *et al.* (2013) depict examples of SuDS:



Figure 2.4: Infiltration trench
(Adapted from Armitage *et al.*, 2013)



Figure 2.5: Bio-retention
(Adapted from Armitage *et al.*, 2013)



Figure 2.6: Green roof
(Adapted from Armitage *et al.*, 2013)



Figure 2.7: Retention pond
(Adapted from Armitage *et al.*, 2013)

Accordingly, SuDS offer a different mechanism to conventional drainage systems by ensuring that surface water drainage systems are managed in a sustainable and

environmentally sensitive manner. SuDS promote more natural and sustainable drainage systems by:

1. Managing runoff volumes through systematic infiltration and retention;
2. Protecting and enhancing water quality to reduce contamination;
3. Protecting natural flow of water using natural solutions;
4. Promoting environmentally sensitive drainage that takes the environment into consideration;
5. Providing attractive habitat for wildlife through systematic water retention;
6. Encouraging natural ground water as a result of natural infiltration;
7. Creating better places for mixed use - live, work and play.

2.5 The Concept of Real Loss

The City of uMhlathuze Five Year Strategic Management Plan for Water Conservation (2012) identified that almost every water distribution system in the world incurs losses through leakages. Clearly, those leaks have been present since the systems were first installed or constructed. Leakage losses cannot be completely avoided although they can be managed to remain within economic limits. To control real or physical losses it is important to understand and systematically manage the components making up real losses. Real losses are made up of mains leaks, service connection leaks and reservoir overflows. The first two typically make up the greatest volume of losses and are the basis for determining the Unavoidable Annual Real Losses (UARL). Minimising these loss components form the basis for determining the economic level of leakage for a water distribution system.

The four-component approach to controlling real losses has been developed as a template for water system operators to maintain economically low leakage levels over a medium-to-long-term period. The core of Figure 2.8 shows that in any system a certain amount of recoverable leakage will incur. However, this can be reduced to its economic value with the proper combination of the four leakage controls namely: pressure management; speed and quality of repairs; active leakage control; and pipe replacement (City of uMhlathuze 5 Year Strategic Management Framework for WC and WDM, 2012).

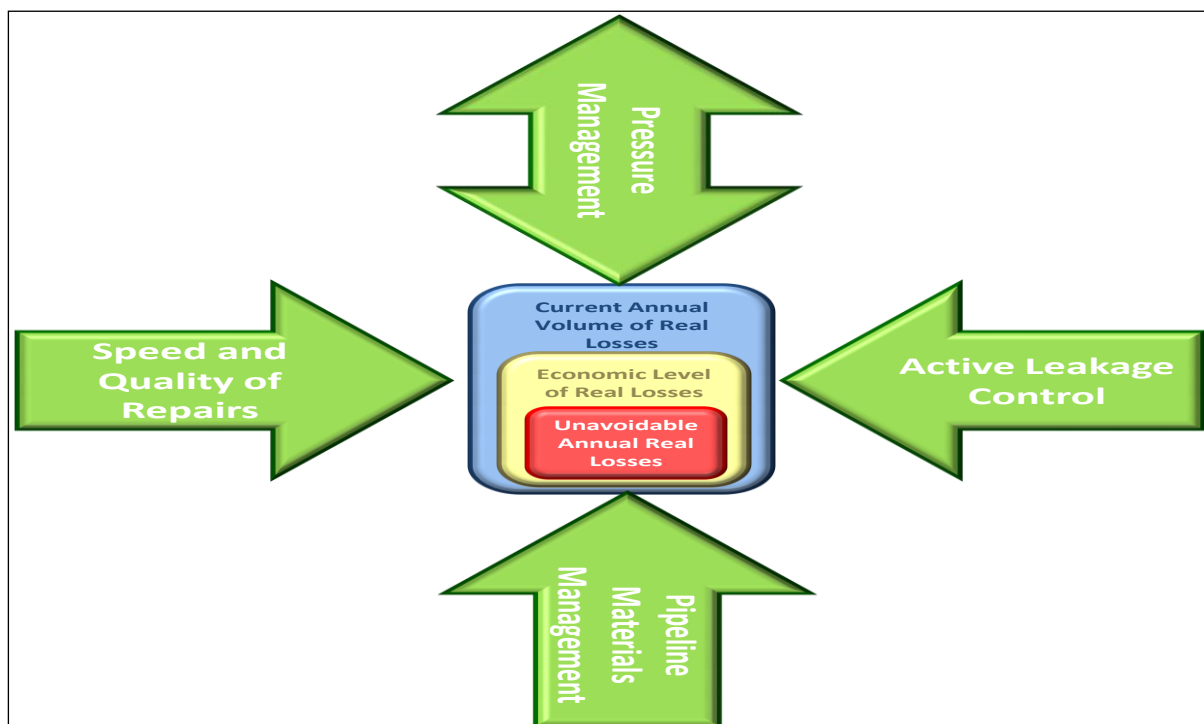


Figure 2.8: Four component approach to the control of real losses: City of uMhlathuze Five Year Strategic Management Plan for Water Conservation, 2012
(Adapted from McKenzie, 2014)

2.6 Water Management Legislative and Policy Framework in South Africa

According to Rabe *et al.* (2012: 3), the world’s freshwater supply faces challenges relating to quality, quantity and potential conflict over shared international water resources. Potential water related conflicts are fuelled by shared water resources among different countries, such as the existing Nile River conflicts. Again, increasing population growth, together with accelerated economic development, urbanisation and industrialisation are resulting not only in increased water demand, but an upsurge in return flows, pollution loads and solid waste. This places ever increasing pressure on limited freshwater resources (Rabe *et al.*, 2012).

In light of this challenge, the South African Government introduced a number of legislative and policy frameworks aimed at responsible management of freshwater as a scarce resource. These are discussed hereunder:

2.6.1 National Services Act

The Water Services Act, 108 of 1997 stipulates that all spheres of government must provide water supply services in an efficient, equitable and sustainable manner. The Act also requires municipalities that have been given water services provider status to provide

measures to promote water conservation and demand management. Such activity should be included in the municipalities WC and WDM Strategy and Business Plan as well as the Water Services Development Plan (WSDP).

Clause 2 (j) states that one of the main objectives of the Act is *“the promotion of effective water resource management and conservation”*. Clause 4 (2) states one of the conditions set for the water services provider (c) (vi) *“must provide for measures to promote water conservation and water demand management”*.

Clause 11 specifies that the duty of water service authorities is to provide access to water services (1),

“every water services authority has a duty to all consumers or potential consumers in its area of jurisdiction to progressively ensure efficient, affordable, economical and sustainable access to water services”.

It specifies that this duty is subject to the duty to conserve water resources. Clause 13 specifies the contents of a draft water services development plan and clause (j) specifies the following: water services development plan must contain details *“of existing and proposed water conservation, recycling and environmental protection measures”*.

2.6.2 Water Services Act Regulations

The water services regulations emanating from the Water Services Act, 108 of 1997 reiterate the importance of water conservation and water demand management by stipulating the following:

- Clause 10 (1) - a water services authority must include a water services audit in its Annual Report on the implementation of its water services development plan required in terms of section 18 (1) of the Act;
- Clause 11 (1) - within two years of the promulgation of these regulations, a Water Services institution must every month *“determine the quantity of unaccounted for water”*;
- Clause 12 - a water services institution must repair any major, visible or reported leak in its water services system within 48 hours of becoming aware thereof;
- Clause 13 - a water services institution must within two years...*“fit a suitable water volume measuring device or volume controlling device to all user connections provided with water supply services that are existing at the time of commencement of these regulations”*;

- Clause 15 – a water services institution must design and maintain every water reticulation system installed after promulgation of these regulations to operate below a maximum.

The abovementioned clauses further illustrate the importance of institutionalisation and implementation of water conservation and water demand management by regulating various aspects of WC and WDM.

2.6.3 National Water Resource Strategy 2nd (NWRS2)

National Water Resource Strategy 2nd (2013) sets out how the country will achieve the following core objectives:

- Water that supports development and elimination of poverty and inequality;
- Water that contributes to the economy and job creation; and
- Water that is protected, used, developed, conserved, managed and controlled sustainably and equitably.

The major focus of the NWRS2 is equitable and sustainable access to and use of water by all South Africans while sustaining our water resource. Equity and redistribution will be achieved through the authorisation process and other mechanisms and programmes such as water allocation reform, financial support to emerging farmers and support to urban and rural local economic development initiatives.

The NWRS states that with growing population, and focus on economic growth and development, there is a need to ensure water security and healthy water ecosystems able to support national imperatives. Apart from the water demands of the economic sectors – energy, mining and agriculture, increasing urbanisation and industrialisation put enormous pressure on scarce water resources in terms of management and allocation (National Water Resource Strategy 2nd, 2013).

Despite well-developed water resources infrastructure with more than 4,395 registered dams, South Africa is rapidly approaching full utilisation of available surface water yields (National Water Resource Strategy 2nd, 2013). There is a need to find new ways of reducing water demand and increasing availability, and such innovative measures will have to move beyond traditional engineering solutions of infrastructure development (National Water Resource Strategy 2nd, 2013).

As a consequence, future water resource planning, management and investment require prioritisation of key interventions such as, *inter alia*:

- greater focus on WC and WDM initiatives where every drop counts and waste of water is reduced;
- increased research, investment and utilisation of ground water;
- prioritisation of wastewater reuse;
- investment in more storage systems such as dams, where opportunity exists;
- investment in desalination of seawater as an alternative source of water and this can include small scale plants;
- treatment of mine water, especially in former and current mining areas; and
- prioritisation of catchment rehabilitation, clearing of invasive alien plants and rainwater harvesting.

2.7 Water Conservation and Water Demand Management Practices and Solutions

Cook *et al.* (2009) (cited in Fry, 2015) described water demand management (WDM) as a process or use of technology to promote the efficient and sustainable use of water. Cook (2009) argues that WDM is the most cost effective method of making more water available while reducing the growth rate of water demand. This could play a crucial role in decreasing the need for large scale investments in the future.

As clearly explained in the Water Conservation and Water Demand Management Strategy (2004), water remains a precious resource needing to be utilised efficiently and sustainably before any consideration of new water resource development. The opportunities to increase water use efficiency are available across all water use sectors and require strong will and leadership.

Fry (2015: 8) stated that: *“water conservation focuses on minimising the percentage of water supply lost through poor maintenance, which leads to burst pipes and leakages, illegal connections and lack of end use efficiency”*

Accordingly, the following are some of the key interventions that can be considered as part of water conservation and demand management solutions:

2.7.1 Water pressure management

According to McKenzie (2014: 9), water pressure management remains one of the most important WDM interventions needing to be considered when attempting to drive down water losses and improve the success of WDM interventions. McKenzie (2014: 9) stated that:

“Leakage is driven by pressure and, while it must be acknowledged pressure management is not the answer in every case, it is often one of the most cost-effective measures to reduce leakage and wastage”.

Figure 2.9 illustrates a typical pressure management system during peak periods.

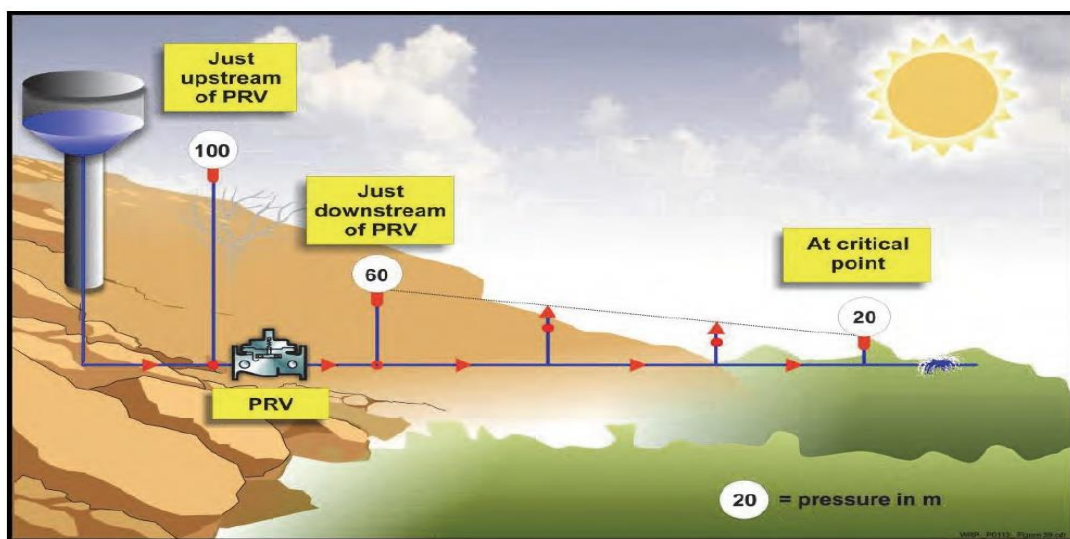


Figure 2.9: Typical pressure during peak demand periods
(Adapted from McKenzie, 2014)

As shown in Figure 2.9, it is assumed that a minimum pressure of 20m is required and most systems are designed to provide a certain minimum level of service during the peak demand period so that if the water pressure in a system can be reduced, for even a short period during times of low demand, the water leakage from the system will be reduced (McKenzie, 2014: 11).

Figure 2.10 illustrates the difference between a leak running at low pressure and high pressure.

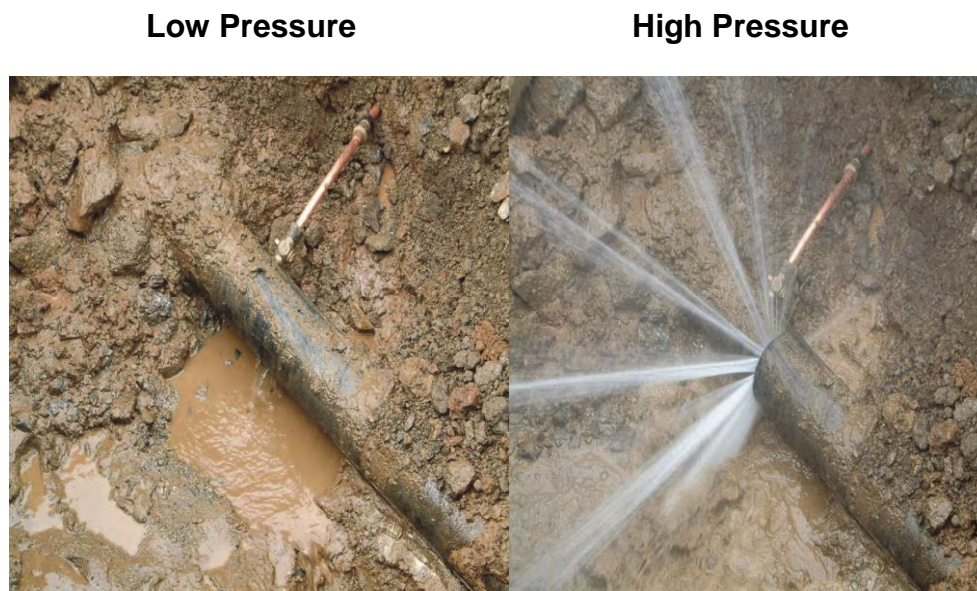


Figure 2.10: Underground leak at low and high pressure
(McKenzie, 2014 adapted from Ken Brothers)

Again, McKenzie (2014: 9) argued that many municipal water supply systems in South Africa are operated at unusually high pressures. Thus, pressure management is often one of the most important WDM interventions that can be quickly implemented in order to reduce unnecessary pipe bursts and leakages.

McKenzie (2014:10) further stated that:

“water supply systems are generally designed to provide water to consumers at an agreed level of service. This is often defined as the minimum level of pressure at a critical point.”

Notwithstanding this minimum level of pressure, leakages in the system are still caused by pressure. In this regard, the higher the pressure, the higher the possibility of leakages and the lower the pressure the lower the possibility of leakages. When pressure is systematically reduced, water leakages from the system are correspondingly reduced. It is imperative, therefore, to maintain an acceptable level of pressure in order to protect the system from leakages as a result of pressure.

To this end, reducing water pressure can be achieved in a number of ways, such as those listed below:

- **Fixed outlet pressure control** involving the use of a device – a pressure reducing valve (PRV) – to control the maximum pressure entering a zone (McKenzie, 2014: 146).
- **Time modulated pressure control** - this device can provide a further reduction in pressure during off-peak periods. This form of pressure control is useful in areas where water pressures build up during the off-peak periods (McKenzie, 2014: 146).
- **Flow modulated pressure control** - provides flexibility and addresses any concerns regarding firefighting flow requirements because the controller will open up pressure if required to maintain the necessary system pressure to support increased flow (McKenzie, 2014: 146).
- **Closed loop and hybrid control** - provides a pressure sensor at the critical point used to monitor water pressure. This provides some form of feedback to the controller at pre-defined intervals. In some instances, it will record a full day of pressure information before transmitting the data to the controller, who will then adjust the pressure profile for the following day (McKenzie, 2014: 146)



Figure 2.11: Examples of water pressure management system in the City of Cape Town

(Adapted from Integrated Urban Water Management CIV507Z, 2015)

2.7.2 Water conservation

According to the National Water Resource Strategy 2nd (2013), water conservation is the minimisation of loss or waste, care and protection of water resources and the efficient and effective use of water, whereas WDM is the adaptation and implementation of a strategy by a water institution or consumer to influence the water demand and usage of water. Consequently, water conservation initiatives should aim to reduce usage of water and recycling of wastewater for different purposes, like domestic usage, agriculture, industries

and businesses. According to the United Nations Environmental Programme (2009), the main goals of water conservation include the following:

- a) **Habitat Conservation:** the aim of habitat conservation is to minimise human water use by helping to preserve freshwater habitats as well as reducing the need to build new dams and other water infrastructure.
- b) **Energy Conservation:** the aim of energy conservation is to reduce the high demand for energy that is devoted to water management in terms of water pumping, delivery, and wastewater treatment facilities.
- c) **Sustainability:** the sustainability approach aims to ensure availability of water for future generations by ensuring that the withdrawal of fresh water from an ecosystem should not exceed its natural replacement rate.

2.7.3 Treated effluent and wastewater reuse

The reuse of treated wastewater effluent is the using of effluent from wastewater treatment plants. This effluent, which is treated wastewater from a sewage treatment works, can be treated to a water quality that is acceptable for use such as the irrigation of golf courses and sports grounds and for industrial purposes such as cooling towers and electricity generation (Rabe *et al.*, 2012: 61). According to the United Nations (2017), some of the general reasons for reuse of treated effluent are those outlined below.

- Limited natural resources can be protected, thus lowering the water demand footprint.
- Prevent current and future potable water shortages by utilising an alternative water source instead of the normal “blue” water or potable water.
- Return streams to seasonal flow conditions meaning the return of unconsumed water.
- Prevent the pollution of the receiving waters.
- Prevent potential health and environmental challenges.
- Irrigation with treated effluent is not limited during water restrictions and can therefore be applied as part of water conservation.

According to Fry (2015:12), the earth’s water is naturally being reused within the ‘water cycle’. This includes conventional methods of wastewater management such as wastewater being pumped away to wastewater treatment facilities where it is processed before being discharged into waterways. Armitage *et al.* 2014 (cited in Fry, 2015) argued that water sensitive urban design shifts the perception of wastewater as spoilage into a usable resource. Wastewater can be treated and directly reused or discharged into the water cycle, therefore indirectly being reused.

Water reuse may include effluent from a treatment works which can be discharged into the water cycle. Fry (2015: 12) stated that:

“Water reuse can be a completely decentralised system that operates on a household scale or it can be a centralised model where one Wastewater Treatment Works services an entire settlement.”

According to the United Nations World Water Development Report (2017), freshwater withdrawals, global consumption and wastewater production by major water use sector are as shown in Figure 2.12.

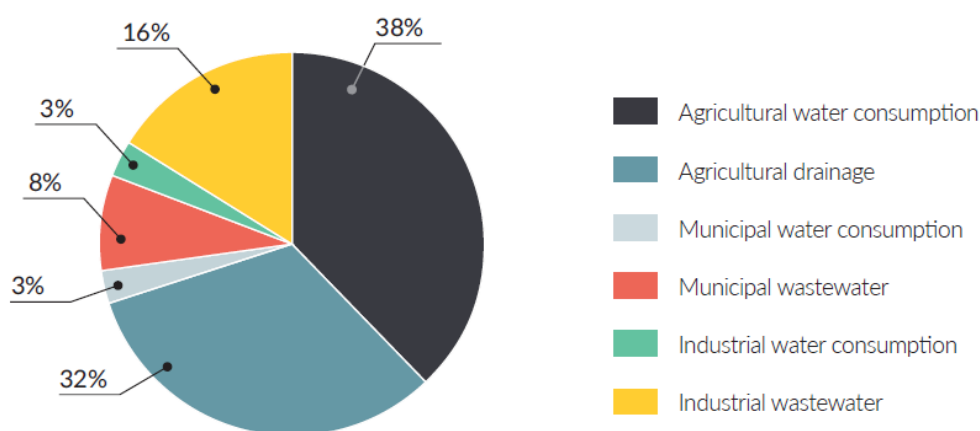


Figure 2.12: United Nations World Water Development Report 2017
 (Source: Based on data from AQUASTAT (n.d.a.); Mateo-Sagasta *et al.* (2015); and Shiklomanov (1999). Contributed by Sara MarjaniZadeh (FAO))

The AQUASTAT database of the Food and Agriculture Organization of the United Nations (FAO) estimates global freshwater withdrawals at 3,928 km³ per year. An estimated 44% (1,716 km³ per year) of this water is consumed, mainly by agriculture through evaporation in irrigated cropland. The remaining 56% (2,212 km³ per year) is released into the environment as wastewater in the form of municipal and industrial effluent and agricultural drainage water (refer to Figure 2.12) (United Nations, 2017). It is estimated that globally, over 80% of wastewater is released into the environment without adequate treatment.

The United Nations (UN) (2017) warned that continuing ‘business as usual’ means allowing overwhelming neglect to worsen, with severe environmental impact. The consequences are alarming. Water pollution is worsening in most rivers across Africa, Asia and Latin America. In 2012, over 800,000 deaths worldwide were caused by contaminated drinking water, inadequate hand washing facilities and inappropriate sanitation services. In the seas and ocean, de-oxygenated dead zones caused by the discharge of untreated wastewater are

growing rapidly, affecting an estimated 245,000 km² of marine ecosystems, impacting on fisheries, livelihoods and food chains (United Nations, 2017).

The 2017 World Water Development Report shows that improved wastewater management is as much about reducing pollution at the source, as removing contaminants from wastewater flows, reusing reclaimed water and recovering useful by-products. Together, these four actions generate social, environmental and economic benefits for all society, contributing to overall wellbeing and health, water and food security, and sustainable development (United Nations, 2017).

In the City of uMhlathuze, the Mhlathuze Water Board⁶ conducted a preliminary assessment on wastewater reclamation and reuse focusing on big consumers such as Mondi Felixton Paper Mill, Mondi Richards Bay, Hillside Aluminium Smelter, Bayside Aluminium, Foskor, Richards Bay Coal Terminal and Richards Bay Minerals. The findings of this preliminary assessment indicated that the Mhlathuze Bulk Effluent System handled on average 126 Ml/day of wastewater, which was discharged to the sea and industrial wastewater constituted a high proportion of this wastewater (Mhlathuze Water Board, 2001).

Table 2.2 summarises the findings of the preliminary assessment report in terms of effluent system.

