

**PUBLIC HEALTH IMPACTS OF STORM
WATER CANALS IN NELSON MANDELA BAY
COMMUNITIES**

L.PAPU

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PUBLIC HEALTH IMPACTS OF STORM WATER CANALS IN NELSON MANDELA BAY COMMUNITIES

By

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DECLARATION

I, Lumka Papu, student number 20429067, hereby declare that the treatise of *Magister Artium in Development Studies* is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

Lumka Papu

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Abstract

Storm water pollution is a serious problem in Nelson Mandela Bay Metropolitan communities and its main waterways, specifically the Swartkops River and Swartkops River estuary. This study focuses on investigating the public health impacts of three storm water canals, namely the Markman Canal and Motherwell Canal in Port Elizabeth and the Kat Canal in Uitenhage. These canals are the main receivers of urban runoff, unregulated sewage water and waste from various activities, and they discharge their waste directly into the Swartkops River and estuary without any purification.

The purpose of the study is to gain a better understanding of the major causes of pollution from the above mentioned storm water canals and come up with recommendations regarding the future mitigation of storm water pollution. The research methodology of the study is descriptive based on a qualitative approach. An empirical survey is conducted by means of developing an interview schedule with semi structured questions to obtain responses from communities in Uitenhage, Motherwell and Aloes Village.

The findings of the study showed that illegal dumping of litter and sewage in the storm water canals are the major causes of storm water pollution. Since the 1980's, the Motherwell Canal has been contaminated by sewage leaks from storm water pipes and the Municipality has failed to prevent this. As a result residents suffer the consequences of air pollution and the canals have become the breeding grounds for mosquitoes, which make people susceptible to diseases. Based on the findings the study has made recommendations that will assist the NMBM to mitigate storm water pollution and improve the quality of life of residents living near these canals.

List of Figures

- Figure 1 The Motherwell Canal next to the Motherwell NU5 residential area.
- Figure 2 The Markman Canal next to the Aloes Village residential area.
- Figure 3 Confluence of the Middle Street Canal on the right hand side, which drains the Kabar residential area, and the Kat Canal on the left, which drains the Joe Slovo residential area.
- Figure 4 Lower reaches of downstream Kat Canal where the contents of this canal flow into the Swartkops River above Niven Bridge.
- Figure 5 A child from Joe Slovo with severe sores on his head.

List of Tables

- Table 1 Responses of community members regarding human health afflictions that are possibly related to storm water pollution.
- Table 2 Residents' perceptions regarding of programmes offered by the municipality to mitigate storm water pollution.
- Table 3 Residents' perceptions of storm water mitigation measures employed by local NGOs.
- Table 4 Perceptions of residents of programmes implemented by NGOs to mitigate storm water pollution.
- Table 5 Responses of residents related to adequacy of health facilities for treating diseases caused by water pollution.

Acronyms

CBA	Critical biodiversity area
DWAF	Department of Water Affairs and Forestry
DEAT	Department of Environmental Affairs and Tourism
IDP	Integrated Development Plan
NEMA	National Environmental Management Act
NGO	Non-governmental organisation
NMBM	Nelson Mandela Bay Municipality
NRDC	National Resource Defence Council
NWA	National Water Act
OECD	Organisation for Economic Co-operation and Development
PCB	Polychlorinated biphenyls
PCD	Pollution Control Department
RDP	Reconstruction and Development Programme
SA	South Africa
TB	Tuberculosis
TDRI	Thailand Development Research Institute
SOER	Statement of Environmental Report
SWMP	Storm Water Management Plan
WWTW	Waste Water Treatment Works
ZC	Zwartkops Conservancy

Table of Contents

ABSTRACT	III
LIST OF FIGURES.....	IV
LIST OF TABLES	IV
ACRONYMS	V
CHAPTER 1	1
INTRODUCTION AND CONTEXT	1
1.1. INTRODUCTION	1
1.2. PROBLEM STATEMENT.....	2
1.2.1. <i>Sub problem 1</i>	3
1.2.2. <i>Sub problem 2</i>	3
1.3. RESEARCH QUESTIONS	3
1.4. RESEARCH AIMS AND OBJECTIVES.....	3
1.5. SCALE AND SCOPE.....	3
1.5.1. <i>Description of sample sites</i>	4
1.6. RESEARCH METHODOLOGY	8
1.7. OVERVIEW OF CHAPTERS	9
CHAPTER 2.....	10
LITERATURE REVIEW	10
2.1. INTRODUCTION	10
2.2. DEFINITION OF TERMS.....	10
2.2.1. <i>Definition of storm water</i>	10
2.2.2. <i>Definition of storm water canal</i>	10
2.2.3. <i>Definition of storm water pollution</i>	10
2.3. LEGISLATIVE FRAMEWORK REGARDING STORM WATER POLLUTION.	11
2.3.1. <i>Policy framework</i>	11
2.3.1.1. The Bill of Rights	11
2.3.1.1 Environmental policy	12

2.3.1.1.1 White Paper on Environmental Management Policy for South Africa (1998)	12
2.3.1.1.2 Draft White Paper on Integrated Pollution and Waste Management for South Africa (1998)	12
2.3.1.1.3 Department of Water Affairs and Forestry (DWAF)	12
2.3.1.1.4 DWAF's Water Quality Guidelines, 1996	12
2.3.1.1.5 A Strategy to Manage the Water Quality Effects of Settlements: Edition 1, 1999	13
2.3.1.1.6 A Strategy to Manage the Water Quality Effects of Settlements: Edition 2, 2001	13
2.3.1.1.7 Water Management: Best Practice Guidelines for Water Resource Protection in South African Mining Industry, August 2006	13
2.3.1.2 Department of Environmental Affairs and Tourism (DEAT)	14
2.3.1.2.1 South African Water Quality Guidelines for Coastal Marine Waters: Guidelines for Recreational Use	14
2.3.2 <i>Legal framework</i>	15
2.3.2.1 <i>National level</i>	15
2.3.2.1.1 National Water Act (NWA) (Act No. 36 of 1998)	15
2.3.2.1.2 National Environment Management Act (NEMA) (Act No. 107 of 1998)	15
2.3.2.1.3 NEMA: Air Quality Act (Act No. 29 of 2004)	16
2.3.2.1.4 Environmental Conservation Act (Act No. 73 of 1989)	16
2.3.2.2 <i>Provincial level</i>	17
2.3.2.2.1 Divisional Councils Ordinance Act (Act No. 18 of 1976)	17
2.3.2.3 <i>Municipal level</i>	18
2.3.2.3.1 NMBM storm water management by-laws	18
2.3.2.3.2 NMBM Integrated Development Plan (IDP) 2013-2014	19
2.3.2.3.3 Local Government Municipal Act (Act No. 32 of 2000)	19
2.4 CONCEPTUAL FRAMEWORK	20
2.4.1 <i>Importance of waterways (Swartkops River and Estuary)</i>	25
2.4.2 <i>Constraints NMBM faces regarding storm water management</i>	26
2.4.3 <i>Storm water pollution prevention measures</i>	27

2.5 CAUSES OF STORM WATER POLLUTION.....	27
2.5.1 <i>Urbanisation</i>	27
2.5.2 <i>Storm water runoff</i>	29
2.5.2.1 Bacteria	29
2.5.2.2 Metals.....	29
2.5.2.3 Sediments	30
2.5.2.4 Insecticides	30
2.5.2.5 Fertilisers.....	31
2.5.3 <i>Canals</i>	31
2.5.4 <i>Waste</i>	31
2.5.5 <i>Wastewater Treatment Works (WWTWs)</i>	33
2.5.6 <i>Illegal dumping of litter</i>	34
2.5.7 <i>Lack of awareness</i>	35
2.6 THEORETICAL FRAMEWORK.....	35
2.6.1 <i>Sustainable development</i>	36
2.6.2 <i>Impacts of storm water pollution</i>	37
2.6.2.1 Public health impacts	37
2.6.2.2 Social impacts of storm water pollution	38
2.6.2.3 Environmental impacts of storm water pollution	38
2.6.2.4 Economic impacts of storm water pollution	39
2.7 SUMMARY	39
CHAPTER 3.....	40
RESEARCH METHODOLOGY.....	40
3.1 INTRODUCTION	40
3.2 DELIMITATION OF STUDY	40
3.3 RESEARCH DESIGN	41
3.4 SAMPLING	41
3.5 DATA COLLECTION METHODS.....	42
3.5.1 <i>Primary sources</i>	42
3.5.2 <i>Secondary sources</i>	43
3.5.3 <i>Validity</i>	44
3.5.4 <i>Observation</i>	44

3.5.5	<i>Interviewing</i>	44
3.5.6	<i>Textual analysis</i>	44
3.6	SUMMARY	45
CHAPTER 4	46
DATA ANALYSIS AND INTERPRETATION	46
4.1	INTRODUCTION	46
4.2.	INTERPRETATION OF STRUCTURED INTERVIEWS WITH RESIDENTS OF KABAR AND JOE SLOVO, ALOES VILLAGE AND MOTHERWELL NU5	47
4.2.1	<i>What is storm water pollution?</i>	47
4.2.2	<i>What is a storm water canal?</i>	47
4.2.3	<i>On whether there is storm water pollution in their areas</i>	48
4.2.4	<i>What are the main causes of storm water pollution in your area?</i>	48
4.2.5	<i>What are the problems caused by storm water pollution in your area?</i> ..	49
4.2.6	<i>What are the reported cases of disease outbreaks caused by storm water pollution?</i>	51
4.2.7	<i>How do residents dispose of their litter?</i>	53
4.2.8	<i>Is there a litter-dumping site in your area? If yes, is it legal or illegal?....</i>	54
4.2.9	<i>Where exactly is this litter-dumping site situated?</i>	54
4.2.10	<i>How often does the municipality collect litter?</i>	54
4.2.11	<i>How do residents dispose of their sewage?</i>	54
4.2.12	<i>How often does the municipality collect sewage from residences?</i>	54
4.2.13	<i>How do residents dispose of their waste if the municipality fails to arrive?</i>	55
4.2.14	<i>What is the government doing to mitigate the effects of storm water pollution?</i>	55
4.2.15	<i>What is the municipality doing to mitigate the effects of storm water pollution?</i>	55
4.2.16	<i>In what programmes is the municipality involved to mitigate the effects of storm water pollution?</i>	55
4.2.17	<i>Do NGOs assist in mitigating the effects of storm water pollution?....</i>	56
4.2.18	<i>What programmes are implemented by NGOs to mitigate storm water pollution?</i>	57

4.2.19	<i>Are health facilities capable of dealing with the people affected by storm water pollution?</i>	58
4.3	RESULTS FROM STRUCTURED INTERVIEWS CARRIED OUT WITH REPRESENTATIVES FROM AN NGO AND THE MUNICIPALITY	59
4.3.1	<i>What is storm water pollution?</i>	59
4.3.2	<i>Effects of storm water pollution on public health</i>	59
4.3.3	<i>To what extent does storm water pollution affect NMBM communities?</i>	60
4.3.4	<i>What are you doing to mitigate storm water pollution in the area of influence?</i>	61
4.3.5	<i>Do you think government departments play a role in mitigating storm water pollution?</i>	61
4.3.6	<i>How are you helping each other in mitigating the effects of storm water pollution?</i>	62
4.3.7	<i>Programmes the municipality and NGO are involved in to mitigate the effects of storm water pollution</i>	62
4.3.8	<i>Are the health facilities capable of dealing with victims of storm water pollution in the areas of concern?</i>	63
4.4	SUMMARY OF FINDINGS	63
4.5	SUMMARY	64
CHAPTER 5		65
CONCLUSION AND RECOMMENDATIONS		65
5.1	INTRODUCTION	65
5.2	RECOMMENDATIONS	67
LIST OF REFERENCES		69
ANNEXURES		80
ANNEXURE A		80
ANNEXURE B		81
ANNEXURE C		82
ANNEXURE D		83

CHAPTER 1

INTRODUCTION AND CONTEXT

1.1. INTRODUCTION

Storm water pollution in South Africa is a major concern. It has severe economic and health implications for downstream users and affects the functioning of national water ecosystems; public awareness of this is minimal (Pretorius *et al.*, 2002). According to Kotze (2000), numerous factors, including mining and industrial effluents, runoff of biocides, nutrients and pathogens from agricultural lands and poor sanitation in urban areas and informal settlements, cause storm water pollution. It is a major environmental and public health threat that leads to unsanitary living environments, unhealthy surface waters, such as lakes, creeks and rivers, unhealthy ocean and beach conditions, and street and neighbourhood flooding during the rainy season (California State Water Resources Control Board, 2013).

The Moreton Bay Regional Council (2002) states that if storm water runoff is managed incorrectly, it increases the likelihood of regional flooding and has the potential to transport high loads of contaminants directly to rivers, streams and wetlands. This causes a variety of effects on public health and safety, local and regional infrastructure, ecological health and recreational amenity of waterways. Storm water pollution is a serious problem in Nelson Mandela Bay Municipality (NMBM) waterways and the Swartkops River and estuary in particular.

Studies conducted by Watling and Watling (1982), Wright *et al.* (1993), Binning and Baird (2001) and Steward (2009) show that polluted storm water runoff has resulted in deteriorating water quality in the Swartkops River and estuary. Binning and Baird (2001) found elevated levels of heavy metals in the sediments of the Swartkops River and estuary, with the highest concentrations of heavy metals in both the estuary and the river recorded at points where runoff from informal settlements and industry enter the system. The researchers compared their results with those obtained by Watling and Watling in 1982 and revealed some remarkable increases.

Hence, three storm water canals, namely the Markman, Motherwell and Kat canals were investigated. These canals are the main conduits of urban runoff, unregulated

sewage water and waste from various activities and they discharge their waste directly into Swartkops River without any purification. The Kat and Motherwell canals in particular are known to discharge raw sewage directly into the Swartkops River and estuary respectively. Canals are the main receptacles for every kind of pollution, and the consequences of pollution include human health risks, ecosystem disturbance and the aesthetic impact on water resources (Simeonova *et al.*, 2012).

