THE ENVIRONMENTAL HEALTH IMPACTS ASSOCIATED WITH FLOODING AND POLLUTION OF RIVERINE ENVIRONMENTS: A CASE STUDY OF THE KUILS AND EERSTE RIVERS

By

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A minithesis submitted in partial fulfilment of the requirements for the degree of

Magister Artium

In the Department of Geography and Environmental Studies

at the

University of the Western Cape

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September 2003

CONTENTS

KEYWORDS

River

Community

Flooding

Pollution

Environmental health

Diseases

Behaviours

Water quality

Sanitation

Waste

ABSTRACT

The aim of this study was to analyse the interrelationship among hazardous environmental exposures – namely flooding and pollution of the Kuils and Eerste Rivers, and the potential health risks to the natural setting and people, alike. Today, hazards related to exposures within the environment are gaining increased attention. The realisation that human development and structural expansion impacts negatively on the natural setting, has led to the concept of 'environmental health.' Populations of differing standards of living have experienced hazards in varying dimensions.

As illustrated by the three communities investigated in the study, it was primarily the disadvantaged socio-economic profiles which suggested that residents were exposed to wide-ranging and occasionally severe threats to health emanating from local environmental exposures. The environmental health impacts under scrutiny highlighted one of South Africa's scarce and endangered natural resources – urban river systems. The rivers are predominantly small by world standards; however, this does not exempt them from the peril of flooding. Human habitation and urban sprawl impact further on the state of inland water bodies by developing in flood-prone regions. Such activity acts as a stimulus for the augmentation of water pollution. Sadly, although expansive documentation exists regarding the risks inherently associated with both flooding and pollution, individuals tend to display dispositions of disregard. The study revealed that although the majority have displayed interest in potential environmental health hazard, they were not likely to implement habits which prevent this.

The results exemplify that the prevalence of flooding and pollution are frequently viewed in isolation of each other. In the study area this was evidently infeasible to do, as surveys and visual observation proved that habitually, one environmental exposure impacts upon, and even worsens the other.

The primary goal of the research was to detect a correlation between the quality of river water, the frequency of flooding, and the prevailing health indices of the investigated communities. The outcome suggested that although the association detected amongst the variables was small (14 %), numerous elements in the

environment exist which levitate the risk of disease and structural destruction experienced, as a result of flood hazard and river contamination.

The study concludes that if environmental health benefits are to be optimised, then it is connoted that community planning and upgrading efforts – particularly in informal settlements, acquires holistic approaches and integrated input from a wide range of sectors as well as community compliance. Therefore, health impacts emanating from risks associated with the river body should be restrained by activities and behaviours of the communities themselves. Moreover, controlling negative impacts should also be a key initiative in the operation of municipal bodies.

DECLARATION

I declare that

The Environmental Health Impacts associated with Flooding and Pollution of Riverine Environments: A Case Study of the Kuils/Eerste Rivers

is my own work, that it has not been submitted before for any degree or examination at any other university, and that all the sources I have used have been indicated and acknowledged by complete references.

YUMNA HENDRICKS September 2003

SIGNED: .....

ACKNOWLEDGEMENTS

I hereby wish to thank the following people who have contributed to the completion of this study:

- My supervisor, Dr. V. Taylor, for his guidance, encouragement and invaluable advice throughout the research process

- The people of Madalabos, the Kramat area (Faure) and Zandvliet, who shared information with me about their daily lives, and motivated me to choose "environmental health" as a research topic

- The staff of the University of the Western Cape's Department of Geography and Environmental Studies who have influenced this work

- The staff at the Macassar Day Hospital for helping me to understand the magnitude of this research topic

- The officials and representatives of the respective communities and the Helderberg Municipality for their contributions

- My loving, patient family for their support while this research was in progress

- Ikraam Lee, who inspired me to continue this research and constantly reminded me of its importance

- Allah who gave me the strength to complete the research

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The concept "environmental health" is perceived differently by various individuals. This adage captures such a broad field that it does not possess a precise definition. According to the World Health Organisation (1989; 1997), *environmental health* embraces aspects of human health and disease, including the quality of life that is determined by biological, physical, social and psychosocial factors in the environment. Moreover, it encompasses the practice of assessing, improving and preventing those factors that could potentially have an adverse affect on the health of present and future generations (MacArthur in Basset (*Ed*), 1999: 1). This definition assumes that environmental health is concerned with guises related to human health and ways of rendering solutions to safeguard 'factors' in the environment that may be detrimental to the well-being of humankind.

One such 'factor' in the environment that poses a threat to human health, is water. Water is one of the most rapidly diminishing resources facing the world today. This is not merely as a result of the imbalanced distribution of water in various parts of the globe, but because of its exploitation by an ever-expanding human population. As Davies and Day (1999) denote, the bulk of water in use in South Africa comes from rivers, and the greater the scarcity of water for human usage, the greater the impact on natural ecosystems – particularly rivers. Moreover, an adequate supply of formal water distribution does not reach the urban poor. Hence, settlements are established on floodplains and near open waterways. Floodplain development and occupancy frequently imply that the river water is directly consumed, fostering the spread of infectious and parasitic diseases. Small-scale water allocation to villages, low-income households and informal settlements pose a serious problem due to financial, technological and political constraints.

Consequently, human health and the well-being of the physical environment bears the brunt, to a point where water the life-giver becomes water the killer.

1.2 BACKGROUND INFORMATION

During recent years, heightened attention has been placed on the deteriorating state of the environment (Brummer, 2000; Smith, 2000). This has led to increased global attention on the impacts of human activity on the environment. The complex and disengaging connection between the characteristic levels of development, the state of the environment, and health, have acquired intensified recognition, of late.

Today, the notion of 'greening' the environment is strongly asserted by economically prosperous stakeholders involved in addressing key environmental concerns – yet, it remains largely uncanny that those ill affected by environmental decay are the poor. As noted by the World Health Organisation (1992) there is little doubt that poverty is a forceful determinant of environmental quality, human health and well-being.

In a climate of scarce water resources, the need is greater to conceive how and why water supply may influence disease and infection amongst communities; and to predispose hygienic behaviour of the population as regards the health implications of contaminated waters. With respect to natural resources in South Africa, an area of dire concern is the state of inland water bodies – its usage and dependence of humans upon it. Sadly, it is the plight of the poor who lack a safe and sufficient supply of this life-giving resource. In South Africa, specifically in the Western Cape region, rapid urbanisation has surpassed the government's ability to avail safe water provision in residential areas with a predominance of poorer households (Coetzee & Bourne, 1996; Davies & Day, 1998). The result has been an influx of people seeking residence in built-up areas and overcrowded informal settlements, frequently where water is freely available and easily accessible. The implication is that dwellings – planned or unstructured, are erected adjacent to open waterways, often below the designated flood levels indicated for development. This further insinuates that residents are susceptible to potential floodplain hazards and associated health risks.

Formal residential communities and informal settlements abutting the Kuils and Eerste River corridors face this dilemma. During winter months with the onset of heavy rains, sizeable amounts of the region become flooded. High levels of water pollution, spurring the incidence of water-related diseases aggravate this occurrence. As noted by

Taylor, Boelhouwers, Solomons, Hendricks and Petersen (2000), the major obstacle associated with the Kuils and Eerste Rivers is the deteriorating quality of the water and the impact that it poses to the people.

Hence, man-made straits and natural phenomena – namely, flooding and pollution beset our freshwater systems, respectively. Simple observation of the variables that were under scrutiny in the selected study area illustrated a marked association with the levels of environmental and social development. The indication was that poverty, basic socio-economic living standards and environmental well-being are becoming increasingly affiliated (World Resource Institute, 1998).

1.3 SIGNIFICANCE OF THE STUDY

Recent years have seen our news headlines dominated by footage on raging floods and the demise of river systems as a result of human development (Brenner, 2002; Capraro, 1988; Gophe, 2002; Hoare, 2000; Kemp, 2000; Mchunu, 2000; Pillay & Adams, 1999; Seeliger, 1993; Stojaspal, 2002; Unauthored, 1995). The outcome of natural disaster (flooding) renders thousands homeless, injured and killed, annually. Despite the destructive nature of floods, people continue to live on flood-prone lands, and assert that they do so for their existence. Thus, it becomes apparent that humans occupy land susceptible to floods to satisfy their socio-economic requirements.

The realisation of the dangers associated with flooding and pollution in the Western Cape, is an important field of study. Genthe and Seager (1996) declare that there is a dearth of published information available relating to the contamination of water to the quality of water consumed and its impacts on health – be it through direct or intermediate contact therewith. Rather, the information accessible tends to be focussed solely on the impact of humans on the environment, and does not address the twofold interrelation of the effects of the natural environment on human health, and vice versa.

Motivation to pursue an investigation into this realm was further prompted by public interest and concern related to the environmental health effects pertaining to the occurrence of flooding and water pollution in developing communities. The Kuils and

Eerste Rivers were specifically selected due to the increased media recognition of the problems associated with the river and the riverine communities (Smith, 1999 & 2000).

Numerous studies that were largely focused on the upper reaches, have concentrated on combating the prevalence of pollution and habitual flooding. However, these studies failed to address the experiences of the people residing in proximity to the river and the impact (of flooding and pollution) on their daily lives and state of health and well-being. This study was unique in that it underpinned the environmental health dilemma by confronting the problems of the river, itself, and the social aspect and involvement of the surrounding communities.

Through research, it was hoped to vindicate the importance and value in promoting intervention to support the institutional capacity needed for informed local control of the planning and exploitation of inland water bodies.

1.4 PROBLEM STATEMENT

In South Africa, population growth and urbanisation have placed huge pressure on the need for adequate, safe water supplies and sanitation, yet due to human and financial constraints it is improbable that high-quality facilities will be provided in the immediate future (Coetzee & Bourne, 1996; Davies & Day, 1998).

In many expanding communities, households are utilising 'serviced sites' which include communal taps, bucket latrines, or outside flush toilets. However, a growing number of communities lack these rudimentary public services. These varying socio-economic circumstances were displayed in the study area investigated. Water availability is probably the most critical natural resource dilemma facing the nation today. In South Africa, particularly in the Cape Metropolitan Area, water supplies are reliant principally on surface waters from the sixteen catchments in the region (see Figure 2 in Addendum D). The study site investigated is situated in the Kuils and Eerste River catchment. The consumptive demands of heightened population density and socio-economic development has placed immense stress on inland water sources.

Subsequently, this study examined the development of communities in proximity to river systems and attempted to infer a relationship between the dual impacts of human activities and occupation of riverine environments, and the resultant outcome on the state of river flow characteristics.

It is against this background that the study endeavoured to deduce whether a correlation could be established between the quality of the river water, the frequency of flooding, and the health indices of the respective communities.

1.5 OBJECTIVES OF THE STUDY

The study will focus on the following objectives:

1. To investigate the selected environmental exposures in riverine communities, specifically flooding and pollution.

2. To identify and describe the prevailing health concerns potentially associated with contaminated water bodies.

3. To promote a means of improving:
   - awareness levels, behaviours and perceptions to inherent health risks, and
   - attitudes relating to environmental pollution and flood mitigation

4. To provide recommendations and guidelines for a framework of environment and health indicators appropriate for use in riverine locations.

1.6 THE RESEARCH PROCESS

Accordingly, in the preparation of this study, the following steps were undertaken to ascertain the procurement of accurate and available data:

- Initial support for the study was obtained through a pilot study and presentation to key groups, and the suggestions and comments of those present were noted

- A community consultation workshop was held in order to gain community permission to execute the study in the area and to acquire public perceptions related to priority environment and health concerns

- A literature search was conducted to obtain information on the variables involved and to attain relevant data on the environment and health of the study area under investigation

- Personal interviews were conducted with key stakeholders, municipal officers and health officials; and

- Study site visits were conducted periodically in order to monitor changes in flood peaks and potential hazards; and to observe habitual pollution levels.

1.7 CHAPTER LAYOUT

Chapter One provides an overview of the research project.

Chapter Two presents the literature on the variables (flooding and water pollution) on a global perspective, and deals with the identification of potential health hazards associated therewith. The chapter also puts forward a theoretical frame of reference in approaching the environment and health in South Africa.

Chapter Three presents the research design and methodology and discusses the instruments applied in the data collection process.

Chapter Four is a compilation of the community profiles of study area and the presentation of the empirical data.

Chapter Five provides a discussion of the empirical data.

Chapter Six provides a summary of conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 THE IMPACT OF HUMAN SETTLEMENT IN RIVERINE ENVIRONMENTS AND FLOOD-PRONE AREAS

For thousands of years, water was considered to be a fixed element of the globe. Water was perceived as a gift from the gods. It was in the late seventeenth century that European scientists reached a clear understanding of the origin of water and its natural cycle. This cycle has four components – the clouds, the ocean, continental surface water and groundwater (Gill, 1991; Rothwell, 1973; Tyler Miller, 1998). Outside Europe, it was generally assumed that the Chinese had understood the water cycle five hundred years before the birth of Christ (Gill, 1991).

The onset of early civilizations and urban societies proved to be highly dependent on nature's cycle. By this stage, it was acknowledged that water is the lifeblood of all living organisms and as a result, it was seen as an essential agent in the organisation of the modern world (Olsen, 1972). Newson (1996) postulates that 'hydraulic civilizations' of prehistoric Mesopotamia, Egypt, the Indus Valley and the Hwang-Ho developed population centres in close proximity to available freshwater, and thrived under conditions that nurtured humans and their crops. Simultaneously, this existence was also a source of disaster. With the advent of modern industry, it was often essential to reside on floodplains, as it ensured an accessible, guaranteed supply of water, food and transportation. In effect, towns mushroomed along riverbanks and coastal plains. Early communities were small, the damage was minimal, and the efforts made to guard against flooding and pollution was insignificant. Yet, as towns continued to grow, the flood hazard became more acute (Biswas, 1970; Bolt *et al*, 1975). In addition, continued urban expansion and the exploitation of inland water bodies lead to the point whereby streams were deemed insufficiently clean to provide a safe, permanent supply of water.

Rivers are an important component of our natural environment and of the socio-economic landscape. Many cultures have adapted to, and benefited economically from

riverine environments. For centuries, rivers have been used as a source of consumable drinking supply, sedimentation, causes of erosion and flooding, and route-ways for navigation (Goudie, 1984). Rivers also serve as a means of hydroelectric power generation, recreational sites for fishing, observing wildlife, and providing educational opportunities for scientific study and aesthetic enjoyment (Begg, 1990). With increased population and accelerated urbanisation patterns, inland water bodies have been subjected to perform a range of added functions, particularly through the introduction of ecotourism, and as sites for unlawful waste disposal (Detwyler, 1972). Thus, the environmental impact of human activity, indeed, heightens the prevalence of water pollution. These human-induced activities coupled with the natural physiology of river systems, has led to a negative change in the nature of rivers, worldwide.

Many countries have spent immense amounts of money, time and effort to curtail river pollution and flood control facilities to reduce potential health hazards. According to Bolt *et al* (1975), two solutions are evident in preventing a water body from potential flood disaster and degradation. Firstly, recognising a hazardous area and avoiding it as a location for habitation; and secondly, if agricultural and industrial investments are vital to the economy that they must be protected, then sound engineering should be in place to control floods and reduce the incidence of contamination. Although the above-mentioned mitigation appears feasible, their execution is problematic. Today, these solutions are frequently redundant, as major land occupation of commercial and residential placement has been firmly established in many flood-prone regions, with little regard to the safety and cleanliness of water systems.

For Earth, a crisis point is nearing, whereby the human demand for freshwater will exceed its capacity to supply. Moreover, increased populations reside along river corridors, resulting in widespread flooding. Today, it is realised that the stress placed on natural resources necessitates the establishment of protection mechanisms. The execution of water management is an arduous task as it entails economic, social, political, legal and environmental issues (Smith, 2001). Irrespective, there is an urgent need to implement sound recommendations and policy guidelines aimed at ensuring the long-term sustainability of water resources.

2.2 FLOODING OF CATCHMENT AREAS

A catchment is an area that is associated with a river, stream or natural water body. It includes the area served by artificial drainage structures such as stormwater reticulation, canals, dams and detention ponds (Cape Metropolitan Council, 1999). Natural catchments generally exist in conditions of relative ecological stability. Nevertheless, long-term variation in the physical environment and interrelated human interaction could lead to harmful effects on the nature and shape of a catchment area. The pivotal factors resulting in such change are the influences of economic and social development, natural erosion, pollution, and unnatural flood damage (Waugh, 2000).

Teclaff (1967) postulates that the driving force behind the construction of early water development schemes and water supply was directed by the provision of water for agriculture and domestic use; and later, the development of structures to prevent the flooding of human settlements. Fisher (1961) notes that in terms of public services, the first flood-warning system - set up by the Chinese in 1574 on the Yellow River, used horseback riders who traveled at a rate faster than the flow of the water. Today, the size of a flood is gauged by utilising advanced mechanisms of hydraulics and by studying a long period of flow records of a particular stream (Moreland, 2001).

Usually, floods are short-lived events that can occur at any time and are habitually influenced by weather patterns (Larson, 1996). Some floods occur seasonally, when persistent rains produce more runoff than an area can store or a stream can carry within its normal channel. As a result, river basins are prematurely filled with excessive amounts of water (Bolt *et al*, 1975; Goudie, 1984). Riverine flooding occurs when a stream overflows its banks and causes inundation of adjacent land. Floodplains refer to the wide flat areas adjacent to the channel, which are normally dry, but are covered with water during times of floods (Moreland, 2001).