⁶ Mhlathuze Water is a statutory water utility that was established in terms of section 176 of the Water Act (Act No.54 of 1956 and is deemed to be a Water Board in terms of the Water Services Act (Act No. 108 of 1997). Mhlathuze Water supplies water to the City of uMhlathuze and other municipalities in the Northern part of the KwaZulu Natal province (Mhlathuze Water, 2017)

Table 2.2: Summary of the current levels of wastewater discharge: Mhlathuze Water Board, 2001

Sources	Average discharge (Ml/day)	Proportion of total (%)
Mondi Felixton	7	5.6 %
Mondi Richards Bay	90	71.4 %
Nsezi WTP	1	0.8 %
Hillside Aluminium	1.5	1.2 %
Bayside Aluminium	1.5	1.2 %
Foscor	5	4.0 %
Alton macerator	10	7.9 %
Arboretum macerator	10	7.9 %
TOTAL	126	100 %

2.7.4 Rainwater and stormwater harvesting

According to Jacobs (2010) (cited in Viljoen, 2014: 26), rainwater harvesting involves the collection of rainwater from a capturing surface, usually the roof of a building and any other catchment designed to collect rainwater. The captured water is then stored and utilised for various uses such as irrigation, toilet flushing and car washing. Most rainwater systems are very simple and work according to the principle that as the water storage levels are drawn down due to use, they are filled up on the onset of rain (Jacobs, 2010, cited in Viljoen, 2014:26). The longevity of water storage depends on the use and storage capacity. In some instances, harvested water is used only when necessary due to water shortage and to supplement water from the traditional water supply system.

Again, Jacobs (2010) (cited in Viljoen, 2014:27) argued that the viability of rainwater harvesting systems might be drastically influenced by external factors such as rainfall patterns, climatic conditions and the end-users of the rainwater.

Viljoen (2014: 28) outlined the general advantages and benefits of rainwater as follows:

- mitigating floods and reducing pressures on water resources around urban areas;
- reduction of river stormwater inflows with the consequent reduction in river/stream bank soil erosion/stability;

- reduction of stormwater inflows into wetlands currently overflowed, causing a corrective function such as restoring flood retention/purification abilities;
- rainwater harvesting is able to assist in relieving pressure on other water sources by supplementing them;
- rainwater harvesting provides a water supply buffer for use in times of emergency or droughts (UNEP, 2009);
- ability to reduce urban flooding and lift the pressure of storm drainage;
- users of rainwater systems are usually the owners of the systems, and therefore are more likely to exercise water conservation methods;
- rainwater harvesting technologies are flexible and feasibly built to meet almost any consumer requirements;
- the construction, operation and maintenance of rainwater harvesting systems are not labour intensive; and
- downstream stormwater treatment devices potentially become more efficient by the reduction of the hydraulic load (Prins, 2012).

In the case of the City of uMhlathuze, the annual rainfall has been generally good over the past 39 years between 1978 and 2017 with the exception of nine years when the annual rainfall was below 1000mm. There appears to be a potential for rainwater harvesting due to generally good rain, but this would require more feasibility studies. Figure 2.13 shows rainfall data from 1978 to 2017 in the City of uMhlathuze.

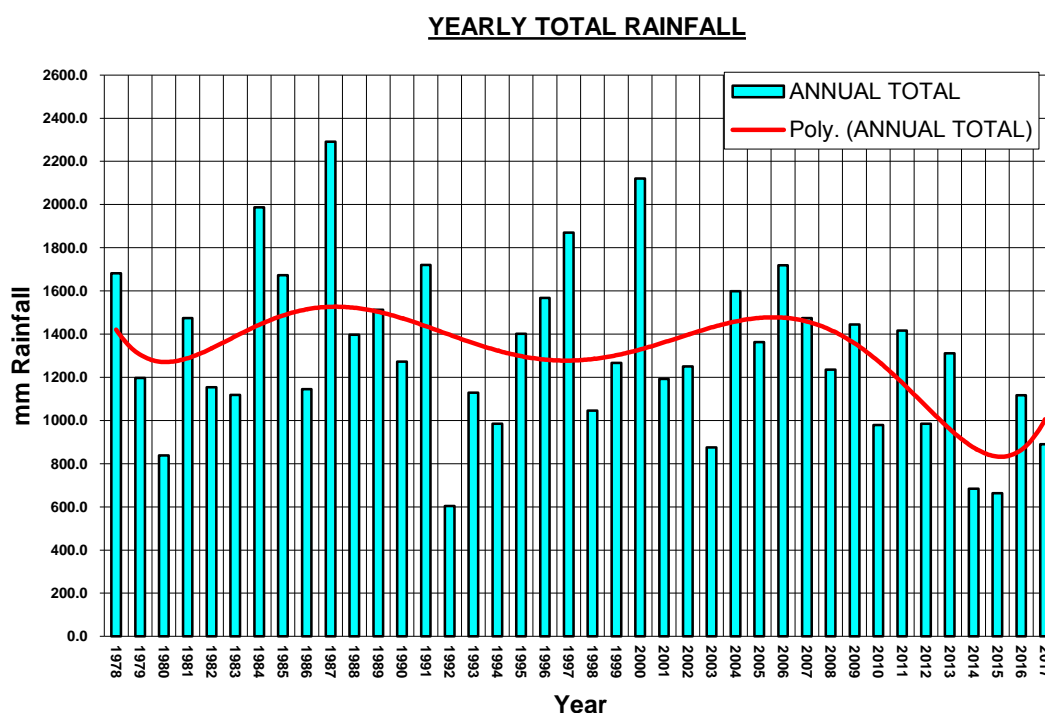


Figure 2.13: City of uMhlatuze yearly total rainfall from 1978 to 2017
(Source: South African Weather Service, 2017)

In terms of stormwater harvesting, Viljoen (2014: 28) further defined stormwater as rainwater which runs off all hard, impervious or pervious land surfaces such as pavements, footpaths, car parks, roads and open spaces. Stormwater can be captured for many non-potable purposes and to recharge existing natural systems such as ponds, lakes, wetland and rivers. As urban development increases, more roads, car parks, paving, compacted open spaces and other hard surfaces are appearing. Consequently, as part of city planning and development, it is therefore, important to develop appropriate systems and mechanisms to make it possible to harvest stormwater.

In this regard, during heavy rains the amount of water able to soak into the ground is reduced, so a higher surface runoff rate occurs. Prins 2012 (cited in Viljoen, 2014: 28) argued that there is a faster build-up and greater volume of stormwater runoff occurring in urban areas. This leads to severe flooding and related damage, as well as risk to human health.

Peter (2006) stated that:

“by harvesting stormwater, the detrimental impacts of urban stormwater runoff on rivers and natural ecosystems can be reduced. It can re-establish natural water system flow and habitat equilibrium, and improve water quality.” (Peters, 2006 *et al.*, cited in Viljoen, 2014).

According to Viljoen (2014: 29), stormwater harvesting has the following advantages/benefits:

- the offsetting of potable water for non-drinking outdoor purposes;
- the protection of natural systems;
- the protection of river/stream water quality, and
- the reduction of runoff and peak flows, thereby reducing flooding and flood damage (Peters, *et al.*, cited in Viljoen 2014: 29)

Viljoen (2014: 29) went further to state that harvesting stormwater can also delay the need for major new water resource infrastructure as more water can be systematically returned into the natural systems through well planned stormwater harvesting. The nature and extent of a stormwater management system in any municipality is critical in ensuring efficient stormwater harvesting. The harvesting of stormwater presents a unique opportunity for the municipalities as part of water conservation and demand management solutions mix.

2.7.5 Seawater desalination

Seawater desalination presents a possible option for water supply to supplement and diversify the country’s dwindling water resources largely reliant on natural sources. Seawater desalination can benefit communities along the coastal areas. In South Africa, the desalination industry is still at its infancy stage as an alternative source of drinking water and other uses.

Swartz (2006: 2) stipulated that *“thermal distillation systems account for the majority of the world’s seawater desalination capacity, while membrane based reverse osmosis systems are rapidly gaining ground”*. In the South African context, thermal desalination processes would normally not be considered for desalination of brackish or sea water unless sufficient waste heat or low cost fuels are available (Swartz, 2006).

According to Oveolia Water Solutions and Technology (2014), South Africa’s largest Desalination⁷ Plant is located in Mossel Bay. The plant has helped to secure Mossel Bay’s

⁷Desalination is considered to be a process whereby the concentrations of both multi-valent and mono-valent ions in saline water can be reduced to levels that are acceptable for potable use. In practice, dissolved salts and other matter are concentrated in a portion of the

future as PetroSA is able to maximise fuel production, although the environmental impact of fuel production is negative because of the toxic nature of this process. Notwithstanding this, Mossel Bay Desalination Plant continues contributing to the region's economy, while residents are ensured of high-quality water in their taps which is suitable for drinking, bathing, and irrigation. The plant provides additional water security to the region, along with the Wolwedans Dam, the Mossel Bay Municipality's main water supply (Oveolia Water Solutions and Technology, 2014).

Du Plessis *et al.* (2006: 2) outlined the following primary considerations for a desalination plant

i) Saline water source, energy source and process selection: Compared to conventional municipal water treatment, desalination processes are energy intensive. No assessment of a desalination process can be complete without proper understanding of the energy requirements and the available sources and cost of energy (e.g. residual steam, spent heat, electricity). The source of energy to be used, the required plant capacity and the feed water quality play a critical role in the selection of the most appropriate desalination process (Du Plessis *et al.*, 2006: 2).

ii) Fouling, scale formation and plant availability: Water (H₂O in its pure form) contains dissolved gases, dissolved and suspended inorganic solids, dissolved and suspended organic matter and suspended micro-organisms. During the desalination process, the concentration of these components can affect various forms of scale formation and other inhibitive contamination of the desalination equipment. Continuous scaling and/or fouling can be one of the most crippling side effects of desalination processes. A well-designed desalination plant always incorporates a well-designed and appropriate pre-treatment system to minimise fouling. A thorough knowledge of the feed-water chemistry and related seasonal variations is thus essential (Du Plessis *et al.*, 2006:2).

iii) Disposal of concentrate and environmental considerations: At first consideration, there is often a tendency to ignore the fact that the concentrate (which can be several times more saline than the feed, depending on the application) needs to be disposed of in an appropriate and environmentally friendly manner. Quite often

feed water (the brine, or concentrate) to render the remaining portion of the feed water (the desalinated product) less saline. Desalination rarely implies complete removal of dissolved salts (du Plessis *et al.*, 2006).

this is an unavoidable consequence of the desalination process, which can contribute to a major portion of the overall project cost (Du Plessis *et al.*, 2006: 3).

iv) Physical location of plant and cost of distribution: Augmentation of municipal water by desalination requires a sensible tie-in into established municipal water supply networks. The selection of an optimum location for a desalination plant in relation to its feed source and its tie-in point can sometimes be less clear-cut than expected. Incorrect positioning can contribute to significant additional capital and operating costs (Du Plessis *et al.*, 2006: 3).

v) Manufacturing specifications and plant life: Incorrect selection of materials of construction and inferior equipment can have serious adverse effects on both the maintenance costs and general operability and availability of the plant. Therefore, clear and unambiguous definitions of the minimum required plant life and construction specifications are essential to avoid plant failure and consequent overhaul after a few years of operation (Du Plessis *et al.*, 2006: 3).

2.7.6 Groundwater and recharge of aquifers

Another water source that is vital to many nations is groundwater. Statistics show that worldwide, some two billion people, including farmers and various industrial premises, rely on it for their water supply (Taylor *et al.*, 2010: 9). Over the past few decades, accelerated development has resulted in great social and economic benefits by the provision of low-cost, drought-reliable and (primarily) high quality water supplies, for both the urban and rural population and for irrigation of (potentially high-value) crops (Taylor *et al.*, 2010: 9).

In addition, Riemann *et al.* (2012: 445) stated that “*groundwater is not being perceived as an important water resource and therefore has been given limited attention in South Africa.*” This fact is reinforced in the general statistics which show clearly that only 13% of the nation’s total water supply originates from groundwater (Riemann *et al.*, 2012: 445). While towns in arid areas depend on groundwater, they make up only a small percentage of total water demand, hence the 13% referred to above.

Despite a growing number of municipalities using groundwater in the form of boreholes on a regular basis (especially during drought) and the fact that groundwater can be used sustainably on an ongoing basis with appropriate management systems, the notion that groundwater is not a sustainable resource for bulk domestic supply, still remains.

Sustainable groundwater use requires aquifer protection, which includes all activities to protect the aquifer from deterioration in water quality and reduction in aquifer recharge, and to rehabilitate an aquifer with respect to its water quality, irrespective of whether the aquifer is utilised or not. The use of groundwater and aquifer protection should be a priority for municipalities in order to diversify potential water sources (Riemann *et al.*, 2012: 446).

2.7.7 Pipe replacement and repair

According to McKenzie (2014: 23), it is considered illogical that council officials often debate at length over a budget allocation of a few thousand rand when a water leak will run unattended for weeks, if not months and which can easily run up a bill of hundreds of thousands of rand. The author further stated that *“many municipalities struggle to appreciate the necessity and benefits of dealing with water losses in their reticulation systems.”*

McKenzie (2014:8) further argued that the decision regarding when to repair or replace a pipe remains a conundrum for many municipalities in the absence of efficient pipe assessment systems and asset management systems in general. Many municipalities still do not have appropriate and accurate databases of their underground infrastructure, and at some point in the life of a pipeline, the repair of the pipe becomes impractical and the only solution is either to reline or replace the pipe (McKenzie, 2014:8). Pipe replacement remains a critical component of water conservation and water demand management. McKenzie (2014: 23) examined eThekweni and Tshwane Metros case studies on pipe replacement and repair as explained below.

1) eThekweni Metro

The eThekweni Metro opted for what is called a “blanket replacement” approach where all pipes of a certain age and/or type were systematically replaced. In this case, the decision was to replace all asbestos cement pipes in the network irrespective of whether or not there were faults identified, as the intention was to remove all asbestos pipes from the water system. This massive project involving pipe replacement of mains was undertaken at an estimated cost of R1 billion (McKenzie, 2014: 23).

2) Tshwane Metro

In terms of Tshwane Metro, they opted for an incremental and systematic approach in which certain types and age of pipes were replaced according to the incidence of burst pipes recorded and monitored by the municipality over a specific period of time, using the municipality’s management information system. Consequently, this approach involved the replacement of pipes as they deteriorate to a level where the occurrence

of new leaks becomes so high that the pipes were effectively no longer conducive for use (McKenzie, 2014: 23).

McKenzie (2014: 24) went on to explain that both of the aforementioned approaches are supported depending on the circumstances facing each municipality as well as the financial resources to be invested. Pipe replacement is an integral part of water conservation and demand management solutions.



Figure 2.14: Examples of pipe loss of physical integrity
(Adapted from Armitage, 2015)

2.7.8 Leak detection and repair

One of the major interventions in water conservation and demand management is a leak detection programme aimed at identifying visible and invisible leaks along the water network. However, the implementation of this programme should be supported by and linked to water pressure management in order to reduce the frequency of burst pipes and leaks due to high water pressure. The normal standard across most municipalities is to repair visible and reported leaks preferably within 24 hours of them being reported (McKenzie, 2014: 8). This is without doubt the most critical and basic intervention which should be expedited and prioritised.

McKenzie (2014: 8) emphasised that if the municipality expects its customers to save water, repair leaks and pay for services, it cannot allow leaks to prevail in its own infrastructure. The municipality is expected to lead by example by ensuring that visible leaks do not run for days without being repaired. McKenzie (2014: 8) goes further to state that:

“if an area is known to have high leakage (the area will have high minimum night flow) and the network is known to be in a poor condition, it may be worthwhile and cost effective to send in a team of leak locators to identify unreported leaks.”

Early detection of leaks assists in saving water and ensures that leaks are repaired on time. It is expected that the municipality should have both proactive and reactive systems to identify possible leaks along the water network system. Figure 2.15 illustrates a leak detection mechanism using sounding equipment.

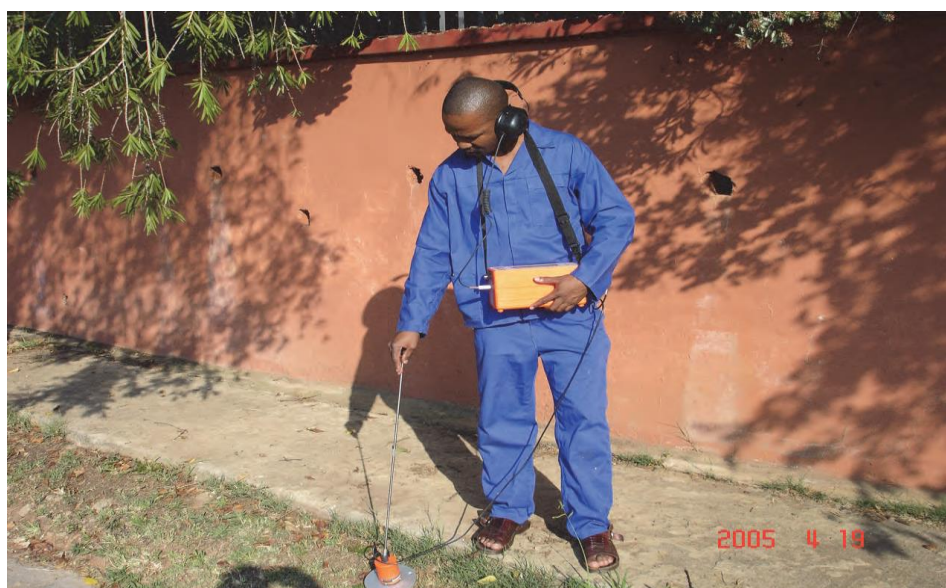


Figure 2.15: Leak detection using sounding equipment
(Adapted from McKenzie, 2014, photo taken in 2005)

Spending time searching for unreported leaks, in particular underground leaks, using leak detection equipment is referred to as active leakage control (ALC) and is important for proactive identification of invisible leaks that may be contributing to water losses. This process also assists the municipality in updating the infrastructure maintenance plans.

2.7.9 Greywater reuse

Greywater is wastewater that is discharged from a house, excluding blackwater (toilet water) and includes water from showers, bathtubs, sinks, kitchen, dishwashers, laundry tubs and washing machines. It commonly contains soap, shampoo, toothpaste, food scraps, cooking oils, detergents and hair, and is usually excluded for purposes of reuse.

Using greywater sustainably for irrigation in small-scale agriculture and in gardens is one possible way of alleviating water stress. Therefore, the main purpose of greywater recycling

is to substitute the precious drinking water in applications which do not require drinking water, quality. The recycling of greywater could assist with the reduction in fresh water consumption in particular as an alternative option for irrigation, car washing, industrial use and toilet flushing, albeit under strict management conditions.

Engelbrecht and Murphy (2006:2) indicated that greywater from the bathroom and from clothes washing has significantly lower levels of pathogens compared to sewage. Usually this water can be used without treatment for irrigation if it is managed efficiently with appropriate guidance.

Figure 2.16 summarises the major possible applications for treated greywater.

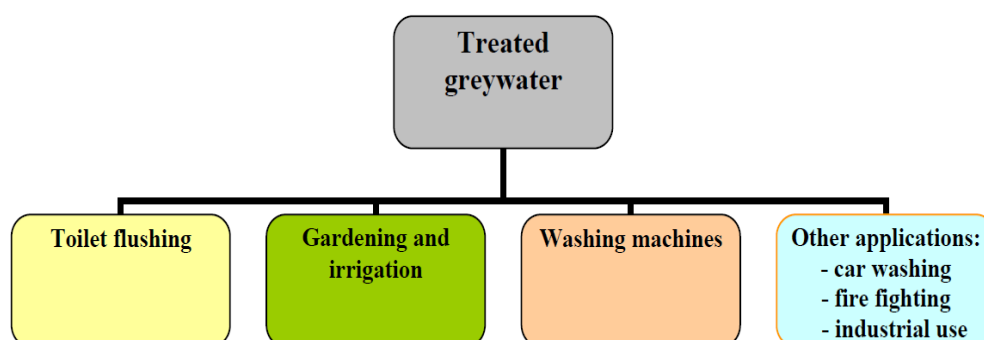


Figure 2.16: Major greywater reuse applications
(Adapted from Association of Rainwater Harvesting and Water Utilisation 2005)

In a South African context, Engelbrecht and Murphy (2006:3) argued that the quality of greywater varies depending on:

- the volume of supply water consumed per person in a household;
- the quality of the water supply; and
- the source of the greywater and the type of chemicals used in the washing/bathing process.

With regard to irrigation, the health risk linked to greywater relates to the microbial quality of greywater. In South Africa, the microbial quality of kitchen greywater is generally the poorest of the greywater sources. In terms of chemical quality, the least suitable greywater for irrigating sensitive crops and soils is laundry greywater, especially greywater from the first wash, mostly due to the high sodium concentrations and the high pH of laundry greywater. Greywater from the first laundry wash is also usually too hot for direct irrigation (Engelbrecht & Murphy, 2006: 4).

2.8 A Case Study of the Long-term Water Conservation and Water Demand Strategy (Cape Town)

The City of Cape Town is one of the leading cities in South Africa in implementing systems and strategies focusing on long-term water conservation and water demand management. In this regard, the City of Cape Town (COCT) (2013) has developed a long-term strategy, which can be used as a case study for any municipality looking at improving water conservation and water demand management. The availability of adequate water resources, as well as the related bulk water and wastewater infrastructure required to meet the city's growing water demand, is a limiting constraint to the social upliftment and economic prosperity of the city (City of Cape Town Water Conservation and Water Demand Management Strategy, 2013).

As early as 1995, the City of Cape Town committed itself to a 10% saving on the historical demand growth of 4% per annum. An Integrated Water Resource Planning (IWRP) study carried out in 2001 also indicated that various WC and WDM initiatives were the most feasible water augmentation options to meet the city's growing water demand. Therefore, the purpose of the WC and WDM strategy was to ensure the long-term balance between available water resources and water demand. It also provided the opportunity to postpone the need for expensive capital infrastructure projects for as long as it is economically viable, and to minimise water wastage (City of Cape Town WC and WDM Strategy, 2013). The City of Cape Town Strategy identifies the following targets set out in Table 2.3.

Table 2.3: COCT WC and WD strategy targets

Goal	Target	
A	Water Losses (unaccounted for water) < 15% by 2015/16	Quantitative
D	<ul style="list-style-type: none"> • Apparent Losses (Unbilled Unauthorised Consumption) • Real Losses NRW < 20%	Quantitative
	<ul style="list-style-type: none"> • Unbilled Authorised Consumption • Apparent Losses (Unbilled Unauthorised Consumption) • Real Losses 	
E	Demand Growth < 2 %	Quantitative
B	On-going effective management systems and implementation of IWRP	Qualitative
C	Mobilise resources according to the Water Conservation and Water Demand Management Strategy.	Qualitative

The above mentioned strategic goals have been the cornerstone of Cape Town’s strategy to ensure water conservation and water demand management.

The strategy update and addition document on the City of Cape Town water conservation indicates the critical aspects of water conservation and water demand management such as the reduction of water losses for unaccounted water by <15% and Non-Revenue Water (NRW) by <20%, and to maintain the demand growth at <2%. This includes effective management systems and the implementation of IWRP (City of Cape Town WC and WDM Strategy, 2013).

Accordingly, the following are ten attributes that have been adopted by the City of Cape Town, which can serve as a point of reference for the City of uMhlatuze.

1. **Product Quality:** This looks at the ability to meet the potable water quality.
2. **Customer Satisfaction:** This looks at the ability to provide basic services to all residents in the city, eradication of sanitation backlogs, provision of affordable service, meeting Service Charter standards, level of service and standard of service.
3. **Employee and Leadership Development:** This looks at the ability to develop and retain its employees and ensure high levels of motivation among employees.

4. **Operational Optimisation:** This attribute compels the city to review its business processes to ensure timely ongoing cost-effective, reliable and sustainable service provision in all its operations.
5. **Financial Viability:** The focus is to improve its collection ratios and ensure that the tariffs, charges or any levies are fully cost-recovering in nature.
6. **Infrastructure Stability:** This business attribute requires clear understanding of when to create and dispose of an asset, the condition of assets, lifecycle costs, the associated costs to be incurred in unlocking asset value to sustain the business.
7. **Operational Resilience:** This business focus area requires assurance of adequate risk management for its water and wastewater business.
8. **Community Sustainability:** This focus area ensures infrastructure investment-led job creation for communities.
9. **Water Resource Adequacy:** As it is, this business attribute focuses on the ability of the department to ensure security of water supply.
10. **Stakeholder Management:** This attribute requires the city to identify the representatives of various stakeholders and ensure adequate engagement on issues that affect them.