The stagnant water in the canals is not only an eyesore, but also gives off an unpleasant odour and poses health and safety risks (Krause *et al.*, 2005). According to Duncan (1999, as cited in Simeonova *et al.*, 2012), pollutants escaping from urban areas are difficult to monitor and regulate because they arise from a multitude of activities and appear at a variety of times because of the effects of weather. This makes storm water pollution one of the greatest threats to the water quality of most industrialised countries.

Effectively lessening the effects of storm water pollution requires the NMBM to integrate communities through public participation and promote close ties between the government departments responsible for litter and sewage disposal to combat illegal dumping and sewage leaks. The aims of the research were to determine the causes of storm water pollution at the canals studied and its effect on public health in the surrounding communities, and to suggest measures for the mitigation of storm water pollution. To this end, the researcher assessed whether the affected communities knew about the dangers of dumping sewage and solid waste in the canals, established whether they received pollution-related education and guidance on how to conserve water and look after the river, and made suggestions about how water pollution can be addressed.

1.2. Problem statement

The impact of storm water pollution on public health and water quality in the Nelson Mandela Bay Municipality (NMBM) is a major concern. The population has increased, largely because of people migrating to urban areas, and the infrastructure has struggled to keep pace with increased urbanisation. Large amounts of solid waste from formal and informal waste disposal land in storm water canals, and high levels of

pollutants and faecal bacteria are found in storm water canals, affecting local rivers and estuaries such as Swartkops.

1.2.1. Sub problem 1

Storm water pollution is associated with pathogens and other contaminants affecting human and aquatic ecosystem health.

1.2.2. Sub problem 2

The cultural and recreational use of the Swartkops River and estuary, for example, by sangomas and for events such as the Red House River Mile, has been affected because of the poor water quality of the water.

1.3. Research questions

- How does pollution in storm water canals affect local communities living within the Swartkops River catchment area?
- What are the primary causes of this water pollution?

1.4. Research aims and objectives

The research project primarily aimed to:

- Gain a better understanding of the major causes of pollution in the storm water canals in the study area; and
- Investigate the public health impacts of water pollution from storm water canals affecting the Swartkops River

1.5. Scale and scope

The research was conducted along the storm water canals located along the length of the Swartkops River in the Nelson Mandela Bay Municipality. The Swartkops River catchment area consists of most of the municipal areas of Uitenhage, Kwanobuhle, Despatch and Ibhayi and half of the Port Elizabeth municipal region, and approximately one million people live and work in the area. The Swartkops catchment area contains the largest part of the metropolitan population, and it is where the

greatest diversity of urban users is found and where urban growth is most rapid. High density, low-income housing is developing in the catchment area, with a concomitant increase in industrial waste affecting the quality and quantity of storm water runoff (Binning & Baird, 2001). The three storm water canals chosen for the research are the Kat Canal, which passes through a low-income, mixed residential area; the Motherwell Canal, which runs through a middle-income residential area; and the Markman Canal, which flows through a low-income residential neighbourhood and industrial area.

1.5.1. Description of sample sites

Three sampling sites draining into the Swartkops River ecosystem were selected. Two of these sites, namely the Motherwell and Markman canals, drain into the estuary and the Kat Canal drains into the Swartkops River. The estuary receives effluent from a canal that runs through Motherwell as well as a canal that contains runoff from the Markman Industrial Estate. Mackay (1993) observes that the close proximity of industrial and informal or formal high-density residential areas in the lower reaches of the Swartkops River has resulted in significantly higher pollution levels in the estuary. Upstream contaminants also affect pollution levels.

Motherwell Canal

The Motherwell Canal (Figure 1) is a large concrete-lined canal made of a series of unlined 2- to 3-metre deep depressions that function as flood detention basins (Alcock, 1999). This canal receives runoff from the township of Motherwell and this research focused on residents in Motherwell's NU5 section, which is the formal housing area the canal passes through before it drains its runoff into the Swartkops Estuary. Alcock (1999) maintains that it became evident in 1986 that water constantly flowed in the Motherwell Canal, even in dry weather. The flow appeared to be polluted and had an unpleasant odour, and a considerable amount of litter was present in the canal. Oil and scum were observed in the estuary near the mouth of the canal (Alcock, 1999).



Figure 1: The Motherwell Canal next to Motherwell NU5 residential area

Markman Canal

The Markman Canal (Figure 2) is lined with gabions with well-established vegetation growing on the bed and sides of the canal. The retention of runoff in the canal near the industrial estate is considerable due to the limited gradient, water filtering into the soil beneath the canal and the effects of dense vegetation (Alcock, 1999). This canal receives runoff from informal settlements located within the Swartkops River floodplain that are not serviced, such as Aloes Village (Arcus Gibb Consultancy,

2009).



Figure 2: The Markman Canal next to the Aloes Village residential area

Kat Canal

The Kat Canal (Figure 3) is located in Uitenhage. The Middle Street Canal drains the informal Joe Slovo settlement and joins the Kat Canal, which drains the formal Kabar settlement made up of Reconstruction and Development Programme (RDP) houses. Joe Slovo residents use the bucket system, while Kabar residents use flushing toilets to dispose of human waste.



Figure 3: Confluence of the Middle Street Canal on the right hand side, which drains the Kabar residential area, and the Kat Canal, which drains the Joe Slovo residential area, on the left hand side.

The lower reaches of the Kat Canal (Figure 4) carries runoff from the Rosedale and MacNaughton townships into the Swartkops River (Alcock, 1999). The runoff in this canal is often contaminated by raw sewage due to sewer blockages. The canal receives runoff from an informal township as well as an industrial area in the Uitenhage region (Binning & Baird, 2001). A study conducted by Binning and Baird (2001) indicated that the concentration of each heavy metal found in the canal was two to four

times higher than in any other non-estuarine sites tested.



Figure 4: Lower reaches of downstream Kat Canal where the contents of the canal flow into the Swartkops River just above Niven Bridge.

1.6. Research methodology

The methodology used in this research was based on a qualitative approach employed to establish the socio-economic factors that contribute to storm water pollution. It involved community participation by means of developing and administering a semi structured interview schedule relating to storm water pollution to obtain responses from residents identified in the sample. Key informant interviews were also conducted at local NGOs and NMBM.

A random sample of 30 respondents living in close proximity to the three canals completed the questionnaire. Respondents included ten community members of the Kabar and Joe Slovo settlements next to the Kat Canal in Uitenhage, ten community members of the Aloes Village next to the Markman Canal and ten community members

of Motherwell NU5 next to the Motherwell Canal. Data were obtained from primary sources, specifically interviews and observation to identify the most likely causes of storm water pollution, and secondary sources, such as published research reports and information available on the Internet.

1.7. Overview of chapters

Chapter One provides the background of the research. It introduces the topic, statement of the research problem and literature review and outlines the research methodology.

Chapter Two offers a further elaboration on literature pertaining to the legal, conceptual and theoretical frameworks and social, public health and environmental impacts of storm water pollution.

Chapter Three contains an extensive discussion of the methodology the researcher employed. This chapter includes information about sampling techniques, data collection and data analysis.

Chapter Four focuses on data analysis and the findings of the study.

Chapter Five presents the conclusion and the researcher's recommendations based on the data analysis.

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

In this chapter, the researcher describes and addresses the legal framework for storm water pollution, the public participation process and the constraints faced by NMBM in providing storm water pollution management and prevention.

2.2. DEFINITION OF TERMS

2.2.1. Definition of storm water

Butler and Davies (2011) define storm water as rainwater or water resulting from any form of precipitation that has fallen on a built-up area. They state that if storm water is not properly drained, it causes inconvenience, damage, flooding and health risks. Storm water is pure rainwater and anything the rain carries along with it. In urban areas, the rain that falls on the roofs of houses or collects on paved areas, such as driveways, roads and footpaths, is carried away through a system of pipes that is separate from the sewerage system (New South Wales Government, n.d.). It is water flowing overland and into waterways during and following rainfalls. In developed areas, storm water is conveyed via a system of pipes and open channels to natural waterways to reduce the risk of localised flooding (Moreton Bay Regional Council, 2002).

2.2.2. Definition of storm water canal

Canals are generally long and narrow with a uniform width and depth and a single outlet (Reilly & Phillips, 1998).

2.2.3. Definition of storm water pollution

According to the California State Water Resources Control Board (2013), storm water pollution is created when trash, cigarette butts, animal waste, pesticides, motor oil and other contaminants left on the ground are washed or thrown directly into storm drains. This toxic soup mixes with millions of litres of rain water and flows untreated into local creeks, rivers and the ocean, polluting waterways as well as degrading neighbourhoods and other natural resources. This definition indicates that it is human-

induced (of anthropogenic origin) and management of the problem should include long-term education programmes to make people aware of their acts and accountable for their actions. It is essential that local communities are included in the prevention of pollution in storm water canals and their immediate surroundings.

2.3. LEGISLATIVE FRAMEWORK REGARDING STORM WATER POLLUTION

2.3.1. Policy framework

2.3.1.1. The Bill of Rights

Chapter 2 of the Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996) contains the Bill of Rights. Section 24 of the Constitution guarantees everyone the right to:

- An environment that is not harmful to their health or wellbeing; and
- An environment protected for the benefit of present and future generations through reasonable legislative and other measures that :
 - i. Prevent pollution and ecological degradation;
 - ii. Promote conservation;
 - iii. Secure ecologically sustainable development and the use of natural resources while promoting justifiable economic and social development; and
 - iv. Promote development.

Moreover, Chapter 2 of the Constitution entrenches environmental protection as a human right. In addition to granting the right to a healthy environment, section 24 imposes a constitutional duty on the state to protect the environment through reasonable legislative and other measures. In an effort to curb storm water pollution, the current constitutional framework determines that individual and government actions and legislation that affect the environment must comply with the institutional right to a healthy environment (Van der Linde, 2006).

2.3.1.1 Environmental policy

2.3.1.1.1 White Paper on Environmental Management Policy for South Africa (1998)

The purpose of this policy is to ensure the development and implementation of integrated environmental systems that identify and control environmental impacts in both public and private sectors to ensure environmental sustainability. Through this policy, the government gives effect to numerous rights entrenched in the Constitution. These rights include rights relating to the environment as well as rights relating to governance, such as the legal standing of parties, administrative justice, accountability and public participation.

2.3.1.1.2 Draft White Paper on Integrated Pollution and Waste Management for South Africa (1998)

The main purpose of this policy is the prevention of pollution, minimisation of waste, control of impacts and remediation. It states that waste management must be implemented in a holistic manner that covers the entire water cycle, including the generation, storage, collection, transportation, treatment and final disposal of waste. This policy acts as a statement of intent by the government on how to manage and minimise South Africa's diverse pollution and waste streams in a manner which is environmentally, socially and politically acceptable as well as economically sustainable.

2.3.1.1.3 Department of Water Affairs and Forestry (DWAF)

The Department of Water Affairs and Forestry's purpose is to manage South Africa's water resources in a manner that conforms to the government's policy of rapidly redressing the inequities of the past. This department is obliged to ensure that aquatic ecosystems are healthy and that they are utilised on a sustainable basis.

2.3.1.1.4 DWAF's Water Quality Guidelines, 1996

The purpose of developing the water quality guidelines for aquatic ecosystems is to provide information that can be used to determine the degree to which water quality may be altered through the return of effluent and other impacts without compromising

the health of ecosystems. The DWAF's policy requires that all effluent is treated and returned to natural watercourses to use scarce resources efficiently. The DWAF emphasises that due to the few available options for mitigating the effects of poor water quality, a precautionary approach of minimising the risk to the environment is required to protect the health of aquatic ecosystems.

2.3.1.1.5 A Strategy to Manage the Water Quality Effects of Settlements: Edition 1, 1999

This report outlines the DWAF's approach to managing pollution from densely populated settlements throughout South Africa. It also outlines the DWAF's policies on water quality management and how the DWAF intends to balance the need to protect the environment with the need to address the backlog in housing and services in South Africa. This report further includes a national strategic process that outlines how the DWAF plans to engage other government departments to develop a common approach to managing pollution from settlements and how pollution problems may be identified and addressed.

2.3.1.1.6 A Strategy to Manage the Water Quality Effects of Settlements: Edition 2, 2001

This report outlines the DWAF's approach to managing the water quality effects of settlements. It describes the underlying causes of pollution and explains how dialogue between the community and service providers may be used to identify these causes. The document outlines how the DWAF intends to ensure the gradual implementation of these approaches in settlements across South Africa.

2.3.1.1.7 Water Management: Best Practice Guidelines for Water Resource Protection in South African Mining Industry, August 2006

The objectives of the SWMP include:

- The protection of life (prevention of loss of life) and property (reducing damage to infrastructure) against flood hazards;
- The prevention of land and water erosion, especially during storms;

- The protection of water resources against pollution;
- Maintaining downstream water quantity and quality requirements;
- The preservation of the natural environment; and
- Minimising the impact of pollution on downstream users.

2.3.1.2 Department of Environmental Affairs and Tourism (DEAT)

The Department of Environmental Affairs and Tourism's mandate is to lead the sustainable development of South Africa's environment by conserving the country's natural resources, protecting and improving the quality and safety of the environment and promoting the global sustainable development agenda.

2.3.1.2.1 South African Water Quality Guidelines for Coastal Marine Waters: Guidelines for Recreational Use

The main purpose of these guidelines is to ensure that South African recreational waters are kept fit to promote public health. To ensure coastal waters are suitable for recreational use, the DEAT has selected the following indicators for the assessment of coastal water quality:

- Presence of objectionable matter;
- Physico-chemical contamination; and
- Microbiological contamination.

The microbiological contamination indicator is used to identify the risk to public health from the presence of disease-causing bacteria, viruses and protozoa in coastal waters. The microbiological indicators identified as suitable for the assessment of water quality are *Enterococci* and *Escherichia coli*. These guidelines classify water quality into various categories using the concentration of *Enterococci* and *E.coli* in coastal waters and its corresponding percentage risk to gastro-intestinal illness. The 'sufficient or fair' category is considered the minimum acceptable risk for South Africa.