2.2.1 CAUSES AND CHARACTERISTICS OF RIVERINE FLOODS

To floodplain inhabitants, a flood occurs whenever water rises sufficiently so that property and life are damaged or threatened. Although excessive rainfall alone can cause flooding, riverine floods usually have multiple causative factors. Substantial

hydrological and socio-cultural evidence suggest a range of reasons as to why river channels become flooded (Baker, Kochel & Patton, 1988; Goudie, 1984; Newson, 1996). The prominent causes of floods include high intensity rainfall; changes in land-use and drainage patterns; increased population levels and the development of new floodplain areas (Goudie, 1984).

An array of flood-intensifying conditions might be present to spur the occurrence of floods. These comprise the removal of vegetative cover, presence of permeable soils and the existence of steep slopes. The conditions, which heighten the prevalence of floods may prove to be comparatively sensitive in specific river basins – to an extent whereby they react diversely as a result of modification in size, physiography, land-use or variation in rainfall characteristics of the event (Baker *et al*, 1988; Newson, 1996).

By world standards, South Africa is not blessed with large rivers, yet those present are often afflicted with steep gradients (Smith, 1999). This suggests that even moderate flooding can be associated with high current velocities. Water velocity, and not necessarily water volume, does the damage. Current velocity may sweep away everything in its path, leaving mass destruction in the wake. The impact of floods is gauged in terms of the numbers injured, homelessness, damage to property and loss of life; however, in scientific terms, floods are assessed by the volume of water and velocity (Smith, 1999). Problems emanate when flooding occurs in areas of large-scale human development of a landscape. Buildings and structures located on floodplains are susceptible to damage by floods by changing the pattern of water flow and increasing flood damage to adjacent property by blocking the flow of water and augmenting the velocity of floodwaters. Floods disrupt normal drainage systems in cities and overwhelm sewerage systems. Consequently, raw or partially raw sewage spills are common in flooded areas. Thus, flooding potentially aggravates the severity of pollution in water systems.

Two scenarios influence the occupation of humans on floodplains. In developing countries, individuals are often compelled to inhabit flood-prone areas as they rely on the rewards of the land for their existence. However, in developed countries, people have premeditated conceptions of settling on floodplains and expect dams, levees and technological devices to protect then from floodwaters (Reed, 1995; Tyler Miller, 1998). As expounded by James and Lee (1971), urbanisation processes also have adverse effects on water bodies. Urbanisation increases the risk of flooding by

replacing water-absorbing vegetation and soil with highways, parking bays and buildings – which invariably, worsen the runoff characteristics of an area.

Optimistically, Smith and Tobin (1979) postulate that floods may also bring benefits – particularly the recharge of groundwater and the deposition of agricultural silt. Successive flooding causes a floodplain to build up in height, keeping the elevation of a land mass above sea-level (Newson, 1975). As a result of the benefits and potentially destructive nature of floods, scientists and hydrologists have an arduous task of assessing the flood hazard (Mitchell, 1974).

2.2.2 HUMAN ADJUSTMENT TO THE FLOOD HAZARD

Human adjustment to flood hazards implies the responsibility of authoritative bodies and the individuals residing in flood-prone areas. Tyler Miller (1998) provides various methods in which humans can reduce the risk of harm from flooding. These include:

i) Straightening and deepening streams; and building levees and dams designed to restrict water to defined limits on the floodplain

ii) Restoring wetlands to take advantage of the natural flood control provided by floodplains

iii) Instituting floodplain management to remove people from flood-prone areas.

The application of Tyler Miller's (1998) recommendations is often impossible to execute, mainly as a result of accelerated population growth. Floodplain evacuation is neither socially desirable nor economically viable, particularly in densely populated areas. Thus, man must adjust to the problem of a floodplain location by minimising the risk of flooding. White (1961) believes that any flood alleviation scheme should aim at optimally reducing the flood, minimising damages, and saving lives and property. However, executing such a scheme proves problematic as the assumption lies in the belief that all floodplain inhabitants would respond rationally to minimise flood disaster. In reality, individuals perceive the flood hazard differently, and subsequently, behave differently. Thus, it is evident that floodplain behavioural patterns and social efficiency

are likely to constitute fundamental considerations in hazard and choice perception in floodplain management and flood alleviation schemes, respectively.

Numerous attempts have been made to identify why people decide to occupy flood hazardous areas. Early studies of floodplain occupation shifted from a preoccupation with physical factors of land and flood, towards a synthesis of human behaviour that could describe the occupancy of floodplains (see Garrison, 1973; Jansen, 1980; Moret, 1972; National Geographical Society, 1978). According to Kates (1962) there is no direct relation between attitudes toward flooding, socio-economic class, or the level of flood hazard and protection information. Rather, it is assumed that man's choice of residing on floodplains entails a combination of complex social, economic and physical factors. These assumptions are firmly supported by Renshaw (1961), in his geographical research into human occupation of floodplains.

2.3 HISTORICAL EXAMPLES OF FLOODING: THE MISSISSIPPI BASIN

The Mississippi River is divided into two parts. The Upper Mississippi runs from its source to Thebes, southern Illinois, where it is met by the Ohio River. The Lower Mississippi runs downstream from Thebes to the Gulf of Mexico. The Mississippi drains one third of the United States of America and a minimal part of Canada. Flooding is an annual event of this river, with late spring being the peak period. Until recently, major floods occur every five to ten years and extreme floods occur approximately once every forty years (Waugh, 2000).

Prior to the 1993 flood, it was perceived that the flow of the Mississippi was relatively well controlled. This preconception had been achieved through a variety of flood prevention schemes, all aimed at reducing potential flood hazard of the physical environment and of human health. The character of the floodplain has changed immensely to accommodate land-use activity, specifically agriculture and urbanisation.

2.3.1 *The 1993 Flood:*

Between April 1 to September 30 of 1993, the Mississippi River at St. Louis, Missouri, was above flood stage for 144 days. Approximately three billion cubic metres of water overflowed the river channel onto the floodplain downstream from St. Louis. On average, seventeen thousand square miles of land was inundated by floodwaters in a region spanning nine states (Larson, 1996). The major flooding of the Mississippi River is attributed to two principle conditions. The region had been subjected to excessive rainfall, which could not be accommodated by local streams, and high levels of ground saturation imply that less rainfall could be absorbed by the soil and more ran off into the river. Flooding was confined to the Upper Mississippi as the river channel widens considerably south of Thebes. Downstream, the level of discharge increased steadily as tributaries added water to the river (Braatz, 1994). The river levels dropped by mid-summer and the Upper Mississippi were not perceived to be a major flood-risk area. Artificial structures, which served to prevent potential flooding, contributed to the volume of water in the channel and increased the size of the flooded area, as many levees were either damaged or broken by water ferocity.

2.3.1.1 *People and the flood:*

The floods had immense social and economic implications. As a direct result, an accounted fifty people drowned in flooded waters, 26 000 were evacuated and over 56 000 homes were wrecked. Economic loss attributed to flooding totaled fifteen to twenty billion dollars in damage. The consequence of flooding was determined by land-use patterns (Waugh, 2000). Eminent economic loss occurred in cities located on the floodplain. Des Moines, Iowa, positioned in the centre of the flood region, became the largest city in the United States to lose its water supply due to the flooding of its water treatment plant. In excess of 250 000 individuals were without formal drinking water supply for nineteen summer days. Primary water systems contaminated with floodwaters carrying sewage and agricultural chemicals had to be flushed out before the municipal water supply was reconnected. As postulated by Larson (1996), the main reason for the flooding of the Mississippi River is excessive urban growth and development on floodplains. Moreover, it is questioned whether human intervention to

curb the flood hazard has been successful in the short-term or whether it has made the danger worse. The flooding of the Mississippi spurred environmental health risks by exacerbating the occurrence of water pollution.

By gauging the impact of flooding, it is apparent that there are a number of factors that may exacerbate the human impact of natural disaster. Ultimately, areas of high density which are located along river corridors, are at continued risk of floodwaters carrying materials which may cause damage to infrastructure and serve as a hazard to river users. Evidently, settlement location plays a significant role in the aggravation of flood hazard and associated water contamination. The following section provides an indication of the dangers associated with befouled water systems.

2.4 WATER POLLUTION

People in various disciplines perceive water pollution differently. According to Tendron and Ravera (1976), as cited in Amavis and Smeets (1976: 355), what humans expects from the river will determine how he defines it. Wisdom (1976) asserts that pollution is that which is due to adding something, which changes the natural quality of the water so the riparian owner does not receive the natural quality of the stream.

The World Health Organisation (1972) deems water as polluted when it is altered in composition so that it becomes less suitable for purposes for which it would be appropriate in its natural state. This definition incorporates changes in the chemical, physical and biological properties of water, or discharge of liquid, gaseous or solid substances into water that may create nuisances or render such waters harmful to public health, safety or welfare, and a variety of multi-uses. Most of the accounts of the term 'water pollution' is consistent with that put forward by the Water Act of 1956 (Act 56 of 1956), which expound that water pollution is defined as the deterioration in water quality to the extent that it is rendered less fit for any legitimate use.

2.4.1 WATER QUALITY CONDITIONS

The concept 'water quality' is used to describe the chemical, physical and microbiological properties of water that determine its fitness for a specific use (Dallas & Day, 1993). The concept of fitness for use implies that water quality complies with published guidelines for different water users. Recognised use of water includes domestic, agricultural, industrial, recreational and the aquatic ecosystem (Ninham Shand & Chittenden Nicks, 1999). In South Africa, specifically in the Western Cape region, the Department of Water Affairs and Forestry (DWAF), in conjunction with the Cape Metropolitan Council (CMC) are responsible for executing the *South African Water Quality Guidelines.* The guidelines are published in eight volumes, and are used to assess the fitness of water for use, for managing water quality of the catchments in a particular area and describing the acceptable level of substances for different water users (Cape Metropolitan Council, 1998). The fitness of the water is evaluated for potential health impacts, economic impacts and aesthetic requirements (Barnard, 1999).

Volume one and two oversees the quality of water sources and the impact on human health. The suitability of water usage is moderated with respect to the impact on human safety with reference to poor visibility of underwater hazards. The impact of poor water quality is assessed in terms of human conditions, including gastro-intestinal diseases and skin and ear infections. Under the principle of aesthetics - bad odours, discoloration, floating matter and nuisance, plants are also taken into consideration.

With direct regard to human health, water for domestic supply should be free from elements harmful to health – such as insecticides, pesticides, pathogens, and metal concentrations; should smell and taste good; and should not cause damage to household appliances and plumbing (Botkin & Keller, 1995).

2.4.2 MAJOR TY PES AND EFFECTS OF WATER POLLUTANTS

The origin of contaminants resulting in water pollution is frequently difficult to detect. Isolating the types, sources, and effects of pollution is often a complex task. Thus, it is useful to make the distinction between *point* and *non-point (diffuse)* sources of water

pollution. Point sources discharge pollutants at specific locations through pipes, ditches, or sewers into surface water (Tyler Miller, 1998). These sources are identifiable, rendering them easy to monitor and regulate. The leading point source of water pollution in developing countries is generated by runoff pipes from industrial plants and sewage treatment plants which discharge chemicals into rivers (Chivian *et al*, 1993). Non-point pollution is scattered and its detection cannot be traced to a single site of discharge. Diffuse contamination originates from surface runoff, particularly in urban areas and enters the river system via overland flow and storm water systems (Ninham Shand & Chittenden Nicks, 1999). This occurrence is exacerbated by human faecal pollution, faecal pollution from livestock watering in rivers, and grey water draining into water bodies from areas where no formal sewage system is available.

Pollutants may be characterised into distinctive classes. They include:

1. **Disease-causing agents (pathogens):** These contaminants include bacteria, parasitic worms, protozoa, and viruses that enter the water from domestic sewage and untreated human and animal waste. There are difficulties in monitoring pathogens directly; however, detecting the number of colonies of faecal coliform bacteria present in a 100-millilitre water sample, provides a good indicator of the quality of water suitable for human consumption (Botkin & Keller, 1995). The World Health Organisation (WHO) recommends a coliform bacteria count of 0 colonies per 100 millilitres for drinking water, and a maximum level of 200 colonies per 100 millilitres for swimming water (Tyler Miller, 1998).

2. **Oxygen-demanding wastes:** This category of pollutants includes organic waste that can be decomposed by aerobic bacteria. These decomposed waste degrade the quality of water by depleting the water of dissolved oxygen, resulting in fish kills and the fatality of aquatic life (Botkin & Keller, 1995). Although water bodies have the potential to degrade organic waste after admission into a specified water body, the quandary results when the river becomes overloaded with biochemical oxygen-demanding waste, thereby overwhelming its natural cleansing function.

3. **Water-soluble inorganic chemicals:** These contaminants include acids, salts, and toxic metal compounds (Cunningham & Saigo, 1990). The most important heavy metals include lead, arsenic and mercury. Increased amounts of these chemicals

make water unfit for drinking purposes, harm fish and aquatic plant life, depress crop yields, and accelerate corrosion of metals exposed to water.

4. **Organic chemicals:** Water may also be polluted by substances such as plastics, cleaning solvents, pesticides and agricultural chemicals – such as chlorinated organic chemicals-DDT, organophosphate or carbamate insecticides and herbicides –2,4D; and volatile organic chemicals such as gasoline products (Cape Metropolitan Council, 1999; Chivian *et al*, 1993; Ninham Shand & Chittenden Nicks, 1999).

5. **Inorganic plant nutrients:** These contaminants include the release of nutrients by intensive human activity. The two principal nutrients resulting in water pollution include water-soluble nitrates and phosphates. These nutrients amplify the growth of algae and aquatic plants, thereby depleting the water of dissolved oxygen, and consequently resulting in fish kills. Botkin and Keller (1995) postulate that nutrient levels in urban water bodies are greater, due to the continual use of detergents, fertilisers, and products generated by sewage treatment plants.

Human beings are reliant on water and its products for their survival. Ironically, it is humans who primarily affect the nature and longevity of rivers and streams. The direct outcome resulting from this contemptible interaction between individuals and nature is the adverse impact of poorly managed water bodies on human health.

2.5 HEALTH HAZARDS OF WATER POLLUTION

Tulchin (1986) stipulates that rivers are used for a variety of purposes, such as ablution, washing clothes, and the disposal of human excreta. These activities lead to contamination, and serve as a principal vehicle for the transmission of infections and infestations. The World Health Organisation (1991), as cited in a joint report by the Council for Scientific and Industrial Research (CSIR) and the Medical Research Council (MRC) in 1996, stipulate that each year, nine hundred million people suffer from diarrhoea or diseases spread by contaminated water such as typhoid, cholera, and diseases caused by intestinal worms. Accounting the number of people it kills annually, dirty water is probably the world's most serious pollution problem. Improved water

supply and sanitation would reduce the incidence of such diseases dramatically. In many developing countries, health hazards resulting from contaminated water is often accelerated with the onset of the rainy season. Intensive rainfall causes the river levels to rise to the extent whereby riverine environments are overwhelmed. Occupants of water corridors are customarily faced with contaminated floodwaters, in tandem.

According to Toepfer (2000), the water crisis is the most immediate environmental health problem challenging the world today (United Nations Environmental Programme, 2000: 21). The United Nations Environmental Programme's Global Environment Report (2000) states that polluted water affects the health of 1.2 billion people a year, and contributes to the death of fifteen million children under the age of five. Furthermore, disease outbreaks create acute economic and social impacts for those concerned. Human health and nature are encapsulated, implying that the environment suffers likewise. Toepfer (2000) as cited by the United Nations Environmental Programme (2000: 21) reassert that the most disheartening aspect of this human and environmental health affliction is that solutions – particularly sustainable water catchment management, are often well-known, but are negligently executed.

2.5.1 WATER-RELATED DISEASES

A water-related disease is one that is related to water in the environment or to impurities within water. Craun (1986) ascribes water-related diseases into four categories, namely, water-borne, water-washed, water-based, and water-vectored diseases.

- **Water-borne diseases:** These diseases are transmitted through the ingestion of contaminated water, whereby the water acts as a carrier of infections or chemical agents. Most diseases of this type are spread by the faecal-oral route. Water-borne diseases include cholera, typhoid, hepatitis, diarrhoea and dysenteries. Of the above-mentioned infections, acute diarrhoea among young children presents one of the greatest health problems for developing nations. In South Africa, diarrhoeal disease in children remains a major cause of mortality, with the marked seasonal mortality pattern evident with peaks during December and March (Yach & Botha,

1986 and Yach, Hoogendoorn, Von Schirnding, 1987 in Coetzee & Bourne, 1996: 15).

- **Water-washed diseases:** These diseases are comprised of two groups – those affecting the gastrointestinal tract (often resulting in diarrhoea) and diseases of the skin and body surface (Tesh, 1988). The prevalence of these diseases can be minimised with improvements in domestic and personal hygiene. However, hygiene improvement often depends upon the adequate availability of water supply. The transmission of water-washed diseases can be reduced following an increase in the quantity of water used for hygiene purposes, irrespective of the quality of the water.

- **Water-based diseases:** In these diseases, the water provides the habitat for host organisms of parasites. The pathogen spends part of its lifecycle in aquatic animals such as water snails, which act as a host for pathogens responsible for disease transmission such as guinea worm and tapeworm infections, helminthes and schistosomiasis. Water quality and socio-cultural behaviour (recreation) play key roles in the transmission of water-based infections.

- **Water-vectored diseases:** Insects which breed in the water and insects that bite near water bodies, such as the riverine tsetse fly and malaria-carrying mosquito, transmit this form of diseases.