2.9 Department of Trade and Industry (DTI) Special Economic Zones driving Re-industrialisation in South Africa

According to the Department of Trade and Industry (2014), the South African Government, in an effort to reposition itself in the world economy, established the Industrial Development Zones (IDZ) programme. This programme's main focus is on attracting foreign direct investment and export value-added commodities.

The policy review and the new Special Economic Zone (SEZ) Programme, which began in 2007, was also brought about by developments in national economic policies and strategies. These included the National Industrial Policy Framework adopted in 2014, the Industrial Policy Action Plan adopted in 2015 and the New Growth Path adopted in 2011, as well as developments in the global economic environment such as the formation of Brazil, Russia, India, China and South Africa (BRICS) (DTI, 2014). The strategic intent of the IDZ is to provide a purpose-built industrial estate that leverages domestic and foreign fixed direct investment in value-added and export-oriented manufacturing industries and services.

The new SEZ policy provides a clear framework for development, operations and management of SEZs in order to:

- Expand the strategic industrialisation focus to cover diverse regional development needs and context;
- Provide a clear, predictable and systemic planning framework for the development of a wider array of SEZs to support industrial policy objectives, the Industrial Policy Action Plan (IPAP) and the New Growth Path (NGP);
- Clarify and strengthen governance arrangements, expand the range and quality of support measures beyond the provision of infrastructure; and
- Provide a framework for a predictable financing framework to enable long-term planning (DTI, 2014).

In the context of the City of uMhlatuze, the proclamation of an Industrial Development Zone (IDZ) in Richards Bay area means that the city has to ensure security of water supply for all new investors to be located in the IDZ Estates. Currently, the 30-year Investment Book of the IDZ includes the new investments listed in Table 2.4.

Table 2.4: Richards Bay Industrial Development Zone Long Term Investment Book 2017

Project Description	Investment Value	Size	IDZ Phase	Country of Origin
Logistics and Heavy Equipment moving	R20 million	1 ha	1A	South Africa
Manufacturing of plastic piping for bulk water transportation	R300 million	2 ha	1A	Spain/ South Africa
Paint manufacturing company	R16 million	1 ha	1a	South Africa
Chemical plant	R500 million	10 ha	1F	South Africa/ India/ Italy
Generation of 60MW electricity from Biomass and 2000MW from LNG	R2 billion/ R9,4 billion	12 ha	1F	South Africa
Chemical plant	R250 million	3 ha	1F	South Africa
Titanium Dioxide Pigment	R4,5 billion	65 ha	1F	South Africa/ New Zealand
Manufacturing of Solar Panels	R650 million	8 ha	1A	South Africa/ China
Manufacturing of MGRP pipes for water, gas, oil distribution	R400 million	1 ha	1A	Iran/ South Africa
Manufacturing of aluminium canisters	R260 million	5 ha	1A	South Africa/ Germany
Manufacturing of Energy Systems and LED Light	R150 million	2 ha	1A	South Africa/ South Korea

Manufacturing of low to medium voltage cables	R150 million	3 ha	1A	South Africa
Manufacturing of Kraft paper	R1,2 billion	15 ha	1F	Switzerland/ South Africa

As Hewitt *et al.* (1992: 3) (cited in Green, 2009) explained, industry can be defined in a number of ways,

“firstly, industry can be defined as the production of material goods, excluding agriculture and secondly, industry can be defined as being made up of the mining, energy and manufacturing sectors. This classification of industry is “defined in terms of the kind of output, not how the goods are made.””

The third definition they offered, however, concerns how the goods are made and focuses on the production process and sees industry as a particular way of organising production (Hewitt *et al.*, 1992: 6). Again, Herwit *et al.* (1992:4) stated that,

“therefore, considering these definitions, the process of industrialisation is not simply about moving away from agriculture to the production of other goods, nor is it just about the production of particular goods since it also includes the process by which these goods are made.”

In the context of the City of uMhlathuze, it is anticipated that the establishment of the Richards Bay Industrial Development Zone will leverage more investors due to the government tax incentive scheme, which will mean growing demand for water and other amenities. The importance of water conservation and demand management, among other approaches, can guarantee long-term water security of supply.

2.10 Conclusion

The literature review has shown that there are a number of solutions available for the implementation of water conservation and water demand management in South Africa, and this is against the backdrop of a water stressed country with scarce surface water. Fry (2015: 3) stressed that *“scarcity of water poses a considerable threat to the future economic development of South Africa”*. From the array of water conservation and water demand management solutions unpacked and investigated in the literature review, there are several solutions available to water service providers, if implemented systematically and in a sustainable manner. The solutions include *inter alia* water sensitive urban design, sustainable urban drainage systems, pressure management, water reuse, leak detection, pipe replacement, greywater and more.

Clearly, there is no single water conservation and demand management intervention that is a panacea to all the water scarcity challenges facing the world. The different options covered in the literature review provide a plethora of progressive solutions and choices for municipalities. Notwithstanding this, for the City of uMhlathuze, there are gaps and critical issues needing consideration in a revised WC and WDM strategy such as community participation and mobilisation framework; funding model for WC and WDM infrastructure; sustainability and economic benefit analysis; impact of climate change on water demand; universal water demand growth measurement and a comprehensive study on incline block tariffs model to curtail excessive water consumption

Evidently, the establishment of the Industrial Development Zone compounds the challenge of water scarcity for the City of uMhlathuze as new industries (Table 2.3) will demand security of supply. As South Africa remains a country with unevenly distributed water resources and large climatic differences, the need for water conservation and water demand management strategies and interventions remains a priority.

Chapter Three: Research Methodology

3.1 Introduction

The purpose of this chapter is to outline and explain fully the methodology for this research project. The chapter includes a critical review of the choice of research techniques, data collection and sampling methods. The advantages and disadvantages of each method are comprehensively analysed.

Huysamen (1996: 44) stated that:

“in any methodological research, it is imperative to expand the knowledge in a justifiable and accountable manner. The methodology which is applied for any purpose should be able to make justifiable and accountable conclusions possible.”

Section 3.2 thus aims at outlining the research methods and techniques applied to enable the researcher to be able to ask appropriate questions and analyse data, as well as the summary of alternative methods that could be used in a research assignment. This case study established the shortcomings and effectiveness of water conservation and demand management strategy and interventions of the City of uMhlathuze.

3.2 Research Methods

Generally, a research method refers to the process used for gathering information and data. The research methods used for this dissertation included both quantitative and qualitative methods. Qualitative methods refer to analysis which is more subjectively interpreted and text or image based, while quantitative data is objective, precise and numerically based (Bryman & Bell, 2011: 312 & 355). Both of these methods added value to this research in order to compile a holistic research foundation on which to evaluate water conservation and water demand management interventions of the City of uMhlathuze.

3.2.1 Case Study

Robson (2002: 178) defined the case study as *“a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence.”* Usually, the research objective is to investigate the dynamics of some single bounded system, typically of a social nature, such as a family, group, community and participants in a project, institution and practice (Welman & Kruger, 2001: 21). The primary method used in this research is a case study method to allow for the specific focus on the City of uMhlathuze. This method of research was identified as the most

appropriate for this study because the case study inquiry reveals the processes and interventions by the city in relation to WC and WDM. The case study inquiry also benefits from the previous development of theoretical propositions to guide data collection and analysis which further validates the review of literature included in the study as a basis for research. According to Bryman and Bell (2011: 110), a case study design entails the detailed and intensive analysis of one or more cases which the researcher aims to study in-depth. In this regard, a case can be a single organisation; a single location and a single event. Bryman and Bell (2011: 357) noted that case researchers use a wide variety of sources for evidence such as visual documents, interviews, questionnaires, field notes, participant observations and recordings. In some cases, the case evidence may also include quantitative data such as a survey of employees in the organisation that was studied.

Advantages of the case study

According to a paper released by Zaidah (2007: 1),

“a case study method enables a researcher to closely examine the data within a specific context. In most cases, a case study method selects a small geographical area or a very limited number of individuals as the subjects of study. Case studies, in their true essence, explore and case study as a research method investigate contemporary real-life phenomenon through detailed contextual analysis of a limited number of events or conditions, and their relationships.”

To this end, Zaidah (2007:4) highlighted the following strengths of the case study:

- the examination of the data is most often conducted within the context of its use (citing Yin, 1984: 20), that is, within the situation in which the activity takes place.
- variations in terms of intrinsic, instrumental and collective approaches to case studies allow for both quantitative and qualitative analyses of the data.
- the detailed qualitative accounts often produced in case studies not only help to explore or describe the data in a real life environment, but also help to explain the complexities of real life situations which may not be captured through experimental or survey research.

Disadvantages of the case study

Zaidah (2007: 5) (citing Yin, 1984:21) argued that notwithstanding the abovementioned advantages, case studies have disadvantages and outlined them as follows:

- *case studies are often accused of lack of rigour and often the researcher allows equivocal evidence or biased views to influence the direction of the findings and conclusions.*
- *case studies provide very little basis for scientific generalisation since they use a small number of subjects, some conducted with only one subject.*
- *case studies are often labelled as being too long, difficult to conduct and producing a massive amount of documentation.*

3.3 Research Techniques

Research techniques differ from research methods in that the latter refers to the process of data collection whereas the former refers to the strategies by which the data is collected. Notwithstanding the selection of a questionnaire method for this study, other techniques provide alternative approaches and are discussed below.

3.3.1 Questionnaires

According to Brouwer and Bell (2011: 191), the self-completion of questionnaires involves respondents answering questions by completing the questionnaires themselves and can come in several forms such as mail, postal, or internet. Some of the advantages of questionnaires include: cheaper to administer; quicker to administer; absence of interviewer effects; convenience for respondents and no interviewer variability. The disadvantages include: prompting is not possible as there is no one present to help respondents; no opportunity to probe respondents to elaborate; sometimes the researcher may not know who answered the questionnaire and there is a greater risk of missing data.

3.3.2 Interviews and focus groups

Interviews are a specialised form of interaction, differing from everyday conversation, with specific roles played by the interviewer and the interviewee in an attempt to obtain comparable answers to set questions. Interviews may include structured interviews, semi-structured interviews or unstructured interviews. (Brouwer & Bell, 2011: 215). Focus group research is a qualitative method that is concerned with studying how participants express their views and perspectives on an issue as members of a group. The moderator or facilitator is expected to guide a fairly unstructured discussion without being too intrusive (Brouwer & Bell, 2011:232). Some of the advantages of interviews include: improved communication and clarity; interviewees normally respond to questions; interviews can be

recorded and they are easy to supervise. The disadvantages include: the length it may take to secure an appointment for the interview; possible intrusion of own biases and expectations; challenges of dealing with sensitive issues and unexpected interviewee behaviour.

According to Brouwer and Bell (2011: 237), the advantages of focus groups are that the research is less artificial and that there is a reduced risk of exploiting respondents or creating power relationships. Disadvantages include: difficulties in organising; recordings are mostly time-consuming; data difficult to analyse: and problems of group effects.

3.3.3 Content analysis

Brouwer and Bell (2011: 299) stated that “*content analysis is an approach to the analysis of documents and texts, that seeks to quantify content in terms of predetermined categories, and in a systematic and replicable manner*”. In a sense, it is not a research method, in that it is an approach to the analysis of documents and texts, rather than only a means of generating data. Notwithstanding this, it is usually treated as a research method because of its distinctive approach to analysis. The advantages of content analysis include: transparent research method and objective method of analysis; allows a certain amount of longitudinal analysis with relative ease; highly flexible in that it can be applied to a wide variety of structured and unstructured information sources; and allows generation of information about social groups that are difficult to gain access to.

The disadvantages of content analysis include: it can have particular problems such as invalid inferences; the content analysis is only as good as the documents on which the practitioner works and content analysis can address the “What?” questions and is not suited to ascertain the answers to the “Why?” questions (Brouwer & Bell, 2011: 305).

3.4 Sampling

Sampling is a process of systematically selecting cases for inclusion in a research project. The properties of the sample are then generalised to the population (Brouwer & Bell, 2011: 168). The commonly used sampling methods are discussed below:

3.4.1 Random sampling

In this type of sampling, elements are selected randomly from a sampling frame. In context, the research selects a smaller subset of cases from a pool of cases. The advantages of this sampling method include that every element has an equal and independent chance of being

selected as a member of the sample; it allows the selection of the sample without bias and the sample selected can be said therefore to be representative of the whole population. The disadvantages of this sampling method include that there is a possibility of leaving out key members as part of the selected sample; random sampling may be relatively difficult to explain; random sampling is best used when there is an accurate and easily accessible sampling frame listing the entire population (Bryman & Bell, 2011: 173).

In the simplest case of random sampling, each member of the population has the same chance of being included in the case sample and each sample of a particular size has the probability of being the sample chosen (Bryman & Bell, 2011). Conceptually, random sampling is one of the most attractive sampling methods.

For the purpose of this study, the simple random sampling method was used to select the sample for the case study. This means that each selection was independent and each official within the municipality who has directly and indirectly participated in WC and WDM processes of the city had an equal chance of being selected.

3.4.2 Systematic sampling

Systematic sampling is a variation on simple random sampling where the starting point is a random number and then selection of every n th record thereafter directly from the sampling frame ((Brouwer & Bell, 2011: 173). This type of sampling is used when lists of the elements are available. The researcher uses a sampling interval. The size of the sample is divided into the size of the sampling frame (population) to determine the sample interval. The disadvantage of this sampling method is that this type of sampling may not be representative in terms of e.g. gender, age, and may also reflect a bias if drawn up in a specific way.

3.4.3 Stratified sampling

Stratified sampling ensures greater representativeness in heterogeneous contexts. This type of sampling ensures that the sample reflects the diversity of the population as the population is divided into subsets such as gender, age, race, education. The advantages of stratified sampling are that the sub-groups can be analysed and different methods of analysis can be used for different sub-groups.

3.5 Method of Investigation, Case Study Identification and Evaluation

Once the case study was selected and in order to assess the understanding and views of professionals on water conservation and water demand management in the City of

uMhlathuze, a questionnaire method was selected, developed and completed by professionals who have knowledge and directly and indirectly participate in water conservation and water demand management processes. The expected outcome of this process was to be able to answer the principle question of whether the City of uMhlathuze has developed and effectively implemented a WC and WDM strategy and interventions.

The summary profile of the respondents and their roles in WC and WDM is outlined below.

1. **Manager Water Demand Management** - The Manager is responsible for planning, execution and monitoring of water demand management initiatives.
2. **Head of Section Revenue** - The Head of Section is responsible for revenue collection and enhancement, dealing with illegal connections and is part of the team working on water demand management.
3. **Chief Risk Officer** - The Chief Risk Officer developed the risk register for water and sanitation, which includes water demand management and serves on the Joint Operations Committee for Drought and Water Demand Management.
4. **Chief Audit Executive** - The Chief Audit Executive audited the City of uMhlathuze's 5 year Strategic Management Framework for Water Conservation and Water Demand Management.
5. **Manager Communications** - The Manager is responsible for communication, stakeholder management and public participation and serves on the Joint Operations Committee for Drought and Water Demand Management.
6. **Head of Section Water and Sanitation** - The Head of Section is the Head of Department for water and sanitation and also responsible for water demand management.
7. **Head of Section Roads and Stormwater Management** - The Head of Section is also the former Director for Technical Services, which included water and sanitation.
8. **Manager Project Management Unit** - The Manager is responsible for all water and sanitation projects including pressure management, pipe replacement, and new infrastructure.
9. **Manager Rural and Urban Planning** - The Manager is part of the city's planning team and is also responsible for environmental management and was part of the team which developed the WC and WDM strategy.

10. **Deputy Manager Water Services and Customer Relationship** - The Manager is part of the Water and Sanitation Department and serves on the Joint Operations Committee for Drought and Water Demand Management.
11. **Manager Land Use Management** - The Manager is part of the city's planning team and has vast knowledge of water conservation and water demand management, and was part of the team which developed the WC and WDM strategy.
12. **Head of Section Financial Services** - The Head of Section Financial Services is also responsible for tariffs, water and electricity losses and budgeting, and was part of the team which developed the WC and WDM strategy.
13. **Head of Section Engineering Services** - The Head of Section is responsible for engineering services, project management unit, asset management and has in depth knowledge of water demand management.
14. **Project Manager Environment Planning and Management** - The Manager is responsible for overall environment planning and management including climate change, conservation and is well vested with water conservation and water demand management.

Based on preliminary investigation undertaken before this study, the estimated total number of professionals in the City of uMhlathuze who directly and indirectly participate in the water conservation and water demand management processes and initiatives was eighteen (18) officials. Using the CheckMarket sample size calculator to analyse representative sample size, the following results were noted: the number of respondents was fourteen (14) giving a confidence level of 95% and a possible margin of error of 13% in terms of representative sample size methodology (CheckMarket Sample Size Calculator, 2018). The size of the sample was also limited by the fact that the concept of water conservation and water demand management is still a relatively new phenomenon for municipalities including the City of uMhlathuze.

As part of the research process, existing documents were assessed to verify the work already done by the city on this subject. During the assessment of existing documentation, it became apparent that the City of uMhlathuze had not reviewed the WC and WDM strategy developed in 2012. The information used to support the arguments and advance certain positions is based on the WC and WDM strategy developed in 2012. Accordingly, officials from the Department of Infrastructure and Technical Services indicated that the strategy would be reviewed before the end of 2018 and the information would be updated accordingly.

A glossary with key terms used in the questionnaire was also made available to the respondents and further individual engagements were conducted in order to clarify each statement before the respondents completed the questionnaire. All the respondents occupied middle to top management positions and worked directly and indirectly with water management systems and processes in the city. The respondents had a broad understanding of the water sector at local government level.

The City of uMhlathuze was the focal point due to the fact that it is one of the only two promulgated Industrial Development Zones in KwaZulu Natal. The City of uMhlathuze was identified as the most relevant case study on account of the drought situation and industrialisation initiatives.

Questionnaires (attached as **Appendix A**) were completed by professionals who have direct and indirect roles in water conservation and water demand management processes, drawn from various disciplines such as engineering, finance, city planning, public participation, integrated development planning and risk management. A total of fourteen (14) questionnaires were administered over a period of three (3) months, which gave the respondents sufficient time to apply their minds and respond to the questionnaires. It was important to get a good spread of professionals from different disciplines to promote fair and equitable representation of responses and ideas beyond the water services team, due to the fact that water conservation and demand management goes beyond technical services.

The case study method was critical in order to gain a rich understanding of the context of the research as well as the processes being enacted and these would undoubtedly generate answers to the research question. Selected respondents were pre-engaged telephonically in order to clear any ambiguity or misinterpretation of the questions and to explain expectations. During completion of the questionnaires contact was maintained with the respondents.

The study used a random sampling method, which involved selecting a sample randomly from the pool of officials in the City of uMhlathuze. In the simplest case of random sampling, each member of the population has the same chance of being included in the case sample and each sample of a particular size has the probability of being the sample chosen (Bryman & Bell, 2011).

For the purpose of this research, a Likert scale evaluation method was used. The summated or Likert scale was introduced by Likert between 1903 and 1981 (Welman & Kruger, 2004: 150). According to Cooper and Schindler (2001: 234), the Likert scale is the most frequently

used variation of the summated rating scale. Summated scales consist of statements that express either a favourable or unfavourable attitude towards the object of interest. The respondent is asked to agree or disagree with each statement and each response is given a numerical score to reflect its degree of attitudinal favourableness, and the scores may be totalled to measure the respondent's attitude. Consequently, in this case study, the respondents had to decide on five (5) items in a rating scale as either 1) strongly agree, 2) agree, 3) neither agree/disagree, 4) disagree and 5) strongly disagree. The meaning of the five rating item is summarised below.

1. **Strongly agree** means the respondents are in total agreement with the statement.
2. **Agree means** the respondents agree with the statement for the most part.
3. **Neither agree/disagree** means the respondents prefer the neutral middle, meaning the respondents have neither a positive response nor a negative response.
4. **Disagree** means the respondents disagree with the statement for most part.
5. **Strongly disagree** means the respondents are in total disagreement with the statement.

Welman and Kruger (2001:18) observed that the purpose of explanatory research is to explain why things are the way they are. It may be so because one thing has caused another to change and we also like to explain what this relationship between things is. There are various qualitative methods and they defined a research method as a strategy of inquiry which moves from the underlying philosophical assumptions to research design and data collection.

The strategic intent of the questionnaire was to determine whether the City of uMhlathuze, as an industrialised city, had developed and implemented a WC and WDM. Respondents had to respond to a number of questions focusing on the following ten statements.

Statement 1: The City of uMhlathuze has developed and implemented water conservation and water demand management strategy

The Water Conservation and Water Demand Management Strategy (2004) identifies fundamental steps to be taken in promoting water use efficiency consistent with the National Water Act (Act 36 of 1998), which emphasises effective management of water resources. Water Services Act, 108 of 1997 requires water service providers to provide for measures to promote water conservation and water demand management. The development of a strategy and implementation of interventions aimed at water conservation and water demand management is important for municipalities. It was, therefore, critical to assess the understanding of city officials in relation to the

existence and non-existence of a WC and WDM strategy and whether any interventions have been implemented at the municipality.

Statement 2: Over a period of time, WC and WDM interventions have drastically reduced water losses in the city

The Water Conservation and Water Demand Management Strategy (2004) emphasises the need to reduce water losses through adequate and technically correct operating and maintenance measures of the reticulation network system. Reducing water losses is essential in order to improve water conservation and demand management. If there were any interventions in the past there should be noticeable reduction of water losses over a period of time. It was important to assess whether city officials had noticed any reduction in water losses in the municipality.

Statement 3: The municipality allocates sufficient budget in each financial year for the implementation of WC and WDM projects such as pipe replacement, pressure management, water sensitive urban design, leaks monitoring and repair etc.

According to McKenzie (2014: 23), budgeting for water conservation and water demand management projects such as infrastructure replacement, leaks monitoring and repair remains a challenge for many municipalities. Municipalities struggle to appreciate the necessity and benefits of dealing with water losses in their reticulation systems.

Water conservation and water demand management interventions and projects require budgetary provision by the municipality. It was, therefore, critical to assess whether the municipality allocates sufficient funding for the execution of water conservation and water demand management related projects, especially projects such as pipe replacement, pressure management, leak monitoring and repairs.

Statement 4: Consumption-based water tariffs are an effective method of reducing water demand

One of the objectives of Water Conservation and Water Demand Management Strategy is to create a culture water conservation and water demand management for all consumers and users (Water Conservation and Water Demand Management Strategy, 2004). In this regard, one of the tools available to municipalities to reduce water demand and consumption is consumption based water tariffs. The principle of consumption based tariffs is that the more water is consumed the higher the bill. It is considered that consumption based tariffs serve as a deterrent to wastage and high consumption thus reducing water demand. There is also an alternative view that the

middle and higher income class of the population use more water and can afford to pay, thus rendering consumption based tariffs ineffective. It was important to gauge the perception of officials regarding the use of consumption based tariffs as a tool to reduce water demand and high consumption.

Statement 5: Pipe replacement, leaks monitoring and repairs, water reuse, rainwater harvesting, water sensitive urban design and water pressure management are the main components of WC and WDM

The Water Conservation and Water Demand Management Strategy (2004) identified opportunities of reducing demand in most water services areas. These opportunities include reduction of leaks in reticulation network distribution, leak detection and repair, pipe replacement. Mckenzie (2014:9) argued that water pressure management remains one of the most important water demand management intervention. Armitage *et al.* (2014:19) outlined the principles of water sensitive urban design as a mechanism to contribute to sustainable water supply in line with WC and WDM objectives,

The aim of this assessment was to test the understanding of officials of different approaches to WC and WDM, and what the municipality could introduce to achieve the objectives of WC and WDM.