2.3.2 Legal framework

2.3.2.1 National level

2.3.2.1.1 National Water Act (NWA) (Act No. 36 of 1998)

The purpose of this Act is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways that take into account the following factors:

- Promoting the efficient, sustainable and beneficial use of water in the public interest;
- Protecting aquatic and associated ecosystems and their biological diversity;
- Reducing and preventing pollution and degradation of water resources; and
- Managing floods and droughts and establishing suitable institutions with appropriate community, racial and gender representation to achieve this purpose.

In addition, it sets out the strategies, objectives, plans, guidelines and procedures of the catchment management agency for the protection, use, development, conservation, management and control of water resources within its management area. It enables communities to participate in managing water resources within their management areas and considers the needs and expectations of existing and potential users.

2.3.2.1.2 National Environment Management Act (NEMA) (Act No. 107 of 1998)

The Act serves as the general framework within which environmental management and implementation plans must be formulated. It guides the interpretation, administration and implementation of NEMA and any other law concerned with the protection or management of the environment. The main principle of the Act is the promotion of ecologically sustainable development, and it states that sustainable development must be socially, environmentally and economically sustainable. NEMA requires that:

- Disturbance of ecosystems and loss of biodiversity should be avoided or, where it cannot be avoided altogether, minimised and remedied;
- Pollution and degradation of the environment should be avoided or, where it cannot be avoided altogether, minimised and remedied;
- Disturbance of landscapes and sites that constitute the nation's cultural heritage should be avoided and, where it cannot be avoided altogether, minimised or remedied; and
- Waste should be avoided or, where it cannot be avoided altogether, minimised and reused or recycled where possible and otherwise disposed of in a responsible manner.

2.3.2.1.3 NEMA: Air Quality Act (Act No. 29 of 2004)

The objective of this act is to protect the environment by

- Protecting and enhancing the quality of air in the Republic;
- Providing reasonable measures for the prevention of air pollution and ecological degradation; and
- Securing ecologically sustainable development while promoting justifiable economic and social development.

It enhances the quality of ambient air for the sake of securing an environment that is not harmful to the health and well-being of people.

2.3.2.1.4 Environmental Conservation Act (Act No. 73 of 1989)

The purpose of this Act is to provide protection and controlled utilisation of the environment and for matters incidental thereto.

Prohibition of littering

Section 19 of the Act prohibits any person from discarding, dumping or leaving litter on any land or water surface, street, road or site in or on any place to which the public has access, except in a container or at a place which has been specially indicated,

provided or set apart for such purpose. Subsection 2 prescribes that every person or authority in control or responsible for the maintenance of any place to which the public has access shall at all times ensure that containers or places are provided which will normally be adequate and suitable for the discarding of litter by the public.

2.3.2.2 Provincial level

2.3.2.2.1 Divisional Councils Ordinance Act (Act No. 18 of 1976)

Subsection 1 of this Act prohibits any person, except with the consent of the council, to:

- Discharge or permit anything to enter any sewer;
- Discharge or permit to enter or put anything other than storm water into a public drain;
- Discharge or permit to enter or put into any sewer or public drain any substance or thing likely to damage it or interfere with the free flow of sewage or water therein; and
- Discharge or permit to enter or put into any natural watercourse into which storm water is drained or water from divisional service works is discharged or from which water is taken for the purposes of any divisional services, any substance or thing likely to damage it, interfere with the free flow of water therein or contaminate or impair the quality of water therein.

It states that any person who contravenes any provision of subsection 1 is guilty of an offence. Therefore, the council has the right to remove anything discharged into, permitted to enter or put into a sewer, public drain or natural watercourse in contravention of this section. In terms of subsection 3, it also has the right to remove anything obstructing, endangering or likely to damage, obstruct, endanger and destroy any divisional service works.

Section 4 indicates that the court convicting a person in terms of this section should impose a fine equal to the estimated or real expenses the council incurred when carrying out any work contemplated in subsection 3 in addition to any other penalty.

Should the guilty party fail to pay this fine, the court should sentence him or her to imprisonment for a period not exceeding six months. According to section 5, any fine paid in terms of subsection 4 must be paid over to the council. However, subsection 6 states that subsection 4 and 5 shall not preclude the council from recovering the full amount of all the expenses it incurred in the execution of any work contemplated in section 3 less the amount of any fine paid in terms of subsection 4. This applies whether or not the person in contravention of the Act has been prosecuted or convicted of an offence in terms of this section.

2.3.2.3 Municipal level

2.3.2.3.1 NMBM storm water management by-laws

The purpose of this by-law is to regulate storm water management and activities that may have an adverse impact on the development, operation and maintenance of the storm water system. Section 4 of this by law prohibits any person, except with the consent of the municipality, to:

- Discharge , place or permit to enter the storm water system
 - anything other than storm water,
 - anything likely to damage the storm water system or interfere with the operation thereof, or
 - anything to pollute the water in the storm water system;
- Discharge from any place or deposit onto any surface any substance other than storm water, where that substance could reasonably be expected to find its way into the storm water system; or
- Undertake any action that is likely to destroy, damage, alter, endanger or interfere with the free flow of water or the storm water system by
 - obstructing or reducing the capacity of the storm water system,
 - opening a pipe, culvert or canal which forms part of a storm water system,or

- constructing or erecting any structure or thing over or in such a position or in such a manner as to destroy, damage, endanger or interfere with the storm water system.

2.3.2.3.2 NMBM Integrated Development Plan (IDP) 2013-2014

The Integrated Development Plan (IDP) is NMBM's strategic planning document. It enhances integrated service delivery and development and promotes sustainable united communities by promoting a full set of services because communities cannot be developed in a fragmented manner. Development is considered a constitutional and legal process required of South African municipalities. In addition to legal compliance, there are numerous advantages to undertaking an IDP, including achieving sustainable development and growth and democratising local government by ensuring public participation in the planning- and decision-making processes of the municipality. The IDP is reviewed every year to align municipal programmes, projects and budgets with community needs.

2.3.2.3.3 Local Government Municipal Act (Act No. 32 of 2000)

This Act establishes a framework for the support and monitoring of and standard setting by other spheres of government to build local government into an efficient development agency capable of integrating the activities of all spheres of government for the overall social and economic upliftment of communities in harmony with their natural environments. It states that the active engagement of communities in the affairs in which they form an integral part, particularly in planning, service delivery and performance management, is a fundamental aspect of local government.

It defines municipal service as a necessity to ensure an acceptable and reasonable quality of life; failure to provide it endangers public health and safety, and the environment. It ensures:

- That the risk of harm to the environment and to human health and safety is minimised to the extent reasonably possible under the circumstances;
- That the potential benefits to the environment and to human health and safety are maximised; and

- Compliance with legislation intended to protect the environment and human health and safety.

In terms of the Act, a municipality's council is duty bound to encourage the involvement of the community and to promote a safe and healthy environment in the municipal area.

2.4 CONCEPTUAL FRAMEWORK

Storm water pollution is a global concern that affects numerous countries. Industrialisation has been the sole factor that increased the prevalence of all kinds of pollution, such as water pollution, air pollution and ozone layer depletion. South Africa is one of the industrial giants in Africa, making the country more susceptible to pollution. Moreover, industrialisation causes urbanisation or the movement of people from rural to metropolitan areas as they seek employment. Melesse (2005) argues that this leads to the expansion of squatter settlements on fragile slopes and in hazardous areas. Similarly, extreme overcrowding in industrial cities leads to problems with sanitation, pollution and public health (Wheeler & Beatley, 2004).

Historically, the need for storm water canals stemmed from an increase in population associated with urbanisation. These urban nodes of growth were frequently at a distance from adequate freshwater supplies, and the need to convey water became apparent. Thus, countries constructed canals, which are channels cut into the earth that allow for the routing of water down slopes in the same way rivers flow (Marold *et al.*, 2001). With the increasing industrialisation of countries, extensive canal systems were created to link towns, cities, quarries and other industrial areas (Fox & O'Dea, 2003). These canals were built to serve drainage needs and to convey water as quickly as possible to local gullies and waterways to reduce local flooding (Moreton Bay Regional Council, 2002; Reilly & Phillips, 1998).

Storm water canals have generally become severely contaminated bodies of water because they have been exposed to emissions consisting of storm water runoff, sewer outflows and industrial pollutants for many years. According to United States of Environmental Protection Agency (2014), contaminants include polychlorinated

biphenyls (PCBs), coal tar washes, heavy metals and volatile organics, and contamination poses a threat to residents that live near these canals.

Aldous (2008) contends that the extensive canalisation of Johannesburg's watercourses has occurred since the early 1900s. In the past, a common response to runoff management has been the replacement of natural streams with concrete canal systems and piped systems. This canalisation became a major contributor to downstream erosion. In 1995, the southern Braamfonteinspruit catchment comprised over 8 5000 metres of piped drainage, but these hard engineered (concrete) conveyances are no longer considered a sustainable storm water approach because they increase the likelihood of flooding and have the potential to transport high levels of pollutant loads directly to rivers, streams and wetlands (Aldous, 2008). This has a variety of effects on public health and safety, local and regional infrastructure, ecological health and the recreational amenity of waterways (Moreton Bay Regional Council, 2002).

Gaffield *et al.* (2003) state that storm water pollution results from the expansion of urban areas, which creates a greater number of impervious surfaces, such as roofs, roads and parking lots, that collect pathogens, metals, sediments and chemical pollutants and quickly transmits them to receiving waters during rain and snowmelt events. Storm water is generally not treated and flows directly from streets and gutters into rivers, harbours and the ocean, which are inhabited by plants and fish, frogs and other aquatic animals (New South Wales Government, n.d.). This is considered non-point source pollution because it does not come from one specific location; it comes from multiple sources, making it difficult to control (Broward County, n.d.).

Non-point source pollution is one of the major threats to water quality and is linked to chronic illnesses from exposure through seafood and contact recreation (Gaffield *et al.*, 2003). Storm water pollution significantly affects water quality, posing risks to the health and safety of residents, degrading natural resources, threatening the area's tourist driven economy and lowering property values in local neighbourhoods (California State Water Resources Control Board, 2013). The four main types of pollution from developing communities that find their way into rivers and ground water are sewage, grey water, storm water and solid waste. Pollution from any one of these

waste types is often an underlying cause of poor water quality in developing communities (Pretorius *et al.*, 2002). Storm water management is not a recent problem to South Africa, and it affects all cities that experience increased urbanisation. Maintaining and upgrading urban water waterways to meet population growth and changing community expectations are becoming increasingly important issues for government authorities, demanding research into the factors that affect water quality and degrade canals and storage areas (Pretorius *et al.*, 2002). According to Fischer-Jeffes *et al.* (2013), studies regarding the impact of water quality on South Africa's urban aquatic systems focus on the failure of sewage systems, due to the emotive nature of this type of pollution, and the ability to identify who is responsible for point source pollution.

The authors further argue that the cities of Cape Town, Johannesburg and Tshwane all note in their state of environment reports that polluted storm water is a significant contributor to the deteriorating water quality in their respective urban aquatic systems and contribute this to the failure of sewage treatment works that become overloaded because of storm water ingress. Within the Nelson Mandela Bay municipal area, water quality at the Swartkops River and Estuary remains a major concern due to its deterioration because of storm water pollution. Numerous researchers, such as Mackay (1993), Alcock (1999), Binning and Baird (2001), Arcus Gibb Consultancy (2009) and Bate *et al.* (2004), have observed that contaminated storm water canals cause significantly higher pollution levels in the estuary and Swartkops River.

Alcock (1999) argues that it became evident in 1986 that the water in the Motherwell Canal was polluted with faecal matter and high in nutrients, especially nitrogen. In 1988, the water quality of the estuary did not meet the criteria specified by Lusher (1984) for direct contact recreation in estuarine and marine environments. Mackay (1993) found that faecal coliform and faecal streptococci counts often reached levels characteristic of raw sewage, which was due to sewer blockages, with up to 78 blockages occurring in one month and one day. This canal is still exposed to sewage leaks today. Mackay (1993) further recommended no contact recreation of any kind should be permitted in the estuary for up to 500 metres on either side of the outlet of the Motherwell Canal.

Arcus Gibb Consultancy (2009) argues that organic pollution from the Motherwell Canal entering the Swartkops estuary has become increasingly evident in recent years, with harmful pathogens in the estuarine water often reaching alarming proportions near the mouth of the storm water canal. It further states that Zwartkops Conservancy attributes the main cause of pollution in the estuary to the Motherwell Canal.

Binning and Baird (2001) measured the concentration of heavy metals along a section of the Swartkops River and estuary near the Motherwell Canal. The results indicated the highest metal concentrations recorded in both the estuary and the river where runoff from informal settlements and industry entered the system, and the concentration of each heavy metal was found to be two to four times higher than at any other estuarine site. The researchers compared the results to those obtained in a similar survey conducted by Watling and Watling in 1982, almost 20 years earlier, and the comparison revealed significant increases.

Alcock (1999) found that the Motherwell Canal showed the highest concentration of all heavy metals except strontium. At the time, the local authority undertook an important remedial measure by installing a bypass sump in the canal to trap dry weather flow and for the water to be pumped to the nearby sewer. Alcock (1999) investigated the Markman Canal in its upper reaches and found that faecal coliform counts were high. He attributed this to the large abattoir and stockyards in Markman Industrial Estate. During Alcock's (1999) study, water quality in the canal close to the industrial estate was often poor, although there was a considerable improvement towards the canal mouth during runoff periods. Faecal coliform counts were not significantly reduced in wet weather, possibly because of runoff from informal settlements near the lower reaches of the canal.