The detection of infections related to human health implies an urgent need to improve the safety and quality of existing water bodies. Appropriate measures are required to protect rivers from microbiological contamination and to develop alternative or advanced means of wastewater reuse to a point where it is considered meticulously safe for human consumption. A lack of human and financial resources obstructs the public works authorities from executing their responsibilities with regard to water surveillance and control.

2.5.2 BIOLOGICAL HAZARDS

The most common infections spread by contaminated water are water-borne diseases, particularly through the medium of biological agents. Diseases contracted are

characterised with mild or asymptomatic symptoms that have not been diagnosed. The principal biological agents which contaminate water are transmitted by pathogenic bacteria, viruses and parasites and can be attributed either to pollution of the actual water source, or to the conveyance of water from source to consumer (Wagner, 1974).

1. **Pathogenic bacteria:** This biological agent is transmitted directly or indirectly by water through water to food (World Health Organisation, 1972). A pathogenic bacterium is mainly conducted to rivers as a result of raw sewage loads. Rivers in the poorest developing countries have shown distinguishable plunges in levels of dissolved oxygen – a key indicator of increased pollution by sewage (The Economist: unauthored 21.03.98). Freshwater supplies that might dilute sewage are diminishing rapidly in many countries. Sewage is the biggest known cause of water pollution and its most significant effect is on human health. Pathogenic bacteria present in water also lead to infantile diarrhoea, dysenteries, and enteric infections, habitually resulting in death.

2. **Viruses:** Viruses present in the alimentary tract of humans may be excreted in faeces. These viruses find their way in sewage streams and already polluted water. One of the most common viruses present in polluted waters is the virus responsible for the infectious hepatitis A and E (Chang, 1968, cited by The World Health Organisation, 1972: 36). The mode of transmission is person-to-person by way of the faecal-oral route. The contamination of water sources and food provides the conveyance link to uninfected persons (Coetzee & Bourne, 1996). As yet, this virus has not been efficiently detected or identified. Despite this, abundant epidemiological evidence exists, which confirm that hepatitis is potentially caused by polluted water.

3. **Parasites:** With regard to microorganisms present in contaminated water, the disease *cryptosporidiosis* occurs. This parasite is resistant to chlorination, and results in stomach flu-like symptoms, often fatal to individuals with depressed immune systems (Botkin & Keller, 1995). Thus, patients suffering from cancer or aids are at particular risk of infection. The ingestion of fish containing the parasite *Entamoebahistolytica* is the causal agent of intestinal ailments and occurrences of liver abscess. These diseases are widespread throughout warm countries, where the

parasites flourish in the humid weather conditions. *Distomatosis* is another parasitic disease that could be contracted by swallowing contaminated water containing the cysts of *Fasciola* or *Dicrocoelium* (World Health Organisation, 1972). A disease rarely contracted by man is *Hydatid* disease, which is transmitted to man through drinking water contaminated with the excreta of a primary host (cattle, dogs, pigs) carrying human hazardous parasites.

Table 1 provides a summary of the diseases frequently transmitted to humans through drinking contaminated water (Tyler Miller, 1998).

TABLE 1: COMMON DISEASES TRANSMITTED TO HUMANS THROUGH CONTAMINATED DRINKING WATER

Type of Organism	Disease	Effects
Bacteria	Typhoid fever	Diarrhoea, severe vomiting, enlarged spleen, inflamed intestine; fatal if untreated
	Cholera	Diarrhoea, severe vomiting, dehydration; fatal if untreated
	Bacterial dysentery	Dairrhoea, rarely fatal except in infants without proper treatment
	Enteritis	Severe stomach pains, nausea, vomiting; rarely fatal
Viruses	Infectious hepatitis	Fever, severe headache, loss of appetite, abdominal pain, jaundice, enlarged liver; rarely fatal but may cause permanent liver damage
Parasitic protozoa	Amoebic dysentery	Severe diarrhoea, headache, abdominal pain, shills, fever; if not treated can cause liver abscess, bowel perforation, and death
	Gardiasis	Diarrhoea, abdominal cramps, flatulence, belching, fatigue
Parasitic worm	Schistosomiasis	Abdominal pain, skin rash, anaemia, chronic fatigue, and chronic general ill health

From Table 1, it is evident that in order to reduce the risk of water-borne diseases, disinfection is imperative in the treatment of drinking water. In developing countries the reliability of water supply and the treatment thereof, is seen as the exception rather than the rule (Pearson & Idema, 1998). Hence, many poor rural settlements and developing areas resort to the use of open waterways as a means of water supply. These raw water sources contain many types of pathogenic microorganisms that pose a risk to human health (Rao & Melnick, 1986 in Pearson & Idema, 1998: 1).

In South Africa, specifically, cholera, typhoid and gastroenteritis are amongst the crucial water-borne diseases. The World Health Organisation (1997) denotes the

significance of water in disease transmission. It is further noted that globally, twenty-five percent of all hospital beds are occupied by people with diseases caused by polluted water or water-related infections. Schalekamp (1990) postulates that an average of thirty-three percent of people die daily as a direct result of water-related diseases, primarily in the rural and developing areas of South Africa, where a greater part of the population is impoverished.

2.6 FLOODING AND WATER POLLUTION IN SOUTH AFRICA

South Africa has numerous rivers, of which many are short in length or flow only during the wet season. Consequently, water is a scarce commodity that requires sound management. The increase in human population has resulted in pressure on urban rivers, both as a resource and in terms of its degradation. Moreover, human settlement and development frequently proliferates alongside waterways, augmenting the risk of flooding and pollution.

2.6.1 DOCUMENTED SOUTH AFRICA N FLOODS

Flooding is gauged by identifying the hazard statistics of a region. Analyses which reflect South Africa's demographics and death rates directive from floods, indicate that those at higher risk tend to be shack-dwellers who are located near open waterways (Simpson, 1990; Smith, 1999). South Africa's natural disasters synonymous with "great floods" are the Laingsburg flood of 1981 and the KwaZulu-Natal flood of 1987. The Laingsburg flood of January 1981 is perceived as the best-documented natural disaster in South African flood history (Smith, 1999). This flood was caused by a high pressure cell toward the south of the country, which produced a strong wind (black southeaster) which blew over the south-western Cape and brought warm air into the cut-off low, resulting in intense precipitation and flooding. The Laingsburg flood left 104 dead and caused approximately one hundred million rand worth of damage. The KwaZulu-Natal flood of September 1987 is seen as the worst natural disaster in South Africa in recent times. Precipitation that led to the flood was caused by a cut-off low weather system,

with rainfall reaching six hundred to nine hundred milimetres recorded over a four-day period in most parts of KwaZulu-Natal. This flood left 388 people dead, 140 000 people were left homeless and post-flood damage included long-term water-related mortality cases. Flood damage was estimated at between R400 million and R1 500 million (Smith, 1999).

One of the major contributors to flooding and flood damage is caused by canalisation and severe 'hardening' of urban rivers (Davies & Day, 1998). The 'hardening' of a catchment is the result of urban development, and implies the construction of tarred roads and freeways, pavements and parking lots. As Davies and Day (1998) postulate, catchment hardening greatly reduces a river's capacity to regulate its own flow. Hence, occupying floodplains and river corridors are hazardous to humans and the physical environment, itself.

2.6.2 THE STATE OF WATER POLLUTION

The development of land adjacent to inland waterways for agriculture, industrial development, recreation or housing often results in pollution. Dallas and Day (1993) state that a river is susceptible to pollution as it is a confined, uni-directional system and a drain for the landscape. In South Africa, river eutrophication is common and largely the result of increased human activity. Nutrient loads emanate from farms, wastewater treatment plants, urban runoff and from untreated human and animal waste (Department of Environmental Affairs, 1990). Building materials used on construction sites are frequently overlooked point sources of pollution. This is prevalent in the Western Cape, where most rivers and vleis are naturally acidic. When alkaline cement dust and leachate from concrete reaches surface waters, it increases the pH of the water, and alters its chemistry, rendering the water unstable for living organisms. Another pollutant common in South African river systems is solid waste, in the form of floating substances and organic pollution (Department of Environmental Affairs, 1990). Depending on the nature and quantity of the materials, surface waters could be physically choked or chemically modified as a result of toxic products from the decomposition of solid waste (Davies & Day, 1998).

As the Department of Environmental Affairs (1990) stipulates, water pollution affects humans in four key ways. It lessens the suitability of available and usable water; it threatens individual health; it lessens the aesthetic quality of water sources; and it increases the cost of living because of the higher cost attached to water purification.

The state of water pollution in South Africa is monitored by the Department of Environmental Affairs and the Department of Water Affairs and Forestry in collaboration with provincial government and local authorities. The subsequent section provides the legislative framework for issues related to water pollution and flooding.

2.7 LEGAL ASPECTS OF FLOODING AND POLLUTION

The National Government is responsible for the drafting and promulgation of legislation associated to flooding and pollution. Hereafter, legislation is conceded and conveyed at a departmental level where it is administered in cooperation with local authorities.

Legislation related to flooding, pollution and health issues often overlap, depending on the nature and magnitude of the resource dilemma. In South Africa, water pollution has been controlled by legislation since 1956 (Department of Environmental Affairs, 1990). According to the Water Act 56 of 1956, any person who lessons, or who may potentially lessen the suitability of a water source for the purpose for which it is utilised, is guilty of pollution. This stipulation is reiterated in the new National Water Act 36 of 1998, which is seen as a key element in conserving the environment and ensuring the equitable usage of water as a resource (Davies & Day, 1998). This Act (36 of 1998) contains the basis for water quality control measures for South African water resources; outlines pollution prevention measures and includes control measures for emergency incidents – particularly, flooding (Barnard, 1999).

Water quality management is administered by the Department of Water Affairs and Forestry and is based on the principle of water quality standards as set out in the *South African Water Quality Guidelines*. In managing water pollution effectively, legislation can be applied in accordance with other departments. The National Environmental Management Act 107 of 1998 and the Environmental Conservation Act 73 of 1989, jointly contains enabling legislation to manage waste disposal and pollution in general.

Effective water management is served in the Health Act 63 of 1977 - administered to ensure public health and to certify that water meant for domestic use complies with the standards set for health requirements. The Hazardous Substances Act 15 of 1973 prohibits the dumping of hazardous substances, which may cause water pollution and the use of materials that could be detrimental to human health or cause death.

In accordance with the National Water Bill of 1998, members of the public have a right to information about water that affects them. Section 144 of the Bill provides surety that individuals who might be affected have access to information about - potential flood hazards; the erection of towns in a manner acceptable to the layout plan of the local authority; and lines indicating the maximum level which floodwaters are likely to reach, on average, once in every one hundred years (Farmer's Weekly: unauthored 18.09.98). Section 145 stipulates that a water management institution must avail information to the public in an appropriate manner. Information should relate advice about a flood which is likely to occur; a water work which might fail or has failed; whether the failure might endanger life or property; any risk posed by the quality of water to life, health or property; and any matter connected with water resources which the public needs to be familiar with.

Evidently, South Africa has sound legislation in place that *should* control hazards such as flooding and pollution; however, whether these regulations, policy guidelines and written laws are being enforced remains questionable. The subsequent section will address the status of environmental health in South Africa, and will also highlight issues contributing to the ineffective execution of legislation in this regard.

2.8 THE ENVIRONMENT AND HEALTH IN SOUTH AFRICA

The start of the twenty first century witnessed defined changes in understanding the relationship between the environment, health and development. This 'new' inclusion has led to the evolution of innovative approaches to public health concerns.

Affirmation relating to environmental health has been exhibited by the Alma Ata declaration, the European Charter on Environment and Health, the Sundsvall Declaration on Supportive Environments for Health, the Ottawa Charter for Health

Promotion, the World Health Organisation's (WHO) Healthy Cities Project, and Local Agenda 21 – all of which have facilitated the advance of 'new' public health approaches (Medical Research Council, 2001). These official statements reasserted the significance of the environment and development in health. The outcome was a conceptual framework in addressing topical health issues. Particular emphasis was placed on:

i) The promotion of good health and the prevention of diseases through cross-sectoral planning and community participation
ii) Preferment of the notion of sustainable development
iii) The use of emerging management tools and technologies (World Health Organisation, 1997)

These concepts formed the pedestal of the World Health Organisation's "Health-For-All" strategy.

2.8.1 TRADITIONAL AND MODERN CONCERNS

The human environment refers to the assemblage of physical, chemical, biological, social, cultural and economic conditions. Similarly, *environmental health* has a dualistic meaning. The concept is seen to imply merely to conditions relating to the physical environment, itself. However, the concept encapsulates the well-being of the physical environment and human environment, alike.

When addressing the impacts associated with environmental health, a distinction may be made between *'traditional'* and *'modern'* hazards. Traditional environmental health concerns include a lack of access to safe water supplies, sanitation facilities, natural hazards, and adequate waste disposal services. Modern environmental health concerns comprise air pollution from vehicle emissions, and chemical contamination of the environment as result of industrial activity (Medical Research Council, 2001). Developing countries tend to display traditional hazards, while developed countries frequently experience the latter.

South Africa illustrates elements of both, a developed and developing country. Thus, the inhabitants may be at risk of exposure to environmental health threats associated with traditional and modern hazards. Many factors operate that predispose the

population to environmental health risks. Prevailing factors include population dynamics, high rates of inequity and poverty, high measures of urbanisation, and comparatively low levels of scientific and economic development (World Resource Institute, 1998). In addition, South Africa exhibits low levels of mass-based environment and health literacy curricula.

The research topic reflected upon all of the above-mentioned phenomena and its relation to the quality of the environment and health status of the communities under investigation. With consideration to environmental hazards, the research study appeared to steer towards traditional environmental health impacts – with reference to sufficient water supplies and flooding. Nonetheless, it became evident that modern environmental health hazards could not be completely isolated. As argued by Davies and Day (1998), water supplies and water pollution are habitually plagued by chemical contaminants as a result of industrial activity and sewage works.

2.8.2 THE ROLE OF POVERTY, INEQUALITY AND ENVIRONMENTAL HEALTH

When embarking upon the study of environmental health impacts of water pollution and flooding as they occur in South Africa, it is almost inextricable to detach these occurrences from the population's level of socio-economic well-being. As noted by Tabibzadeh, Rossi-Espagnet and Maxwell (1989) the poor often face a twofold burden of environmental exposure and disease, as they are likely to experience multiple environmental health risks. Observation in many South African cities have indicated marked disparities, suggesting that differing living conditions may also impact on the environment and health.

When attending to South Africa's economic development, the previous apartheid system should be included as one of the key aspects in engineering environmental hazards on the basis of differentiation by 'race' (Medical Research Council, 2001). Education and labour preference policies, influx control legislation and the Group Areas Act have resulted in the majority of black people being forced into townships and informal settings along the urban fringes. *Table two* provides a synopsis of the

proportion - by former population group, living in informal settlements with access to indoor piped water supply.

TABLE 2: PROPORTION OF BLACK PEOPLE LIVING IN INFORMAL SETTLEMENTS WITH ACCESS TO AN INDOOR WATER SUPPLY

	% *African/Black*	% *Coloured*	% *Indian/Asian*	% *White*
Proportion living in informal settlement	15.5	4.2	0.4	0.06
Proportion with a tap inside their dwelling	27	72	97	96

Source: Statistics South Africa, Census in Brief (1996) 1998

The absence of public amenities, specifically water delivery and sanitation services, renders these people susceptible to wide-ranging environmental health threats. Consequently, the lack of basic service provision has led to the expansion of settlement in areas where water and land is freely available - primarily abutting river corridors and floodplains, predisposing them further to natural hazards (Mathee & von Schirnding. 1996).

2.9 CONCLUSION

The detection of a direct or indirect correlation between the environment and health is a laborious task. Environmental health indicators selected for an intended usage should be based on a suspected or known relationship between the environment and health.

In South Africa, there is a growing interest to understand the health impacts of contaminated waters and natural hazards (flooding) alike, as they frequently produce synergistic effects. Though the state of the physical environment may be impacted upon by pollution or natural hazard, it does not necessarily suggest that humans will be exposed. As put forward by Briggs, Corvalen and Nurminen (1996), numerous factors play a role in determining the extent to which an individual might become exposed to risk. Factors include human behaviour, age, place, standard of living and the duration of the measurements of exposure. Following exposure, health effects may occur immediately (acute) or may take years to manifest.

In undertaking this research study, the researcher hoped to explore the discernible relationship between the health of humans and the physical environment, and the exposures that operate in nature. The researcher further attempted to draw inferences with regard to the role of socio-economic factors in either minimising or augmenting negative health implication.

CHAPTER THREE

RESEARCH METHODOLOGY

The purpose of this Chapter is to provide an overview of the research instruments applied in the study. It further presents motivation for utilising the specific methodologies in acquiring accurate and reliable data. The research tools deployed include the use of primary data and secondary data through the medium of questionnaire surveys, informal interviews with regional officials and visiting relevant literature sources pertinent to the research.

As the study site is located with the Kuils and Eerste River catchment area, it is noteworthy to impart a review of the river system under investigation.

3.1 OVERVIEW OF THE KUILS AND EERSTE RIVERS

The Eerste River's headwaters arise in the Jonkershoek Mountains where it flows in a northwesterly direction to Stellenbosch, and southerly to Macassar before discharging into False Bay (Harrison, 1998). The Kuils River rises in the Durbanville Hills, east of Cape Town (Ninham Shand, 1999). Formerly, the Kuils River was seasonal with little or no flow during the summer months and unremitting flows in winter (Cape Metropolitan Council, 1999). Resultantly, the river petered out in an expanse of temporary wetland, with restricted flow into False Bay during the winter months. At present, the Kuils River has a continual flow that is due to urban development in the catchment area. The river is fed by sewage effluent from a series of wastewater treatment plants - Bellville and Zandvliet sewage works, and increased runoff as a result of human habitation and industrial activity in the region (Wiseman & Simpson, 1989). The Kuils River has a total catchment area of 660 km² of which 420 km² belongs to the Eerste River (Ninham Shand, 1994). The catchment area of the Kuils River to the confluence with the Eerste River is 261 km². The now, perennial Kuils River flows into the lower Eerste River, before entering the sea via a small estuary. The section of the

river flowing from the confluence downstream is known as the Eerste River (Fisher, 2000).