Statement 6: The municipality has sufficient water sources to support existing and new industries

The National Water Resource Strategy 2nd (2013) sets out the following core objectives: to support development and elimination of poverty and inequality; water that contributes to the economy and job creation, and water that is protected, used, developed, conserved, managed and controlled sustainably and equitably.

As discussed in the literature review, the city has limited water sources to support existing and new industries and the main source of supply, which is the Goedetrouw Dam, had been at low levels - below 35% since 2016. It was, therefore, critical to assess the understanding of city officials in relation to the status of water sources and the need to look at different options in order to improve security of supply while investing in water WC and WDM solutions.

Statement 7: Investment in alternative water supply options such as seawater desalination, water reuse, stormwater and rainwater harvesting, ground water and recharge of aquifers etc. will provide long-term water security of supply for businesses, industries and residents

According to the National Water Resource Strategy 2nd (2013), the Department of Water and Sanitation aims to support the development of alternative water sources such as seawater desalination, rainwater harvesting, water-reuse and groundwater development. These water sources are crucial in achieving the objectives of the Water Conservation and Water Demand Management Strategy.

Reliance on traditional water resources such as rivers and lakes in a water scarce country with a growing population is not sustainable. In order to guarantee future supply, it is imperative for water services authorities to invest in alternative water options such as seawater desalination, ground water and water reuse. The intent therefore, was to assess whether city officials had an appreciation of the importance of progressively investing in alternative water supply solutions as one of the contributors to WC and WDM.

Statement 8: The municipality has developed and implemented an effective and efficient water leaks detection and repair system

Mackenzie (2014:8) provided guidelines for reducing water losses in South African Municipalities and identifies leak location and repairs as a basic intervention that should be implemented as a top priority.

Early detection and repair of leaks helps to save water and reduce water losses. It is important for municipalities to invest, develop and implement effective systems to detect and repair water leaks timeously. This is important because of ageing water infrastructure as highlighted in the literature review. Assessing the understanding of city officials in terms of the importance of effective and efficient water leaks detection and repair systems was fundamental.

Statement 9: Residents, industries and businesses are adequately informed and empowered on water conservation and water demand management strategies

Mackenzie (2014:33) argued that

“too often, well designed and implemented technical interventions fail miserably purely due to the fact that the community they serve are not included in the overall process with the result that they do not buy-into the project. In extreme cases, the community representatives may go out of their way to ensure that some technically sound project fails. Proper consultation with the community is therefore an essential element of any WC and WDM intervention”.

To this end, municipalities have a responsibility to engage communities as part of the public participation process. City officials, therefore, should play a leading role in galvanising stakeholders to embrace the objectives of WC and WDM. This assessment aimed at determining the perception of officials regarding the municipality's commitment to informing and empowering various stakeholders on WC and WDM.

Statement 10: Municipal elected political office bearers are leading and driving community based campaigns and projects focusing on water conservation and water demand management

The Water Conservation and Water Demand Management Strategy (2004) emphasises the need to promote the efficient use of water by consumers and customers. Elected political office bearers such as mayors, speakers and councillors play a critical role in providing interface between consumers, customers and the municipalities. The mayor, in particular, is the face of the municipality as the first citizen. It is expected that elected office bearers should lead community campaigns and public engagements. This anticipated leadership responsibility extends to community based campaigns and projects such as WC and WDM. The aim of this statement was to assess the perception of city officials in respect of the involvement and participation of elected office bearers on WC and WDM community based campaigns and projects.

A total of fourteen (14) questionnaires were issued to respondents (city officials) and all of them were completed and returned. This method of investigation was selected because it allowed respondents freedom to respond to the questionnaire without being influenced in one way or another. The questionnaire also provided an opportunity for the respondents to provide additional information to substantiate their agreement or disagreement with the statements. It was clearly mentioned to the respondents that the researcher was always available to provide clarity, if required.

Furthermore, a balanced opinion was considered to have been achieved by allowing respondents space to substantiate their answers through additional comments on the questionnaire.

3.6 Research Question and Data Collection

The case study should be able to answer the following fundamental and pertinent research question: *Has the industrialised City of uMhlathuze developed and effectively implemented a*

Water Conservation and Water Demand Management Strategy and interventions? The questionnaire focused on key interventions identified as imperative in water conservation and water demand management. The objective was to assess the understanding, attitudes, perceptions and observations of city officials in respect of the city's strategy and interventions relative to water conservation and water demand management.

Data was collected from city officials using semi-structured Likert scale questionnaires. The respondents had to answer a set of statements as to whether or not they agreed or disagreed with the statement, and the extent and level of agreement or disagreement. Provision was made for respondents to provide additional comments to substantiate their answers and/or provide new information in relation to the statement. To this end, the objective of the questionnaire was to gauge the shortcomings and effectiveness of water conservation and water demand management strategies and interventions of the City of uMhlathuze.

3.7 Reliability, Validity and Limitations of the Study

The following were some of the key consideration in terms of reliability, validity and limitations of the study.

Control over responding. The advantage of a questionnaire was that the respondents had control and time to respond to the questions and the questions were in writing to avoid ambiguity. The respondents had an opportunity to engage the researcher during the process of answering the questions as well as make additional comments, observations and recommendations as provided for in the questionnaire.

Anonymity. The questionnaire could be completed anonymously if deemed necessary and that assurance was provided as part of the consent forms.

Response Rate. Due to proper engagements and support provided to the respondents, there was less chance of the questionnaires not being answered.

Limitations. There were a few limitations in this study, such as time constraints to undertake the study; limited sample size due to few officials who participate in the water conservation and water demand management processes; lack of updated data from the City of uMhlathuze and the concept of WC and WDM being relatively new for many municipalities. The limitations were addressed by using existing literature and review of available documentation to support arguments and observations. Despite these limitations, the scope of this study was sufficient to evaluate WC and WDM in the City of uMhlathuze.

Using a questionnaire was appropriate for this study and allowed the researcher control over responses thus protecting validity of the study. Personal interaction with the respondents was used to clarify any misunderstandings and placed more emphasis on the importance of the study.

3.8 Data Analysis

Saunders, Lewis and Thornhill (2000: 56) emphasised that the first action should involve classifying the data into meaningful categories. The research question was categorised on the basis of responses in terms of the five rating items. The next step included evaluation and summation of the responses against the strategic objectives and framework of water conservation and water demand management. This illustrated the shortcomings and progress of water conservation and water demand management in the City of uMhlathuze.

3.9 Conclusion

This chapter outlined the method of investigation followed for the research project and the mechanisms applied in the administration of questionnaires and responses. It outlined and explained the methodology, data collection and sampling method. The next chapter deals with the overview of the City of uMhlathuze.

Chapter Four: Overview of City of uMhlathuze Municipality

4.1 Introduction

The City of uMhlathuze Local Municipality is the third largest municipality in KwaZulu-Natal. Located on the north-east coast of the province, it is a strategically placed as an aspirant metropolis due to its close proximity to Durban. It is also home to the country's largest deep-water port and an Industrial Development Zone enjoying the associated economic spin-offs.

The uMhlathuze area covers 795 km² and incorporates Richards Bay, Empangeni, eSikhaleni, Ngwelezane, eNseleni, Felixton and Vulindlela, as well as the rural areas under Traditional Councils such as Dube, Mkhwanazi, Khoza, and Zungu (City of uMhlathuze IDP, 2016).

During the re-determination of municipal boundaries in 2014, the Demarcation Board resolved that the boundaries of uMhlathuze Municipality must be changed in line with the proposal of the Board. This was in relation to parcels of land from the Ntambanana Municipality needing to be incorporated into uMhlathuze Municipality following the Local Government elections of 2016.

The estimated uMhlathuze's population is 453,459 with 34 wards, as per Statistics South Africa Community Survey 2016. The area is inundated with a system of wetlands and natural water features such as Lakes Cubhu, Mzingazi, Nsezi and Nhlabane. Major close waterways are the Mhlathuze and Nsezi Rivers.

The municipality has the benefit of a 45km coastline of which about 80% is in its natural state. Linked to its coastal locality is the Richards Bay deep-water port that has been instrumental in the spatial development of the area in the past and will impact on the area's future spatial development.

The key spatial structuring elements⁸ highlighting spatial configuration of the city with specific reference to key urban nodes within the City of uMhlathuze are the Richards Bay Central Business District (CBD), Empangeni CBD, Felixton Township, Ngwelezane Township, Esikhawini Township, Vulindlela Township and eNseleni Township. These are the nodes with the highest water demand in the city (City of uMhlathuze IDP, 2016). Figure 4.1 depicts an aerial view of the spatial framework in terms of urban centres, traditional authority

⁸ A spatial element is the generalisation of all spatial elements that might be used to define a spatial structure or to define spatial zones and activities taking place in a space (COU Integrated Development Plan, 2017/17).

areas, primary, secondary and tertiary sectors, roads, local nodes, main corridors, provincial and national routes, port expansion and Industrial Development Zone proposed estates.

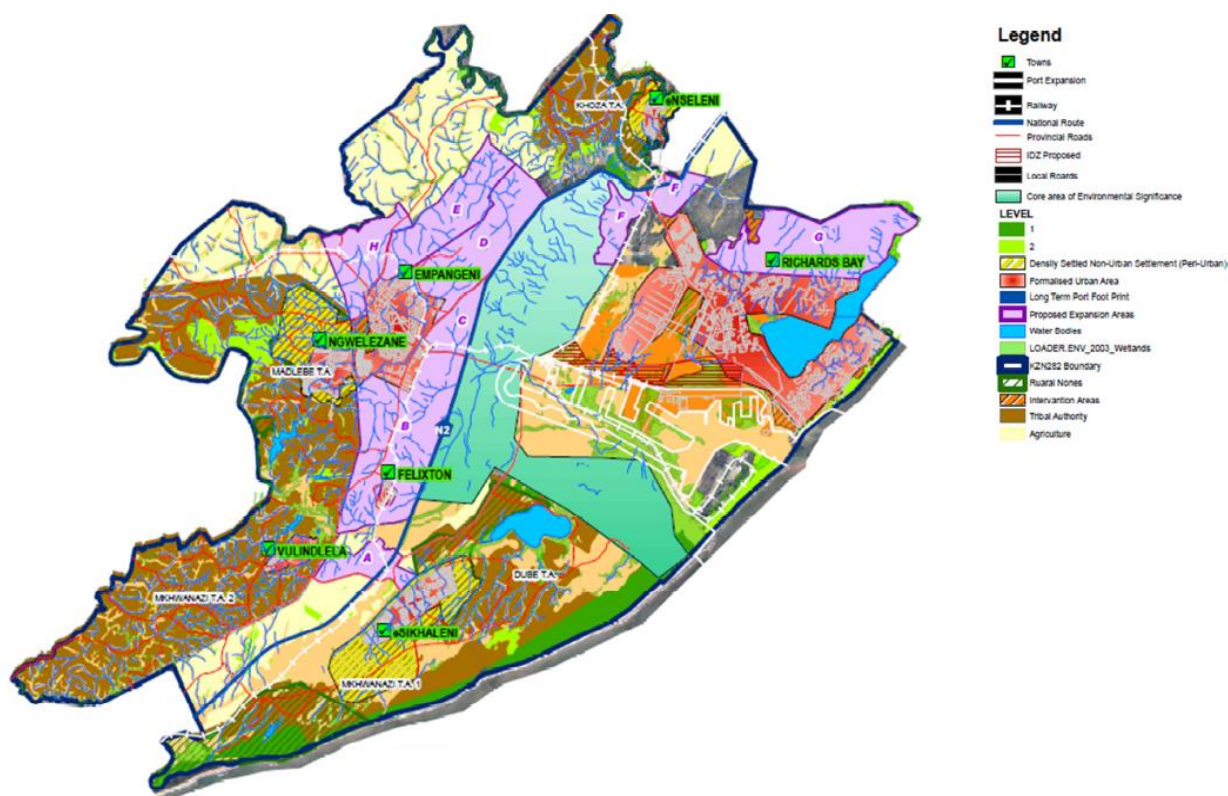


Figure 4.1: City of uMhlathuze spatial structuring elements
(Source: City of uMhlathuze Spatial Development Framework 2016)

4.2 Population Distribution between Urban and Rural

Geographically, traditional areas, commonly known as rural areas, account for 58% of the total population, and these areas are under the legal authority and jurisdiction of the Ingonyama Trust⁹. This is followed by urban areas representing 39% of the total population, and 3% of the population resides on farmland (City of uMhlathuze IDP, 2016). Figure 4.2 illustrates population distribution between urban and rural.

⁹ The Ingonyama Trust is a corporate entity established by KwaZulu Natal government to administer the land traditionally owned by the King of the Zulu Nation for the benefit, material welfare and social well-being of the Zulu Nation (Ingonyama Trust Board, 2017).

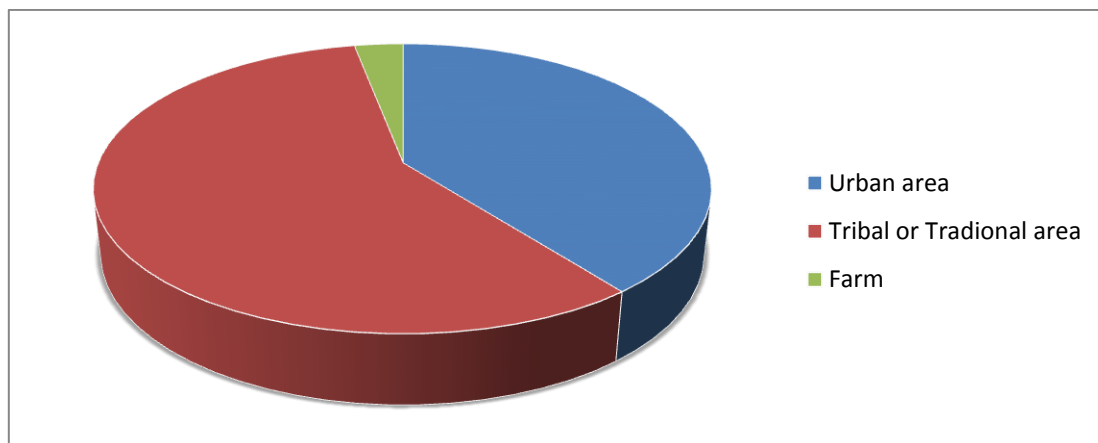


Figure 4.2: Illustration of population distribution
(Source: City of uMhlathuze Integrated Development Plan 2016)

According to the City of uMhlathuze Water Services Development Plan (2013), the water supply system consists of three Water Treatment Works (WTW) together with their associated pump stations, 12 potable water pump stations, more than 80 reservoirs (some of which are currently not being used), some 60 km of bulk water supply mains and more than a hundred kilometres of reticulation piping. This infrastructure is augmented through Mhlathuze Water's Nsezi WTW. The City of uMhlathuze has a backlog of water supply estimated at 17,000 households according to the Water Services Development Plan developed in 2013. Figure 4.3 depicts households with no access to piped water, which indicates future water requirements and piped water expansion areas.

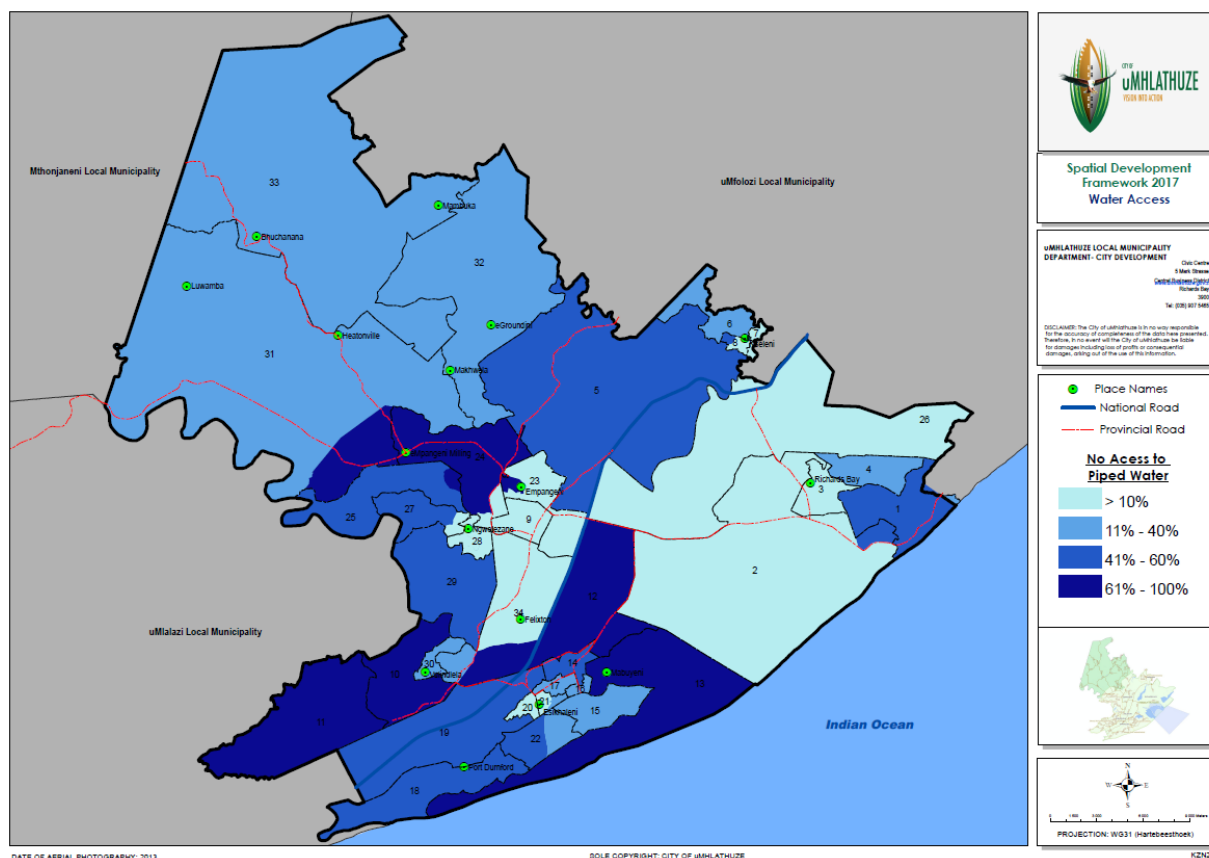


Figure 4.3: City of uMhlathuze households with no access to water in 2017
(Source: City of uMhlathuze Integrated Development Plan 2017)

4.3 The Effects of Drought on the uMhlathuze Water System

The South African Weather Service Seasonal Climate Watch¹⁰ from 2015 to 2017 has provided much information. Their forecasting system has confidently exhibited that going towards the mid-and-late-summer season of the year 2017, the likelihood of continuing dry conditions over most parts of the country is high, especially in KwaZulu Natal. In addition, the mid-summer season from 2015 to 2017 produced way below normal rainfall totals (South African Weather Service Seasonal Climate Watch, 2017).

As reported by the Department of Water and Sanitation¹¹, the city’s main dam water levels remained at 32.77% as at September 2017. Figure 4.4 depicts the Goedertrouw Dam Level.

¹⁰ The South African Weather Service Seasonal Climate Watch is a service currently being maintained by the South African Weather Service focusing on two separate seasonal forecasting systems. One dynamical global Ensemble Prediction System (EPS) and atmospheric General Circulation Model (AGCM) as well as a statistical forecasting system which is based on a Model Output Statistics (MOS) approach and downscaled to the Southern African Development Community (SADC) area of interest (South African Weather Service Seasonal Climate Watch, 2017).

¹¹Department of Water and Sanitation has imposed level 4 Restrictions: Industries 15%, Domestic 40% and Agriculture 85% (COU Tariff Methodology, 2016/17).

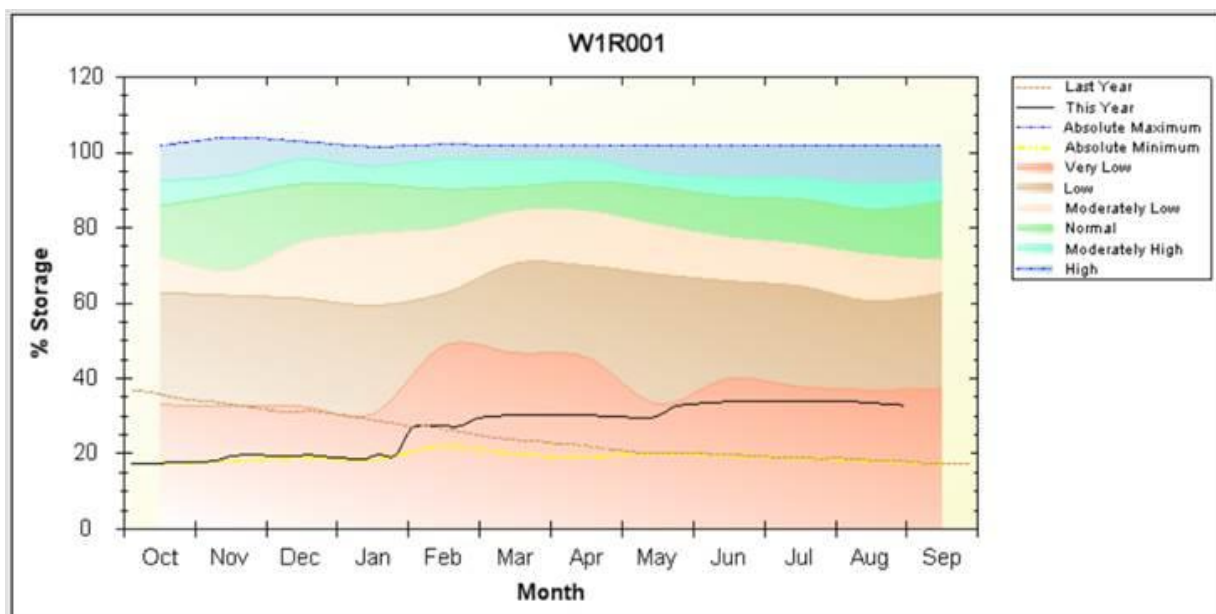


Figure 4.4: Goedertrouw Dam levels

(Source: Department of Water and Sanitation, KwaZulu Natal Office Report September 2017)

Compared to October 2016, at which time the water level was approximately 19% (Department of Water and Sanitation, KwaZulu Natal Office, 2017), Figure 4.4 illustrates a small increase of the Goedertrouw Dam level to 32.77%, which was still a serious challenge. Approximately 10% represents an absolute minimum level for water abstraction from the dam (Department of Water and Sanitation, 2017). This absolute minimum level of extraction is based on the need to preserve the dam ecosystem as well as to take into consideration the existence of sediment at the bottom of the dam.

In response to the persistent drought, the City of uMhlatuze embarked on a comprehensive campaign to mobilise communities, businesses and industries to save water.

Save Water Pamphlets!



Figure 4.5: Save water campaign
(Source: City of uMhlathuze Campaign Pamphlet 2016/17)

In 2016, as a result of persistent drought, the City of uMhlathuze implemented level 4 water restrictions in line with the guidelines provided by the Department of Water and Sanitation, and these restrictions remained in force in 2017. The main aim of restrictions was to reduce available water and water pressure. Conditions of level 4 restrictions were to reduce water supply to sectors with the following percentages: agriculture 80%, domestic 40% and industrial 15% (Department of Water and Sanitation Report, 2015). During this study, water restrictions were still being implemented during the times of the day shown in Table 4.1.

Table 4.1: City of uMhlathuze Water Restrictions Timetable 2016/17

	TIME		
	Morning	Afternoon	Evening
Urban	04h00 -	16h00 - 20h00	20h00 – 04h00
Rural	04h00 -	16h00 - 20h00	20h00 – 04h00
(including Industrial)	08h00 07h00 -		22h00 - 06h00

Level 4 water restrictions were implemented in line with the directive from the Department of Water and Sanitation. The implementation of restrictions included the installation of valves to control pressure and water flow. In terms of the restrictions, water was reduced by 80% for

agricultural use, 40% for domestic use and 15% for industrial use during the times listed in Table 4.1.