The Zwartkops Conservancy refers to the Kat storm water canal as a 'sewerage canal' because it is always contaminated by raw sewage. Alcock (1999) supports this view and ascribes this pollution to sewer blockages. Steward (2009) assessed the ecological integrity of the Swartkops River and other NMBM rivers and concluded that these rivers require safeguarding to meet the required conservation targets for freshwater systems. They stressed that the Swartkops River was so degraded that it

required urgent rehabilitation. Arcus Gibb Consultancy (2009) maintain that water quality monitoring conducted during the last few years often identified high levels of *E.coli* in the water of the Swartkops River and Estuary, which could seriously affect the health and well-being of residents living near the Swartkops Estuary who are dependent on natural ecosystems. According to the Enviro-fish (2011), both the Swartkops Estuary and river and the nature reserves have been designated critical biodiversity areas (CBAs) that need to be protected.

Due to the ongoing issue of poor water quality, primarily caused by sewage and associated health risks from *E.coli* contamination in the Swartkops River and estuary, the Zwartkops Conservancy has addressed its concerns to NMBM and the minister of environmental and water affairs through several attorneys in the form of letters. The minister requested that NMBM provide her with an action plan detailing how it intends to address the problems (Enviro-fish, 2011).

Scarcity results when the quality of water is unfit for human use (Environmental Literacy Council, 2008). This was seen in 2011 when the Nelson Mandela Bay Metropolitan Area was seriously affected by an extended drought and residents were asked to use water responsibly. Lack of access to clean water remains one the most significant threats to human health worldwide. The NMBM State of Environment Report (Klages *et al.*, 2011) indicates that the municipality has spent large proportions of the water services budget during the past few years on replacing dilapidated or dysfunctional infrastructure. Water service infrastructure quality and the quantity of potable water available are threatened by the aging infrastructure, increased tourism, residential- and industrial-related water demand, pollution and alien invasive species. This indicates a breakdown in the financing of storm water pollution and a lack of capacity and policy implementation, planning and management in the NMBM.

This has implications for storm water management, as having sufficient capacity is a prerequisite for ensuring storm water pollution is factored into rehabilitation and health sector reform. Pollution in the Swartkops River has continued to increase since the 1980s and remains unresolved. This demonstrates that NMBM does not provide basic protection to the estuary, which is vulnerable to pollution sources such as storm water canals, industrial plants and sewage treatment plants. Pollution leads to water

contamination, habitat degradation and beach closures, and storm water pollution erodes the nation's water bodies, imposing health, financial and environmental costs on local communities (National Resource Defence Council, 1998). Because storm water pollution is caused by numerous factors, communities should be included in the prevention and reduction of pollution. Moreover, the municipality should consider building, renovating and replacing infrastructure, especially which of the wastewater treatment works (WWTW), to reduce pollution. Hosking (2011) argues that a high level of water quality is achieved when strict water monitoring and treatment occurs; water quality is poor when monitoring and treatment are lacking. King (2004) stresses that there are numerous risks involved in the public receiving poor quality water, including increased sicknesses and even deaths. Therefore, water must be subjected to extensive treatment and cleaning processes where all components of the water need to be verified.

2.4.1 Importance of waterways (Swartkops River and estuary)

Waterways provide economic and social benefits to regions by supporting local fishing aquaculture, agriculture, commercial and tourism industries and providing drinking water (Moreton Bay Regional Council, 2002). They further provide the opportunity to engage in a range of recreational activities common to metropolitan regions, such as swimming, fishing and boating (Moreton Bay Regional Council, 2002). Thus, NMBM is responsible for ensuring that storm water runoff is managed to reduce the impact of storm water pollution on public health, waterways and the environment because there are few natural lakes in South Africa.

South Africa depends on rivers, dams and underground water to meet water supply needs. Approximately 75 percent of the water flowing from the land into the sea does so along the eastern and southern seaboard where many short rivers are located. Maintaining good water quality is necessary for the improvement of quality of life and essential to the maintenance of all forms of life (Strydom & King, 2009). The Swartkops River is one of the valuable freshwater systems in South Africa and is considered ecologically vital because it supports an estuary rich in biodiversity. In addition, the Swartkops River supplies water for agricultural activities and irrigation; it flows through

several industrial areas, including Uitenhage and KwaNobuhle, and suffers damage resulting from induced activities (Odume, 2011).

According to Odume (2011), various types of pollution of freshwater bodies have become a serious threat to biodiversity and ecological integrity because of deteriorating water quality. Scharler and Baird (2005) state that estuaries are productive systems that are of economic, recreational and aesthetic value. They further contend that estuaries are end users of the water of an entire catchment area, reflect the land use in the catchment area and play an important role in trapping nutrients and other chemical compounds before discharge occurs into the adjacent ocean.

Estuaries are considered popular settlement and recreation areas. Worldwide, they have been affected and are threatened by anthropogenic influences, such as population, runoff and over fertilisation from nutrients in agriculture (Scharler & Baird, 2005). The lower catchment area around the Swartkops River estuary is densely populated and numerous industrial concerns, such as clay mines, salt works, sewage treatment works, wool washing plants and tanneries, are located in the region (Mackay, 1993). Point sources of nutrients in this estuary include the Swartkops River and Markman Canal, which drain an underserviced, heavily populated residential township and industrial developments respectively (Mackay, 1993). Estuaries are affected by events upstream and concentrated materials, such as pollutants and sediments, land run off and industrial, agricultural and domestic waste, enter rivers and are discharged into estuaries. Contaminants that are introduced, including plastics, pesticides, furans, dioxins, phenols and heavy metals, cannot disintegrate rapidly in the marine environment (Dennison *et al.*, 1993).

2.4.2 Constraints NMBM faces regarding storm water management

According to the NMBM State of Environment Report (SOER) (Klages, *et al.*, 2011), the following driving forces are putting pressure on its biodiversity resources:

- Population growth;
- Demand for economic growth to provide wealth and job creations;

- Demand for housing and associated services for historically disadvantaged people;
- Unsustainable extraction of natural resources because of poverty or greed;
- Poor waste and pollution management; and
- A lack of understanding, specifically ignorance of the importance of conserving biodiversity.

2.4.3 Storm water pollution prevention measures

Various types of pollution traps act as filters that capture pollution before it enters waterways. These traps have to be cleaned and emptied regularly and their contents carried away to landfills (New South Wales Government, n.d.). Storm water is generally not treated. In some cases, it is filtered through traps located at the end of pipe systems, but it still flows directly from the streets and gutters into rivers, harbours and oceans. Storm water runs straight from the street to waterways inhabited by plants and fish, frogs and other aquatic animals. The most effective way to solve this problem is to prevent pollution entering the storm water system in the first place. Traps are inefficient and fail to catch all the silt or litter and prevent chemical contamination (New South Wales Government, n.d.).

2.5 CAUSES OF STORM WATER POLLUTION

2.5.1 Urbanisation

South Africa faces the problem of the rapid, largely uncontrolled growth of low cost, high-density urban settlements, and local authorities have difficulty meeting demands for even the most basic services and infrastructure in such areas. These areas are expected to increase in the next 20 years (Schoeman *et al.*, 2001). South Africa is a developing country characterised by urbanisation and continued population growth (Pretorius *et al.*, 2002). These factors have a significant effect on metropolitan areas because of the influx of people from rural areas and surrounding towns seeking employment. This population movement causes the high growth rate of informal settlements, which are mostly concentrated on the periphery of large cities, on steep

hillsides, in river gorges and on flood plains. The main reason for the expansion of squatter settlements in these fragile and hazardous areas is that land there is cheap or can be occupied without payment and eviction from such sites is unlikely (Melesse, 2005).

Moreover, Dywer (1975) argues that the growth of squatter settlements within and on the edges of cities in developing countries became a parallel problem to that of overcrowding in regular accommodation because of the low economic status of many families and their inability to pay relatively high rents and maintenance charges. This extreme overcrowding of industrial cities leads to problems in providing sanitation services, increases pollution and affects public health (Wheeler & Beatley, 2004). Aldous (2008) contends that the rapid expansion, development and re-development of commercial and residential properties and the associated densification of the built environment have resulted in an increasingly severe impact on natural and engineered watercourses and adjacent riparian areas.

According to Aldous (2008), an analysis of historical records provided an indication of the hydrological impact of urban development on the catchment area of the Braamfonteinspruit in Johannesburg. Significant negative effects had been identified in the 1930s and continued to grow in parallel to the changing form of the city. The high concentration of population, commerce and industry in urban areas results in large-scale production of waste material and pollutants, which affects the quality of storm water runoff.

Storm water is not a pollutant; it serves as the vector to pollutants (Wright *et al.*, 1993). The range of pollutants varies and includes those demanding oxygen, nutrients, solid fractions, heavy metals, bacteria, hydrocarbons and pesticides (Wetherby & Novak, 1977, as cited in Wright *et al.*, 1993; Schoemann *et al.*, 2001). These substances cause water quality problems, which lead to human and environmental risks through contact recreation and through the use of untreated water, higher purification costs and loss of amenity value and recreation potential (Schoemann *et al.*, 2001). Aldous (2008) identifies stream channel erosion, diminished ground water recharge, impact on regional climate, high levels of runoff intensity and the degradation of streams, rivers and lakes as additional environmental effects of urbanisation.

2.5.2 Storm water runoff

According to Oregon Environmental Council (2007) urban areas impervious surfaces created by buildings, pavements cause rainwater and snowmelt to flow quickly over the landscape, rather than soaking naturally into the soil or being absorbed by plants. This can change stream flows, increase in flooding, endanger public and private infrastructure, erode stream banks and channels and destroy fish habitat. Pollutants commonly found in storm water runoff include heavy metals, bacteria, pesticides and fertilizers, oil and grease, sediment.

2.5.2.1 Bacteria

Combined sewer overflows that discharge untreated raw sewage into receiving waters when runoff waters overwhelm treatment capacity is a major source of bacteria in rivers, according to Gaffield *et al.* (2003). The presence of *E.coli* and faecal coliform bacteria in our rivers, lakes and oceans makes them unsafe for swimming as the pathogens can cause numerous cases of illness Oregon Environmental Council, 2007) including ear and eye rashes, skin rashes and gastro intestinal problems (Gaffield *et al.*, 2003). Consumption of seafood from contaminated water is linked to diarrhoeal and paralytic illnesses caused by the Hepatitis A and Norwalk viruses, *Vibrio* species and marine biotoxins formed by algal blooms.

A DNA study of bacteria in Thilatin Basin streams and storm water pipes found that birds are the most significant source of bacteria in that area. According to Oregon Environmental Council, 2007) another major source of bacteria in some rivers is combined sewer overflows. During storm events, old systems found in some cities expel raw sewage directly into rivers because their pipes do not have enough room to accommodate sewage and storm water (Gaffield *et al.*, 2003, Oregon Environmental Council, 2007).

2.5.2.2 Metals

According to Oregon Environment Council (2007) the effects of metals on humans can be far reaching. Excess nitrogen from urban and agricultural sources exacerbates harmful algal blooms. Major sources of nitrogen from suburban areas include fertilizers carried by storm water, vehicle exhausts and septic systems (Gaffield *et al.*, 2003).

They also state that nitrogen poses direct health threats, exposure to nitrate in drinking water increases the risk of methenoglobinemia, causing shortness of breath and blueness of skin especially for infants' consumption of water with elevated nitrate is also suspected to increase miscarriage risk (Gaffield *et al*, 2003). Lead often used as an indicator of toxic pollutants in storm water can be harmful and deadly for human and aquatic life (Oregon Environmental Council, 2007).

Cadmium can bio-accumulate in an ecosystem and it is harmful to human health. Chromium damages fish gills, causes defects in animals and also dangerous to human health (Oregon Environmental Council, 2007). Cadmium, copper, cobalt, iron, nickel, lead and zinc are deposited into the environment by vehicle exhausts, brake linings, tyres and engine wear. They accumulate on roads waiting to be washed into storm drains with the next rainfall.

2.5.2.3 Sediments

Exposed soil resulting from construction activities is vulnerable to erosion during storms. Poorly managed construction sites can contribute significant amounts of sediment to urban runoff. Storm water transports the eroded soil downstream into nearby storm water drains and waterways, and when sediment-laden water slows down, the sediment settles on the bottom of the stream, river, lake or estuary. When sediment settles, it may cover fish eggs and destroy important habitats, such as those formed by submerged aquatic vegetation (Oregon environmental Council, 2007). Moreover, sediment loads reduce the clarity of water and its attractiveness and can increase boating, swimming and diving accidents (National Resource Defence Council (NRDC), 1998).

2.5.2.4 Insecticides

Insecticides occur widely in sediment and fish in urban streams at levels considered harmful to wildlife, raising concerns about its carcinogenic effects and the disruption of hormonal systems in humans (NRDC, 1998).

2.5.2.5 Fertilisers

Nitrogen and phosphorus nutrients from fertilisers used in gardens, parks and sport fields cause eutrophication in bodies of water. Pesticides from gardening are also considered a significant pollutant (Schoemann *et al.*, 2001; Wright *et al.*, 1993). Once fertilisers enter waterways, they cause algal biomasses that cloud and block sunlight, stressing underwater vegetation. Furthermore, when vegetation dies it sinks to the bottom where bacteria decompose it. As the bacteria feed, they reduce the water's oxygen content; fish and other organisms need oxygen to survive and depletion can result in the death of aquatic fauna (Gaffield *et al.*, 2003).

2.5.3 Canals

Canals are channels cut into the earth that allow for the routing of water down slopes in much the same way rivers flow (Marold *et al.*, 2001). Canals are generally long and narrow, with a uniform width and depth and a single outlet (Reilly & Phillips, 1998). People learned how to construct canals due to increasing industrialisation and growing population centres in regions located some distance from freshwater supplies, which made the need to transport water apparent. As populations grew and prospered, the spread of diseases from the pollution of nearby water supplies gave new impetus to the importation of water from more pristine sources (Marold *et al.*, 2001).

Storm water canals have been fashioned to convey water as quickly as possible to local gullies and waterways to reduce local flooding. It has been recognised and accepted that this approach is contributing to both the increased likelihood of regional flooding as well as the degradation of water quality and health of water ways (Moreton Bay Regional Council, 2002). The eutrophication of canals with poor circulation is accelerated by a heavy pollution load, which is related to population density and shoreline length (Kruczynski, 1999).