Estuaries can be classified as places where rivers reach the sea (Davies & Day, 1999). These water bodies fulfill fundamental environmental functions and could have great biotic potential. However, human impact is largely responsible for the deterioration of estuarine environments and threatens the loss of its aesthetic and recreational value (Wiseman & Simpson, 1989). The Eerste estuary illustrates a system that has been altered by human and urban intervention.

3.1.1 FLOODING OF THE KUILS AND EERSTE RIVERS

The catchment area is faced with urban encroachment that has led to a significant increase in flooding. These flood peaks, which threaten adjacent residential areas and informal settlements, are partly protected by the Driftsands Detention Dam in the Driftsands Nature Reserve. This dam was built as a storm water retention dam in order to mitigate flooding in the lower areas of the catchment (Ninham Shand, 1999).

Currently, the river comprises an earth-lined channel with steep banks that are prone to collapse and erosion during periods of high flow. Vegetation and bridges that further constrict flow, choke the river channel. The realisation that canalisation frequently poses a physical disturbance to the riverbanks and natural channel, has led to the initiation of the Kuils River upgrade. This engineering solution was started as a result of the river's incapacity to contain the one in fifty year flood (Ninham Shand & Chittenden Nicks, 1999), and entails increasing the capacity of the channel through deepening and widening.

Extensive urban development occurs above and below the confluence of the Kuils and Eerste Rivers. Along various stages of the river, mitigation techniques have been constructed in order to contain river flow and prevent flooding. Despite these mitigations, banks continue to flood and damage to property persists. Flooding downstream has resulted in a proposal to widen the channel and remove vegetation and sand from the lower reaches of the river near the estuary (Ninham Shand & Chittenden Nicks, 1999). As put forward by Wiseman and Simpson (1989), development which

does not facilitate adequate river reserves and walling or canalisation of the river to curb floods, has an inverse effect of increasing flooding problems downstream.

3.1.2 WATER POLLUTION IN THE KUILS AND EERSTE RIVERS

Wiseman and Simpson (1989) denote that concern for the poor water quality of the Kuils and Eerste Rivers have been expressed since the 1950s and 1960s. The river system is severely degraded and typical of an urban water body. Water quality sampling is performed bi-monthly so as to control diffuse and point sources of pollution (Ninham Shand, 1999; Ninham Shand & Chittenden Nicks, 1999).

The concentration of point and non-point sources of pollution render the river water unfit for domestic use, full contact recreation and irrigation (Ninham Shand, 1999). Point sources of pollution include effluent from the operation of the wastewater treatment plants and industrial activity in the area. Diffuse contamination of the river comprises runoff from the built environment such as oil and toxic substances. The emission of effluent below the general standard of discharge has resulted in high concentrations of *E.coli* counts (Ninham Shand & Chittenden Nicks, 1999). This occurrence is exacerbated by faecal pollution from livestock watering in the river, and grey water draining into the water bodies from informal settlement areas where no formal sewage system is available (Taylor *et al*, 2000). Sewage and fertilizers rich in nutrients entering the river as surface runoff hasten eutrophication levels and leads to the prolific growth of aquatic weed (Harding, 1994). Poor water quality is also the result of litter and plastic pollution, particularly in areas where no formal waste disposal technique is in place (Taylor *et al*, 2000).

Pollution of inland water bodies can annihilate natural ecosystems and result in the extinction of flora and fauna. The primary concern is that pollution can result in degradation, with consequent loss of quality to life (Cape Metropolitan Council, 1999).

3.1.3 THE KUILS RIVER METROPOLITAN OPEN SPACE STUDY

The Kuils and Eerste Rivers have been considered well with respect to flooding and environmental issues. The Metropolitan Open Space System (MOSS) Study provides the framework for development and urban planning of the entire Kuils River corridor from its source in the Durbanville Hills, the Eerste River and the river corridor from the confluence to the mouth at Macassar (Ninham Shand & Chittenden Nicks, 1999). The MOSS Study is based on previous studies undertaken to identify problems such as poor water quality, flooding of houses, and environmental degradation (Ninham Shand, 1990; Ninham Shand, 1994, Ninham Shand & Chittenden Nicks, 1999) of the catchment area. This study is of significance in that it recognises the value of the Kuils and Eerste River floodplain and its link within the urban edge.

3.2 STUDY SITE

3.2.1 *STUDY SITE SELECTION*

In an attempt to identify the areas that represent the highest risk incidence in relation to the existing water bodies, various residential areas within the Helderberg municipal substructure were examined. The major criteria utilized in the selection of the study area were:

- the current state of the river under investigation
- the frequency of flooding in the immediate surroundings
- the current status of environmental health (human and physical)
- logistical accessibility for the researcher
- availability of supporting data and co-operation of administrative and interested and affected parties

In this respect, three communities – Zandvliet, Madalabos and the Kramat area at Faure were selected. The aforementioned communities were specifically chosen as the study site as it illustrated different levels of socio-economic ranking, health indices, and water

and sanitation provision. Furthermore, a pre-existing relationship between the researcher, municipal administration, health service staff and community leaders had been established. This facilitated greater accessibility to background information. The study area was appropriate in that it met the criteria of selection as stated above. Figure 1 provides a visual description of the Kuils and Eerste Rivers and the demarcated study areas.

3.2.2 *STUDY SITE DESCRIPTION*

The study site, which is comprised of the three communities – Zandvliet, Madalabos and the Kramat area, is positioned within the Helderberg Administration, one of the Cape Metropolitan Region's municipal substructures. The site is situated between the floodplain of the Eerste River and the Macassar dune system, one of the tallest and most extensive on the Cape Flats (Cape Metropolitan Council, 1999). The river valley is a natural floodplain and the 1:50 year flood line of the Eerste River extends onto the subject sites. As a result, the residents inhabiting the area are at flood risk, particularly in the wet season.

Geologically, the site is largely comprised of calcareous sediments and sands of the Wolfgat member of the Bredasdorp formation (Cape Metropolitan Council, 1999). These soils are strongly calcerous, with a high free lime content and pH values greater than seven. Light, windblown, shelly sand (Calcite cemented Aeolian calcarenite) and active dune sand composed of quartz grains and shell fragments constitute the soil structure. The vegetation in the vicinity of the study area supports good quality Dune Thicket vegetation, particularly in the Kramat area which is perceived as an area of "very high" conservation value. Australian plants have invaded much of this site, primarily Port Jackson willow (Acacia saligna) and Rooikrans (Acacia Cyclops). With regard to the faunal characteristics of the site, increased human traffic and settlement has resulted in the displacement of many sensitive mammal species.

The study falls within the Cape winter rainfall region. It is characterised by high summer temperatures and cool moist winters. Generally mild temperatures characterize the area, with a mean maximum of 21.6°C in January and a mean maximum of 12.2°C in July. Annual rainfall at the AECI complex, east of the Eerste River estuary is

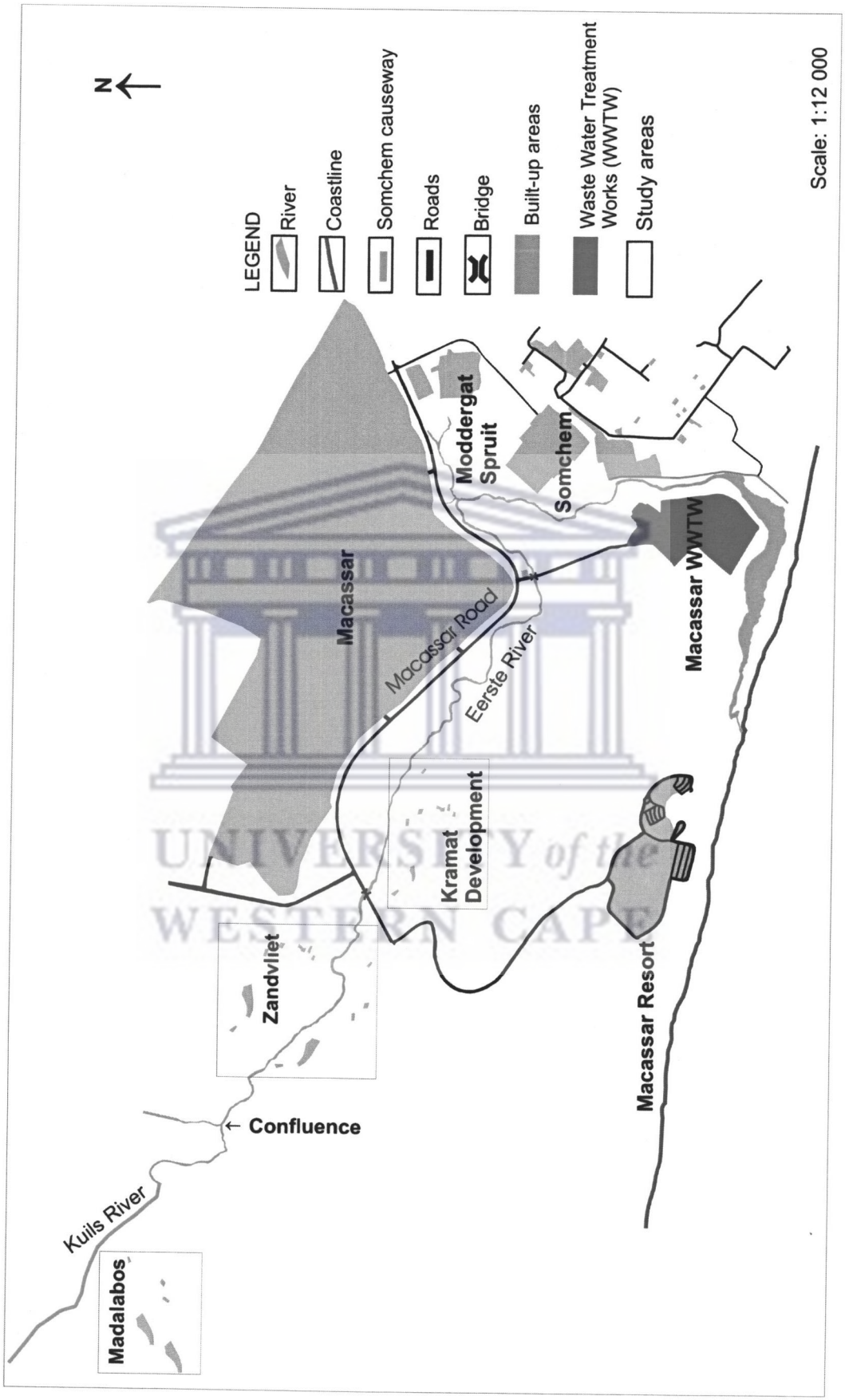

FIGURE 1: LOCATION OF THE KUILS AND EERSTE RIVERS AND THE INVESTIGATED COMMUNITIES (FROM PETERSEN, 2002)

recorded at 606 mm, with approximately 75 % of the total rainfall occurring during the winter period (Ninham Shand, 2000). Wind in the area is predominantly south and south-easterly in summer, with a maximum speed of 40 to 50 km/h.

Detailed profiles of the respective communities are provided in subsequent chapters.

3.3 RESEARCH DESIGN AND STUDY POPULATION

One of the underlying principles of the study was that any information gained in the research undertaking should provide a reflection of the social reality of those affected by hazards within the environment. The participants that were approached assisted the researcher in understanding and explaining the human dilemma faced as a consequence of pollution and flooding in their locale.

3.3.1 *RESEARCH DESIGN*

The research topic proved too complex and extensive to be investigated by using one specific methodology only. As the study required a high level of accuracy in addressing issues related to the health of the population and the physical setting, a combination of qualitative data collection and quantitative techniques were applied to meet the objectives of the study and the nature of the data which was collected.

The variables involved in the research study facilitated the implementation of three types of research – exploratory and descriptive research, correlational research and participatory research. The purpose of executing exploratory research was to gain insight into the selected communities within the study site. This was achieved through the implementation of a pilot study which formed the initial stage before embarking on the actual study; and simple observation, whereby particular phenomena of interest was noted (Bless & Higson-Smith, 1995). In that the research was based on an investigation of a 'cause-effect' relationship, correlational research was best suited. The primary outcome of correlational research is to detect the existence of a relationship between

variables that suggests a possible base for causality (Bless & Higson-Smith, 1995). The third research technique applied was participatory research methods. This technique of research was of great significance as it acknowledged the value, importance and thoughts of the respective communities in relation to the research theme. The definition which best describes the importance of incorporating the community as part of the research question is exemplified by Tandon (1988). Accordingly, participatory research "attempts to present people as researchers themselves in pursuit of answers to the questions of their daily struggles and survival" (Tandon, 1988 as cited by Collins, 1998: 3).

Before continuing with any community consultation, an introductory meeting was scheduled at a venue (Macassar Clinic) that was accessible to all group members. The meeting was set out for two hours, which allowed the facilitator/researcher to explain the purpose of the project and open discussion to the group. The participants were all given the opportunity to introduce themselves, and their presentations included their backgrounds in relation to the topic under discussion, namely flooding and pollution issues and the associated health risks. As noted by Collins (1998), health issues are specifically well-suited to the participatory research approach because individuals tend to know more about their own conditions and can assist in the diagnosis of their problems. By utilising the three methodologies simultaneously, it ensured a high degree of data reliability and accuracy.

3.3.2 *SAMPLING PROCEDURE*

Questionnaires that were put into service in the form of face-to-face interviews with prospective respondents were based on two sampling methods – systematic sampling and accidental or availability sampling.

In order to ensure that the sampling frame was an operative representation of the population, samples were drawn on the principle of randomness from probability theory and non-probability sampling. Probability sampling was undertaken as it suggests that the selection process in a random method allows each element an equal probability of being selected and facilitates the researcher in determining the relationship between the sample and the population (Babbie & Mouton, 2001; Neuman, 1997).

The type of probability sampling deployed was systematic sampling. Systematic sampling is based on the selection of elements (households) at equal intervals, starting with a randomly selected element of the population list (see Addendum C for sampling procedure). This research technique was administered in the formalised residential areas of Zandvliet and the Kramat area in Faure, as the intervals between the units (households) were easily identifiable. In situations whereby respondents of the pre-chosen units were not present at the time of administering the interviews, or refrained from assisting the researcher in completing the questionnaires, the immediate household on either the left or right side of the appointed one was selected.

Non-probability sampling took the form of accidental or availability sampling. In performing the research, it was found that potential respondents displayed attitudes of withdrawal, disinterest and hostility toward the researcher. In order to minimise this limitation in data acquisition it was necessary to execute accidental or availability sampling. This method of sampling was administered in the informal settlement of Madalabos and was based on the assurance of finding large numbers of people in a convenient place. Time and financial constraints were also key factors in selecting this method, as it is relatively cheap and constructive.

The sample size consisted of 100 respondents; thus, a total number of 100 questionnaires were completed by utilising the above-stated techniques. In the Madalabos informal settlement, a 12 % sample (n = 38) was drawn and in the formalised areas of Zandvliet and the Kramat area in Faure, a 20 % sample (n = 42) and 50 % sample (n = 20) was drawn, respectively. The motive for selecting a 12 % sample in Madalabos was influenced by the instability of the units (dwellings), as the numbers fluctuated continuously. In the two formalized residential areas of Zandvliet and the Kramat area, sample size was directed by the unproblematic identification of units and their associated stability.

3.3.3 *DATA COLLECTION METHODS*

The primary source of data acquisition was through face-to-face interviews with sampled households within the three selected areas of the study site. This was achieved by designing a non-scheduled structured questionnaire which elicited information

relevant to the research study (see Addendum A). The researcher decided upon a structured questionnaire, as there was a list of tentative issues taken into account prior to the interviews. The questionnaire contained fixed questions in order to minimize improper recording of answers and potential biases by the interviewer. Certain questions that required extensive understanding and investigation, were facilitated by allowing for alternatives or sub-questions relating to the main question. The interviews were non-scheduled in that the interviewer was free to formulate supplementary questions as deemed appropriate for the given situation. In the Madalabos informal settlement, the common languages spoken are English, Afrikaans and a minimal amount of Xhosa. The questionnaire designed was translated and verified by back translation from English into Afrikaans. In order to minimise interviewer bias, an interpreter was present to authenticate the administration of the questionnaires.

The questionnaire sought data relating to the following:
(Specifically in terms of the pollution and flooding of the Kuils and Eerste Rivers)

Household-related/demographic factors:

- parental age, education and occupation
- household density
- household's socio-economic status
- type of housing

Behavioural and hygiene factors:

- river usage: consumption and recreation
- land-use activities
- attitudes/perceptions relating to flooding and pollution
- defecation behaviour and disposal of stool
- disposal of waste water and refuse

Environmental/physical factors:

- access to water and sanitation facilities
- type of water and sanitation facilities
- domestic waste disposal
- frequency of flooding
- impact of river pollution and flooding on dwellings

Health indicators:

- nature of illnesses and complaints
- long-term ailments
- children's health characteristics
- presence of medical facility
- water related diseases
- knowledge of potential environmental health hazards

Simple observation methods (non-participant observation) were also adopted so as to record events as surveyed by the researcher. This method of gaining data is relatively weak in that participants frequently alter their behaviour and become uneasy. Accordingly, the researcher collated an adjunct checklist in order to observe activities and assess community behaviours (see checklist in Addendum B). The spot checklist was conducted after each questionnaire with potential respondents. Informal discussion was also held with responsible municipal officials so as to confirm particular responses as communicated by the participants and was recorded by means of a videocassette recorder. Visual portrayal of the frequency of flooding, occurrences of water pollution, and community behaviours were of particular note. In this respect, photographic evidence was recorded.