According to the City of uMhlathuze Annual Financial Statements for 2016/17 financial year, a noticeable reduction in water bulk purchases was recorded due to the implementation of water restrictions and drought tariffs. In 2015/16 financial year, the city spent R126 670 598 (35 232 475 kilolitres) on water bulk purchases and in 2016/17 financial year, the city spent R114 314 760 (32 596 276 kilolitres) (CoU Annual Financial Statements, 2017).



Figure 4.6: The river system during good times in 2012 and bad times in 2015/16
(Adapted from Department of Water and Sanitation
KwaZulu Natal Office Report 2015c)

For a number of years, the City of uMhlathuze had been concerned about the growing trend of water losses, which were already above the national target of 15% (National Water Resource Strategy 2nd, 2013). This was especially concerning in a municipality severely affected by drought. The audited water losses for the past financial years are outlined in Table 4.2 (Auditor General of South Africa, 2013/14, 2014/15 and 2015/16).

Table 4.2: Water losses – City of uMhlathuze
Audited Financial Statements by the Auditor General

Financial Year	Kilolitres	Cost	% water losses per annum
2013/14	17,50 million kilolitres	R25,09 million	36%
2014/15	16,33 million kilolitres	R36,74 million	33%
2015/16	9,246535 million kilolitres	R34 million	26%

NB: The auditing of 2016/17 financial year had not been completed at this time of this study.

4.4 Reduction of Non-Revenue Water Project Analysis

Water losses in a distribution network are often an indication of the health of the water distribution network of the municipality as most WC and WDM activities are related to the operation and maintenance of the system. In a well maintained and managed system the input volume is known, leaks are fixed, consumers are metered and billed, and there is limited disruption in the supply and pressures as they are all within the acceptable range. To this end, the City of uMhlathuze developed a mechanism to focus on the reduction of Non-Revenue Water (NRW) as part of its overall WC and WDM Strategy. The city tried to adhere to the objectives of the national water conservation and water demand management initiatives. During this study, these initiatives were still underway throughout the country in support of protecting the scarce water supply resources.

The City of uMhlathuze had recognised the need to focus on the reduction of Non-Revenue Water (NRW) as part of its WC and WDM strategy, as well as its contribution towards the objectives of the national water conservation and water demand management initiatives.

Accordingly, the roadmap below, shown in Figure 4.7, depicts the overall framework within which the WC and WDM programme was being implemented in the city informed by a five-year NRW Reduction Master Plan, three-year Leakage Control Programme and one-year Leakage Reduction Plan.

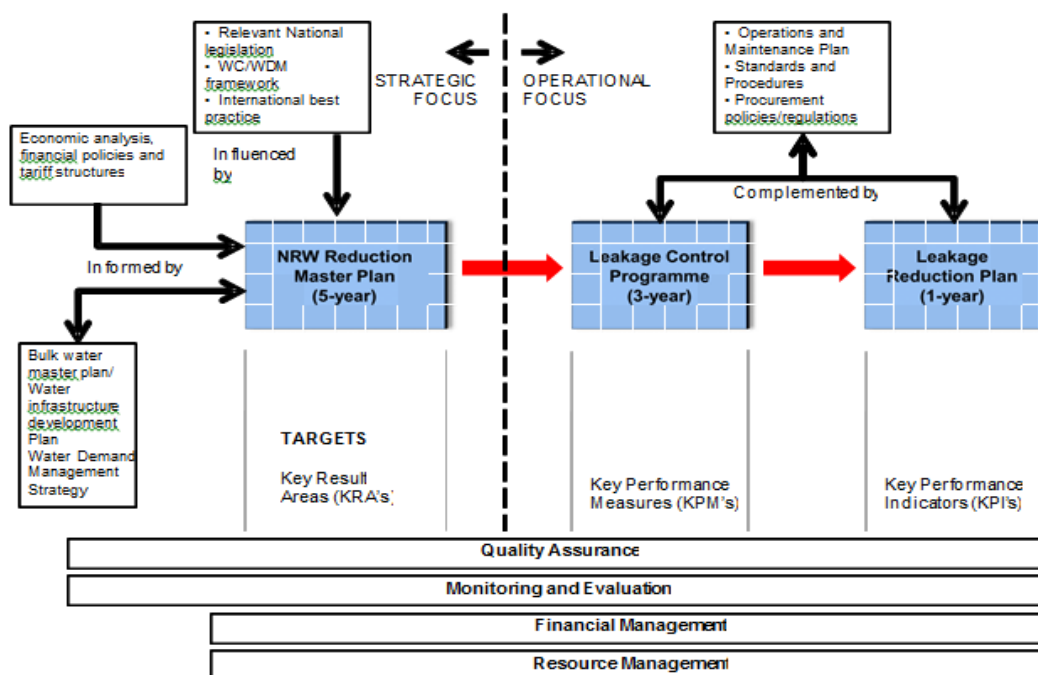


Figure 4.7: City of uMhlatuze 5 Year WC and WDM Strategic Management Framework 2012

Evidently, the implementation of the strategy has, to some degree, contributed to a noticeable reduction in water losses between 2013/14 and 2015/16 (Table 4.2) although the cost of water losses remains relatively high due to general water tariff increases and drought tariffs imposed by the Department of Water and Sanitation. In the main, the objectives of the strategy included the following:

- To determine the baseline situation in terms of water balances for each supply system in accordance with international and national best practice;
- To identify areas of possible Non-Revenue Water (NRW) reduction, by water balance component and per supply system, prioritise these in order of impact and prepare a consolidated NRW Reduction Intervention programme;
- To establish targets in terms of NRW by volume, supported by key performance indicators (KPI) and budget/funding requirements;
- To address the internal requirements necessary for the successful implementation of a NRW reduction programme in terms of resources, systems and critical success factors;
- To identify short-term problems that are being experienced with the municipality's billing database and determine any necessary corrective actions;
- To embrace the principles of water demand management;

- To identify possible water conservation projects; and
- To develop and implement a basket of water demand management interventions.

4.5 Key System Information

Table 4.3 outlines the key water system information in terms of mains, registered water connections, number of households and average operating pressure according to the City of uMhlathuze Department of Infrastructure and Technical Services (DI&TS), Water and Sanitation Unit Council Report 2016.

Table 4.3: City of uMhlathuze – key system characteristics

Supply Area	Length of Mains – Trunk and Reticulation (km)	Registered Water Connections (all types)	No. of households (all service types)	Total Population (as per 2011 census)	Average Zone Operating Pressure (m)
Richards Bay	396	9 638	14 884	57 452	40
Nseleni	256	4 848	10 140	39 141	55
Empangeni	180	5 563	7 433	28 690	53
Ngwelezane	428	6 956	15 125	58 383	58
Vulindlela	250	387	8 238	31 800	60
eSikhaleni	494	9 207	30 827	118 993	45
Totals	2 005	36 599	334 459	86 609	49

(Source: Water and Sanitation Unit Council Report 2016)

4.6 Water Balance

The quantity of water lost is an important indicator of the positive or negative evolution of water distribution efficiency, both in individual years and as a trend over a period of years. A leak-free network is not a realisable, technical or economic objective and a low level of water loss cannot be avoided, even in the best operated and maintained systems where water suppliers pay a great deal of attention to water loss control. Reductions in Non-Revenue Water (NRW) are an attractive and economically viable means of increasing the headroom between supply and demand. NRW comprises the following categories: unbilled metered; unbilled un-metered; illegal connections; inaccurate meters; mains leaks; reservoir overflows and service connection leaks (DI&TS, 2017). The tables below outline the water balance for three (3) different zones in the City of uMhlathuze as reported by the Department of Infrastructure and Technical Services in June 2017.

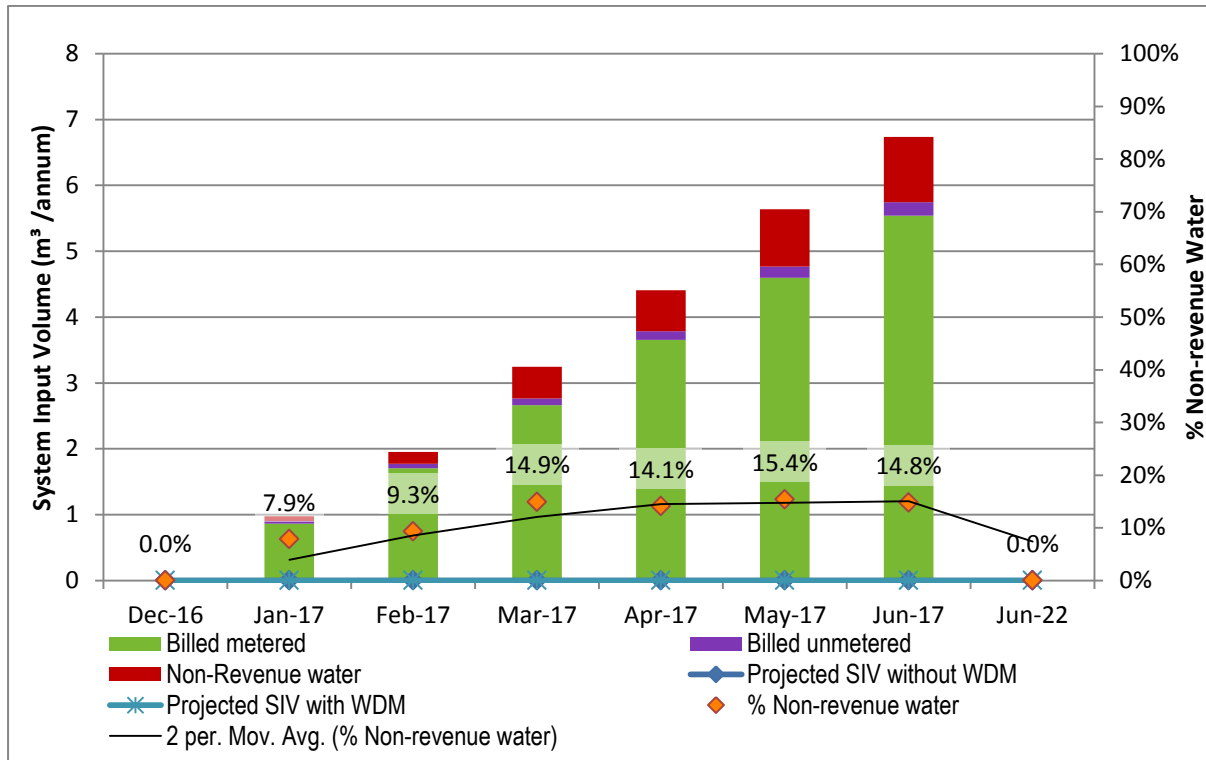


Figure 4.8: Richards Bay supply system zone water balance
(Source: DI&TS, 2017)

The Richards Bay Supply System Zone consists of bulk meters in Veldenvlei, Wildenweide, Aquadene, Brackenham, Alton, eNseleni LL, eNseleni HL, KwaKhoza and Mzingazi Village. During this study, the zone was still experiencing a high volume of losses (15.8% in May and 14.8% in June 2017) due to a number of factors such as faulty meters, ageing infrastructure and illegal connections.

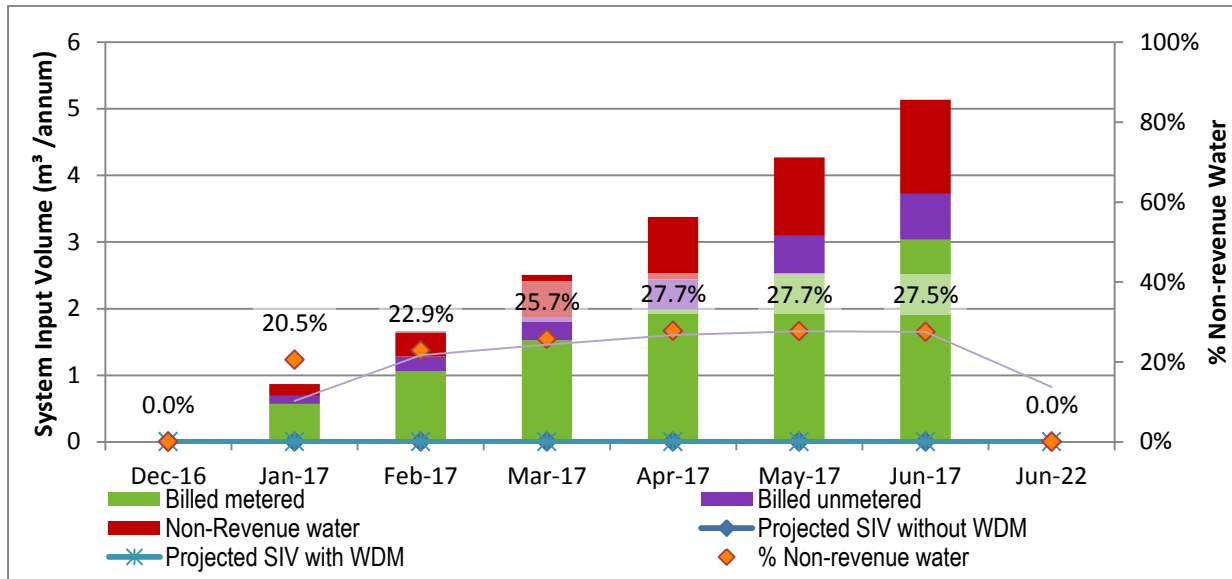


Figure 4.9: Esikhaleni supply system zone water balance
(Source: DI&TS, 2017)

The Esikhaleni Supply System Zone consists of bulk meters such as Felixton, Mtunzini, Dlamvuzo, Esikhaleni, Dube Traditional area, Vulindlela, University of Zululand, Mkhwanazi and Godandlovu. During the study, the zone was still experiencing high levels of water losses from 20.5% in January 2017 to 27.5% in June 2017. This increase was attributed to ageing infrastructure, illegal connections, burst pipes and faulty meters.

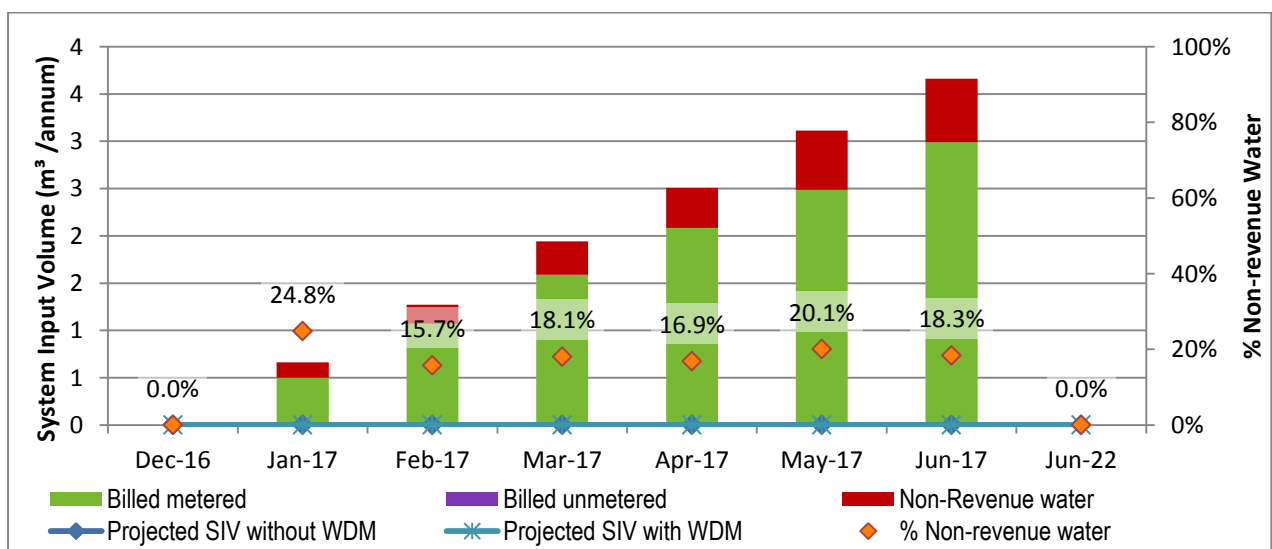


Figure 4.10: Empangeni supply system zone water balance
(Source: DI&TS, 2017)

The Empangeni Supply System Zone consists of bulk meters such as Grantham Park, Empangeni Rail, Exxaro, Prison, Dumisani Makhaye Village, Nyala Park, Kildare, Empangeni CBD and Magazulu Remainder. During the study, the zone showed stability and reduction in water losses from 24.8% in January 2017 to 18.3% in June 2017. This was attributed to the pipe replacement project in Empangeni CBD and Ngwelezane Township, respectively.

Figure 4.11 provides a comparison of NRW figures for the City of uMhlathuze with the South African and other international cities average at a time when the WC and WDM strategy was developed in 2012. It is expected that these figures would change after the review of the WC and WDM strategy.

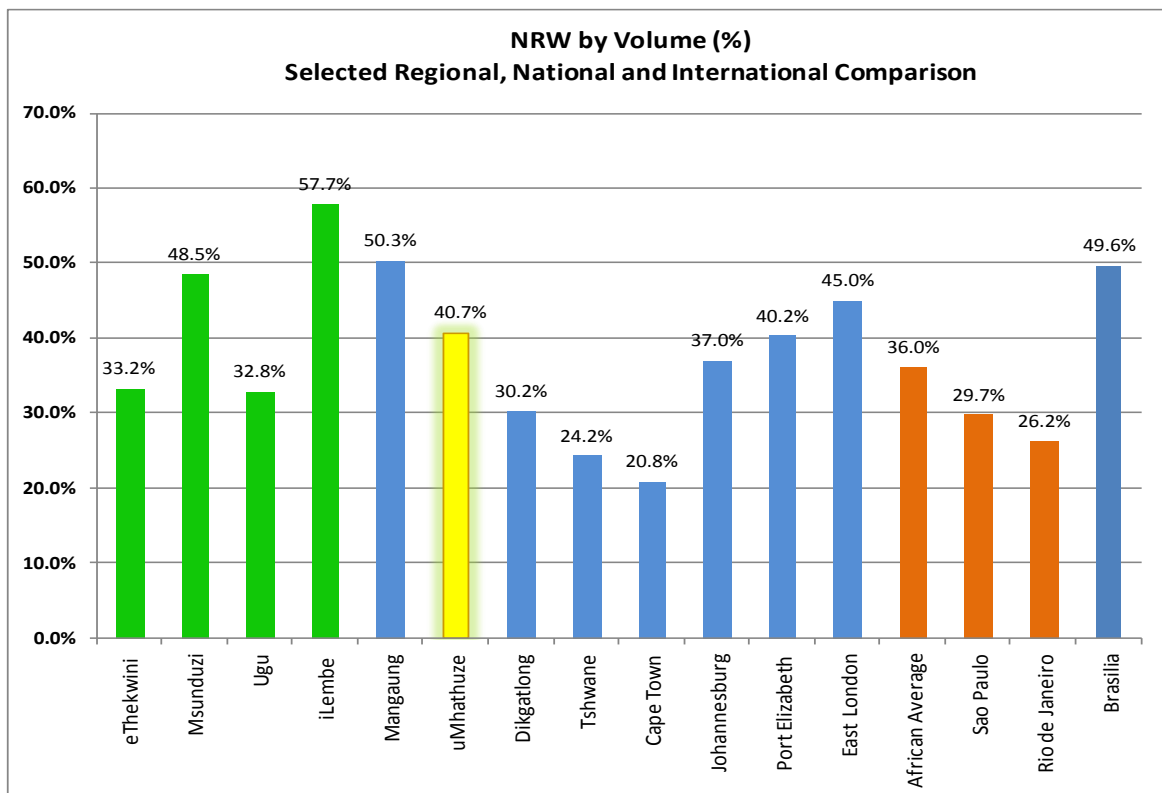


Figure 4.11: Selected regional, national and international comparison of NRW by volume 2012

(Source: City of uMhlathuze 5 Year WC and WDM Strategic Management Framework 2012)

At the time when this data was compiled, the City of uMhlathuze’s NRW was among the highest compared to other cities locally and internationally. Since then, the city has seen a noticeable decline in NRW, as reflected in the latest water balances for the three zones.

Again, Figure 4.12 provides a comparison of NRW figures for municipalities in KwaZulu Natal, including the City of uMhlathuze. In terms of this comparison conducted in 2012, the City of uMhlathuze had a relatively low NRW compared to other municipalities in KwaZulu Natal. During this study, it was established that the City of uMhlathuze WC and WDM strategy had not been reviewed since 2012, and that certain information contained therein was old. It was confirmed that a process was underway to review the strategy before the end of 2018. This study did not focus on comparing the NRW of the City of uMhlathuze to that of other cities. The review of documentation was based on available information.

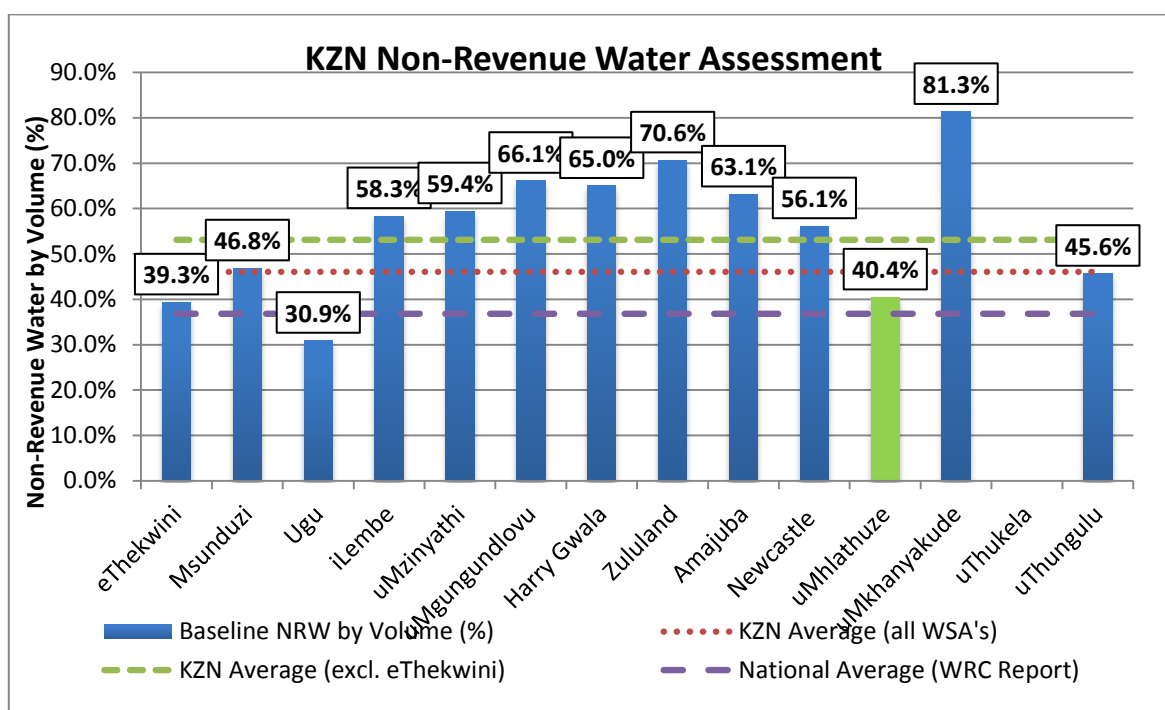


Figure 4.12: KwaZulu Nata; NRW figures for 2014/2015 financial year (Source: Department of Water and Sanitation KZN Office Report 2015)

4.6 Existing Water Resources and Utilisation

Table 4.4 provides a summary of water resources supplying the city, excluding the Goedertrouw Dam under the management of the Mhlathuze Water Board. The table outlines the extent of daily abstraction per source.