2.5.4 Waste

The United States Environmental Protection Agency (2014) contends that canals have become one of the nation's most extensively contaminated water bodies because of years of exposure to emissions, storm water runoff, sewer outflows and industrial pollutants. Contaminants include polychlorinated biphenyls (PCBs), coal tar washes,

heavy metals and volatile organics, and contamination poses a threat to residents that live near these canals.

Densely populated human settlements produce large quantities of waste. If this waste remains uncontrolled or unchecked, it pollutes the rivers, streams and ground water resources (DWAF, 1999). Kruczynski (1999) states that humans derive nutrients and energy from the food they eat, but the human body cannot remove nutrients from food completely, which results in human waste containing nutrients, such as phosphorus, carbon and nitrogen. Waste can enter canals and other near-shore waters from cesspits, septic tanks, injection wells, ocean outfalls and live-aboard vessels (Kruczynski, 1999).

Approximately 80 percent of nitrogen and 55 percent of phosphorus loading derives from wastewater (Kruczynski, 1999). According to Wright *et al.* (1993), residential catchment areas are responsible for introducing organics, bacteria and nutrients to urban storm water canals. These originate from litter, plant material and human and animal excreta. Organic elements, such as carbon, oxygen and nitrogen, change through the action of aerobic bacteria to carbon dioxide, water and nitrate. This process leads to oxygen depletion in storm water and provides energy for increased bacterial growth (Wright *et al.*, 1993).

Nitrogen and phosphorus from fertilisers cause eutrophication in bodies of water, and pesticides are considered significant pollutants (Schoemann *et al.*, 2001; Wright *et al.*, 1993). Both domestic and industrial sources are responsible for the pollution of the Swartkops River system. Beginning in the north of the study area, a wool-processing factory upstream of Uitenhage discharges wash water into open aeration ponds on the bank of the river. Seepage from the ponds has a significant impact on water quality further down the river. The downstream Kat Canal carries runoff from the Rosedale and MacNaughton townships into the river. The runoff is often contaminated by raw sewage due to sewer blockages. These anthropogenic sources of pollution severely affect water quality in the Swartkops River and estuary (Alcock, 1999; Bate *et al.*, 2004).

According to the Bangkok State of Environment (2001) a study carried out by the Thailand Development Research Institute (TDRI) showed that domestic sources

account for 75 percent of the wastewater generated in Bangkok, while industrial sources account for the remaining 25 percent. The Pollution Control Department (PCD) (1996) estimated that industrial waste in the Bangkok region was less than estimated in an earlier plan, which placed pollution at 475 980 cubic metres per day (m³/day) in 2000 and 167 410 m³/day in 2016. Pollution in Bangkok has decreased because the government encourages industries to relocate to outside the Bangkok area by using tax breaks and duty exemption (Bangkok State of the Environment, 2001)

Research in North America indicated that approximately half of the 129 listed United States Environmental Protection Agency's priority pollutants have been detected in urban storm water runoff (Wright *et al*, 1993). According to Redfern (2006), almost all industrial processes that produce waste discharges are potential sources of heavy metal contamination in the aquatic environment, and domestic wastewater sewage sludge, urban runoff and leachate from solid waste disposal sites are obvious sources of heavy metals that contaminate rivers, estuaries and coastal waters.

2.5.5 Wastewater Treatment Works (WWTWs)

In many countries, fresh water is a natural resource in limited supply with numerous users. The demand for water is increasing, which highlights the importance of strict enforcement and control of wastewater treatment by authorised agencies before discharging waste into natural receiving bodies and promoting the campaign for efficient water use in the development of water resource conservation and maintenance of a sustainable water supply (Wright *et al.*, 1993).

A national survey of WWTWs conducted from 2008 to 2009 reviewed the management and operation of plants across South Africa (Quibell, 2011). Quibell (2011) notes that only 7.4 percent of WWTWs achieved the Green Drop standard and only 449 out of approximately 582 municipal WWTWs agreed to be assessed. The majority of WWTWs in the country showed unsatisfactory performance. The following reasons were provided:

- Lack of funding for maintaining and upgrading WWTWs because funds are being deflected into other municipal priority areas;

- Poor financial management in local government; and
- A serious decline in the number of skilled workers operating WWTWs, which has led to most works not being operated effectively (Quibell, 2011).

The Swartkops River receives treated effluent from KwaNobuhle, Calvin Jones (Uitenhage) and Despatch wastewater treatment works. The river downstream of Uitenhage is highly eutrophic, and treated effluent from these three wastewater treatment works is a source of nutrients in the river and a major contributor to surface runoff in the river (Alcock, 1999). Combined storm and sanitary sewer systems discharge untreated sewage into receiving waters when runoff overwhelms their treatment capacities (Gaffield *et al.*, 2003). In the case of combined sewage and storm water drainage, the wastewater treatment plants should ensure that the sewage does not enter rivers and that their drainage pipes are not leaking (NRDC, 1998).

2.5.6 Illegal dumping of litter

Litter is a physical symbol of disorder or incivility, along with vandalism, dilapidated or abandoned housing and dirty vacant lots (Florida Center for Solid and Hazardous Waste Management, 1998). Since the 1970s, littering has been considered an anti-social behaviour and educational problem, which means that the community is to blame for the problem and would offer a solution given the opportunity to do so (Marais & Armitage, 2003). Moreover, Marais & Armitage, 2003) state that the temptation to litter is increased where there is a failure by authorities to enforce effective penalties as a deterrent to offenders. The more sinister aspect of the presence of litter is that it is associated with neighbourhood decline, and it seriously interferes with aquatic life in receiving streams, rivers, lakes and oceans (Victoria Storm Water Committee, 1999).

Urban litter is an additional factor that affects the environment through the storm water transport mechanism (Aldous, 2008). Studies carried out in the City of Cape Town indicated that the drainage system accumulated 3 544 tons of litter per year based on 2003 land use data (Marais *et al.*, 2004). According to the C.A.P.E. Estuaries Management Programmes (2011), litter that accumulated in the estuary came directly

from residents, riparian land owners, estuary users and poachers in the reserves and litter may have blown into the estuary.

Armitage *et al.* (1998) noted that little data is available on the nature and quantity of litter that find its way into storm water systems. The authors argue that South African studies have concentrated on removing litter from drainage systems once it is already there rather than on reducing it before it reaches the drainage system. Marais & Armitage, (2003) support this view and maintain that without an integrated catchment management strategy composed of planning controls restricting litter from entering drainage systems, the problem of urban litter cannot be addressed.

2.5.7 Lack of awareness

Most South African communities still labour under the burden of an unjust past and are unable to afford high levels of services or maintain the services that have been put in place. This has led to severe pollution of nearby surface and groundwater resources and has affected the quality of life in settlements, which threatens the sustainable use of water resources (DWAF, 1999). According to Pretorius and Villiers (2000), public awareness of storm water pollution is minimal in some urban areas, and only a few attempts have been made to develop and implement strategies that address the causes of environmental degradation due to water pollution.

2.6 THEORETICAL FRAMEWORK

Development theory varies in the theoretical framework applied to different countries and regions (De Beer & Swanepoel, 2000). Development theory is a conglomeration of theories about how desirable change in society is best achieved (Preston, 1988). Such theories draw on a variety of social science disciplines and approaches, including modernisation theory, structuralism, dependency theory, basic needs theory, neo-liberalist theory, recent trends post-development theory, sustainable development theory and human development theory (De Beer & Swanepoel, 2000). The researcher selected sustainable development theory as the framework for this study.

2.6.1 Sustainable development

With the advent of democracy, South Africa emerged from a period of unsustainable and inequitable development that not only threatened the livelihoods and degraded the quality of life of a large portion of the population but also was responsible for environmental devastation (DWAF, 1999). To move towards development that is sustainable in all sectors, society has to undergo a governance transition towards public accountability and participation.

Lohani *et al.* (1997) define sustainable development as the result of carefully integrating environmental, economic and social needs to achieve both an increased standard of living in the short term and net gain or equilibrium among human, natural and economic resources to support future generations. The lack of development and development processes has caused and continues to cause environmental degradation. Poverty remains rampant and exerts tremendous pressure on regional resources. Existing development processes have a tendency to place low priority on environmental concerns.

Lohani *et al.* (1997) further argue that to meet development challenges, poverty alleviation through environmentally sound development must be implemented to overcome a number of significant and constraining problems. These problems include land degradation and the depletion of natural resources, human settlements unfit for habitation due to inadequate shelter, sanitation and water supplies, soil, water and air pollution and global issues such as global warming, ozone depletion and loss of biodiversity.

Population pressure, lack of development and the development process itself contribute to the existing storm water pollution in rivers. Water pollution affects the social, economic and environment spheres (Lohani *et al.*, 1997). It also calls for an inter-sectorial and multidisciplinary approach to water resource management that ensures the coordinated development and management of water and related resources to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Environmental Literacy Council, 2008).

Protecting and restoring the ecosystems that naturally capture, filter, store and release water, such as rivers, wetlands, forests and soils, is crucial for increasing the availability of good quality water (UN Water, 2005). According to Biswas and Tortajada (2005), the interpretation of environmental care has expanded to encompass economic vitality, social cohesion and environmental integrity, factors collectively known as the triple bottom line.

The Organisation for Economic Co-operation and Development (OECD) (2007) states that achieving sustainable development depends on good governance practises, particularly the effective implementation of national sustainable development strategies that integrate government decision making in the economic, environmental and social spheres. Government needs to rely on partnerships to design, plan and implement regional approaches that attempt to integrate environmental facets with economic and social dimensions of development.

2.6.2 Impacts of storm water pollution

2.6.2.1 Public health impacts

According to the California State Water Resources Control Board (2013), storm water pollution poses health risks to swimmers and anglers. Pickle (2012) supports this view and states that pollutants in storm water runoff adversely affect public health by conveying large volumes of human pathogens into recreational waters. This was seen in Nelson Mandela Bay in 2010 when the Red House River Mile was moved to the nearby Sundays River estuary because of the poor water quality in the Swartkops Estuary caused by water pollution.

Gaffield *et al.* (2003) point out that impervious surfaces lead to the pooling of storm water, increasing potential breeding areas for mosquitoes, disease vectors for dengue haemorrhagic fever, West Nile Virus and other infectious diseases. A study conducted by the Santa Monica Bay Restoration Project found that storm water pollution leads to the increased incidence of viral infections, earaches, sinus problems, flu and skin rashes and viral diseases, such as hepatitis, in those swimming in the ocean close to drain outlets. This is especially true following rainstorms when litter and contaminants are flushed into the storm drain system (California State Water Resources Control

Board, 2013). Moreover, storm water pollution poses a public health threat in neighbourhoods. Trash and animal waste left on the ground carry harmful disease-spreading bacteria, putting children and their families at risk. According to the DWAF (1996), urban wastewater, particularly from informal settlements that lack sewage and water purification facilities, causes pollution that in turn contributes to serious human health problems, such as typhoid, cholera and gastroenteritis transmitted by water contaminated with untreated sewage. Gastroenteritis is one of the main causes of death in South African children under the age of five.

2.6.2.2 Social impacts of storm water pollution

The California State Water Resources Control Board (2013) claims that storm water drains clogged with trash and debris result in street and neighbourhood flooding during the rainy season. This leads to closed roads and increased traffic, and creates an unhealthy environment characterised by unpleasant odours and unsanitary conditions, affecting local aesthetics and lowering property values. The organisation further indicates that the cleanliness of communities influences the financial and personal investment residents make in their property and contributes to the overall sense of community pride and civil engagement. Stagnant water in canals is not only an eyesore but also gives off an unpleasant odour and poses health and safety risks (Krause *et al.*, 2005).

2.6.2.3 Environmental impacts of storm water pollution

Storm water runoff is responsible for the majority of chemical, nutrient, biological and plastic pollutants found in the South African ocean environment. These pollutants have the potential to interact and accumulate, and degrade ocean ecosystems in a variety of ways. Some of the pollutants remain active within the marine environment for extended periods of up to several years (DEAT, 2012). The DEAT (2012) indicates that storm water runoff into the marine environment is a significant source of plastics and toxic heavy metals introduced into the ocean and that this kind of pollution is difficult to regulate and control. Durban and Cape Town municipalities have established strategies preparing for the first heavy rainfalls of the season. Observed environmental effects include sudden fish deaths in marinas and near-shore environments, usually because of low oxygen levels due to pollution and a lack of

flushing. Reilly and Phillips (1998) state that the disturbance of draining or cleaning for development of acid sulphate soils can produce sulphuric acid, which is toxic to fish and has resulted in several mass fish deaths in New South Wales in Australia.

2.6.2.4 Economic impacts of storm water pollution

Recreation and tourism industries are major employers in South Africa and are of particular importance to the coastal economy. According to the DEAT (2012), coastal tourism generates R13.5 billion annually. Recreational fishing is a popular activity, with approximately 500 000 sports anglers active in South Africa. Although the value of fishing is difficult to quantify, it contributes substantially to the economy. Additional coastal recreation activities include diving, sunbathing, swimming and picnicking. Some religious groups also use waterways and coastal environments for performing activities and ceremonies (DEAT, 2012). For example, the Zion Christian Church uses the Swartkops Estuary close to the Markman and Motherwell canals, sangomas can be seen using the heavily polluted Kat Canal and River above the Niven Bridge and many South Africans gather seawater for medicinal uses. Ocean imagery is embedded in the beliefs, poetry and songs of coastal communities (DEAT, 2012).

If the water quality of waterways and beaches continues to deteriorate, it holds broader implications not only for the NMBM economy but also for the national economy. The National Resource Defence Council (1998) maintains that the combination of potential human illness and aesthetic losses can cause loss of revenue from tourism and recreational activities. If storm water pollution is not managed properly, it can result in beach closures.