Data entry, coding and cleaning was achieved by the aid of a personal computer. The data collected through the medium of questionnaires was analysed with the implementation of the Statistical Package for Social Sciences (SPSS) computer programme. Thematic analyses was utilised – specifically with reference to qualitative data collected, to critically examine the information collected and to validate the occurrence of patterns in the responses. Analysing the thematic categories was achieved by registering the main theme and sub-dominant themes in the Excel software programme. Thematic patterns were identified by classifying recurring words or phrases that seized common concepts, ideas, feelings, viewpoints and opinions as proclaimed by respondents. By applying quantitative research methodologies with a thematic interpretation, the researcher was able to identify fundamental differences in the replication as reported by individuals.

3.4 CONTROLLING FOR BIAS

In the act of preventing the expression of bias, controls were taken to minimise error at all levels of the research process. When administering the questionnaires, the researcher considered the dangers of interviewer bias. In order to reduce this source of error, stringent steps were taken in personal conduct by steering away from over-aggressiveness, impatience, leniency or partiality in the interviews. The adjoined observational assessment sheets at the end of each questionnaire also minimised a degree of interviewer variation and bias. The verbal interpretation of the primary data collection instrument was also necessary to avoid modification by the researcher in terms of breaching the language barrier.

Biases introduced by obstinate and unresponsive respondents and fear of providing false information due to mistrust, conformity and social pressures were curtailed by means of fixed and structured questions in the interviews. Where additional information was required, sub-questions were appended to gain supplementary responses. The final analysis of the data collected was performed in the most structured method possible. This was imperative to evade the misinterpretation and erroneous classification of answers, specifically open-ended questions.

As the research study held a stance toward the environment and social realm, it was apt to border the natural sciences and social sciences, alike. The natural phenomena investigated in the study – namely flooding, could be approached more unprejudiced; however, as the study also incorporated a strong human dimension, the researcher encountered difficulty in remaining purely neutral. The intercourse of the researcher within the research process was continually at risk of emotional convictions, political attitudes and personal viewpoints. The realisation that this bias could be of detriment to the final analysis and interpretation of the data incessantly prompted the researcher to remain objective and apathetic. It was imperative to repress personal inferences so as to alleviate inconsistencies in the research results.

3.5 PILOT STUDY

Prior to the research study, a pilot study was undertaken within the study area. This was executed by completing fifty questionnaires to randomly selected units within the study area. The purpose of the pilot study was to aid the responsible municipal authority on the subject at hand. Implementing the pilot study assisted the subsequent study and provided a framework for the content and relevance of the variables to be investigated. It also proved to be instrumental in establishing communication with respective communities and responsible authoritative bodies.

3.6 ETHICAL CONSIDERATIONS

Before embarking on the research, permission to implement the study in the area under investigation was obtained from the responsible local authority, that is, the Helderberg Administration and the relevant health centres. Relevant community representatives were duly informed about the nature of the study and consent was granted to proceed with the interviews and observational studies.

The study was explained to all participants in the research study. Participants were informed about the potential benefits of the study and the reasons for undertaking a study of this nature. The respective participants were further informed about the duration of the study and the length of which their co-operation was required. As the researcher did not want to invade the participants' privacy, they were assured that their participation in the research study was voluntary, and they were free to refrain from the study at any time. The respondents were assured that the information given would be treated with confidentiality and would only be used for the purpose of the research and that no other person would have access to the interview data. Once assured of these conditions, the respondent was asked to provide information that was honest and complete.

3.7 LIMITATIONS OF THE STUDY

As a result of time constraints, the researcher would have favoured a broader insight into a more scientific and medical interpretation of the correlation between poor water quality and human health. However, the attempt to analyse these phenomena as they occur in nature, has been acceptably achieved through their respective social underpinning within the geographical sphere.

With respect to respondent communication, identifiable institutional bodies that approached community households in an unbefitting research manner have hampered information networks. As a result, the researcher experienced hostility and had to pursue impressionable modes of regaining community trust and research ethics to ensure the acquisition of reliable data.

The following Chapter provides an analysis of the assessment results and also includes profiles of the respective communities under scrutiny. It contends with the subject relating to environmental health and seeks to identify potential links with the frequency of flooding and pollution within the study site. This is primarily achieved by evaluating the primary data source – namely, the prepared questionnaire.

CHAPTER FOUR

ANALYSIS OF THE EMPIRICAL DATA

4.1 INTRODUCTION

This Chapter presents the analyses of the questionnaire data and attempts to emphasise the anticipated relationship between flooding and pollution, and the health of the riverine communities under investigation. The data gathered will be augmented by information gained by local representatives, municipal officials, and informal discussion with the local people.

Before administering the interviews with potential respondents, the researcher approached the local representatives and explained the reason for wanting to execute the questionnaires. Permission was granted to proceed with the study in the selected research site. The researcher analysed the responses of one hundred (100) people. The questionnaire surveys provided a means of determining the social characteristics of the floodplain population in order to ascertain the type of people affected by flooding and pollution within the three communities. As the researcher assumed that certain social attributes could possibly influence individual perception and behavioural patterns related to hazard in the environment, personal information was collected from sampled floodplain residents. Structural factors were considered and assessed by registering the location and type of dwellings involved. The questionnaire (see Addendum A) formed the guide to presenting the data and findings.

The section that follows provides a brief description of the three study areas – Zandvliet, the Kramat area of Faure and the Madalabos informal settlement. Figure 1 provides a visual layout of the location of the investigated areas and their proximity to the Kuils and Eerste Rivers.

4.2 PROFILE OF ZANDVLIET

The farm, Zandvliet is located near the mouth of the Eerste River. The total area of the farm is approximately 54 hectares in size (van der Westhuizen, 2001). As a result of its close proximity to the river, the adjacent agricultural land is frequently inundated with floodwaters during the wet months. The farm has had a lengthy history of land ownership since the seventeenth century.

In 1699, the farm was granted to the Reverend Petrus Kaldun (Burman, 1970), who managed the farm – mostly in absence, until 1708 when he was summoned to missionary work in India. At this time, the "Kompanjie" – the authority at the time, ordered that the land be sold to Willem Adriaan van der Stel. It was purchased by van der Stel at R2 500, an amount which was costly at the time (van Bart, 1991). The next owner (from 1717 to 1726) was Johannes Swellengrebel, who later passed the ownership to Hendrik Cloete. The last private owner was a branch of the Faure family, who managed the farm since 1900 (Burman, 1970; van Bart, 1991). It was in their possession for four generations and therefore one of its farms on the land was named 'Faure'. In 1977, Zandvliet was repossessed from Mr. Sam Faure and placed in the ownership of the Stellenbosch Divisional Council. Thereafter, it was owned by the former Western Cape Regional Services Council. As the farm falls within the municipal boundaries of the Helderberg Municipality, it is now administered by this metropolitan substructure.

At present, Zandvliet displays degradation in both, its farming practices and historical buildings (personal observation). There has been suggestions by the South African History Museum to restore the old Cape-Dutch buildings on the farm, spurring the idea of its tourism potential (van Bart, 1991).

The community is largely comprised of Muslim and Christian families. An average of 206 families occupy the land. Zandvliet and neighbouring Faure (Kramat area) signify areas of great cultural and religious significance. This farm was home to Sheikh Yusuf, a political expatriate born in Macassar, a location positioned adjacent to Zandvliet. As a result of his religious background, Sheikh Yusuf was housed well away from the Cape on the farm, Zandvliet. The area is now generally referred to as Macassar (van Bart,

1991). At Zandvliet, the Sheikh's settlement became a sanctuary for fugitive slaves. It was also at this farm that the first cohesive Muslim community in South Africa was established and disseminated to greater Cape Town (Da Costa & Davids, 1994). Sheikh Yusuf died at Zandvliet on the 23 May 1699 and was buried at Faure on the farm Zandvliet (Die Burger: unauthored 23.07.77).

Today, Zandvliet still illustrates the characteristics of a farming community. However, a recent study conducted by Taylor *et al* (2000), revealed that a meagre forty percent of the inhabitants is actively involved in farming activities. The community displays marked differences in socio-economic status, which is most evident in the variation of housing structures. On the basis of socio-economic indicators and housing structures, residents of this area display a wide variation of infrastructural facilities – housing structures of stable construction are availed with sanitation supply, electricity and piped water, and poorer households are lacking either one, if not all of these basic amenities. The residential area is serviced by municipal waste removal, however this service appeared to be infrequent (Personal observation).

4.3 PROFILE OF THE KRAMAT AREA IN FAURE

The Kramat area is generally seen as one with the farm Zandvliet. In earlier years, the two areas were a combined piece of land, however, with urban development, a road (Macassar Road) was constructed which now separates and distinguishes the two areas. The Kramat area covers a total surface area of approximately 2.8 hectares and is situated at the eastern end of the Macassar Dune System which is seen as an area of high conservation value (Cape Metropolitan Council, 1999).

The Kramat area is regarded as an important site in the history of Islam in South Africa. The Kramat (shrine) is the grave of the political exile, Sheikh Yusuf (*Abidin Tadia Tjoessoep*) who was sent from South East Asia to the Cape in 1694 (Ninham Shand, 2000). The area has spiritual and cultural significance for Muslims in South Africa. It also holds a political symbolism as it is regarded as signifying the struggle of the Muslims to establish Islam at the southern most point of Africa. For over three hundred

years, the history of the Kramat area has provided inspiration for the Muslim community's struggle for acceptance in this country (Karaan, 2000).

In 1861, Muslims were given the opportunity to purchase the area surrounding the Shrine of Sheikh Yusuf. A group of individuals bought a portion of the area collectively and those who contributed substantially to the purchase price were granted the right to build small cottages (Ninham Shand, 2000). During the 1980s, the Muslim community approached the Regional Services Council with an offer to buy the rest of the land for the purpose of erecting a Muslim seminary. On agreement, the property was transferred to the Diyaarul Ilm Wad-Dawah Trust, the current owners of the property.

The Kramat area abuts the floodplain of the Eerste River and the 1:50 year flood line extends into the subject property. This constitutes a significant flood risk to the residents living on the lower lying areas adjacent to the river, particularly during the winter months. Residents of this community are supplied with electricity, adequate water supply and sanitation facilities throughout the year. Waste generation is minimal within the community, and a workable means of waste disposal and removal system is in place. However, proper pathways and tarred roads within the area are lacking. It is suggested that infrastructure be addressed, particularly when bearing in mind the tourism potential of the Sheikh Yusuf shrine situated in the residential area.

4.4 PROFILE OF MADALABOS

The Madalabos informal settlement neighbours the farm, Zandvliet and covers an area of 10.8 hectares of land. It is estimated that the settlement has been in existence for twelve years (Helderberg Official: personal correspondence, 2002). The people living in Madalabos are predominantly black; however, the settlement is rapidly becoming a mixed community of coloureds and blacks. The families residing in this area are considered as illegal occupants as the land is acknowledged as provincial property and owned by the city council. The settlement is a temporary accommodation until the community can be relocated to a suitable site; however, the community appears to be

growing in numbers. According to locals, the community was promised free housing approximately five years ago, but this has yet to materialise (Taylor *et al*, 2000).

At the time of the study, the area was comprised of 303 units (shack dwellings) which are subject to fluctuation as a result of fires and floods. According to Mr. Samuels, an official of the Housing Unicity – Cape Town, Madalabos has been identified as one of the sites for the relocation of flood victims (van der Westhuizen, 2001). This exacerbates the living conditions of the people already residing in the area as they, themselves are susceptible to annual flooding. The Madalabos community, itself, is an area to be relocated as a result of hazard due to the occurrence of flooding and pollution of the Kuils and Eerste Rivers.

Madalabos is a characteristically unstructured informal settlement. The area lacks basic public services and infrastructure such as sanitation facilities, sewerage systems, roads and electricity. The local authority – the Helderberg Municipality provides the area with potable water in the form of a single communal tap that services roughly 1 348 individuals. The absence of any form of toilet facility and formal waste removal intensifies the improper use of the river and its surroundings.

4.5 DATA ANALYSIS

The analyses of the data have been summarised and tabled for each respective community as they illustrate heterogeneous characteristics and perceptions toward issues related to flooding and pollution within their particular living environment.

4.5.1 QUESTIONNAIRE ANALYSIS FOR ZANDVLIET

4.5.1.1 SOCIO-ECONOMIC PROFILE OF RESPONDENTS

The questionnaire surveyed socio-economic variables such as age, education levels, employment, household size and structure, and income levels. Table 3 provides a summary of the selected data procured for these variables.

As displayed in Table 3, the age distribution revealed a peak in the age group 51 – 60 (47.6 %) and above. The visual impression displayed a relatively mature population group. This was reaffirmed by a figure of 73.8 %, which includes the age groups from 51, and above. More than half of the population reached a formal education level ranging between Standard 4 and 6. A minimal amount of 2 individuals reported attaining a tertiary qualification.

TABLE 3: SELECTED SOCIO-ECONOMIC VARIABLES IN ZANDVLIET

Variable	*Frequency*	*Percentage (%)*
Gender: % head of household		
Male	25	59.5
Female	17	40.5
Age: % head of household		
Below 20	0	0
21 – 30	1	2.4
31 – 40	3	7.1
41 – 50	7	16.7
51 – 60	20	47.6
61 – 70	11	26.2
Above 70	0	0
Education: % head of household		
No schooling	0	0
Sub A/B	0	0
Std.1 – 3	0	0
Std.4 – 6	24	57.1
Std.7 – 10	16	38.1
Tertiary level	2	4.8
Employment: % head of household		
Permanent employment	19	45.2
Casual work	2	4.8
Unemployed	18	42.9
Retired/pensioner	3	7.1
Income:		
Less than R500	1	2.4
R500 – R800	3	7.1
R801 – R1000	5	11.9
R1001 – R1500	0	0
R1501 – R2000	7	16.7
Above R2000	26	61.9
Household size:		
Mean number of persons	2.7	
Mean number of adults	2.07	
Mean number of children	0.6	
Housing structure:		
Brick	100 %	

N=42

Although the abundance of the population appeared to be in the 51 – 60 and 61 – 70 age distribution categories, 50 % reported that they were permanently employed or engaged in casual labour. A further 42.9 % of the sampled respondents stated that they were unemployed. On closer inspection, it was revealed that those who claimed to be

unemployed were either housewives or husbands who were reliant on their respective spouses for income generation. As seen in Table 3, the level of income generated amongst respondents illustrated wide variation. An extensive proportion (61.9 %) falls in the division exceeding R 2000, while the remainder was distributed in lower income brackets. A deduction could be made that this community was comprised of an admixture of 'comfortable' and struggling, poor people.

The marked differences in income levels in Zandvliet were particularly evident in the variance of housing structures, ranging from disrepaired buildings to well-restored farmhouse-type dwellings. In terms of building type, the total sampled households (N = 42) were constructed of brick/cement fabrication. House type was believed to be of importance in determining effective remedial actions in the event of a flood. The mean number of persons per dwelling in Zandvliet was estimated at 2.7. The results also indicated a diminutive amount of 0.6 children per household.

4.5.1.2 PERCEPTION OF THE RIVER AND ITS USAGE

The Kuils and Eerste Rivers form the focus of the area under investigation. While the river itself should offer opportunities for recreational activities for members of the community, water quality investigations have indicated the river to be littered and polluted at times, exhibiting an eye-sore and serious health implications to those who may use it. Table 4 provides a summary which displays the attitudes of residents, the level of importance placed on the passing waterway and the use thereof.

Based on the figures in Table 4, it is evident that the majority of respondents (97.6 %) places a high level of significance on the river and its immediate surroundings. An average of 95.2 % of the sample stipulated that the river enhances their immediate environment, and stated that the river's flow and trickling sound adds a degree of tranquility to the area. The 2 respondents, who dissented that the river adds aesthetic value, stated that it was too dirty to affix any type of beautification to the region.

TABLE 4: ATTITUDES TOWARD, AND USE OF THE RIVER IN ZANDVLIET

Characteristic	*Frequency*	*Percentage*
Importance placed on river:		
High importance	41	97.6
Low importance	1	2.4
River adds aesthetic value:		
Agree	40	95.2
Disagree	2	4.8
Observant of river contamination	38	90.5
Odour emission from passing waterway	39	92.9
Recreational use of river:		
Yes	5	11.9
No	37	88.1
Commercial use of river:		
Crop irrigation	9	21.4
Stock watering	7	16.7

Respondents (92.9 %) also affirmed that the river frequently emitted a foul smell which was evident in their particular community. Odour effusion was particularly evident during hot summer months and winter months, when raw sewage resultant of spills combine with floodwaters. Respondents (90.5 %) were decidedly attentive of the tainted state of the river, and a high score refrained from using the waterway for full (swimming) or intermediate (paddling) contact recreational purposes. To some extent, this suggested that residents were perceptive of pollution to the water body and made note that its use could be of potential detriment to their health. The majority (73.8 %) also affirmed that they were not plagued by fly and/or mosquito infestation. It was suggested that housing type and environmental living conditions played a major role in the attraction of vermin (Helderberg Official: personal correspondence, 2001).