Table 4.4: Existing water resources in the City of uMhlathuze 2017

Municipality	Source	Supply System	WTWs Design Capacity
City of uMhlathuze	Lake Mzingazi	Richards Bay	65 MI/day
	Nseleni River/Lake Nsezi	Empangeni	18 MI/day
	Lake Cubhu	Esikhaleni	36 MI/d
	Mhlathuze River	Ngwelezane	8 MI/day

(Source: DI&TS, 2017)

According to the 2017 water demand and supply report by the Department of Infrastructure and Technical Services, the following applies to uMhlathuze Water System:

- The Richards Bay Water Network is augmented through the Nsezi Water Treatment Plant and the demand is 55 megalitres per day (55MI/day), but the Mhlathuze Water supplies 33 megalitres in line with level 4 restrictions.
- The Empangeni/Ngwelezane Water Network is augmented through the Nsezi Water Treatment Plant and the demand is 30 megalitres per day (30MI/day) with MWB supplying 22 megalitres per day in line with level 4 restrictions.
- The Esikhaleni Water Network is augmented through the Nsezi Weir and the demand is 20 megalitres per day (20MI/day) with Mhlathuze Water supplying 11 megalitres per day in line with level 4 restrictions.

Water restrictions reflected in Table 4.1 assisted the city with water rationalisation, pressure management and water demand reduction in order to meet and reduce daily consumption.

Future water supply to the envisaged new industries to be located at the RBIDZ Estates would be supplied by the Richards Bay System. Table 4.5 outlines current percentage utilisation of water in the Richards Bay System. It indicated that commercial, business and industries consumed 70.88% of water whereas 29.12% was consumed by residential.

Table 4.5: Percentage utilisation in Richards Bay system 2016

Month Billed	Business /Commercial / Industrial (KI)	% Consumption Business /Commercial / Industrial	Residential (KI)	% Consumption Domestic	Grand Total (KI)
Nov'15	1839878	72.53%	696742	27.47%	2536620
Dec'15	1566316	69.68%	681625	30.32%	2247941
Jan'16	1586244	71.33%	637431	28.67%	2223675
Feb'16	2095235	68.72%	953788	31.28%	3049023
Mar'16	1742264	71.45%	696324	28.55%	2438588
Apr'16	1746622	72.00%	679176	28.00%	2425798
Grand Total	10 576 559	70.88%	4 345 086	29.12%	14 921 645
Average Monthly	1 762 759.83	70.88%	724 181	29.12%	2 486 940.83

(Source: DI&TS Council Report 2016)

Evidently, business/commercial and industrial sector accounted for the bulk usage and as a result, further industrial growth would increase the demand for potable water in the city. One of the proposals by the city was to diversify its water sources by investing in wastewater reuse and desalination plant as an alternative option to supplement current supply and thus free up the demand for potable water by business/commercial and industrial sector.

4.7 Richards Bay Industrial Development Zone

The history and potential of the Richards Bay Industrial Development Zone (RBIDZ)¹² remain vital in considering the development of industry and manufacturing in uMhlathuze. Initially, Trade and Investment KwaZulu-Natal was the majority shareholder in the RBIDZ. However, the RBIDZ ownership was moved to the Department of Economic Development and Tourism, making the Provincial Government the single shareholder. The RBIDZ owns fully serviced Industrial Estates, which are attracting investment to the city due to the tax incentives package provided by the state (CoU Integrated Development Plan, 2016/17).

The City of uMhlathuze is also home to the Port of Richards Bay, which is currently one of the largest and busiest ports on the South African Coastline. Furthermore, the port is set to

¹²The Richards Bay Industrial Development Zone (RBIDZ) is a purpose built and secure industrial estate on the North-Eastern South African coast. The N2 business corridor links the Province's two major ports, Durban and Richards Bay, and connects with Maputo in Mozambique and, ultimately, areas of East Africa. It is linked to the international sea port of Richards Bay, tailored for manufacturing and storage of minerals and products to boost beneficiation, investment, economic growth and, most importantly, the development of skills and employment. First-world infrastructure allows for the full exploitation of the areas' natural and strategic advantages. Through the superb industrial infrastructure, well-established network of shipments, tax and duty free incentives, the IDZ aims to encourage international competitiveness and the attraction of export-orientated manufacturing investment (DTI, 2014).

enter a long-term expansion phase that would see a three-fold increase in surface area and five-fold extension of the existing quay length.

The total container capacity being planned for the Port of Richards Bay in phases 1 to 11 would amount to approximately two million Twenty-Foot Equivalent Units (TEUs)¹³ per annum over a period of approximately fifty years. In addition to the development of a container handling facilities in phases 1 to 11, extensive port development was anticipated inside the existing port boundary. The following are some of the multinational companies already located in the city: Mondi; Richards Bay Minerals, Sappi, Tronox, Bell Equipment, Foskor, South 32, Port of Richards Bay, Richards Bay Coal Terminal, Isizinda, Richards Bay Coal Terminal, and Isizinda Aluminium (CoU Integrated Development Plan, 2016/17).

It is anticipated that from now until 2050 the Industrial Development Zone would continue to attract multi-billion dollar investments. Furthermore, the expansion of the Port of Richards Bay was expected to contribute to accelerated industrialisation of the city informed by the long-term vision of the municipality, which is: *“The Port City of uMhlathuze offering a better quality of life for all its citizens through sustainable development and inclusive economic growth.”* In support of the above municipal-wide vision, the uMhlathuze Municipal Spatial Development Framework Vision is to: *“Sustain socio-economic development and distribution of opportunities for the benefit of all communities in an efficient, cost-effective manner”* (COU Integrated Development Plan, 2016/17).

Aligned with Basic Service Delivery and Infrastructure Provision and Local Economic Development Key Performance Areas (KPAs), the following key objectives form the basis of the Spatial Development Framework (SDF), which guides the industrialisation initiatives:

- Promote socio-economic balance and improve quality of life for all citizens through sustainable development.
- Provide guidance for spatial distribution of desirable land development and promote densification.
- Promote spatial justice and an efficient land use management system.

¹³TEU stands for Twenty-Foot Equivalent Unit which can be used to measure a ship's cargo carrying capacity.

4.8 Conclusion

The City of uMhlathuze recognised the need to focus on water conservation and water demand management in support of the national programme and protection of scarce water supply resources. In recent times, the city welcomed the establishment of an Industrial Development Zone and this establishment meant that, in future, there would be more demand for water for industrial purposes.

The City of uMhlathuze remains strategically placed as an aspirant metropolis due to its close proximity to Durban. Likewise, it is home to the country's largest deep-water port and enjoys the associated economic spin-offs. It is, therefore, imperative for the city to continue implementing strategies and interventions aimed at water conservation and water demand management.

Chapter Five: Research Findings and Data Analysis

5.1 Introduction

The purpose of this chapter is to analyse and interpret data collected during the research. A case study was conducted at the City of uMhlathuze on water conservation and water demand management. The respondents had to respond based on statements rated as either strongly agree, agree, neutral, disagree or strongly disagree (**Appendix A**). The research results are presented and discussed hereunder.

5.2 Results and Discussion

The research was conducted within the City of uMhlathuze and a total of 14 questionnaires were issued to officials who directly and indirectly participate in water conservation and water demand management processes. The questionnaires were drafted in such a way that respondents were allowed to add their comments on each statement. The responses are summarised and discussed below.

5.2.1 Statement: the City of uMhlathuze has developed and implemented a Water Conservation and Water Demand Strategy

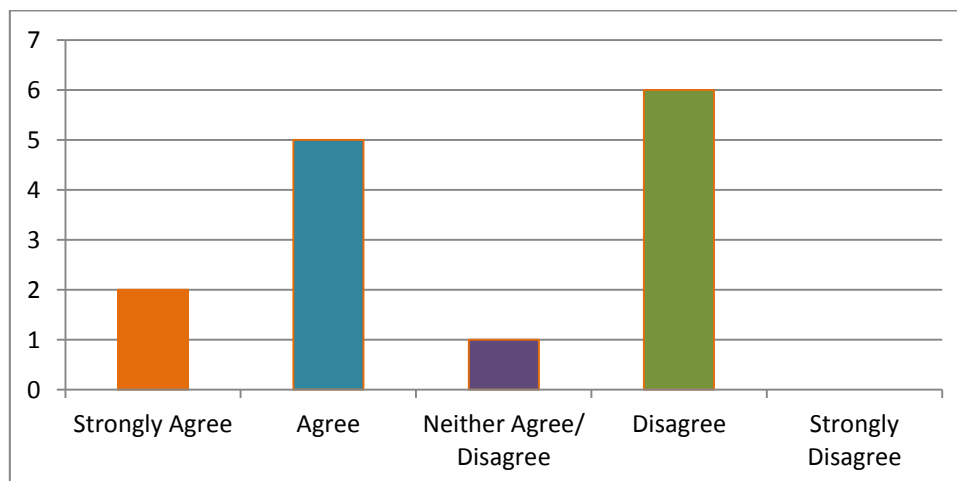


Figure 5.1: CoU WC/WDM strategy statement

A total of six (6) (43%) of the respondents disagreed with the statement that the City of uMhlathuze had developed and effectively implemented a WC and WDM strategy. However, a total of five (5) agreed and two (2) strongly agreed with the statement.

The results highlighted inconsistencies regarding the understanding of the strategy, irrespective of the fact that the strategy was developed in 2012 and certain aspects of the

strategy were being implemented by the city, such as pipe replacement, water loss management and pressure management.

5.2.2 Statement: Over a period of time, water conservation and water demand interventions have drastically reduced water losses in the city

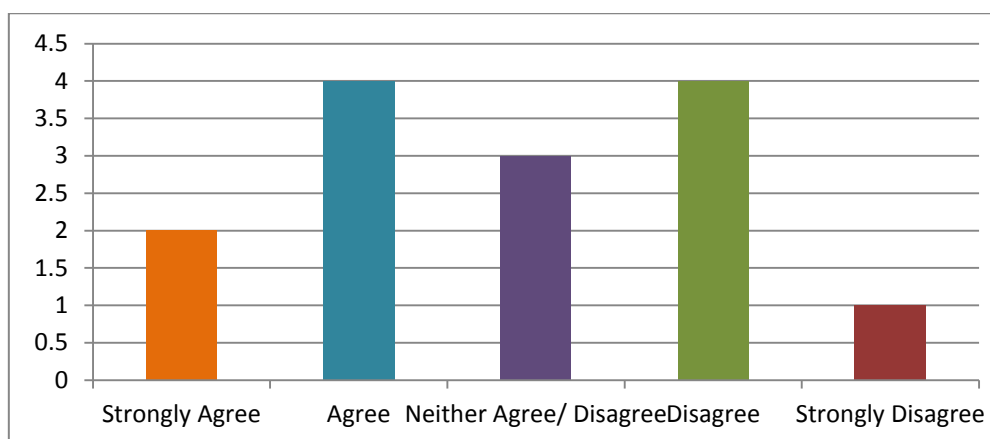


Figure 5.2: Water losses statement

With regard to the above statement, a total of four (4) (28%) of the respondents agreed and two (2) strongly agreed with the statement that water conservation and water demand management interventions had drastically reduced water losses in the city over a period of time. However, a total of four (4) respondents disagreed with the statement and three (3) respondents neither agreed nor disagreed, meaning they were neutral.

Responses indicated a lack of information about certain water conservation and water demand management interventions that had been performed and changed the landscape since being implemented by the city. Those who recorded neutral, disagreed and strongly disagreed combined constituted 57% of the responses.

Evidently, the officials knowledge of the outcome of interventions in relation to water conservation and water demand management was limited, especially as it related to water losses. This indicated that such initiatives had not been properly institutionalised to achieve desired outcomes. The following actual reduction in water losses had been recorded and reported in the previous financial years:

Table 5.1: CoU total water losses from 2013 to 2016

No.	Financial Year	Total Water Losses	% Reduction
1.	2013/14	36%	Highest Losses
2.	2014/15	33%	3% Reduction
3.	2015/16	26%	7% Reduction

(Source: City of uMhlatuze Audited Financial Statements)

From the above, a significant reduction in water loss is apparent. Overall, between the 2013/14 and 2015/16 financial years, there was a total of 10% reduction in water losses.

5.2.3 Statement: the municipality allocates sufficient budget in each financial year for the implementation of WC and WDM projects such as pipe replacement, pressure management, water sensitive urban design, leaks monitoring and repairs, etc.

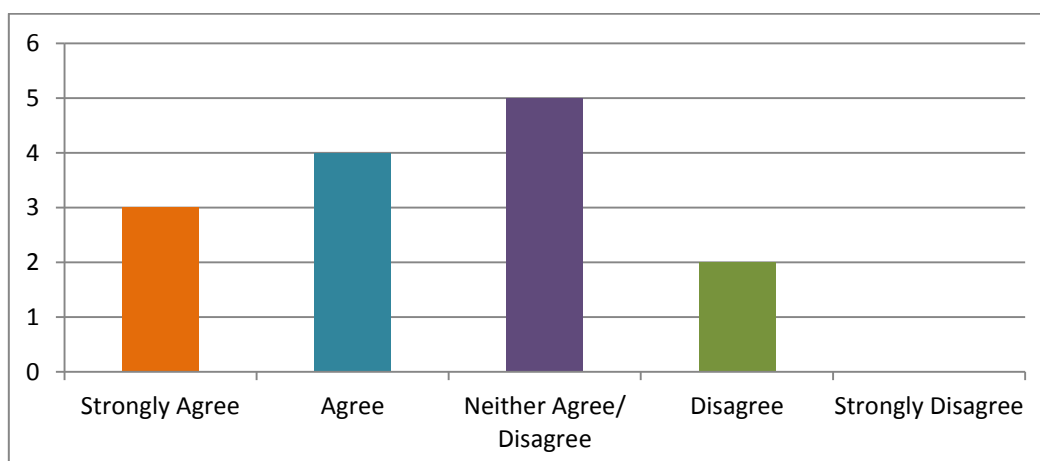


Figure 5.3: WC and WDM budget statement

Pertaining to this statement, a total of five (5) (36%) respondents neither agreed nor disagreed (neutral) with the statement that the municipality allocated sufficient budget in each financial year for the implementation of water conservation and water demand management projects such as pipe replacement, pressure management, water sensitive urban design, leaks monitoring and repair. Conversely, four (4) agreed and three (3) strongly agreed with the statement.

The responses indicated a degree of uncertainty regarding the budgeting processes and allocation of resources by the city for the implementation of water conservation and water demand management projects. This may also be as a result of a common trend at municipal level wherein departments always complain about limited resources and insufficient budgets

in general. Further assessment of the budgeting processes for water conservation and water demand management would be necessary as part of the strategy review.

Some of the additional comments highlighted that a Climate Change Adaptation and Mitigation Plan was being developed for the City of uMhlatuze. Consequently, water conservation and water demand management projects were identified as an integral component of climate change adaptation initiatives.

5.2.4 Statement: consumption based water tariffs are an effective method of reducing water demand

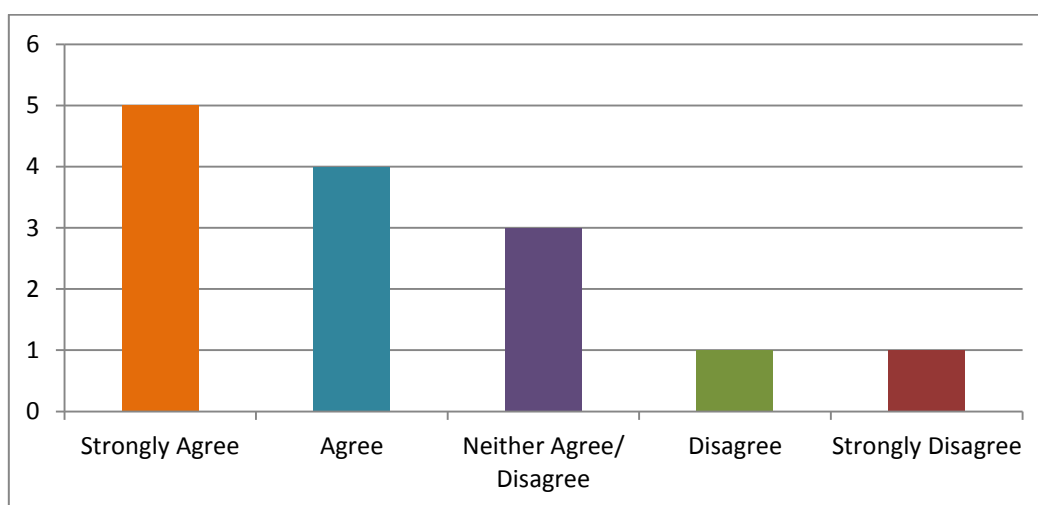


Figure 5.4: Consumption based water tariffs statement

On this statement, a total of five (5) (36%) respondents strongly agreed that consumption-based water tariffs were an effective method of reducing water demand. In all, a total of four (4) respondents agreed with the statement. Respondents who agreed and strongly agreed constituted 64%. This indicated support for consumption-based water tariff as an effective method of reducing water demand. However, three (3) respondents could not agree or disagree with the statement. Finally, one (1) respondent disagreed and another strongly disagreed. Based on the responses, most respondents agreed that consumption-based water tariffs could be an effective method of reducing water demand and consumption.

Again, the current drought in South Africa has had a negative and severe impact on the availability of water. This is due to extremely low rainfall starting in 2014 and continuing through 2015, and the better part of 2016 and 2017 (Department of Water and Sanitation, 2017). During the study, it was difficult to obtain a concrete prediction that there would be sufficient rain into the future due to changing weather patterns. To curtail the demand for water, the National Department of Water and Sanitation introduced drought tariffs based on

the severity of the drought. In terms of levels, stage 1 drought tariffs were the lowest and stage 5 drought tariffs were the highest.

As a result, drought tariffs had been applied by affected municipalities and the City of uMhlathuze was currently charging stage 4 drought tariffs (**Appendix B**).

Part of the challenge regarding consumption-based tariffs in the city was the proliferation of illegal connections as a result of affordability challenges. During this study, the city was planning to assess the nature and extent of illegal connections, especially in the townships and rural areas where the City of uMhlathuze struggled to get payment for services. One of the biggest problems in these areas was backyard dwellings, which drastically increase households consumption levels (City of uMhlathuze IDP, 2016/17).

5.2.5 Statement: pipe replacement, leaks monitoring and repair, water use, rainwater harvesting, water sensitive urban design and water pressure are the main components of water conservation and water demand management

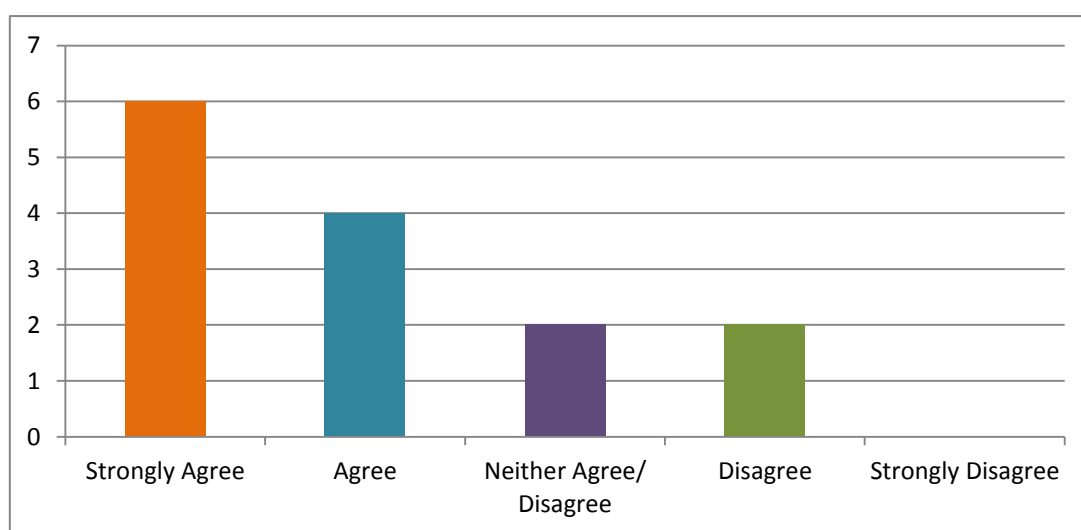


Figure 5.5: Main components of WC and WDM statement

In respect of the above, six (6) (43%) respondents strongly agreed with the statement that pipe replacement, leaks monitoring and repair, water reuse, rainwater harvesting, water sensitive urban design and water pressure management were the main components of water conservation and water demand management. A total of four (4) respondents agreed with the same statement.

Consequently, the combined respondents who strongly agreed and agreed constituted 71% of those who responded. Only two (2) respondents neither agreed/disagreed and disagreed,

respectively. Clearly, most respondents supported the proposition, at various levels of agreement.

Some respondents suggested that water conservation and water demand management should furthermore incorporate land use and natural resource/ecological aspects. This was based on the fact that the city has three Lakes within its area of jurisdiction. At some point, prior to the drought in 2014, the Lakes supplied industrial and domestic potable water. These Lakes dependent on ground water recharge and hence their survival would be ultimately determined by the ecological integrity of wetlands draining into the systems.

The loss of wetlands or decrease in ecological integrity through undesirable land use management and encroachment into compaction of wetlands implied that the process of ground water recharge was severely compromised.

5.2.6 Statement: the municipality has sufficient water resources to support existing and new industries

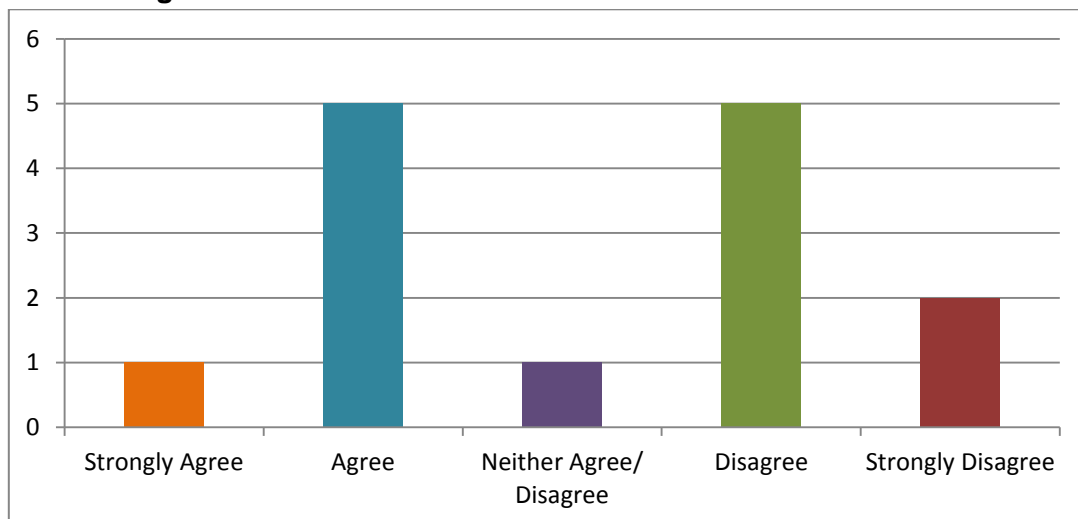


Figure 5.6: Water sources statement

Pertaining to the above statement, a total of five (5) (36%) respondents agreed with the statement and five (5) said they disagreed, with two (2) stating that they strongly disagreed. Conversely, seven (7) respondents, constituting 50% of all respondents who disagreed and strongly disagreed did not support the statement that the City of uMhlathuze had sufficient water sources to support existing and new industries. Consequently, the responses were inconclusive on the subject matter.

During the study, it was established that the primary source of bulk water, the Goedetrouw Dam level was at 32.77%, whereas the Mzingazi Lake, a secondary water source was at 90% and the Cubhu Lake was at 100%. The Cubhu Lake offered very minimal contribution

due to its size and limited supply areas. This data was obtained in September 2017 (City of uMhlathuze Water and Sanitation 4th Quarterly Report, 2017).

Some of the respondents indicated a need for city planners to urgently look at alternative and sustainable water sources in order to diversify the city’s options. This would reduce heavy reliance on Goedertrouw Dam as one of the city’s main sources of water supply.