2.7 Summary

The aim of this chapter was to explore the literature on storm water pollution in South Africa and in Nelson Mandela Bay, the constitutional responsibility of the state in preventing storm water pollution through the use of policies and the role of the local municipality. The next chapter offers a discussion of the research methodology utilised to collect the data used in the study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter, the researcher elaborates on the research methodology used and discusses the delimitation of the study, research design, population, sampling, data collection methods, interview methods used, validity, observation and textual analysis. Qualitative research methods were used to gathered perspectives of storm water pollution from a number of residents living close to the Kat, Motherwell and Markman canals in NMBM. Hakim (2000) explains that qualitative research is concerned with individuals' own accounts of phenomena based on their attitudes, motivations and behaviour, and it provides descriptive reports of individuals' perceptions, beliefs, views and feelings and the meanings ascribed to and interpretations of events and objects.

3.2 DELIMITATION OF STUDY

Because the researcher could not reach the entire population of NMBM, only residents living near the Kat, Markman and Motherwell canals were interviewed regarding storm water pollution. An interview schedule was developed and administered to obtain responses to questions about pollution from residents identified in the sample. The semi structured questions were administered by conducting interviews with residents. Purposive sample consisting of 32 respondents from different areas was approached to complete the research questionnaire. The sample included:

- One representative from NMBM
- One representative from the NGO

- Ten community members of Kabar and Joe Slovo in Uitenhage, located next to the Kat Canal;
- Ten community members of Aloes Village, located next to the Markman Canal; and
- Ten community members from Motherwell NU5, located next to the Motherwell Canal.

3.3 RESEARCH DESIGN

The qualitative research method was used to:

- a. Understand the issues from the viewpoints of the participants;
- b. Describe the social setting of the participants so their views were not isolated from their contexts; and
- c. Understand the participants' thoughts, feelings and behaviour; these were examined along a developmental or temporal continuum (Struwig & Stead, 2001).

The first step in the research process was to identify the water quality problems affecting the canals under study by conducting site visits and reviewing published literature. The second step was to identify the socio-economic factors that contribute to physical problems to ensure the sustainability of any physical interventions. Semi structured questions were compiled to capture the data provided by affected residents. The field survey was conducted in July 2014. The final step was to analyse the data collected and make recommendations based on the results obtained. The research method was descriptive and the research approach is qualitative, which means the participants had an opportunity to express their views and feelings on storm water pollution.

3.4 SAMPLING

A sample is a subset of the population drawn to represent the whole population in a research project because it reflects characteristics of the entire population (Du Plooy,

2001). The intention of sampling is to select individuals who are representative of a population to ensure that the results can be generalised to a population and that inferences can easily be drawn (Creswell & Plano Clark, 2007). Obtaining information from a sample is often more practical and accurate than obtaining the same information from an entire population (Struwig & Stead, 2001). Since it was impossible to reach the entire population within the NMBM a purposive sampling was used to select participants of this study, thus the original sample allowed access to households that live close to the storm water canals that are impacted by anthropogenic pollution. Sample sites were identified from the work of previous researchers who pinpointed areas where storm water runoff was the major contributor to pollution in the Swartkops River and estuary.

The focus sample included 1 representative from the Nelson Mandela Bay Municipality, 1 representative from the NGO and 30 residents living close to the storm water canals, namely the:

1. Kat River Canal passing through Kabar and Joe Slovo townships and flowing into the Swartkops River above the Niven Bridge;
2. Motherwell Canal passing through the Motherwell NU5 township; and
3. Markman Canal that passes through Aloes Village.

These areas were chosen because they were accessible to the researcher, limiting the costs of personal interviewing.

3.5 DATA COLLECTION METHODS

Qualitative research revolves around the collection of data through observation, interviews and surveys (Kigozi, 2008). Data was collected from both secondary and primary sources.

3.5.1 Primary sources

The interview is one of the main data collection tools used in qualitative research. It is considered a good way of accessing people's perceptions, meanings, definitions of situations and constructions of reality. Interviewing has a wide variety of forms and a

number of uses. The most commonly used types of interviewing are individual, face-to-face group interviewing, mailed or self-administered questionnaires and telephone surveys (Punch, 2005). This study used self-administered questionnaires. Data was obtained by means of semi structured interview questions used to gain an in-depth understanding of issues. Interviews for the pilot study were conducted on 1 July 2014. The interviews were conducted individually with each participant. The purpose of the interviews was to understand the central themes of participants' perceptions of anthropogenic pollution and its effects on them. The participants were encouraged to interpret their feelings and behaviours regarding the issues being discussed and to provide detailed information (Klave, 1983, as cited in Struwig & Stead, 2001).

The researcher obtained respondents' permission to conduct the interviews by approaching the councillor of each community included in the sample and the representatives of NMBM and the NGO. The researcher verbally explained the purpose of the study and emphasised that participation was voluntary. Participants were convinced to participate freely as their personal details would not be revealed in the research report.

3.5.2 Secondary sources

Secondary research methods and sources used to gather data for this study included:

- A desktop analysis and literature review using a substantial amount of literature from NMBM, the DWA and the DEAT;
- The continuous exchange of information with other specialist study personnel;
- The collection and review of published and unpublished data sources, including periodicals, dissertations and theses reports from research institutions, conference papers, textbooks and library reference services (Struwig & Stead, 2001); and
- Gathering unpublished materials relevant to the study using questionnaires directed at the study's target group (Struwig & Stead, 2001).

3.5.3 Validity

The validity of interviews was addressed by asking participants to comment on the researcher's interpretations after all interviews were completed. Triangulation was employed to verify findings using independent measures (Struwig & Stead, 2001). The United Nations World Food Programme (n.d.) defines triangulation as assessing the reliability and validity of data using a range of tools and techniques for data collection and analysis, and different sources of information about the same problem. This allowed the researcher to examine and, if required, address the reliability and bias of the findings. Therefore, triangulation was used for the process of cross checking information.

3.5.4 Observation

Observations helped to substantiate the information gathered through literature surveys and textual analysis. Recordings allowed repeated and comparative observations without the need to reassemble the participants or community members (Kigozi, 2008). The first observation took place in June 2014 with the intent to witness the pollution in the three storm water canals that affect the Swartkops River and estuary (first hand observation). The researcher was given a tour of the three polluted storm water canals and an environmental officer of the Zwartkops Conservancy assisted her. The second was carried out on 26 July 2014 while conducting interviews at Aloes Village.

3.5.5 Interviewing

The qualitative questionnaire is one of the main data collection tools used in this study. It is considered an excellent method of accessing people's perceptions, meanings and definitions of situations and constructions of reality. Interviewing has a wide variety of forms and a multiplicity of uses (Punch, 2005). The most common type of interviewing used was individual, face-to-face interviews using self-administered questionnaires.

3.5.6 Textual analysis

Textual analysis plays an important role in providing information with regard to what has been documented about storm water pollution in the past (Kigozi, 2008).

3.6 SUMMARY

This chapter focused on a discussion of the research methodology used in the study. An examination of the qualitative approach was followed by a discussion of semi structured interviews used as the data collection tool. Research participants include the residents of Kabar, Joe Slovo, Motherwell NU5 and Aloes. Two informant interviews with representatives of the local NGO and municipality were also used.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

Data analysis involves breaking up the data into manageable themes, patterns, trends and relationships (Nortje *et al.*, 2011). The main purpose of analysis is to understand various constitutive elements of one's data through an inspection of relationships between concepts, constructs or variables to establish whether there are any identifiable or distinguishable patterns or trends and to establish themes in the data (Mouton, 2001). Kigozi (2008) supports this view and explains that qualitative research entails recording information and analysing it by finding themes and classifying data accordingly.

Qualitative research therefore explores traits of individuals and settings that one cannot easily describe numerically. It allows selected issues to be studied in depth and promotes openness and detail. Kigozi (2008) further states that qualitative analysis involves three processes: describing the phenomena, classifying them and establishing how concepts interact. Without describing the phenomena under study and classifying them, there would be no way of knowing what was being analysed or of making meaningful comparisons between different kinds of data. Therefore, classifying data is an integral part of qualitative analysis.

Moreover, Kigozi (2008) stresses that keeping a diary and recording field notes are essential throughout the process of qualitative data analysis. Once the data has been transcribed, each line of information is categorised into logical units with descriptive classification labels. In addition, the author recommends using tables and graphs to ensure that concepts are related and to illustrate their connections. The results obtained from conducting structured interviews with residents living near the Kat, Markman and Motherwell canals were analysed.

4.2. INTERPRETATION OF STRUCTURED INTERVIEWS WITH RESIDENTS OF KABAR AND JOE SLOVO, ALOES VILLAGE AND MOTHERWELL NU5

4.2.1 What is storm water pollution?

All 20 respondents from Kabar and Joe Slovo and Motherwell NU5 and nine of the ten respondents from Aloes Village did not know what storm water pollution is. Only one resident defined it as dirty and stinking water running in the storm water canal.

Summary

There are a number of education initiatives, primarily offered by the Zwartkops Conservancy, designed to teach people living near the Swartkops River and estuary about water pollution and its associated risks. The results of this study highlight that this message has reached only a fraction of the population and that further efforts need to be made, such as improved signage, conservation officers approaching and educating users, and the municipality handing out pamphlets that are easy to read to every household when it delivers garbage bags.

4.2.2 What is a storm water canal?

The State of Michigan (1992) defines a storm water canal as a permanent waterway designed to convey storm water runoff. It provides a means of transporting concentrated surface runoff without causing erosion or flooding, particularly in urban areas. However, unlike natural waterways, storm water canals behave almost entirely as conduits of water and have a limited ability to remove pollutants such as nutrients, bacteria, matter that affects oxygen levels and sediment.

A recurring theme that arose from the responses of residents of Kabar and Joe Slovo townships (seven out of ten respondents), Aloes Village (eight out of ten) and Motherwell NU5 (eight out of ten) was that the storm water canal is a running channel. The remaining three residents from Kabar and Joe Slovo thought of a canal as a river and did not know what a storm water canal was. Because the canal is always filled with sewage, they viewed it as a sewer. One of the remaining two residents from Aloes Village said it was where storm water runs and the other did not know what a storm water canal was. One of the remaining residents from the Motherwell NU5 community

said “it’s where water from the Motherwell community goes to” and the other did not know what it was.

Summary

Most of interviewees had an idea of what a storm water canal is, describing it as the water channel that is running, the place where storm water runs or where water from the Motherwell community goes.

4.2.3 On whether there is storm water pollution in their areas

All respondents indicated that there is storm water pollution in their areas.

4.2.4 What are the main causes of storm water pollution in your area?

Five residents from Kabar and Joes Slovo cited sewage as the main problem that causes storm water pollution. One of them stated, “Community members of Joe Slovo drop their buckets full of sewerage in this canal”. Four residents complained about illegally dumped litter left at the corner near the storm water canal. Lastly, one resident stated that people also dump dead cats and dogs in the canal.

The recurring theme derived from the responses of eight residents of Aloes Village is that storm water pollution is caused by sewage, dumped litter and industrial chemicals. To elaborate, one of the residents stated that:

When it comes to sewerage and chemicals, I can even differentiate the pollutants: Whenever I see whitish foam, I know sewerage or industrial waste is coming. However, when I see whitish foam and green colour along the edges of the Markman storm water canal, I know chemicals have been dumped. Sewerage forms a sludge and is slippery.

Another resident indicated that he was a long-time resident of the area and explained that:

The municipality usually comes to take out the mud from the dam upstream, so that the polluted storm water goes in there to settle and filter out pollutants before it comes into the canal, but now the municipality does not do that anymore. As a result, the dam is full of mud; it cannot filter out pollutants from the industries, the polluted water goes straight to this canal and this affects us a lot. We cannot even eat - if we want to do so we are forced to close the doors.

Lastly, one of the residents explained that sewage overflows and runs into the Swartkops River “when the Studebaker pump and Aloes sewerage pump generators are not working”, causing storm water pollution.

The recurring theme that emerged from the responses of eight residents of Motherwell NU5 is the illegal dumping of litter and frequent sewage leaks from storm water pipes. According to one resident, “the community dumps litter, dead pets or dogs and sometimes... human underwear or shoes and sometimes human blood”. The other resident claimed that “illegal dumping of litter is the main cause of storm water pollution - community members don’t use the legal dumping site they just dump next to it”.

Summary

Based on the responses from communities living near the canals, the main causes of storm water pollution include illegal dumping of solid waste and sewage. Aloes Village drains waste from industrial companies, which led to the identification of chemicals as one of the main causes of storm water pollution. That residents can differentiate between the different types of pollutants, such as sewage and chemical waste, suggests that the education initiatives of the Zwartkops Conservancy have enlightened this community (see 50/50 video footage on Zwartkops Conservancy website). Motherwell residents identified sewage leaks and illegal dumping of litter as the main problems affecting them.

4.2.5 What are the problems caused by storm water pollution in your area?

The Kabar residents live in formal housing, whereas the Joe Slovo residents live in informal structures. There was no recurring theme regarding the causes of storm water pollution from residents of Kabar and Joe Slovo. They highlighted the following issues:

- When it rains steadily the canal overflows while full of dirty water and litter, and in dry conditions the litter in the canal stinks unbearably with the unpleasant odour lingering for two months;
- During the rainy season, children play in the canal and contract waterborne diseases;

- The bad smell or air pollution forces them to eat with the doors to their homes closed;
- Dogs die after drinking the polluted water;
- Mosquitoes and flies irritate them day and night;
- They live in fear when it is raining and the storm water canal overflows. The dirty water flows across the street and nearly to their houses. Although it had not reached their houses, they are convinced that heavy rains will cause flooding and do not sleep well when it rains;
- Joe Slovo residents think Kabar residents are better off than they are because Joe Slovo is downwind from the canal. Joe Slovo residents are more severely affected by air pollution than Kabar residents;
- One resident injured his leg after stepping on whitish foam in the canal that looked like dry soil and slipping in water; and
- Children suffer injuries when they play in the canal and fall in the litter trap that is placed in the canal to catch litter.

One of the residents of Aloes Village expressed her concern that residents "are coughing up blood and others have been diagnosed with TB". Three residents responded that children who play in the canal suffer from waterborne diseases, three complained of the "bad smell", and the remaining three residents stated that they are restless because mosquitoes and flies trouble them constantly.