On entering the community, it appeared to be a typical farming community; however, the questionnaire surveys dispute this. Only 38.1 % of the respondents stipulated that they were subsistence farmers. Animals kept were mainly cows, sheep and horses. Moreover, these farmers also acclaimed utilising the river for purposes of stock watering and crop irrigation, despite the noted polluted nature of the waterway.

4.5.1 3 INTERPRETATION OF THE FLOOD EVENT AND KNOWLEDGE OF THE FLOOD HAZARD

As noted by Smith and Tobin (1979), when viewing floodplain behavioural patterns, it is of utmost importance to note the perception of environmental hazard, since it is probable that individuals will respond according to their beliefs, rather than to the real situation as viewed by an objective outsider. Accordingly, this section of the questionnaire survey attempted to assess this particular aspect of community attitudes.

Table 5 provides an outline of the perception of flood events and measures undertaken to prevent negative flood impacts.

TABLE 5: PERCEPTION OF FLOOD EVENTS AND ADOPTION OF FLOOD DAMAGE REDUCTION MEASURES BY ZANDVLIET RESIDENTS

Attitude	*Frequency*	*Percentage*
Anticipate future flood:		
Yes	42	100
No	0	0
Uncertain	0	0
Aware of floodplain occupation:		
Yes	42	100
No	0	0
Uncertain	0	0
Property damage as result of flooding:		
Yes	11	26.2
No	31	73.8
Preventive measures to curb flood:		
No action taken	27	64.3
Standby preparations	5	11.9
Utilities and motors	0	0
Elevation of dwelling and removal of Possessions	10	23.8
Unspecified	0	0
Reaction to participation with public officials:		
Positive	12	28.6
Negative	30	71.4

It is well established that the perception of environmental problems and hazards are closely related to the frequency of such events. The total sample (N = 42) stipulated that they foresaw a future flood during the next winter season, particularly during the months of July and August. Informal discussion with respondents also disclosed that they did not view the occurrence of flooding as the most serious of environmental problems, and rated daily local community issues foremost. Flood experience and the

perception of future flooding were related to certain social characteristics of the floodplain residents. Age of the respondents (predominantly aged 50 and above) by way of example, was inversely related to the anticipation of prospective flooding, since older residents were exposed to a greater frequency of flood experiences based on their length of residence on the floodplain. Residents (100 %) also stated that they were well aware that they are residing on a floodplain and some even reaffirmed that they were located below the 1:50 year flood level. Nonetheless, habitual contamination and flooding of the river was not seen as being of detriment to their health, and was thus, not reason enough to relocate.

Informal discussion with a community elder disclosed that the individual had lost a child who had drowned as a result of playing in the flood-raged river passing the area. This statement could not be validated by authorities as officials assured the researcher that no report had been made regarding the incident.

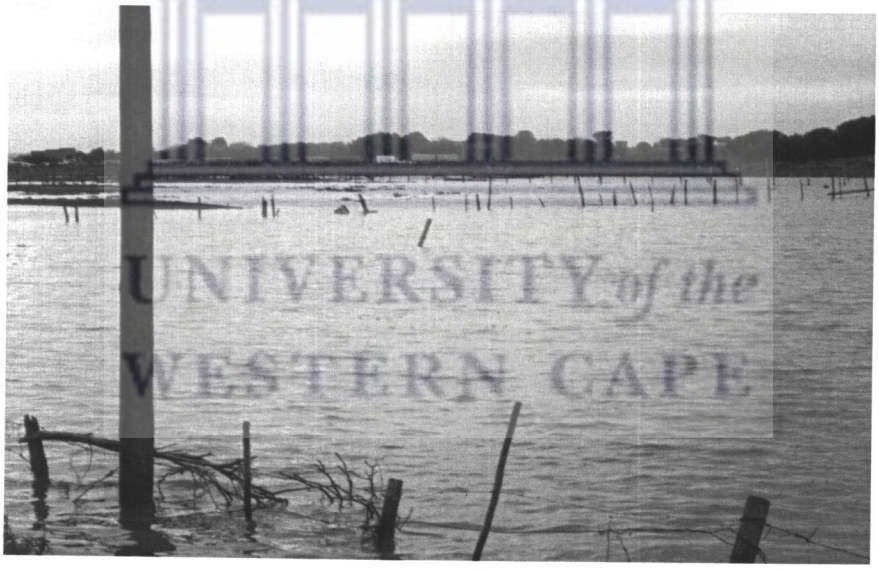

PLATE 1: Seasonal flooding of agricultural land

To residents who were involved in subsistence or recreational farming, flooding of the Kuils and Eerste River was seen as a positive occurrence. As illustrated in Plate 1, flooding inundates most of the agricultural land during the wet season. This is favoured as it is thought that floodwaters distribute rich nutrient loads over a wide expanse, thus nourishing the soil.

The sampled households reported no significant monetary losses as a result of flood damage (73.8 %) to their homes. The researcher thought that this could be due to structural factors (housing type) that act as a protection barrier against floodwaters, and which appeared to be relatively stable in this community. The percentage of the respondents (26.2 %) who stipulated that their homes were damaged by floodwaters at some or other time, were those houses which were poorly constructed and accommodated no preventive structure to their homes. Floodwaters often carry raw sewage and materials that may cause damage to infrastructure and serve as a hazard to river users. The majority (64.3 %) claimed that they do not prepare any type of action with the advent of a flood. Once again, this could be attributed to the relatively sturdy construction of their dwellings. 23.8 % reported that their homes were flood-proofed by raising the construction of their houses, thereby safeguarding their possessions. A minimum of 5 households stated that flood mitigation involved merely rearranging wares within their homes to avert potential damage. This is largely due to the likelihood that their homes would not be seriously affected by floodwaters.

Questions related to remedial measures to curb flood disaster revealed that a greater number (71.4 %) reacted negatively to accepting assistance from local organisations with regard to flood risk. Further probing indicated that this was attributed to a notion that respondents perceived a decrease or even absence of flood hazard when it came to their particular community. Those in favour of support were those who had experienced damage to property or loss of possessions as a result of flooding.

4.5.1.4 WATER SUPPLY AND SANITATION SERVICES

The common water supply options and sanitation systems found in Zandvliet are enlisted in Table 6.

TABLE 6: WATER SUPPLY AND SANITATION FACILITIES IN ZANDVLIET

Variable	*Frequency*	*Percentage*
Water supply:		
In-house tap	34	81
Outdoor private tap	8	19
Communal tap	0	0
No formal water provided	0	0
Sanitation:		
In-house flush toilet	34	81
Outdoor private flush toilet	5	11.9
Bucket system	3	7.1
Pit latrine	0	0
No toilet	0	0
Interruption of principle water source:		
Yes	0	0
No	42	100
Alternative water source:		
None	0	0

As seen in Table 6, the main source of water in Zandvliet is indoor supplies. Approximately 81 % of households in the area have access to water inside their dwellings. A further 19 % are availed with on-site private outdoor taps. The total sample asserted that they were generally satisfied with their present water source and claimed that there was no requirement to make use of the Kuils River as an alternative water source, as the principal source was reliable.

The area displayed wide variation in sanitation facilities. The primary mode of sanitation supply is in-house flush (81 %) and outdoor flush toilets (11.9 %), respectively. Approximately 7.1 % reported that they rely on the 'bucket latrine' system. Of particular concern in terms of health is the use of 'bucket toilet' systems. This type of sanitation facility may lead to soil contamination and run-off into the river; predisposing inhabitants to direct and indirect contact with faecal matter.

4.5.1.5 ENVIRONMENTAL HEALTH STATUS OF RESPONDENTS

One of the main reported health concerns in Zandvliet was tuberculosis (26.2 %). No cases of cholera and typhoid had been reported. The community reported no cases of skin-related infections often associated with contaminated waters. This was on par with

the respondents' confirmation that they refrained from using the river for direct or indirect personal contact.

Diarrhoea and infections of the gastrointestinal tract appeared to have affected majority of the respondents (61.9 %). It was also communicated that diarrhoea usually showed marked increases in levels during the hot summer months. Questions relating to respondents' knowledge about the occurrence of diarrhoea received wide-ranging responses. As seen in Table 7, the majority (73.8 %) was unsure as to how the disease was caused. Certain respondents claimed that it was transmitted by direct or indirect contact with the Kuils River, and others ascribed the disease to a lack of sanitation (4.8 %) and water supply (4.8 %).

TABLE 7: RESPONDENT KNOWLEDGE RELATING TO DIARRHOEAL CASES IN ZANDVLIET

Knowledge item	*Responses*	*Percentage*
Causes of diarrhoea:		
Unknown	31	73.8
Lack of sanitation	2	4.8
Poor water supply	2	4.8
Unhygienic water handling and storage	0	0
Direct/intermediate river contact	7	16.6
Prevention of diarrhoea:		
Improved personal hygiene	4	9.5
Sanitary handling and storage of water	0	0
Disuse of open waterway	28	66.7
Oral re-hydration solution	0	0
Clinical visits	10	23.8
Potable water treatment	0	0

Regarding ways of impeding the spread of diarrhoea, majority (66.7 %) stipulated refraining from using the river for domestic or recreational purposes. 23.8 % of the respondents said that if symptoms of diarrhoea were evident, they would consult a medical practitioner at the local clinic, while 9.5 % voiced that diarrhoea could be minimised by improving personal cleanliness.

It is of concern that the majority of the respondents are unable to determine the potential causes of diarrhoea. In addition, the reports which communicated that the inhabitants refrained from using the river for any purpose, suggested that respondents do, indeed, attribute the passing waterway as a potential mode for infection transmission.

4.5.2 QUESTIONNAIRE ANALYSIS FOR KRAMAT AREA

4.5.2.1 SOCIO-ECONOMIC PROFILE OF RESPONDENTS

Table 8 provides a summary of the selected socio-economic variables for the Kramat community in Faure.

TABLE 8: SELECTED SOCIO-ECONOMIC VARIABLES IN THE KRAMAT AREA (FAURE)

Variable	*Frequency*	*Percentage (%)*
Gender: % head of household		
Male	11	55
Female	9	45
Age: % head of household		
Below 20	0	0
21 – 30	0	0
31 – 40	0	0
41 – 50	3	15
51 – 60	12	60
61 – 70	4	20
Above 70	1	5
Education: % head of household		
No schooling	0	0
Sub A/B	0	0
Std.1 – 3	0	0
Std.4 – 6	7	35
Std.7 – 10	11	55
Tertiary level	2	10
Employment: % head of household		
Permanent employment	0	0
Casual work	9	45
Unemployed	5	25
Retired/pensioner	6	30
Income:		
Less than R500	0	0
R500 – R800	0	0
R801 – R1000	1	5
R1001 – R1500	4	20
R1501 – R2000	5	25
Above R2000	10	50
Household size:		
Mean number of persons	3	
Mean number of adults	2.7	
Mean number of children	0.3	
Housing structure:		
Brick	100 %	

N=20

As shown in Table 8, the age characteristics of the cases illustrated quite similar attributes as that in the Zandvliet community. The 51 – 60 (60 %) and 61 – 70 (20 %)

age categories accounts for the major proportion of the Kramat community. It was assumed that residents in this locale were predominantly in the division of inactive working population. Further investigation unveiled that this population trend may be associated with the probability that the bulk of the economically productive age group residents (aged 21 – 30 and 31 – 40) migrated to the inner city to seek employment. Education levels ranked higher than that in the former community, with 35 % having attained less than seven years of formal schooling. 55 % of the population has attended one or more years of secondary school education, while 10 % reported having a tertiary education. In consideration of the event that the predominance of the population constitutes the inactive working force, a considerable amount of the respondents (45 %) explained that they were involved in casual work such as informal trading, sewing and the operation of food stalls. Approximately 25 % were unemployed, while 30 % were pensioners or retired.

With regard to income levels in this community, the majority (50 %) stated that they received an average monthly income of R 2000 or more. Respondents proceeded that their incomes were boosted as a result of support from children who had relocated to the city of Cape Town. The remaining respondents stated that their earnings ranged the income brackets of R 1001 – R 1500 (20 %) and R 1501 – R 2000 (25 %), respectively. Only one respondent claimed an average household monthly income between the R 801 – R 1000 bracket. The total sample stipulated that because their household size was relatively small (mean number of persons = 3), their proceeds received entitled them to experience a moderately above-average standard of living. Household density consisted primarily of adults (2.7) with a minimal amount of children. Housing infrastructure was fairly well-maintained, with the total sample occupying stable brick structured houses (N = 20).

4.5.2.2 PERCEPTION OF THE RIVER AND ITS USAGE

In this area, the residents placed an unprecedented level of significance on the river that flows past their neighbourhood. The community is fairly homogenous, and colloquial discussion revealed that their faith and spirituality has led them to view the waterway as 'one of God's wonders.'

Henceforth, the total population perceived the river as eminently important, for economic and ecological reasons. Notably, 80 % conceded that the river added a sense of beauty to the immediate surroundings, despite admitting that they were conscious of the littering and pollution of the waterway and constant plaguing of odour emissions (see Table 9). Respondents (100 %) further asserted that they perceived the local sewage works in the area to be of negative impact to the diseased state of the river.

TABLE 9: ATTITUDES TOWARD, AND USE OF THE RIVER IN THE KRAMAT AREA (FAURE)

Characteristic	*Frequency*	*Percentage*
Importance placed on river:		
High importance	20	100
River adds aesthetic value:		
Agree	16	80
Disagree	4	20
Observant of river contamination	20	100
Odour emission from passing waterway	20	100
Recreational use of river:		
Yes	3	15
No	17	85
Commercial use of river:		
Crop irrigation	0	0
Stock watering	5	25

This community appeared to be keenly responsive to the potential health hazards associated with the river. The majority (85 %) abstained from using the river for any recreational purposes, yet an occasional amount utilised water from the passing river for watering their livestock.

4.5.2.3 INTERPRETATION OF THE FLOOD EVENT AND KNOWLEDGE OF THE FLOOD HAZARD

General information relating to past floods was articulated with eagerness amongst residents of this community, particularly those who lived in close distance to the passing river. As this is a predominantly religious community, the residents tended to approach potential natural disaster with a sense of devout or holy attributes. As the total sample were generally of mature age and lived in the particular setting over two to three decades, the total sample (100 %) resolutely affirmed that they predicted a future flood during the subsequent winter month. Moreover, residents were aware of the reality that

they were located on a floodplain, yet did not consider floods with much dispute. This is presumably because most respondents (80 %) do not experience damage to their property as a direct result of floodwaters.

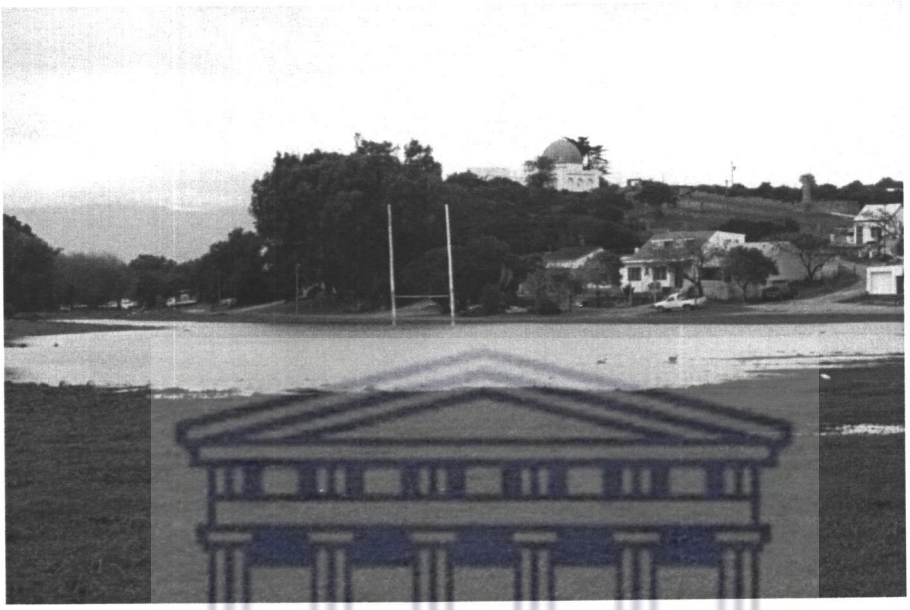

PLATE 2: Inundation of sports field and proximity of dwellings to floodwaters

Plate 2 was taken during a typical winter month in the Kramat area. The photo illustrates the extent of floodwaters that have spilled the banks of the Eerste River. It is evident that during construction, potential flooding was accounted for, as all the older houses (75 %) in this area have been elevated on cement blocks to prevent floodwaters reaching their dwellings. As seen in Table 10, very few (20 %) stated that their homes had been damaged as a consequence of the overflowing river.

Visual observation indicated that many households plants shrubbery and water-absorbing flora to curb water from reaching high levels. Flooding of the lower-lying houses adjacent to the river is common in winter. In such instances, respondents (10 %) undertook temporary standby preparations which includes moving boards and metal sheeting in front of their homes. Respondents who acclaimed that they took no action to curb flooding and were not affected by inundation under any condition, were those households which were located on private property and were positioned on the higher-lying area behind main residence.

TABLE 10: PERCEPTION OF FLOOD EVENTS AND ADOPTION OF FLOOD DAMAGE REDUCTION MEASURES BY KRAMAT AREA (FAURE) RESIDENTS

Attitude	*Frequency*	*Percentage*
Anticipate future flood:		
Yes	20	100
Aware of floodplain occupation:		
Yes	20	100
Property damage as result of flooding:		
Yes	4	20
No	16	80
Preventive measures to curb flood:		
No action taken	3	15
Standby preparations	2	10
Utilities and motors	0	0
Elevation of dwelling and removal of Possessions	15	75
Unspecified	0	0
Reaction to participation with public officials:		
Positive	14	70
Negative	6	30

Even though this community illustrated the least risk of hazard from flooding, participants (70 %) displayed a positive response when it came to the inclusion of public officials to act as an aid in the event of a flood.