Again, some respondents recommended the augmentation of the uThukeka Water Transfer Scheme¹⁴ and upgrading of the Goedetrouw Dam wall to increase capacity. Respondents highlighted that the ecological risks to the city were significantly high considering the impact of climate change and rising sea level temperatures.

5.2.7 Statement: investment in alternative water supply options such as seawater desalination, water reuse, stormwater and rainwater harvesting, ground water and recharge aquifers, etc. will provide long-term security of supply for businesses, industries and residents

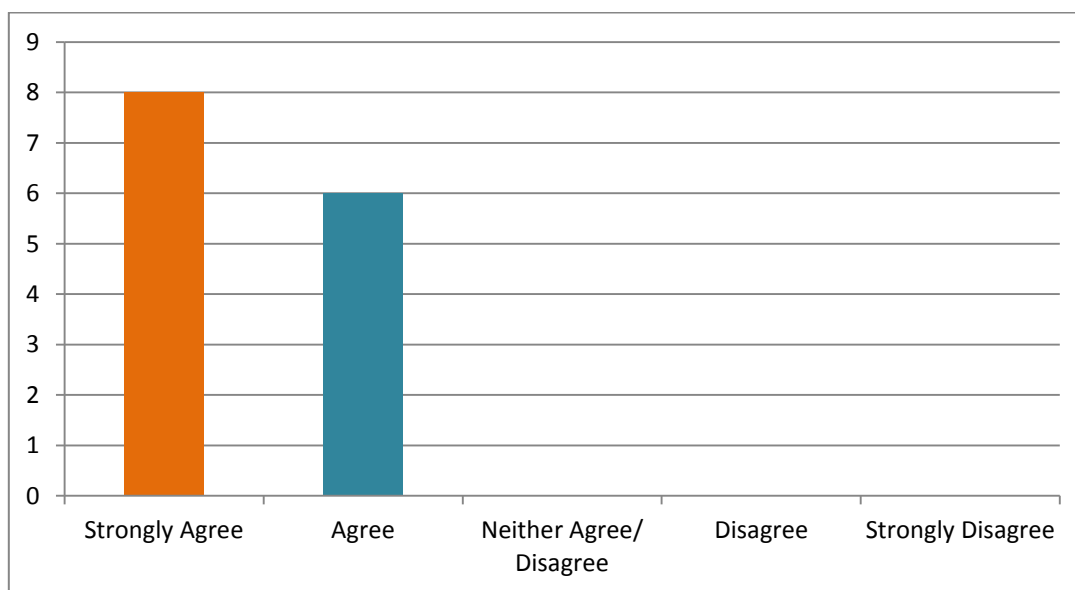


Figure 5.7: Alternative water supply options statement

A total of eight (8) (57%) respondents strongly agreed and six (6) (43%) agreed with statement on investment in alternative water supply options. Seawater desalination, water reuse, stormwater and rainwater harvesting, ground water and recharge of aquifers could provide a long-term water security of supply for businesses, industries and residents.

The respondents who strongly agreed and agreed with the statement combined constituted 100% agreement with the statement. This clearly showed that there was a need to look for

¹⁴uThukela Water Transfer Scheme is a scheme currently transferring water from uThukela River to Goedetrouw Dam in order to increase water levels. This scheme transfers 1,2m3 cubic meters of water and the capacity needs to be upgraded to double the capacity.

alternative water supply options in order to guarantee security of supply for residents, industries and businesses.

The respondents, however, stressed that any increase in water supply should be supported by systematic water conservation and water demand management interventions. Furthermore, it was mentioned that options such as seawater desalination (although costly), water reuse, ground water and recharge of aquifers etc. should be considered as alternative sources.

5.2.8 Statement: the municipality has developed and implemented an effective and efficient water leaks detection and repair system

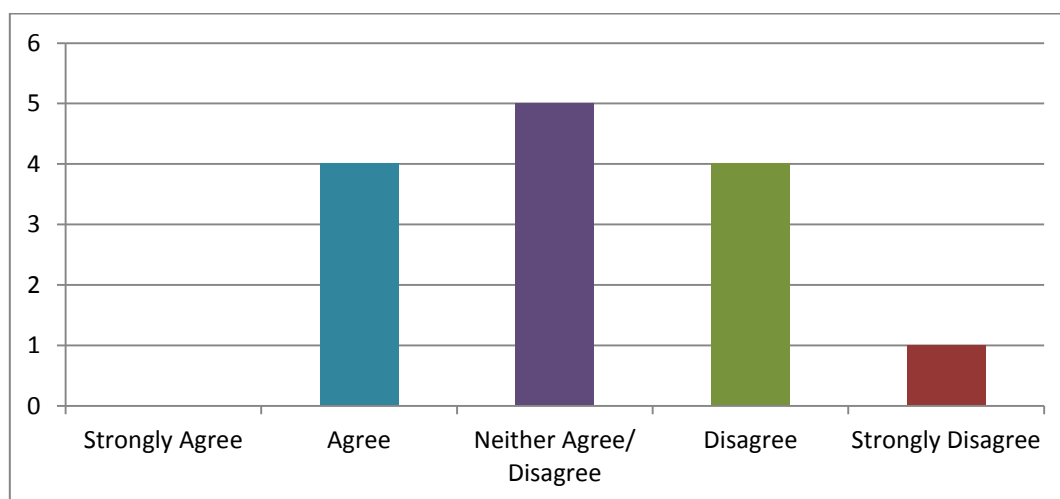


Figure 5.8: Water leaks detection and repair system

Analysis of the above figure showed that a total of four (4) (28%) respondents agreed with the statement, whereas five (5) (36%) respondents neither agreed nor disagreed. This illustrated limited intervention by the city regarding the development and implementation of an effective and efficient water leak detection and repair system. Four (4) respondents disagreed with the statement with one (1) respondent strongly disagreeing. Together, those respondents who neither agreed nor disagreed and strongly disagreed constituted 71% of all respondents.

The above responses were misaligned considering the objectives of a five-year strategy developed by the City of uMhlathuze in 2012, which identified leak detection and repair programme as part of priority interventions. The responses highlighted that the implementation thereof was not satisfactory.

As elucidated in the literature review, repairing visible and reported leaks immediately after being reported was important and should be implemented as a top priority. The repair of

such leaks needed no financial justification or preliminary assessment to determine its significance in terms of water demand management. It is one of the most cost-effective measures any municipality can undertake. According to the Mckenzie (2014):

“no municipality can expect customers to save water and pay for services if the municipality allows visible leaks to run for months without being repaired and repairing visible leaks is the most basic and obvious water loss reduction intervention that can be implemented.”

5.2.9 Statement: the residents, industries and businesses are adequately informed and empowered on water conservation and water demand management strategies

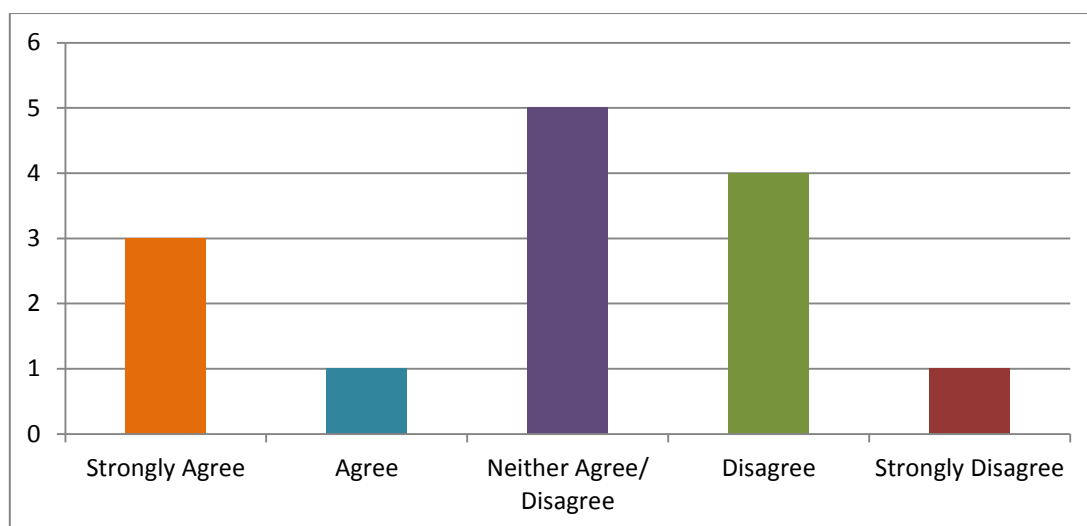


Figure 5.9: Information dissemination statement

With regard to this statement, only three (3) (21%) respondents strongly agreed and one (1) agreed. The remaining respondents neither agreed/disagreed (5) (36%), with four (4) (28%) respondents who disagreed and only one (1) strongly disagreed. Accordingly, it was clear that more respondents remained neutral and did not agree or disagree with the statement.

Evidently, the perception created by the responses was that residents, industries and businesses were not adequately informed and empowered on water conservation and water demand management strategies. This suggested a weakness in the municipality’s processes regarding public engagement, civic education and stakeholder management on issues of water conservation and water demand management.

Additional comments from the respondents highlighted the severe impact of drought which resulted in level 4 water restrictions being implemented. The restrictions in turn compelled

the municipality to implement campaigns and conservation programmes, but these were not aligned to any strategy or broader plan. The WC and WDM initiatives were not adequately communicated to broader stakeholders in order to forge strong strategic partnership.

It was further indicated that the challenge for the municipality in the successful implementation of good strategies was to make implementation plans more proactive and less reactive. Communication with the public was just one example where it took more than two years of drought conditions before the administration began implementing community awareness campaigns.

5.2.10 Statement: municipal elected political office bearers are leading and driving community based campaigns and projects focusing on water conservation and water demand management

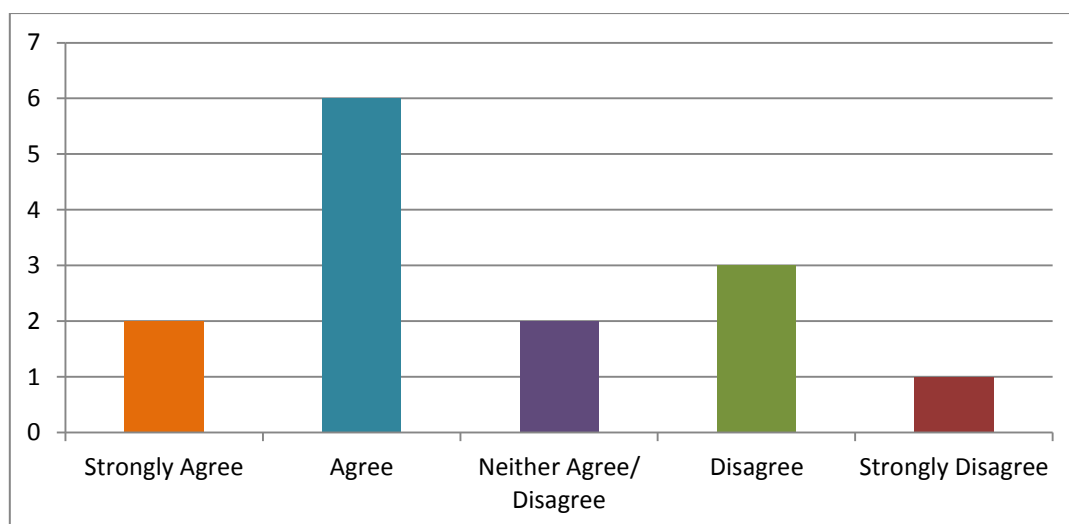


Figure 5.10: Municipal elected office bearers statement

A total of six (6) (43%) respondents agreed with the statement that municipal elected political office bearers were leading and driving community based campaigns and projects focusing on water conservation and water demand management. The remaining responses were as follows: two (2) strongly agreed; two (2) neither agreed/disagreed; three (3) disagreed and one (1) strongly disagreed. The perception of the respondents was that there was a level of visibility by municipal political office bearers including the mayor, deputy mayor, speaker and councillors. Fifty-seven per cent (57%) of combined respondents strongly agreed and agreed with the statement.

Political office bearers, as elected representatives, were expected to lead and support community campaigns. It is recommended that the mayor, as first citizen, should be the face of water conservation and demand management community campaigns. Being community

representatives, politicians are in a better position to articulate community responsibilities and also forge partnership with communities.

Some of the additional comments included the need for the political leadership to spend less time on short term deliverables, but focus on addressing medium to long-term service delivery requirements in terms of WC and WDM.

5.3 Conclusion

A total of fourteen (14) questionnaires were issued to respondents working for the City of uMhlatuze. All fourteen (14) questionnaires were completed and returned. All respondents were willing to participate after the purpose of the study had been fully explained. The overall picture of how the respondents answered the ten (10) statements is summarised below.

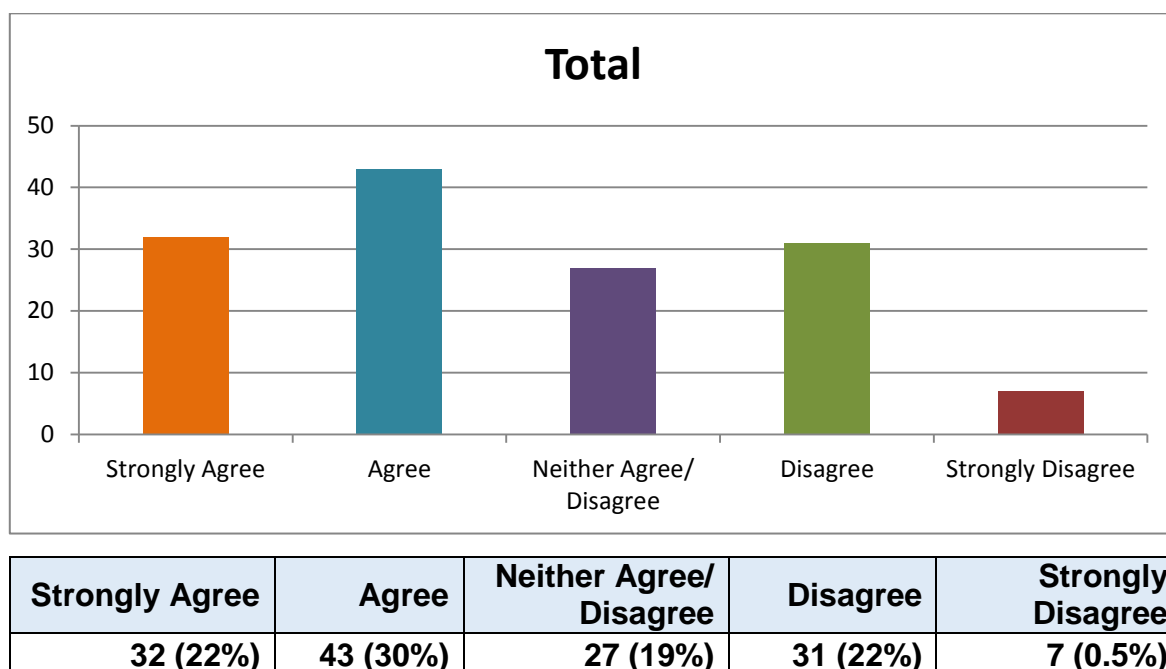


Figure 5.11: Summary of overall respondents

Figure 5.11 illustrates the overall summary of how the fourteen (14) respondents answered each of the ten (10) statements linked to water conservation and water demand management in the City of uMhlatuze. The consolidated picture is as follows: strongly agreed 32 (22%); agreed 43 (30%); neutral 27 (19%), disagreed 31 (22%) and strongly disagreed 7 (0.5%). Based on these findings, it was evident that there was room for improvement by the city considering the number of respondents who neither agreed/disagreed, disagreed and strongly disagreed. This number combined constituted 65 (46%) of the 140 individual questions completed.

It was evident from the responses that water conservation and water demand management remained a new phenomenon for the municipality, and that it would take much longer to effectively implement water conservation and demand management solutions, despite the fact that the City of uMhlathuze had already developed a progressive strategy, albeit not periodically reviewed since 2012. Perceptions of inconsistencies in terms of strategy implementation were noticeable from the responses. The limitation in terms of officials who are involved in water conservation and water demand management processes affected the sample size. Moving forward, the focus should be on WC and WDM strategy review and getting more broad-based participation by officials and stakeholders.

The foregoing conclusion leads to the final chapter dealing with conclusions and recommendations. Chapter Six evaluates the outcome of the research against the research question and makes recommendations on possible solutions to improve water conservation and water demand management in the City of uMhlathuze.

Chapter Six: Conclusions and Recommendations

6.1 Conclusions

Wegelin and Jacobs (2012: 415) identified that:

“the implementation of water conservation and water demand management at municipal level has been inadequate for many years, despite South Africa being one of the driest countries in the world. This could be attributed to a lack of planning, and not realising the importance and potential benefits of water restrictions”.

To this end, many South African municipalities have not prioritised the development of a WC and WDM strategy and some do not have the capacity and expertise to develop such a strategy (Wegelin & Jacobs, 2012).

Again, the Water Services Act, 108 of 1997 stipulates that all spheres of government must provide water supply services in an efficient, equitable and sustainable manner. The Act also requires municipalities that have been given water services provider status to ensure that measures to promote water conservation and demand management are included in their WC and WDM strategy as well as in the Water Services Development Plan (WSDP).

This study has sought to evaluate water conservation and water demand management in an industrialised city using the City of uMhlathuze as a case study. It is anticipated that, in future, the demand for water in the city for industrial development and production purposes would increase exponentially. The serious threat to the City of uMhlathuze industrialisation programme is that future water supply may not meet the growing demand. This problem could be further compounded by continuous drought in the Province of KwaZulu-Natal.

This study, therefore, supports the review and implementation of a water conservation and water demand management strategy and interventions for continuous, inclusive and sustainable economic growth including access to water by all for domestic consumption and industrial purposes.

In this final chapter, the findings are synthesised in order to understand how the various aspects relate to one another and have informed the recommendations. The respondents' answers broadly reflected the current situation in respect of the City of uMhlathuze WC and WDM strategy and interventions. When interrogating the respondents' responses and available documentation, it became evident that there was still a lack of broad participation and institutionalisation of the WC and WDM processes and this also affected the sample size for the study.

6.2 Key Findings

The key findings are summarised hereunder based on the responses to the questionnaire statements and assessment of available documentation.

6.2.1 Statement: the City of uMhlathuze has developed and effectively implemented a Water Conservation and Water Demand Management Strategy

During the study, it was found that the City of uMhlathuze developed a WC and WDM strategy in 2012 and the strategy was being implemented, albeit at a slow pace. The strategy seemed to be lacking a number of key elements relative to water conservation and water demand management solutions and guidelines, as the greater part of the strategy focused on water loss management. Based on certain responses, there was some indication that the City of uMhlathuze had made progress in addressing certain aspects of water conservation and water demand management, such as a noticeable reduction in water losses from 36% in 2013/14 to 26% in 2015/16 financial year.

Although the City of uMhlathuze was severely affected by drought, the pace at which water conservation and water demand management interventions were being implemented was very slow and some aspects were simply non-existent; therefore, there was still scope for improved performance, repackaging and alignment of the strategy including institutionalisation thereof.

6.2.2 Statement: water conservation and water demand management interventions have drastically reduced water losses in the city over a period of time

Notwithstanding some reduction in water losses as reflected in the Chapter Five, the percentage losses remained high for a municipality of the City of uMhlathuze's size and fell short of the 15% target set by the Department of Water and Sanitation. Based on the responses, it could be argued that there was still a lack of information in relation to how certain aspects of water conservation and water demand management interventions performed and changed the landscape since being introduced by the City of uMhlathuze. This was as a result of the strategy not being reviewed since adoption. Evidently, the management of water losses was being undertaken as a financial requirement outside the overall WC and WDM strategy for greater impact.

6.2.3 Statement: the municipality allocates sufficient budget in each financial year for the implementation of WC and WDM projects

The responses indicated a degree of uncertainty regarding budgeting processes and allocation of resources by the City of uMhlathuze for the implementation of water conservation and water demand management projects. The investigation carried out during the course of this study highlighted the fact that the City of uMhlathuze did not allocate its own funding for WC and WDM projects. Instead, it relied on grant funding from the National Department, in particular, the Department of Water and Sanitation and Municipal Infrastructure Grant, respectively. This approach highlighted the need for the City of uMhlathuze to also invest its own resources to implement WC and WDM projects using the strength of its own approximately R3.5 billion budget (City of uMhlathuze IDP, 2016/17).

In the absence of grant funding from the National Government, the City of uMhlathuze would not be in a position to continue investing in WC and WDM projects. According to the City of uMhlathuze's Budget for the 2015/16 and 2016/17 financial years, the budget allocated for WC and WDM related projects were R50 million and R30 million, respectively (City of uMhlathuze IDP 2016/17).

6.2.4 Statement: consumption based water tariffs are an effective method of reducing water demand

Based on the responses, most respondents agreed that consumption-based water tariffs could be an effective method of reducing water demand. The implementation of consumption based tariffs was evident during the study and was being used as a tool to manage water demand, particularly as a result of drought. In terms of the tariffs structure, customers who used less than 200 litres per day and capped at 6 kilolitres per month were exempted from paying for water.

As highlighted in Chapter Five, a sliding scale tariff was applied for consumption above 200 litres per day, with the highest being R18.06 for consumption above 2.0 kilolitres per day in 2016 and R19.14 consumption tariff in 2017. It was found that this method had not been tested to determine its impact on changing consumption levels and customer behaviour although there was noticeable decrease in bulk purchases. It was noted that consumption based tariffs have the potential to control water usage and punish those who do not use water sparingly.

6.2.5 Statement: pipe replacement, leak monitoring and repair, water reuse, rainwater harvesting, sensitive urban design and water pressure management are considered the main components of water conservation and water demand management

The responses indicated that there was an acknowledgement that interventions such as pipe replacement, leak monitoring and repair, water reuse, rainwater harvesting, water sensitive urban design and water pressure management were considered important components of WC and WDM. Despite this, it could be argued that the City of uMhlathuze had not implemented some of these interventions, with the exception of pipe replacement and pressure management. It must be noted, however, that pipe replacement and pressure management were prioritised and considered key to reducing water losses as a result of issues raised by the Auditor General and as a mechanism to replace ageing water infrastructure (City of uMhlathuze IDP, 2016/17).

6.2.6 Statement: the municipality has sufficient water sources to support existing and new industries

The responses for this statement were inconclusive. Based on the information contained in Chapter Four, it was found that the City of uMhlathuze had limited water sources to support existing and new industries due to reliance on the Goedertrouw Dam, which had consistently remained below 35% from 2015 to 2017 as a result of drought (Figure 4.4). The existence of Lakes in the city provided some relief, but there was a lack of integrated and long-term planning on future water sources to support industrialisation. It was evident that more sustainable and integrated planning for future water sources was required to guarantee long-term security of supply.

6.2.7 Statement: investment in alternative water supply options, such as seawater desalination, water reuse, stormwater and rainwater harvesting, groundwater and recharge aquifers, will provide long-term water security of supply for businesses, industries and residents

During the study, it was found that most respondents agreed with the notion that investing in alternative water supply options such as seawater desalination, wastewater reuse, stormwater and rainwater harvesting, groundwater and recharge of aquifers could provide long-term security of supply and alternative water source for the city. The literature review showed that there was no single option that is a panacea for all water scarcity challenges, but different options, providing a variety of progressive solutions should be considered based on local circumstances. A number of these options are viable if well planned and considered

best fit. As indicated in Chapter Four, the options that have been considered by the City of uMhlathuze included seawater desalination and wastewater reuse.