A recurring theme that emerged from the responses of five of the residents of Motherwell NU5 is that children play in the canal and contract waterborne diseases, and because the canal is slippery, they could drown or be washed out into the Swartkops River. According to one resident:

The dogs are dying because they become trapped in this canal and can't go out because the canal is shallow and deep. The municipality needs to fence the canal and also a crossing bridge is recommended.

Four residents complained of air pollution and the bad smell that forces them to close their doors when they want to eat, and the last resident objected to the high level of mosquito and fly activity.

Summary

The recurring theme that emanated from all three residential areas is that children are playing in this canal and suffer from water borne diseases. In addition, residents are irritated by mosquitoes and flies constantly, and a bad odour or air pollution affects residents' quality of life.

4.2.6 What are the reported cases of disease outbreaks caused by storm water pollution?

Reported diseases from Kabar and Joe Slovo residents are skin rashes and severe sores on the heads of children who swim in the storm water canal (as seen in Figure 5 below), tuberculosis (TB), chest pains, mouth sores and skin irritations ("mond sere en jeuk puisies"), diarrhoea and a leg injury (see Table 1). Diseases reported by residents from Aloes Village include skin rashes, gastroenteritis or diarrhoea, chest pains, TB and bronchitis. Diseases reported by Motherwell NU5 residents are TB, skin rashes, chest pains, gastric disorders, bronchitis and asthma.

Table 1. Responses of community members regarding human health afflictions possibly related to storm water pollution

Residents	Responses
<p>Skin rashes</p> <p>Kabar and Joe Slovo n=3</p> <p>Aloes Village n=2</p> <p>Motherwell NU5 n=3</p> <p>Tuberculosis</p> <p>Kabar and Joe Slovo n=1</p> <p>Aloes Village n=1</p> <p>Motherwell NU5 n=4</p> <p>Chest pains</p> <p>Kabar and Joe Slovo n=3</p> <p>Aloes Village n=2</p> <p>Motherwell NU5 n=1</p> <p>Gastric disorders/diarrhoea</p> <p>Kabar and Joe Slovo n=1</p> <p>Aloes Village n=2</p> <p>Motherwell NU5 n=1</p> <p>Bronchitis</p> <p>Aloes Village n=1</p> <p>Motherwell NU5 n=1</p> <p>Asthma</p> <p>Aloes village n=2</p> <p>Motherwell NU5 n=1</p> <p>Others</p> <p>Kabar and Joe Slovo n=2</p>	<ul style="list-style-type: none"> • Children have sores on their heads (Figure1) • Skin infections, such as itching blemishes • A young girl was admitted to Dora Nginza Hospital suffering from a severe skin rash • Children suffer from skin rashes because they play in the canal, especially those in Grades R and 6 • Diagnosed with TB • Diagnosed with chest pains and flu • Diarrhoea from swimming or playing in the canal • Young boy admitted to Dora Nginza Hospital for three weeks • Diagnosed with gastric disorder • Diagnosed with bronchitis • Diagnosed with asthma • Young boy diagnosed with asthma • Mouth sores ("mond sere en jeuk puisies") • Leg injury because one of the residents fell in the canal

Summary

Residents from the three study areas have identified a number of symptoms affecting children in particular. These include skin infections and diarrhoea, conditions that were probably contracted through direct contact with and ingestion of polluted water. In addition, symptoms and diseases such as chest pains, TB, bronchitis, asthma and mouth sores were also reported. One resident injured a leg when falling into a canal.



Figure 5: A child from Joe Slovo with severe sores on his head

4.2.7 How do residents dispose of their litter?

NMBM assists the Joe Slovo, Kabar and Motherwell NU5 residents with waste disposal. However, Kabar and Joe Slovo residents sometimes burn solid waste because the municipality does not always provide disposal services. In Aloes Village, EnviroServe helps residents to dispose of their litter and provides them with black refuse bags.

4.2.8 Is there a litter-dumping site in your area? If yes, is it legal or illegal?

All respondents from Joe Slovo and Kabar agreed that there are illegal litter-dumping sites in their areas. They indicated that they use these dumping sites when municipal services are unavailable and to dump garden refuse and construction material. There was no dumping site at Aloes Village because EnviroServe provides a bin. However, when the bin is full the litter overflows, causing illegal dumping. There is a legal dumping site in Motherwell NU5, but residents do not use it and dump their waste illegally next to it. When asked why this happens, they responded that municipal workers are employed to clean their dumpsite, which translates to “no dumping, no job”.

4.2.9 Where exactly is this litter-dumping site situated?

The dumping sites for Kabar, Joe Slovo and Motherwell NU5 are located near the storm water canal upstream of the residents. There is no formal dumping site in Aloes Village.

4.2.10 How often does the municipality collect litter?

The municipality is supposed to collect litter from Kabar and Joe Slovo residents once a month on Thursday and from Motherwell every two weeks on Fridays. In addition, EnviroServe aim to collect litter every two weeks. However, it appears that these schedules are not adhered to and residents often have to contact service providers to remind them.

4.2.11 How do residents dispose of their sewage?

Kabar and Motherwell residents use flushing toilets, whereas those living in Joe Slovo and Aloe Village use the bucket system.

4.2.12 How often does the municipality collect sewage from residences?

The municipality is scheduled to collect sewage from buckets in the Joe Slovo settlement and Aloes Village twice a week on Mondays and Fridays. However, the municipality is inconsistent and residents often have to dispose of sewage themselves.

4.2.13 How do residents dispose of their waste if the municipality fails to arrive?

If the municipality does collect waste, Joe Slovo residents dump their sewage in the storm water canal or dig holes in their yards and dispose of it by burying it. Aloes Village residents empty their buckets in a hole behind the bushes. Others empty their buckets in black refuse bags and dump them behind nearby bushes.

4.2.14 What is the government doing to mitigate the effects of storm water pollution?

The recurring theme that emerged from responses of residents of Kabar and Joe Slovo settlements is that the government does not help at all. One of the residents stated that “when there is a problem, [he reports] this pollution to the media or newspaper (The Sun)”. The recurring theme that emerged from the responses obtained from residents of Aloes Village is that government is not helping at all, and when they tried to complain, they did not receive any response. They have written numerous letters to the mayor complaining about this pollution and suggesting solutions, but have yet to receive a reply. Motherwell NU5 residents stated that the government was not helping at all; if it was, they would not be having these problems.

4.2.15 What is the municipality doing to mitigate the effects of storm water pollution?

The residents stated that the municipality does not help to mitigate storm water pollution in any of the three residential areas. Aloes Village residents added that they always promise to come, but never do. However, there are mechanisms in place for lessening the effects of storm water pollution, such as the installation of solid waste traps in the canal, the creation of artificial wetlands, cleaning out of the canals, promotion of waste tips and refuse removal. It seems that these measures are ineffective and that residents are unaware of them.

4.2.16 In what programmes is the municipality involved to mitigate the effects of storm water pollution?

The residents are unaware of the programmes the municipality offers to mitigate the effects of storm water pollution (see Table 2). Some of these programmes, such as

refuse removal at the canal using solid waste traps and refuse removal at homes, are mentioned in question 15. This indicates that storm water pollution education initiatives did not reach the residents that were interviewed.

Table 2. Residents' perceptions of programmes offered by the municipality to mitigate storm water pollution

Residents	Responses
Kabar and Joe Slovo n=10 Aloes Village n=10 Motherwell NU5 n=10	<ul style="list-style-type: none"> Residents stated that the municipality offered no programmes to mitigate storm water pollution.

4.2.17 Do NGOs assist in mitigating the effects of storm water pollution?

The residents of Joe Slovo and Kabar and Motherwell NU5 stated that NGOs do not assist them (see Table 3). However, this is inaccurate as NGOs monitor and evaluate these canals. One NGO uses "trash bashes" involving schoolchildren to clean up storm water canals. In addition, the Masifundise Project educates Grade 6 learners about litter and storm water. Unfortunately, neither project reached the fraction of residents interviewed. Residents of Aloes Village stated that they do receive some assistance.

Table 3. Residents' perceptions of storm water mitigation measures employed by local NGOs.

Residents	Responses
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Kabar and Joe Slovo n=10	Residents stated that they do not receive assistance.
Aloes Village n=10	NGOs do assist a great deal, although they cannot fix the problem; they help by calling the municipality whenever residents have a problem. They always call the NGO to report sewage leaks. An NGO educated them about dumping litter near and sewage in the canal, and taught them to report problems related to storm water canals and not to allow their children to play in the canal. EnviroServe assists with refuse removal.
Motherwell NU5 n=10	Residents stated that they do not receive assistance.

4.2.18 What programmes are implemented by NGOs to mitigate storm water pollution?

Motherwell, Kabar and Joe Slovo residents stated that NGOs have implemented no programmes in their areas (Table 4). This shows that the fraction of residents interviewed were unaware of NGOs' activities. The NGOs should continue with their awareness programmes until they reach everybody. The residents of Aloes Village acknowledged the implementation of programmes by the NGO in their area (Table 4).

Table 4. Residents' perceptions of programmes implemented by NGOs to mitigate storm water pollution

Residents	Responses
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Kabar and Joe Slovo n=10	No programmes
Aloes Village n=10	NGOs educate residents about keeping the environment clean. For example, an NGO uses "trash bashes" with schoolchildren to clean up litter in the storm water canals. It educates the community of Motherwell at the Motherwell Enviro Club.
Motherwell NU5 n=10	No programmes

4.2.19 Are health facilities capable of dealing with the people affected by storm water pollution?

The residents of Kabar, Joe Slovo and Motherwell NU5 all felt that the health facilities in their areas were capable of dealing with the diseases that result from storm water pollution (Table 5). Residents from Aloes Village do not have a nearby health clinic and residents, particularly the aged, find it difficult to reach the nearest facility.

Table 5. Responses of residents related to the capability of health facilities to manage diseases caused by water pollution

Residents	Responses
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Kabar and Joe Slovo	Health facilities are capable of dealing with patients
Aloes Village	Residents do not have health facilities and have to walk long distances to reach Wesley Clinic to receive treatment. Older residents cannot go to the clinic due to a lack of transport.
Motherwell NU5	Health facilities are capable of dealing with patients

4.3 RESULTS FROM STRUCTURED INTERVIEWS CARRIED OUT WITH REPRESENTATIVES FROM AN NGO AND THE MUNICIPALITY

The researcher conducted interviews with a representative of the local NGO, the Zwartkops Conservancy, and a representative of NMBM.

4.3.1 What is storm water pollution?

When asked to define storm water pollution, the representative from the local NGO stated that it is when sewage or other kinds of pollution, such as industrial waste, enters gutters and drains in the street that lead to storm water pipes and then to storm water canals. The municipal representative stated that storm water pollution is the discharge of pollutants (litter, sewage and so forth) into the storm water system. He further defined it as poor drainage caused by solid waste that enters surface drains and sewers causing blockages and reducing flow. The main cause he identified is that many RDP houses have flushing toilets, but few homeowners have access to maintenance to unblock drains and sewers on their properties.

4.3.2 Effects of storm water pollution on public health

The local NGO indicated that children who swim in the polluted storm water canal become ill. She stressed that residents are affected by diseases like diarrhoea and skin rashes ("kwasa kwasa"). The unpleasant odour emanating from these canals is

unbearable and creates a breeding ground for mosquitoes, which irritate residents incessantly. She added that people cannot avoid walking through polluted storm water because it is in the streets where they live. Cattle and dogs drink the polluted water in these canals.

The municipal representative stated that storm water pollution affects the health of individuals and children who play in the storm water canal. He further indicated that it causes air pollution due to the stinking, illegally dumped litter caught in the canals. In areas with inadequate sanitation, pathogens spread through the community and increase health risks from waterborne diseases.

4.3.3 To what extent does storm water pollution affect NMBM communities?

The representative from the local NGO stated that residents are affected by air pollution emanating from the canals, and they suffer from diseases like TB and gastritis. Children are affected by skin-related diseases because they play and swim in the canals. People with compromised immune systems contract all kinds of illnesses. Dogs die and cattle become ill because they drink polluted water from the canals. The municipal representative stated that the children are the ones who are affected because they are the ones who play in the canals.

Air pollution would be one of the problems that affect them because blockages cause unbearably bad smells. In addition, blockages caused by litter often lead to flooding of the canals. Community members contract waterborne diseases, such as skin rashes and diarrhoea. Storm water pollution at the Motherwell Canal stems from sewage leaks caused by the carrying capacity of pipes being exceeded and poor maintenance of the infrastructure. The area contains many RDP houses built by the government. The problem from the municipality's point of view is that it lacks the finances to construct new storm water systems that can serve the whole community of Motherwell. According to the municipal representative, the municipality is working to remedy the situation. The residents who live in close proximity to the Markman Canal (Aloes Village) reside within the Swartkops Estuary flood plain, and their lives are at risk from floods and diseases associated with living in damp houses. Most of these residents have been relocated to Wesley Estate, but some who have lived in the area for a long time refuse to leave, fearing that their houses will be taken over once they leave. The

municipal representative indicated that the municipality has been consulting with engineers to find a solution to the problem but no decision has been finalised.

4.3.4 What are you doing to mitigate storm water pollution in the area of influence?

The local NGO stated that it supervises four ladies who clean up the area and undertakes “trash bashes” with schoolchildren to remove as much litter as possible to prevent solid waste washing into the drains in the streets and, finally, into the storm water canals. The organisation educates the community through performances by the Motherwell Enviro Club – often in the street - that have environmental messages. The NGO also runs the Masifundise Project that targets Grade 6 learners. It presents lectures and demonstrations every Wednesday, and takes learners to the Motherwell storm water canal and explains important facts about litter and storm water.