4.5.2.4 WATER SUPPLY AND SANITATION SERVICES

The water supply available in the Kramat area is constant, permanent and reliable. The area is availed with indoor supplies (100 %) and sanitation facilities are efficient. Sanitation services in these formal households are in the form of in-house flush toilets (100 %).

TABLE 11: WATER SUPPLY AND SANITATION FACILITIES IN THE KRAMAT AREA (FAURE)

Variable	*Frequency*	*Percentage*
Water supply:		
In-house tap	20	100
Sanitation:		
In-house flush toilet	20	100
Interruption of principle water source:		
No	20	100
Alternative water source:		
None	20	100

As evident in Table 11, water supply and sanitation in this area of study portrayed no indication of concern with respect to sanitation-related diseases. Respondents also indicated that there was no requirement to utilise the passing river or seek alternative water sources, as their principle source had never been unavailable or interrupted.

4.5.2.5 ENVIRONMENTAL HEALTH STATUS OF RESPONDENTS

The prevalent diseases reported were asthma (20 %), tuberculosis (25 %) and diarrhoeal infections (35 %). It was assumed that no direct statistical relationship could be made between the occurrence of these ailments and the environmental exposures under investigation – namely flooding and water pollution. No respondents stated that diseases of the skin and/or scalp had affected them. The researcher thought that this could, in part, be related to the validity that respondents generally refrained from using the frequently contaminated river water.

As the incidence of defiled water coupled with flooding is often seen to be a risk factor in the spread of diarrhoeal dysenteries, the researcher inquired community responses as to how they thought diarrhoea could possibly be contracted. Table 12 enlists the respondents' reasons given for the causes of, and prevention mechanisms employed for the onset of diarroeal symptoms.

TABLE 12: RESPONDENT KNOWLEDGE RELATING TO DIARRHOEAL CASES IN THE KRAMAT AREA (FAURE)

Knowledge item	*Responses*	*Percentage*
Causes of diarrhoea:		
Unknown	23	60.5
Lack of sanitation	0	0
Poor water supply	0	0
Unhygienic water handling and storage	0	0
Direct/intermediate river contact	15	39.5
Prevention of diarrhoea:		
Improved personal hygiene	5	13.2
Sanitary handling and storage of water	0	0
Disuse of open waterway	14	36.8
Oral re-hydration solution	0	0
Clinical visits	11	28.9
Potable water treatment	8	21.1

Diarhoea does not occur largely in this community; however, it was interesting to interpret the participants' responses. 60.5 % reported that they were unsure about the possible causes of diarrhoea, and none attributed sanitation and water supply as risk factors. This could be due to the incidence that this area is serviced with adequate formal sanitation and water provision. Approximately 39.5 % replied that diarrhoea could be the cause of personal contact with the passing river, and asserted that diarrhoeal cases were particularly evident during winter months, when floodwaters intensify water contamination. Respondents who owned livestock reaffirmed that during winter and summer months, cattle displayed severe symptoms of diarrhoea coupled with vomiting, and even death.

4.5.3 QUESTIONNAIRE ANALYSES FOR MADALABOS

4.5.3.1 SOCIO-ECONOMIC PROFILE OF RESPONDENTS

The Madalabos informal settlement illustrated the study area with the most heterogeneity in terms of socio-economic standards and perceptions to environmental health hazards. Table 13 portrays the selected socio-economic variables for this community.

As can be seen from Table 13, the 21 – 30-year old age category (usually the most economically productive age group) accounts for the dominant portion of the population. A lesser 18.4 % lie in the 31 – 40-year age group, while approximately 15.8 % of the population was younger than twenty years of age. The number of adolescents entering the area is steadily increasing (Helderberg Official: personal correspondence, 2002). Casual discussion disclosed that many of this relatively young population hail from the Eastern Cape in search of improved living conditions and job availability, while others have been reallocated to Madalabos as a result of flooding in their initial informal settlements in greater Cape Town.

TABLE 13: SELECTED SOCIO-ECONOMIC VARIABLES IN MADALABOS

Variable	*Frequency*	*Percentage (%)*
Gender: % head of household		
Male	21	55
Female	17	45
Age: % head of household		
Below 20	6	15.8
21 – 30	24	63.2
31 – 40	7	18.4
41 – 50	0	0
51 – 60	0	0
61 – 70	0	0
Above 70	1	2.6
Education: % head of household		
No schooling	21	55.3
Sub A/B	0	0
Std.1 – 3	10	26.3
Std.4 – 6	7	18.4
Std.7 – 10	0	0
Tertiary level	0	0
Employment: % head of household		
Permanently employed	0	0
Casual work	20	52.6
Unemployed	18	47.4
Retired/pensioner	0	0
Income:		
Less than R500	29	76.3
R500 – R800	7	18.4
R801 – R1000	2	5.3
R1001 – R1500	0	0
R1501 – R2000	0	0
Above R2000	0	0
Household size:		
Mean number of persons	3	
Mean number of adults	2.7	
Mean number of children	0.3	
Housing structure:		
Brick	0 %	
Wood	23.7	
Zinc	15.8	
Zinc and wood	60.5	

N=38

Approximately 55.3 % of the population does not have formal education and the remaining 44.7 % have less than seven years of recognised schooling. None of the respondents acclaimed to be in a permanent working position; however, 52.6 % were employed in casual labour. This was mainly in low and semi-skilled jobs. The rate of unemployment was also quite high (47.4 %), and taking into consideration that their current jobs were transient, this estimate could be on the rise. Consequently, the average monthly income was low. In Madalabos, 76.3 % reported that their earnings were less than R 500 per month, which is below the international poverty line. A minor

fraction (18.4 %) procured an income of between R 501 – R 800, while the remainder (5.3 %) obtained between R 801 - R 1000, respectively.

Informal settlements are habitually associated with high household densities. Unpredictably, the mean number of persons per dwelling was calculated at 3. The average number of children reported was minimal, yet, visual observation and the presence of a crèche (with large numbers) suggested an increased amount of young children. Characteristically, the housing structures were unsteady and of poor construction material. The abundance of dwellings were comprised of wood and corrugated zinc sheeting (60.5 %), while 23.7 % were built from wood only. Dwellings have also been insulated with materials such as polystyrene which is highly flammable.

4.5.3.2 PERCEPTION OF THE RIVER AND ITS USAGE

The residents of Madalabos illustrated an immense combination of mixed feelings toward the river. A high proportion (73.7 %) placed a prominent level of importance on the passing waterway, while 26.3 % did not view the river as significant. When inquiring as to whether the river added an attraction to the immediate surrounding, the majority of the respondents (71.1 %) agreed. As summarised in Table 14, more than half (65.8 %) suggested attentiveness to the pollution of the Kuils and Eerste Rivers and were made aware thereof as a result of frequent sewage spills and foul stenches (89.5 %) emanating from the river.

Unlike the two former communities under investigation, the river plays a great role in executing recreational and relaxation purposes for the inhabitants of Madalabos. A considerable 68.4 % stated that they utilised the river for full or intermediate contact recreational purposes – particularly during the hot summer months. This may be attributed to the lack of social amenities such as parks and basic recreational facilities. Those who refrained from using the river reiterated that it was too dirty for human utilisation.

TABLE 14: ATTITUDES TOWARD, AND USE OF THE RIVER IN MADALABOS

Characteristic	*Frequency*	*Percentage*
Importance placed on river:		
High importance	28	73.7
Low importance	10	26.3
River adds aesthetic value:		
Agree	27	71.1
Disagree	11	28.9
Observant of river contamination	25	65.8
Odour emission from passing waterway	34	89.5
Recreational use of river:		
Yes	26	68.4
No	12	31.6
Commercial use of river:		
Crop irrigation	15	39.5
Stock watering	7	18.4

Simple observation illustrated that the river also serves an economic purpose for certain individuals. The reeds growing along the banks of the river are used to make ornaments (bags, hats, bins) which are then sold in order to gain an income. Respondents who owned livestock (18.4 %) let their cattle roam the water's edge as it is their source of drinking supply and also seemed dependant on the river for watering of crops (39.5 %).

PLATE 3 (a): Dumping of household solid waste

PLATE 3 (b): Dumping of household solid waste

Disturbingly, a high proportion (52.6 %) openly stated that they dump household solid wastes such as leftover food, packaging and redundant items alongside the banks of the passing river. Hazardous substances such as medicines, solvents, cleaning materials and batteries are also disposed of in this manner. Plate 3 (a) and (b) provides a visual description of the heaps of rubbish scattered across the settlement. The primary reason for this was ascribed to the absence of formal waste removal services in the area. This exacerbates water pollution as strong winds and floodwaters often carry uncollected solid waste in the direction of the river. Simple observation displayed that after winter, disused polystyrene used for insulation was also discarded and found its way into the flow of the river. Thus, the unavailability of formal solid waste removal poses numerous health risks to the local people and the aquatic life of the Kuils and Eerste Rivers.

The majority of respondents (76.3 %) were perceptive of the operation of the Zandvliet Treatment Works and Macassar Sewage Plant in the vicinity. It was asserted that frequent sewage spills and pipe bursts deposits unprocessed waste into the river, predisposing residents to potential health hazards.

4.5.3.3 INTERPRETATION OF THE FLOOD EVENT AND KNOWLEDGE OF THE FLOOD HAZARD

In Madalabos, respondents illustrated uncertainty with regard to the prevalence of a future flood. As in the former two communities, flood anticipation was largely dependant on the length of stay in the particular setting. Respondents (63.2 %) whose residence in the informal settlement exceeded six or more years, were more convinced that the area would experience a flood by the next winter season. As illustrated in Table 15, only 23.6 % of the respondents did not expect flooding to occur in the next year, although a 13.2 % were undecided. The proportion anticipating future flooding reiterated that they have little confidence in the ability of the authorities to overcome the problem of flooding and potential hazard.

TABLE 15: PERCEPTION OF FLOOD EVENTS AND ADOPTION OF FLOOD DAMAGE REDUCTION MEASURES BY MADALABOS RESIDENTS

Attitude	*Frequency*	*Percentage*
Anticipate future flood:		
Yes	24	63.2
No	9	23.6
Uncertain	5	13.2
Aware of floodplain occupation:		
Yes	6	15.8
No	32	84.2
Property damage as result of flooding:		
Yes	34	89.5
No	4	10.5
Preventive measures to curb flood:		
No action taken	7	18.4
Standby preparations	27	71.1
Utilities and motors	0	0
Elevation of dwelling and removal of Possessions	0	0
Unspecified	4	10.5
Reaction to participation with public officials:		
Positive	14	36.8
Negative	24	63.2

Alarmingly, it is evident that a high score (84.2 %) were not knowledgeable that they were positioned on a floodplain. Of this score, the total population was not informed as to what a floodplain is. The respondents (15.8 %) who claimed that they understood what a floodplain is, could not, however, provide a detailed explanation thereof. As the structure of dwellings are unstable and of poor construction, respondents were

particularly susceptible to hazard as a result of floodwaters. A high 89.5 % reported that their shacks were damaged directly by flooding and had even lost their dwellings and possessions in the event of a flood. The 10.5 % who claimed that they were not affected by flood hazard were located relatively remotely from the river. Those who stated that they were habitually affected by flooding continued to elucidate the measures taken to prevent damage as a result of flooding. Respondents (18.4 %) who claimed that they secured no action to curb damage were those who displayed uncertainty as to the incidence of a future flood. The majority (71.1 %) of the participants stipulated that they assumed standby preparations with the advent of heavy rain, and consequent flooding of the river. These preparations included lining their shack floors with polystyrene sheetings and pounding two sheets of corrugated zinc deep into the ground – temporary measure to withhold polluted floodwaters from penetrating their dwellings.

With regard to participation with the local authorities to prevent flood disaster, a sizeable amount of respondents (63.2 %) replied with uncertainty. Those reacting negatively to authoritarian remedial control measures once again had little faith in the ability of the municipality to alleviate flood hazard. Interestingly, those who responded positively (36.8 %) to association with public officials were participants in the younger age groups (below 20 and between 21 –30-years).

4.5.3.4 WATER SUPPLY AND SANITATION SERVICES

The primary source of water supply in Madalabos is the communal tap (89.5 %).

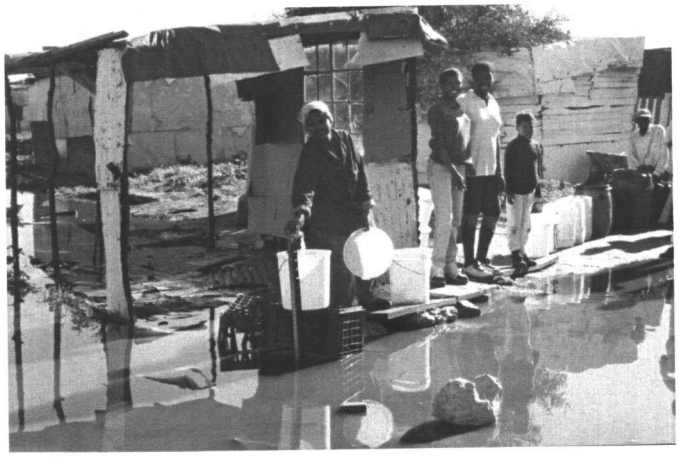

PLATE 4: Communal tap facility and surroundings

Plate 4 depicts the single tap facility which services the informal settlement and also shows an abandoned shack dwelling, washed away by floodwaters. The photo (taken during Winter, 2002) displays unsanitary conditions surrounding the water supply. Moreover, the tap facility lacks a proper standing structure. During winter, the tap facility becomes particularly contaminated as the immediate surrounding is inundated with raw sewage-ridden floodwaters. Visual inspection revealed pools of stagnant water, floodwater from the passing waterway and piles of refuse in the vicinity of the tap. This unsavoury setting provides fertile conditions for the growth of vectors of disease, including rodents and insects; and also serve to attract animals such as dogs, poultry, goats, sheep and cattle.

TABLE 16: WATER SUPPLY AND SANITATION FACILITIES IN MADALABOS

Variable	*Frequency*	*Percentage*
Water supply:		
Communal tap	34	89.5
No formal water provided	4	10.5
Sanitation:		
No toilet	38	100
Interruption of principle water source:		
Yes	27	71.1
No	11	28.9
Alternative water source:		
River	17	44.7
Sewerage works	6	10.5
Neighbouring settlement	3	15.8

As seen in Table 16, 10.5 % of the respondents stated that they were not supplied with any form of water provision. This was largely because they were located distantly from the communal tap, and as a result, made use of the river as the principal source of water. Many of the respondents – typically females, stated that it was more convenient to convey water from the river than that of the tap facility, based on the proximity to the formal water supply. The inadequate mechanism and practices in relation to the collection of water may also pose a health risk. A major environmental and public health dilemma lies in the absence of any form of sanitation facility in the area. Madalabos lacks even the most rudimentary of sanitation services, compelling respondents to dispose of excreta in the vicinity of the passing river. Respondents claimed that it was favourable to do so as the river had a dual purpose of acting as an ablution facility. In terms of disease-causing organisms, faecal coliform contain *E-coli*,

viruses, bacteria, protozoan or worms (helminthes). This may threaten effective environmental health as individuals (68.4 %) often have recreational contact with the river, predisposing them to a range of sanitation-related diseases, particularly diarrhoea. Respondents (86.8 %) also said that for most of the year, they experienced fly infestation within their homes.

Despite claims that most of the respondents were aware of river contamination, a high proportion (44.7 %) affirmed that they resorted to utilising the Kuils River as a means of domestic water supply in times of formal water interruption. Evidently, as displayed in Madalabos, the lack of basic amenities such as adequate water supply and sanitation indeed impacts on the well-being of the river and the riverine community.

4.5.3.5 ENVIRONMENTAL HEALTH STATUS OF RESPONDENTS

The diseases that recurred were associated with water-related infections. The incidence of diarrhoeal infections (81.6 %) was reported to be a common virus, particularly amongst women and children. A model which postulates the interactions between water quality and diarrhoea, is shown in Figure 3 (see Addendum E). The model shows the process whereby various risk factors drive a child from a healthy to an unhealthy status. The order of events is not necessarily sequential, but rather, depends on the exposure to numerous additional environmental risk factors including the type of water supply and storage. Characteristically, those who were routinely in contact with the river, seemed to report the incidence of diarrhoea and skin-related infections.

Responses that demonstrated knowledge of the symptoms of diarrhoea, revealed that the total sample (100 %) attributed infection to a lack of sanitation and inadequate water supply. Interestingly, 85 % stipulated the spread of diarrhoea to unhygienic methods of water handling and storage – either from the tap facility or the river. Certain respondents (75 %) were more specific and assured the researcher that diarrhoeal infection had been contracted as a result of direct or intermediate contact with the polluted river. Tuberculosis also appeared to be relatively high (31.6 %). The prevalence of surface skin infections was alarmingly high, with 65.8 % mentioning

acute body rashes as a long-term ailment and 47.4 % stating that they experience scalp dermatitis.