6.2.8 Statement: the municipality has developed and implemented an effective and efficient water leak detection and repair system

Based on the responses to this statement, the perception of the respondents was that the development and implementation of an effective and efficient water leak detection and repair system remained a challenge because the City of uMhlathuze had not developed a proactive system to detect water leaks. The city mainly relied on information reported by members of the public and stakeholders through the Customer Call Centre in order to undertake repairs. As evidenced in the literature review, one of the major interventions in water conservation and water demand management is leak detection and repair programme aimed at identifying visible and invisible leaks along the water network so that arrangements can be made for the repair of identified and reported leaks. Accordingly, early detection of leaks would assist in saving water and ensure that leaks are repaired on time.

6.2.9 Statement: residents, industries and businesses are adequately informed and empowered on WC and WDM strategies

According to the responses, the perception of respondents was that residents, industries and businesses were not adequately informed about WC and WDM strategies and interventions. There was a potential to enhance this activity at community level to facilitate better understanding of community involvement in water conservation and water demand management interventions. The literature review highlighted that building a community of practice aimed at creating strategic learning alliances so that stakeholders can engage in collective sense-making and vision building, while placing strong emphasis on community participation in developing a water sensitive strategy is fundamental. Community structures at municipal ward level, stakeholders and community based planning structures could be used as platforms for driving active community participation on matters of WC and WDM.

6.2.10 Statement: Municipal elected political office bearers are leading community based campaigns and projects focusing on WC and WDM

The concept of leaders leading by example finds expression in the public administration environment. For any intervention to be successful, especially in public institutions, elected political office bearers are expected to lead community based campaigns. The literature review showed that a paradigm shift in water resources management requires an integrated approach and commitment by all key players. This is essential to ensure and effect a period of culture change in the way water resources are managed. The responses indicated that

elected political office bearers were, to some extent, leading and driving community based campaigns, albeit there was still room for improvement in strengthening community based involvement using existing platforms such as ward committees, stakeholders' forum and community based planning structures.

This study has achieved its objective of ascertaining whether the industrialised City of uMhlathuze had developed and implemented a WC and WDM strategy and interventions. The responses to a questionnaire by professionals who have direct and indirect roles in water conservation and water demand management processes in the City of uMhlathuze provided useful feedback and data for the study. Some of the general findings included: failure to review the WC and WDM strategy by the City of uMhlathuze since adoption in 2012; poor records keeping and data management by the city; fragmented water management systems and processes; water conservation and water demand management still remained a relatively new concept for the municipality.

6.3 Recommendations

This study examined key elements of WC and WDM strategies and interventions aimed at achieving sustainable water management. As indicated in this report, the key consideration for future economic growth and social upliftment in South Africa includes efficient use of water supplies and reducing water consumption through improved management of demand for water. Notably, if the demand for water continues to grow, with no steps taken to reduce the demand, water shortages would become the order of the day.

The recommendations being presented here are specific to the study conducted at the City of uMhlathuze.

6.3.1 Review of the Five Year Strategic Management Plan for WC and WDM

According to the information obtained during this study, the WC and WDM strategy had not been reviewed since 2012. It is proposed that the strategy be reviewed to ensure that it embraces all aspects of water conservation and water demand management as encapsulated in the Department of Water and Sanitation, WC and WDM strategy for the Water Services Sector. Consideration should be given to other new strategies that have been developed to promote water use efficiency and effective management of water resources in order to enhance the CoU revised strategy. The revised strategy should clearly articulate and consolidate water conservation and water demand management intervention policies, strategies and programme of action focusing on the management of fresh water as

a sustainable resource, strategies to protect water environment and progressive interventions to meet current and future demand. The review should take into consideration anticipated population growth, increase in household size, long-term economic growth trajectory and improving standard of living.

The latest Statistics SA Community Survey (2016) noted that the population of the City of uMhlathuze had increased from 334,459 in 2011 (approx. 85,000 households at 3.9 persons/household) to 410,465 in 2016 (approx. 105,000 households at 3.9 persons/household), a population increase of 22.7% and a land area increase of approx. 50% (79 334 Ha to 123 325 Ha). Again, during the study, multiple investments were expected in the Richards Bay Industrial Development Zone. All of these factors affect how much water would be needed into the future. The City of uMhlathuze should consider benchmarking and partnering with other cities as part of knowledge exchange and benchmarking in reviewing the WC and WDM Strategy.

6.3.2 Rainwater and stormwater harvesting

There had not been any definitive study on the feasibility of rainwater harvesting as a viable option for the City of uMhlathuze. This study did not include measurement and assessment of rainwater yields. As noted in the literature review, rainwater harvesting has certain advantages and benefits, and harvested water can be utilised for various purposes. The viability of rainwater harvesting systems could be influenced by external factors such as rainfall patterns, climatic conditions and the end-users of the rainwater. Further study on above-ground potable top-up roof harvesting and below-ground harvesting systems is required to determine viability.

The literature review showed that stormwater can be captured for many non-potable purposes and to recharge existing natural systems. Harvesting of stormwater can also delay the need for major new water resource infrastructure as more water can be systematically returned into the natural systems through well planned stormwater harvesting. The combined usage of well-planned rainwater and stormwater harvesting is highly recommended to supplement water from the traditional water supply sources.

It is recommended that further research into the feasibility of rainwater and stormwater harvesting should be prioritised by the City of uMhlathuze.

6.3.3 Wastewater reuse

It is recommended that the City of uMhlathuze considers a wastewater reuse system.

This should be done by conducting further research and updating the preliminary assessment on wastewater reclamation and reuse conducted by the Mhlathuze Water Board focusing on big consumers. The findings of the preliminary assessment indicated that the Mhlathuze bulk effluent system handled on average 126 Ml/day of wastewater, which was discharged to the sea and industrial wastewater constituted a high proportion of this wastewater (Mhlathuze Water Board, 2001).

To this end, the industrial recycling and reuse presents high potential for the reuse of suitably treated effluent in industrial activities. In order to provide adequate water quality, treatment process selection needs to take into account acceptable levels of constituents in the reclaimed wastewater, related to scaling, corrosion, biological growth and fouling. Consideration should be given to potential public health concerns on wastewater reuse and also issues of environmental impact and public acceptance. It is further proposed that construction of a Waste Reclamation Plant to provide treated effluent for reuse by industries in the Richards Bay Area be included as part of the research. This would require consultation with major industries in exploring opportunities for using suitably treated effluents that would not affect the quality of their products. A comprehensive study on wastewater reuse for the City of uMhlathuze is necessary to determine its full potential.

6.3.4 Water Sensitive Urban Design (WSUD)

During this study, it became evident that the City of uMhlathuze had not embraced the principles of Water Sensitive Urban Design (WSUD) in its development planning processes. In fact, WSUD had never been considered as part of the urban design processes. The literature review showed that WSUD has the potential to mitigate the negative effects of water scarcity; manage and reverse water pollution; develop social and intergenerational equity; increase sustainability and develop resilience within water systems (Armitage *et al.*, 2014). The WSUD principles include: sustainable water supply; wastewater minimisation; stormwater management; and blue-green infrastructure. WSUD connects the concepts of water sensitivity and urban design, thus ensuring that urban design is undertaken in a water sensitive manner (Armitage *et al.*, 2014).

It is recommended that a further study on how the principles of water sensitive design guided by Water Sensitive Urban Design (WSUD) Framework for South Africa should be incorporated into the City of uMhlathuze Development Planning Frameworks.

6.3.5 Water pressure management, leak detection and pipe replacement long-term project

During the study it became evident that, notwithstanding some interventions by the city regarding the above, there was no coherent and systematic approach including resource allocation methodology for water pressure management, leak detection and pipe replacement. It is recommended that the city develops a long-term programme that would address pressure management, leak detection and pipe replacement. Part of the programme should include the replacement of old pipes with new pipes compatible with pressure reducing values.

The literature review highlighted that pipe replacement is imperative when pipes deteriorate to a level where the occurrence of new leaks becomes so high that the pipes are effectively no longer suitable for use (Mckenzie, 2014). It is recommended that the city should introduce a programme of searching for unreported leaks with some form of leak detection equipment, which is referred to as active leakage control in order to proactively identify invisible leaks. The city's water losses in 2017 were reported to be around 26% at a cost of more than R34 million against a target of 15% set by the national government (CoU AFS, 2017).

It is further recommended that the city sets aside a multi-year budget for long-term programme implementation. The implementation process should focus on starting with areas worst affected by water leaks as well as areas where there is prevalence of pipe bursts due to ageing infrastructure. This requires the city to conduct a full assessment of water infrastructure to determine its remaining useful life.

6.3.6 Groundwater and aquifer recharge

Further research should be conducted on groundwater and recharge of aquifers to determine available quality and quantity. A recharge scheme that would be suitable for the City of uMhlathuze should be investigated. The literature review showed that groundwater was not being perceived as an important water resource and had been given limited attention in South Africa. As noted in the literature review, only 13% of national total water supply originates from groundwater (Riemann *et al.*, 2012). Consequently, there is an opportunity for the City of uMhlathuze to investigate the potential of groundwater and aquifer recharge.

A geohydrological survey investigation on groundwater recharge involving the assimilation of reclaimed wastewater for replenishment and storage in groundwater aquifers or establishment of hydraulic barriers to saltwater intrusion is recommended. The focus should

be on groundwater recharge within the catchment of Lake Mzingazi to allow it to percolate into the surface water system, which would be a typical application for the city. This means that potential constraints for using reclaimed wastewater for groundwater recharge such as possible high levels of organic chemicals in the treated effluent and their toxicological effects, levels of total dissolved solids, nitrates and pathogens should form part of the proposed investigation.

6.3.7 Stakeholder engagement, education and awareness programme

According to the results obtained during this study, it is recommended that the City of uMhlathuze should develop a comprehensive stakeholder engagement, education and awareness programme, with the mayor being the champion of the programme. The programme should focus on:

- Creating an informed public on efficient water use;
- Establishment of water conservation and water demand management local ambassadors;
- Establishing partnership between the community, industries, businesses and the municipality;
- Implementation of comprehensive education and awareness programmes;
- Promoting and enforcing water-wise behaviour and bylaws;
- Encouraging ownership and partnership of water loss reduction and infrastructure development; and
- Community based infrastructure protection.

6.3.8 Joint planning and research team with the Richards Bay Industrial Development Zone

It is recommended that a joint planning and research team be established by the City of uMhlathuze to work with the Richards Bay Industrial Development Zone (RBIDZ) to undertake different studies that would include long-term projections for future water demand by new industries. This approach will allow the city to be proactive in its endeavours to guarantee water supply for industrial purposes. It was found during this research that the RBIDZ long term investment book containing potential new investors highlighted substantial increase in future water demand. This information needs to be integrated into the City's Planning Frameworks (RBIDZ, 2017).

6.3.9 Consumption based water tariffs study

The consumption based water tariffs should form part of the WC and WDM strategy.

It is recommended that the City of uMhlathuze should conduct a detailed investigation on how the consumption based tariffs and drought tariffs affect water usage. This investigation should examine consumption trends for industries, businesses, agriculture and residents. This would assist the city to verify the impact of these tariffs because water usage is influenced by many factors other than the tariffs. During this study, it was found that the city was already implementing consumption based tariffs (CoU Tariffs Methodology, 2017). This study did not assess the impact of consumption based water tariffs as a mechanism to change the patterns of water usage and consumer behaviour.

6.4 Conclusion

The aim of this study was to evaluate WC and WDM strategy and interventions of the industrialised City of uMhlathuze. During the study, it was noted that the city had achieved some progress with more work still needed to be done to ensure full and effective implementation of water conservation and water demand management initiatives. The abovementioned recommendations should assist the city in developing a coherent and implementable strategy that embraces all the key pillars and guidelines of sustainable water conservation and water demand management.

The study further noted that the concept of water conservation and water demand management was still relatively new in the local government sphere. Consequently, support from other partners such as the Department of Water and Sanitation would be essential in ensuring effective and efficient implementation of the strategy and priority projects. The importance of introducing WC and WDM interventions is further compelled by the latest Statistics SA Community Survey showing that the city's population grew by 22.7% in 2016 due to the re-demarcation of municipal boundaries. The Industrial Development Zone long term investment book projected an upward trajectory for water demand (RBIDZ, 2017). The Goedertrouw Dam level remained at less than 35% between 2015 and 2017. All these factors further compel the city to urgently address the challenges of water scarcity.

It was evident from the study that there were more opportunities to increase water use efficiency and those should be explored, especially because of anticipated economic growth and future investments. To this end, all consumers and industries have a duty to the city, the environment and themselves to implement adequate measures that would contribute to water use efficiency in line with sustainable water conservation and water demand management principles.

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Appendix A: Research Project Questionnaire

Evaluating Water Conservation and Water Demand Management in an Industrialised City: A Case Study of the City of uMhlathuze in Richards Bay

ONLY FOR OFFICIALS OF THE CITY OF UMHLATHUZE

My name is Nathi Mthethwa, student no MTHNKO008. I am currently registered with the University of the Cape Town, Faculty of Engineering and the Built Environment, Department of Civil Engineering. To fulfil the requirements of achieving an MPhil Degree in Infrastructure Design and Management, I am conducting a research project on ***“Evaluating Water Conservation and Water Demand Management in an Industrialised City: A Case Study of the City of uMhlathuze”***

This letter serves as confirmation that all information that you will provide is private and confidential. The information will only be shared with the university for academic purposes no names will be used in the research report.

1. The City of uMhlathuze has developed and effectively implemented Water Conservation and Water Demand Management Strategy.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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2. Water conservation and water demand management interventions have drastically reduced water losses in the City over a period of time.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree

1	2	3	4	5

Additional Comments:

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3. The municipality allocates sufficient budget in each financial year for the implementation of water conservation and water demand management projects such as pipe replacement, pressure management, water sensitive urban design, leaks monitoring and repair etc.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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4. Consumption based water tariffs are an effective method of reducing water demand.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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5. Pipe replacement, leaks monitoring and repair, water reuse, rainwater harvesting, water sensitive urban design and water pressure management are the main components of water conservation and water demand management.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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6. The municipality has sufficient water sources to support existing and new industries.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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7. Investment in alternative water supply options such as seawater desalination, water reuse, stormwater and rainwater harvesting, ground water and recharge of aquifers etc. will provide long-term water security of supply for businesses, industries and residents.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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8. The municipality has developed and implemented an effective and efficient water leaks detection and repair system.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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9. The residents, industries and businesses are adequately informed and empowered on water conservation and water demand management strategies.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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10. Municipal elected political office bearers are leading and driving community based campaigns and projects focusing on water conservation and water demand management.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1	2	3	4	5

Additional Comments:

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Additional and general comments on water conservation and demand management in the City:

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Not compulsory

Name:

Position:

THANK YOU FOR TAKING TIME TO COMPLETE THE QUESTIONNAIRE, IT IS GREATLY APPRECIATED.

Appendix B: City of uMhluthuze Consumption-based Water Tariffs for Domestic Consumers, Businesses and Industries

No	Tariff Description	01 July 2015	01 July 2016
Domestic Customers			
1.	0.0 - 0.2 Kl (kilolitres) per day, total consumption capped at 6 kl per month	Nil	Nil
2.	0.0 - 0.2 Kl per day	3.7200	3.9432
3.	0.2 - 0.5 Kl per day	4.4640	4.7318
4.	0.5 - 1.0 Kl per day	10.4499	11.0769
5.	1.0 - 2.0 Kl per day	13.8477	14.6786
6.	Above 2.0 Kl per day	18.0617	19.1454

In terms of the above tariff structure, customers who consume less than 0.2 Kilolitres per day and capped at 6 kilolitres per month are exempted from paying for water. A sliding scale tariff is applied for consumption above 0.2 kilolitres per with the highest being 18.06 for consumption above 2.0 kilolitres per day in 2015 and a 19.14 consumption tariff in 2016.

With regard to business and industries, consumption-based water tariffs are as follows:

No	Tariff Description	01 July 2015	01 July 2016
1.	Other consumers – business and industrial		
2.	0.0 - 0.5 Kl per day	8.1855	8.6766
3.	0.5 - 1.0 Kl per day	11.9364	12.6526
4.	1.0 - 2.0 Kl per day	14.0969	14.9427
5.	Above 2.0 Kl per day	13.9245	14.7600

Evidently, the above table indicates tariffs for businesses and industries are slightly lower compared to domestic tariffs. This is part of the City's initiative to encourage and support investment as well as economic growth. Further, the City acknowledges businesses and industries use water as a means of production unlike domestic customers.

It is, therefore, prudent to allow discounts for businesses and industries. The sliding scale tariff for consumption above 2.0 kilolitres per was 13.92 in 2015 and 14.76 in 2016. Comparatively, domestic customer tariffs for similar consumption levels were 18.06 in 2015 and 19.14 in 2016.

Appendix C: Stage 4 Drought Tariffs

NO	Tariff Description	01 July 2015	01 July 2016
1.	DROUGHT WATER TARIFFS STAGE 1		
2.	Domestic		
3.	0.0 - 0.2 Kl per day, total consumption capped at 6 kl per month	0.0000	0.0000
4.	0.0 - 0.2 Kl per day	4.3178	4.9223
5.	0.2 - 0.5 Kl per day	5.1814	5.9068
6.	0.5 - 1.0 Kl per day	12.1292	13.8273
7.	1.0 - 2.0 Kl per day	16.0730	18.3232
8.	Above 2.0 Kl per day	20.9642	23.8992
9.	Other consumers (business and Industries)		
10.	0.0 - 0.5 Kl per day	9.5009	10.8310
11.	0.5 - 1.0 Kl per day	13.8546	15.7942
12.	1.0 - 2.0 Kl per day	16.3623	18.6530
13.	Above 2.0 Kl per day	16.1622	18.4249
1.	Drought Water Tariffs Stage 2		
2.	Domestic		
3.	0.0 - 0.2 Kl per day, total consumption capped at 6 kl per month	0.0000	0.0000
4.	0.0 - 0.2 Kl per day	4.8699	5.5516
5.	0.2 - 0.5 Kl per day	5.8438	6.6620
6.	0.5 - 1.0 Kl per day	13.6800	15.5952
7.	1.0 - 2.0 Kl per day	18.1280	20.6659
8.	Above 2.0 Kl per day	23.6446	26.9548
9.	Other consumers		
10.	0.0 - 0.5 Kl per day	10.7156	12.2158

11.	0.5 - 1.0 Kl per day	15.6259	17.8136
12.	1.0 - 2.0 Kl per day	18.4543	21.0378
13.	Above 2.0 Kl per day	18.2286	20.7806
1.	Drought Water Tariffs Stage 3		
2.	Domestic		
3.	0.0 - 0.2 Kl per day, total consumption capped at 6 kl per month	0.0000	0.0000
4.	0.0 - 0.2 Kl per day	5.5796	6.3608
5.	0.2 - 0.5 Kl per day	6.6956	7.6329
6.	0.5 - 1.0 Kl per day	15.6738	17.8681
7.	1.0 - 2.0 Kl per day	20.7702	23.6780
8.	Above 2.0 Kl per day	27.0907	30.8834
9.	Other consumers		
10.	0.0 - 0.5 Kl per day	12.2774	13.9963
11.	0.5 - 1.0 Kl per day	17.9034	20.4099
12.	1.0 - 2.0 Kl per day	21.1439	24.1041
13.	Above 2.0 Kl per day	20.8854	23.8093
1.	Drought Water Tariffs Stage 4		
2.	Domestic		
3.	0.0 - 0.2 Kl per day, total consumption capped at 6 kl per month	0.0000	0.0000
4.	0.0 - 0.2 Kl per day	6.2492	7.1241
5.	0.2 - 0.5 Kl per day	7.4990	8.5489
6.	0.5 - 1.0 Kl per day	17.5547	20.0123
7.	1.0 - 2.0 Kl per day	23.2626	26.5193
8.	Above 2.0 Kl per day	30.3416	34.5895
9.	Other consumers		
10.	0.0 - 0.5 Kl per day	12.2774	13.9963
11.	0.5 - 1.0 Kl per day	17.9034	20.4099
12.	1.0 - 2.0 Kl per day	21.1439	24.1041

13.	Above 2.0 Kl per day	20.8854	23.8093
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Source: City of uMhlathuze Drought Tariff Methodology for 2015/16 and 2016/17 Financial Years

Appendix D: Consent Form

CONSENT FORM

Name of Researcher: Nkosinathi Mthethwa, student no - MTHNKO008

Contact Details: cell- 082 377 4075 and email- nathim29@gmail.com

Faculty: Faculty of Engineering and the Built Environment, Department of Civil Engineering

Research Project: *Evaluating Water Conservation and Water Demand Management in an Industrialised City: A Case Study of the City of uMhlatuze in Richards Bay*

My name is Nathi Mthethwa, student no MTHNKO008. I am currently registered with the University of the Cape Town, Faculty of Engineering and the Built Environment, Department of Civil Engineering. To fulfil the requirements of achieving MPhil Degree in Infrastructure Design and Management, I am conducting a research project on ***“Evaluating Water Conservation and Water Demand Management in an Industrialised City: A Case Study of the City of uMhlatuze in Richards Bay”***

This consent form serves as confirmation that all information that you will provide is private and confidential. The information will only be shared with the university for academic purposes no names will be used in the research report.

By filling out this questionnaire:

- I agree to participate in this research project.
- I have read this consent form and the information it contains and had the opportunity to ask questions about them.
- I understand that I was selected to participate in this study due to my expertise.
- I understand that I was selected randomly from a larger group of people with my expertise.
- I agree to my responses being used for education and research on condition my privacy is respected. I understand that my responses will be used in aggregate form only, so that I will not be personally identifiable.
- I understand that I am under no obligation to take part in this project.
- I understand I have the right to withdraw from this project at any stage.
- I understand that this research might be published in a research journal or book. In the case of dissertation research, the document will be available to readers in a university library in printed form, and possibly in electronic form as well.

Name of Participant : _____
Signature of Participant : _____
Date : _____

Your participation in this project is highly appreciated and valued

Appendix E: Ethics Approval

EBE Faculty: Assessment of Ethics in Research Projects

Any person planning to undertake research in the Faculty of Engineering and the Built Environment at the University of Cape Town is required to complete this form before collecting or analysing data. When completed it should be submitted to the supervisor (where applicable) and from there to the Head of Department. If any of the questions below have been answered YES, and the applicant is NOT a fourth year student, the Head should forward this form for approval by the Faculty EIR committee: submit to Ms Zakiya Chikwa (Zakiya.chikwa@uct.ac.za), New EBE Building, Ph 021 650 5739). Students must include a copy of the completed form with the dissertation/thesis when it is submitted for examination.

Name of Principal Researcher/Student: **Nkosinathi Innocent Mthethwa** Department: Faculty of Engineering and the Built Environment, Department of Civil Engineering

If a Student: **MTHNK008** Degree: **MPHIL: Urban Infrastructure Design and Management**
Supervisor: **Dr. Kirsty Carden**

If a Research Contract indicate source of funding/sponsorship: **N/A**

Research Project Title: **Evaluating Water Conservation and Water Demand Management in an Industrialised City: A Case Study of the City of uMhlatuze in Richards Bay**

Overview of ethics issues in your research project:

Question 1: Is there a possibility that your research could cause harm to a third party (i.e. a person not involved in your project)?	YES	NO X
Question 2: Is your research making use of human subjects as sources of data? If your answer is YES, please complete Addendum 2.	YES X	NO
Question 3: Does your research involve the participation of or provision of services to communities? If your answer is YES, please complete Addendum 3.	YES X	NO
Question 4: If your research is sponsored, is there any potential for conflicts of interest? If your answer is YES, please complete Addendum 4.	YES	NO X

If you have answered YES to any of the above questions, please append a copy of your research proposal, as well as any interview schedules or questionnaires (Addendum 1) and please complete further addenda as appropriate.

I hereby undertake to carry out my research in such a way that

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

Signed by:

	Full name and signature	Date
Principal Researcher/Student: MTHNK008	Nkosinathi Innocent Mthethwa Signed by candidate	19 September 2016

This application is approved by:

Supervisor (if applicable):		21 September 2016
HOD (or delegated nominee): Final authority for all assessments with NO to all questions and for all undergraduate research.		2/3/17
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.		