In addition to the project, the NGO educates primary school children in Grade 6, sponsors outreach programmes conducted through churches, conducts meetings and presents educational concerts. The events teach locals about the effects of sewage that flows into the canal, illegal dumping and throwing stones down the sewage pipes, which causes blockages and overflowing. The local NGO checks the canals regularly and reports problems to the municipality. The municipal representative stated that the municipality installed a new litter trap in the Kat Canal in Uitenhage. It also created a reed bed to filter out litter and debris coming down the Motherwell Canal before the water is discharged into the estuary. In addition, NMBM is attempting to resolve the issues at Kelvin Jones Wastewater Treatment Works in Uitenhage. Furthermore, the municipality sponsored a master's degree student (Ms Liaan Pretorius) to research the pollution points in the Swartkops Estuary. NMBM will consider the recommendations from the research in an attempt to resolve the pollution issues.

4.3.5 Do you think government departments play a role in mitigating storm water pollution?

The representative from the local NGO stated that they do play a role but follow up is often lacking and, in many cases, polluters are not fined or punished. They do not adequately police the areas and should force people to comply with the regulations.

The updated DEAT recreational water quality guidelines now recommend less than 500 colony units per 100 millilitres for *Escherichia coli* (*E. coli*) and for faecal coliforms. The Swartkops Conservancy feels that the guidelines are not sensitive enough and that NMBM fails to take appropriate action when they report violations.

The representative of the municipality indicated that the government is doing its best to check storm water canals for health hazards. He claims that it uses the water quality guidelines provided by the DEAT to provide quality objectives for water in the canals and to check the pollution levels of the water going into these canals regularly.

4.3.6 How are you helping each other in mitigating the effects of storm water pollution?

The representative of the local NGO stated that the municipality is quite good and does call back after a sewage blockage is reported. Usually workers fix the blockage the following day, but sometimes repairs take longer depending on the type of the problem. The municipality does not spend enough on the maintenance and upgrading of sewage pipes. She added that the municipality is hampered because it has only a certain amount set aside in the budget for maintenance and this amount is inadequate:

It is the councillors who decide how much for what in the budget. They only think of houses and do not think about the infrastructure and that with so many more houses sewerage pipes need to be bigger, so of course there will be problems with the sewerage system overloaded.

The municipal representative stated that the NGO monitors the storm water canals and reports problems and blockages of the sewerage pipes going into the storm water canals.

4.3.7 Programmes the municipality and NGO are involved in to mitigate the effects of storm water pollution

The representative of the local NGO indicated that the municipality has funded an NMMU study of the Swartkops Estuary to develop a monitoring plan. The study forms the basis of an MSc dissertation by Ms Liaan Pretorius, which focuses on pollution points in the Swartkops Estuary and suggestions for solution to pollution problems.

The results of the study were presented to the municipality on 2 April 2014 and the dissertation has been submitted for the November 2014 examinations.

She added that the municipality is taking action to help solve the problems, for example, a new litter trap was installed in the Kat Canal in Uitenhage. They are trying to reduce the volume of fresh water coming down the Motherwell Canal, so that all of the water can be diverted for filtering through the artificial reed bed at the bottom of the canal. Currently, the reed bed cannot manage all the water coming down (~25 percent of the flow is diverted at present). The representative further indicated that the municipality is trying to resolve the issues at Kelvin Jones Water Treatment Works in Uitenhage, which has become the main source of pollution into the Swartkops River and estuary and is even worse than the Motherwell Canal.

The representative from the municipality stated that the NGO carries out clean ups at the affected areas. Further, it manages projects that target Grade 6 pupils and teach them about the sewage that goes into the canal, illegal dumping and the throwing of stones down manholes. They also educate communities on the importance of storm water canals.

4.3.8 Are the health facilities capable of dealing with victims of storm water pollution in the areas of concern?

The representative of the local NGO stated that Aloes Village residents do not have health facilities nearby and visit a clinic at Wesley Estate. The residents near the Motherwell and Kat canals do have these facilities.

The municipal representative stated that the health facilities near the Motherwell and Kat canals are adequate, but that the Aloes Village site is within the Swartkops floodplain, making it unsuitable for a health clinic. The most suitable option is for residents to visit the Wesley Estate clinic.

4.4 SUMMARY OF FINDINGS

The major causes and most significant effects of storm water pollution are:

- Illegal dumping of litter;

- Illegal dumping of sewage in the storm water canals;
- The illegal dumping site at the Motherwell Canal and the illegal dumping sites at Kabar, Joe Slovo and Motherwell NU5 are situated near the storm water canal. When it is windy, the trash from these dumping sites is blown into the storm water canal;
- Air pollution caused by stinking storm water canals resulting from illegally dumped litter and sewage leaks at the Motherwell Canal;
- The canals have become mosquito breeding grounds;
- Unpleasant odours force residents to eat behind closed doors; and
- The NGO is doing a sterling job of educating the communities, but the residents interviewed at the sample sites were unaware of the awareness campaigns. This means that the NGO should continue with awareness programmes until it reaches everybody. The municipality has to improve its strategy by ensuring awareness campaigns reach all residents.

4.5 Summary

This chapter provided a presentation of the findings of the research in a detailed format. Themes and tables were used to analyse the data obtained by conducting structured interviews with the inhabitants of three residential areas and two key informant interviews with representatives of the local NGO and the municipality.

The findings indicate that the awareness programmes did not reach the fraction of residents interviewed for this study. They further show that the municipality experiences difficulties in providing services, such as litter and sewage removal and the refurbishing of dilapidated infrastructure. In the chapter that follows, the researcher discusses the conclusions and recommendations of the study.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, the researcher presents the conclusion of the study and recommendations that could be useful in mitigating storm water pollution. The aims and objectives of this research were to gain a better understanding of causes of storm water canal pollution in the study area, to investigate the impacts of water pollution on the Swartkops River and estuary and to assess the strategies and policies in place to lessen storm water pollution.

The illegal dumping of litter caused by the inconsistency of municipal service delivery, especially in informal settlements (Joe Slovo in this case) is one of the most significant causes of storm water pollution. The municipality does not collect garden refuse and construction waste. In Kabar, Joe Slovo, Aloes Village and Motherwell NU5 residential areas there are illegal dumping sites near storm water canals. Port Elizabeth is often referred to as 'the windy city', and whenever there is wind, litter from illegal dumping sites blows into the storm water canals. If the municipality can move these dumping sites far away from the storm water canals, it would help to reduce the amount of litter being deposited in the canals. The municipality should ensure that it does not fail to collect refuse and should offer services for the disposal of garden refuse and construction matter.

Sewage is the second major cause of storm water pollution. Residents in informal settlements, specifically Joe Slovo, illegally dump sewage and sewage leaking from storm water pipes and dilapidated sewage pumps causes sewage contamination. Residents resort to illegally dumping sewage in storm water canals because the municipality does not provide a consistent sewage collection service. To reduce dumping, the municipality must not fail to collect sewage on scheduled collection days, and it must move these residents to proper RDP houses.

Since the 1980s, Motherwell Canal has been contaminated by sewage leaks from storm water pipes and the municipality has failed to prevent this. As a result, residents suffer the consequences of air pollution and the canals have become breeding grounds for mosquitoes, which make people susceptible to diseases. This indicates that NMBM lacks the capacity to implement storm water pollution prevention measures because the municipality and government have failed to find a solution to a problem that has existed for decades.

According to the SOER (Klages *et al.*, 2011), the NMBM faces the challenge of replacing dilapidated or dysfunctional infrastructure. Water services in this municipal area are threatened by aging infrastructure, increased tourism, residential- and industrial-related water demand, pollution and invasion of alien species. The dysfunctional infrastructure is one of the root causes of the municipality's failure to eliminate storm water pollution. If the municipality can compromise and include the

conservation of wastewater pipes and increasing the carrying capacity of sewerage drains to meet the current needs of the population in the areas of interest in its budget, it can minimise sewer overflow, especially at the Motherwell Canal.

The NMBM lacks capacity in terms of implementing, planning and managing storm water management. For capacity to exist, it needs to use political will to address storm water pollution in communities through a ward councillor because government intervention can provide an air of legitimacy. Political will promotes equal access to services and resources for all political parties and public communities. Addressing inequalities in planning and implementing storm water management between government, municipalities, private companies and communities can ensure service delivery, accountability and legitimacy, both nationally and internationally.

To ensure effective sustainable development, these water resources need to be managed, maintained and conserved. This must be carried out by community members to ensure that there is no illegal dumping at any time. Government officials, project managers and funders must ensure that they include the community or local committees, through training and decision making, in conserving the resource, thereby creating job opportunities.

5.2 RECOMMENDATIONS

Communities should be permitted to share their perceptions of and suggestions regarding storm water pollution, such as those revealed by the Aloes Village resident who stated that the municipality's failure to maintain the artificial wetland that aided in water filtration led to unbearable air pollution. In addition, communities should take part in planning, implementation and decision making. The government, funders and NGO stakeholders must teach the community to manage, maintain, evaluate and conserve the resource. They must also train people on how to reuse or recycle litter because it is one of the causes of storm water pollution.

Government and stakeholders must play a key role in ensuring that sustainable development is implemented successfully. The municipality should employ community members and train them for the projects that mitigate pollution. Training should include education about what storm water pollution is, what causes it, where the water and

pollutants end up and what the consequences of pollution are. NMBM should implement the Corporate Governance Department's Community Works Programme strategy that involves community members being employed to clean streets, schools and government departments.

The results of this study indicate that illegal dumping sites near storm water canals make these canals susceptible to contamination from litter. The NMBM needs to remove these dumping sites and improve its service delivery by making disposal options available for garden and construction rubble. If the removal of illegal dumping sites is impossible, the municipality should endorse the Community Works Programme by employing community members to clean these dumpsites. Furthermore, it must ensure that the "the polluter pays" principle is applied by employing a caretaker to ensure that offenders are prosecuted.

The NMBM should improve its service delivery in the disposal of sewage and litter by ensuring that it does not fail to collect buckets and refuse on even one day. It needs to move residents to RDP housing and dispense with informal housing. The dysfunctional infrastructure is one of the essential factors that prevent the municipality from stopping storm water pollution. The municipality needs to reassess its budget and allocate funds for maintaining and expanding the sewer system to avoid sewer overflow, particularly at the Motherwell Canal.

Although the respondents interviewed were unaware of the projects managed by the Zwartkops Conservancy, the organisation performs several valuable services. It evaluates and monitors the condition of the canals, reports problems and engages community members and learners. It has carried out environmental awareness campaigns and has informed parents of the dangers of allowing their children to play in the canals. The municipality should employ its own community liaison officers to evaluate and monitor these storm water canals.

Lastly, municipal departments, such as the Catchment Management Agency, River Management Agency, Department of Roads and Storm Water, Department of Public Health and Department of Environmental Management and Waste, should be integrated or should work together closely to fight water pollution in general. In future,

since the information is not enough to address storm water pollution challenges the study can be used to improve the NMBM's storm water management services.

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ANNEXURES

ANNEXURE A

Structured interviews for residents representing Kabar, Joe Slovo, Aloes Village and Motherwell NU5 communities in NMBM

1. What is storm water pollution?
2. What is a storm water canal?
3. Is there storm water pollution in your area?
4. What are the main causes of storm water pollution in your area?
5. What are the problems caused by storm water pollution?
6. What are the reported cases of disease outbreaks caused by storm water pollution?
7. How do you dispose of your litter?

8. Is there a litter-dumping site in your area? If yes, is it legal or illegal?
9. Where exactly is this litter-dumping site situated?
10. How often does the municipality collect litter?
11. How do you dispose of your sewage at home?
12. How often does the municipality collect sewage at home?
13. If they did not come, what do you do?
14. Do you think the government plays any role in mitigating storm water pollution?
15. How does the municipality help to mitigate the effects of storm water pollution?
16. Can you list programmes that the municipality is involved in to mitigate the effects of storm water pollution?
17. Do NGOs assist in mitigating storm water pollution?
18. Can you list any programmes that are being offered by NGOs?
19. Are health facilities capable of dealing with victims of storm water pollution in your area?

ANNEXURE B

Request to send a Questionnaire

I am a student at Nelson Mandela Metropolitan University completing a master's degree in development studies. I am currently working on my treatise and my topic is "Determining the Public Health Impacts of Storm Water Pollution on Nelson Mandela Bay Communities: Joe Slovo and Kabar, Aloes Village and Motherwell NU5". The main aim of the study is to gain a better understanding of the major causes of storm water canal pollution in the study area and to investigate the public health impacts of storm water pollution. To determine these impacts, I need your help.

I wish to invite you to participate in the study. All the information provided will be confidential - only my supervisor and I will have access to the questionnaire and

NMMU collects the documents once the research is complete. You have the right to withdraw your questionnaire at any time. The questionnaire will take 10 to 15 minutes of your time and I further request an appointment to come and hand you the questionnaire.

Yours faithfully,

Lumka Papu (Researcher)

Contact Number 0783871994

Student Number: 20429067

Your assistance will be highly appreciated

ANNEXURE C

INTERVIEW SCHEDULE FOR THE MUNICIPAL REPRESENTATIVE

1. What is storm water pollution?
2. What are the effects of storm water pollution on public health?
3. To what extent has storm water pollution affected Nelson Mandela Metro communities?
4. What is the municipality doing to mitigate storm water pollution in the areas of influence?
5. Do you think government departments play a role in mitigating storm water pollution?
6. How are the NGOs helping to mitigate the effects of storm water pollution?
7. Can you list programmes intended to mitigate the effects of storm water pollution in which the NGO is involved?

8. Are the health care facilities capable of dealing with victims of storm water pollution in the areas of concern?

ANNEXURE D

INTERVIEW SCHEDULE FOR THE REPRESENTATIVE OF THE NGO

1. What is storm water pollution?
2. What are the effects of storm water pollution on public health?
3. To what extent has storm water pollution affected Nelson Mandela Metro communities?
4. What are you doing as the NGO to mitigate storm water pollution in the areas of influence?
5. Do you think government departments play a role in mitigating storm water pollution?
6. How is the municipality helping to mitigate the effects of storm water pollution?
7. Can you list programmes intended to mitigate the effects of storm water pollution in which the municipality is involved?

8. Are the health care facilities capable of dealing with victims of storm water pollution in the areas of concern?