TABLE 17: RESPONDENT KNOWLEDGE RELATING TO DIARRHOEAL CASES IN MADALABOS

Knowledge item	*Responses*	*Percentage*
Causes of diarrhoea:		
Unknown	0	0
Lack of sanitation	20	100
Poor water supply	20	100
Unhygienic water handling and storage	17	85
Direct/intermediate river contact	15	75
Prevention of diarrhoea:		
Improved personal hygiene	4	20
Sanitary handling and storage of water	18	90
Disuse of open waterway	15	75
Oral re-hydration solution	0	0
Clinical visits	7	35
Potable water treatment	0	0

The health care facility (Macassar Day Clinic) which services the community, is said to treat high numbers of skin rashes and sores, especially among young children. Clinic staff highlighted poor living conditions, unsanitary play areas for children and recreational use of the river as significant potential causes of skin infections and gastroenteritis (Sister Fatima Langeveld: personal correspondence, 2002). Even though no statistical correlation could be made between the direct or intermediate use of the river and infection, it was evident that an association indeed exists. The researcher noticed that during winter months, the local children were often observed to play in waste-water streams and contaminated floodwaters that exist in Madalabos. It was of interest to note that during winter, with the onset of flooding and sewage spills, coupled with the respondents' deprived environmental living conditions, outbreaks of diarrhoea and symptoms of diarrhoea and skin irritations were dramatically magnified.

Examining the data (as tabled above), it becomes apparent that the quality of the living environment is recognised to be a powerful determinant of the health status of the community and the natural setting. The results revealed that the three communities under investigation displayed wide variation in the perception of the river and its usage, interpretation and knowledge of potential flood events, and attitudes toward the status of community health and well-being. Moreover, it generally appears that the communities

have moderate confidence in the local authorities to assist them in the event of a flood or/and pollution scare.

This chapter has presented the analyses of the primary data sources collected. Hereafter, Chapter 5 sets out to provide the discussion of the findings as tabled above.

CHAPTER FIVE

DISCUSSION

The results of the analysis revealed that the relationship between the environmental exposures under investigation and health is complex, with a variety of factors and processes playing multiple roles. The correlational analysis indicated a positive interdependence between health and environmental hazard. That is, the greater the number of flooding and pollution respondents were exposed to, the higher the health risk. The computed correlation coefficient was determined at 0.38 (or 14 %), which marked a low (+) association between health indicators and the prevalence of flooding and river contamination. Despite the small, yet definite statistical relationship determined, the probability insinuated a dependence of some kind. More accurately, it can be stated that the health status of the environment is not merely attributable to exposures relating to the Kuils and Eerste Rivers, alone, but includes an agglomeration of the holistic environment and the standard of living of communities residing on the floodplain.

5.1 ENVIRONMENTAL HAZARDS: FLOODING AND POLLUTION OF THE KUILS AND EERSTE RIVERS

The questionnaire surveys indicated that differences in socio-economic status played a significant role in the current state of environmental health within the three respective communities. It was evident that respondents' length of stay in the particular setting influenced the manner in which potential hazard was perceived and the degree of urgency that was placed on such hazard. Moreover, it was thought that the level of education reached would be a reflection as to how respondents placed importance on natural resources. Surveys and casual discussion validated this assumption. Those who have attained a higher schooling displayed greater concern about the state of the passing river and the potential impacts of flooding and water pollution on human habitation.

Housing quality and the living environment also served as an important determinant in either fostering or inhibiting ill health, injury and destruction. As illustrated in the

Kramat area and certain households in Zandvliet where housing was of stable structure, it served as a defence against damage as a result of contaminated floodwaters. Of particular concern were the health hazards occurring in the Madalabos informal settlement. This settlement was characteristic of a high-risk location and was especially susceptible to negative impact. Residents occupied ramshackled shelter, lacked recreational facilities and were inadequately accessible to basic environmental health services. Sanitation systems were non-existent and water supply was poor. Resultantly, the majority utilised the river for ablution practices, washing clothes, disposing of household waste, and for purposes of relaxation. Flooding, and contamination of the river system itself, did not appear to be of dire urgency in the study area. However, when the two environmental exposures were combined (as visualised during winter of 2001 and 2002 during fieldwork expeditions), marked changes were seen in the environmental destruction caused to dwellings, and to the state of human health. Medical staff at the local clinic stated that water-related diseases were highest during hot, dry, summer months; however, questionnaire responses dispute this. Participants claimed that occurrences of diarrhoeal infections and skin-related ailments tended to peak during winter months. Evidently, when contaminated waters – largely the result of outlet pipes from the sewage treatment plants in the area, mix with huge water loads in the Kuils and Eerste Rivers, the result is hazardous, exposing riverine inhabitants to faecal coliform bacteria. This, in turn, is a key conveyance mode of acute diarrhoea and skin infections (Coetzee & Bourne, 1996).

The environmental health impacts related to flooding in the study area appeared to be largely structural. This implies that hazard associated with flood loss was primarily afflicted to material possessions, dwelling structure and replaceable household items. Thus, respondents did not place flooding as a key environmental issue in their day-to-day activities. This environmental health hazard was seen as generally controllable. Questionnaire surveys, however, indicated that contamination of the river was regarded as an exposure to be dealt with. Respondents who were dependent on the river for domestic use and/or recreational purposes, saw water pollution as a key problem in their existence. It was gathered that during summer months, river usage was stable, however, during winter when floods spurred, the water was perceived to be of detriment to their health. This insight displayed by respondents also indicated that educational programmes relating to flood abatement and pollution control is imperative in the study

area. It became apparent that health dilemmas relating to flooding and water pollution are often visited in isolation of each other, yet, as illustrated in the study, it remains irrefutable that they be addressed in separation.

5.2 HEALTH INDICATORS

No integrated system for the collection and analysis of data in relation to noteworthy environmental health concerns exists for Madalabos. While data concerning selected ill health symptoms have been collated, they failed to represent the health indices of the Madalabos informal settlement in separation of other towns within the respective municipal area (Helderberg). For the researcher, this was problematic, as health service statistics could not statistically substantiate the data gathered from the questionnaire surveys and observational data.

One of the primary reported health concerns in Madalabos is tuberculosis. The incidence of tuberculosis increased dramatically over the past two years, and health statistics revealed that the occurrence of the disease indicated the highest reported cases within the Cape Metropole (Sister Fatima Langeveld: personal correspondence, 2002). Moreover, the poor state of the environment, inferior living conditions and influx of people into the area, provide a suitable climate for the spread of tuberculosis.

Even though no statistically significant association between poor water quality and health (particularly, diarrhoeal/gastroenteric ailments and skin infections) was observed, the analysis of the questionnaires and simple observation identified some risk factors for severe diarrhoea within the physical environment. The study indicated that respondents who were availed with constant, safe water supply and sanitation facilities demonstrated a healthier existence. However, those in Madalabos, were principally affected by more than three loose or watery stools per day, often accompanied by vomiting and fever. Diarrhoeal transmission is primarily by ingestion of faecal organisms and contaminated waters; and is encouraged by conditions where there is faecal contact and spread (Coetzee & Bourne, 1996; Pearson & Idema, 1998).

Interestingly, respondents in the formalised residential areas of Zandvliet and the Kramat area in Faure reported no cases of skin-related infections. Conversely, skin ailments were dominant in the informal settlement of Madalabos. Correspondence with environmental health officials and staff at the local clinic rendered the incidence of skin rashes and fungal infections of the scalp to unsanitary living conditions, domestic consumption of contaminated river water and intermediate contact with floodwaters (Helderberg Municipality: personal correspondence, 2001; Sister Fatima Langeveld: personal correspondence, 2002). In addition, it was noteworthy to observe the specification placed on the frequently diseased status of river users in the settlement. This revelation led the researcher to accept that although no marked statistical correlation could be directly detected, environmental hazard coupled with additional factors in the environment, influenced the health index.

An increased risk of water-related diarrhoea and epidermal infection was associated with poor knowledge regarding the use of contaminated floodwaters for domestic use; as well as a lower level of knowledge regarding the causes and prevention of these diseases. The spread of diarrhoea and skin infection was primarily ascribed to the categories of *water-borne and water-washed diseases.* Water-borne diseases are conveyed through the ingestion of contaminated water, while the latter illustrate diseases that may be reduced with improvements in domestic and personal hygiene. Nonetheless, in Zandvliet and the Kramat area it appeared as though diarrhoea and skin infection was fairly controllable, based on sound sanitation facilities and water supply. Madalabos, once again, portrayed concern relating to minimising the frequency of water-related diseases. The main reason for this was due to the implication that the informal settlement is unstructured, with no public amenities provided. Hence, the lack of adequate, reliable formal water supply and sanitation compelled residents to have contact with the passing river, for household use, defaecation, or recreational purposes. From the study, it can be deduced that negative environmental health impacts of flooding and pollution will persist, particularly in instances where infrastructural facilities are lacking or unavailable.

In addition, the overall perception and behaviour of the floodplain residents faltered in the degree of emphasis placed on the probability of negative health impacts resultant from overflowing, and/or contaminated river waters.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

The objective of this Chapter is to infer conclusions from the analyses of the data collated. The Chapter further attempts to provide solutions to some of the problems that arose from the results of the empirical analyses. As the study embraced two environmental exposures, namely *flooding* and *pollution* of the Kuils and Eerste Rivers, the researcher presupposed that it would be favourable to provide recommendations under the classification of each respective environmental impact.

The results have indicated that fundamentally, humans exist in an ecological relationship with their environment and have to live with a range of natural hazards which threaten life and property. Hazards of this kind are a function of both, human society and the geophysical realm. In this study, the Kuils and Eerste Rivers represent the most common global health risks - encompassing a wider range of flood events and frequently associated contamination.

The analyses of the communities investigated, revealed that the quality of the living environment is recognised to be a powerful determinant of the health status. This thesis was collated with a view to the development of environment and health baselines, against which the future environmental health impacts of current and planned improvement initiatives in the study areas might be measured. Based on the findings, in conjunction with the risks eminent as a consequence of flooding and pollution, a set of core environmental health indicators has been identified. It is therefore proposed that information related to these indicators be gathered, analysed for discussion and publicly disseminated at regular intervals. An often neglected, yet cost-effective and powerful component of settlement upgrade initiatives, is the improvement of community knowledge of the relationship between the environmental conditions and exposures, and community health and well-being.

6.2 FLOODING OF THE KUILS AND EERSTE RIVERS: RECOMMENDATIONS

Since humans are unable to control the atmospheric processes that produce most floods, attempts have been made to adjust to the hazard by means of flood alleviation projects. Through the application of advanced technology and substantial capital investment, the flood threat to human life has decreased appreciably. In contrast, it is becoming increasingly evident that the flood risk has, in no way, been eliminated.

The following recommendations will briefly highlight prospective advances, which, if implemented, could play a significant role in minimising flood impact. Generally, the strategies put forward to reduce flood risk is largely constructional and involves the erection of artificial levees, embankments and channelisation as means of controlling overflowing rivers. The Kuils and Eerste Rivers, themselves, have been subject to structural measures designed to control the physical characteristics of the flood hazard. In practice, the range for adjustment available to floodplain planners is to adopt social and behavioural schemes to prevent negative impact. For this reason, the focus of the recommendations put forward, places considerable attention on practical social dimensions in flood mitigation.

1. *Public health education* There is a demonstrated need for floodplain occupants to adopt a realistic perception of the hazards which threaten them. This awareness should be implemented by the local authority, which has to take central responsibility for a modest education programme. The programme may take the form of a simple, easily communicable and carefully asserted leaflet containing advice on suitable action in a flood emergency. This information should be circulated to all households at risk. Particular emphasis should be placed on explicit guidance relating to effective remedial measures, including flood-proofing.

Public health education is seen as the science of preventing disease, prolonging life, promoting health through organised community efforts, and the sanitation of the environment (Draper, 1991). It does not merely imply health to humans, but to the holistic relation of humankind and the environment. Faechem (1984) claims that the

availability of information related to health benefits and water quality could produce a definite change in human behavioural patterns and improved water quality.

At present, no integrated system for the collection and interpretation of information in relation to crucial environmental health concerns exist within the Helderberg Municipal database. It is therefore recommended that the responsible authorities in association with the Municipality distribute public health education materials to the riverine communities. In part, this could be achieved by engaging in public discussion, dispensing photographic materials highlighting potential environmental health threats, hosting workshops and regular visitations to the communities. As the results indicated that the level of education reached, influenced the degree of importance placed on environmental health hazards, the local authorities would have to develop innovative techniques in which to promote health education.

2. *Warden schemes* It could be an added advantage to appoint an official flood warden during seasons of heavy rain and habitual flooding. Wardens may be part-time, volunteer residents. These individuals could be a source of continuing information and could organise social groups regarding interactive flood education. Flood wardens could play a key role in the dissemination of warning messages and aid, so as to alert flood damage and reduce psychological stress. Since most riverine dwellers are likely to respond favourably to a warning from a local authoritative source, this procedure could enhance credibility of a flood-warning message.

3. *Development control* There is considerable scope for responsible organisations in land-use planning and for the water industry to organise rational floodplain development. Frequently, development control is achieved by engineering adjustments to curtail potential flood hazard. Following the completion of such control measures, the municipal body should introduce a realistic appraisal of the design limits of structural schemes – largely, this implies public participation to communicate appropriate activities and livelihoods in substantially unsafe riverine environs.

4. *Administrative reality* No flood alleviation development is likely to occur and achieve optimal success without a positive guidance from responsible authorities

and coordinating bodies. Successful administrative implementation can be achieved by obtaining data relating to flood hazard in differing circumstances (social variance of respective communities) according to a statistical methodology. The municipality must realise that flood risk and the anticipated health implications are largely influenced by variation in the socio-economic living standards as exemplified by the three communities under investigation.

5. *Further research* Evidently, the research study revealed that there is a need for more research into the environmental health implications of flooding of inland urban water bodies, especially in terms of the attitudes and behavioural response of riverine residents. Moreover, since the development of the Kuils and Eerste River corridors appear to be rooted, reduction of flood risk and loss is best suited to an educative stance by way of improving community reaction.

As earlier mentioned, these recommendations were assembled with a stance to the progression of environmental health baselines, against which future environmental health impacts in similar communities might be considered. Based on the recommendations presented above, it is proposed that the information related to these indicators be accumulated, evaluated for communication and circulated to the respective local authorities.

6.3 POLLUTION OF THE KUILS AND EERSTE RIVERS: RECOMMENDATIONS

The water quality conditions and sources of pollution of the Kuils and Eerste Rivers are identified, accounted for, and monitored by the Department of Water Affairs and Forestry and the Cape Metropolitan Council's Scientific Services and Catchment Management Departments which have appropriate standards and procedures in place to address such hazards. Numerous management strategies have been implemented to control diffuse and point sources of pollution (Cape Metropolitan Council, 1998). Sources of pollution include litter, accidental incidences involving toxic substances, discharge from the sewage treatment works in the vicinity, sewer leaks, and surface runoff. Nonetheless, it has been reasserted that despite the visibly tainted state of the

river, the water analyses indicates that the parameters tested conform with the water quality guidelines and deem the water fit for use (Cape Metropolitan Council, 1999).

Ironically, the results of the analyses revealed that the respondents who were habitually in contact (direct or intermediate) with the passing waterway, displayed poor physical characteristics differing from those respondents who refrained from the use of the river altogether. Moreover, the researcher who was continually exposed to the river during fieldwork visitations was medically diagnosed with diarrhoea and mild skin irritation. The infection was treatable, yet it insinuated that although the relationship amongst the variables at hand was slim (correlation 0.38), other stimulating factors within the environment operated to foster negative health impacts.

Once more, recommendation in this respect needs to focus on attitude change of the communities. The suggestions for minimising environmental health risk as a result of pollution are listed below.

1. *Discouragement of the utilisation of river water for domestic application* This recommendation can be effective if formal water supply is adequately available, particularly in informal settlements. The placement of rudimentary public amenities (wooden play structures) could also deter children from playing in the river. And stagnant floodwater pools. Ultimately, it is probable that this recommendation will not be implemented as erecting a facility of this nature is seen as serving as a headway for the growth of informal settlements.

2. *Public awareness* Local clinics and municipal workers should facilitate community workshops to encourage health promotion by striving to alter behaviours that lead to increased risk. Residents need to be informed about potential hazard related to contaminated waters.

3. *Provision of portable toilet facilities* The Helderberg Municipality sees the Madalabos informal settlement as a temporary living space until alternative placement can be found to house the occupants. However, the community has been in existence for over ten years, without any form of sanitation facilities. It is therefore suggested that basic toilets be provided to increase sanitary conditions in

the settlement, itself, and of the river. So doing, it is hoped that this could decrease the levels of faecal coliform in the river – a direct indicator that water contains raw faecal matter.

4. *Provision of waste removal services* The two residential areas - Zandvliet and Kramat area are serviced by formal waste removal. The Madalabos informal settlement, however, lacks this service. Consequently, household litter and redundant items are disposed of in the vicinity of, or in the river itself. If municipal plastic dispenser drums or Wasteman services be provided in such areas, it can greatly reduce the contamination caused by domestic activities.

5. *Educate residents about water treatment and disinfection processes* In the informal settlement where water supply is inadequate and inaccessible, residents often make use of the water from the river for human consumption. Residents should be advised as to the methods of disinfection on a continuous, automatic basis as a precaution against health hazards. This is important in the treatment of water for human consumption as the purpose is to destroy all pathogenic bacteria and harmful organisms (Alth, Alth & Duncan, 1992). There are numerous ways in which water can be disinfected, but because chlorine compounds work well and are readily available at relative low cost, it is the most widely used disinfectant. The chlorine concentration is the amount of chlorine held by a certain amount of water and is expressed in terms of milligrams per litre (of water).

Customarily, the social and behavioural aspect of hazard has been an underestimated element of efficient hazard response. However, the trend toward non-structural adjustments in combination with structural measures has placed heightened notability on this dimension. The assumed behavioural patterns and attitudes of respondents related to issues such as flooding and pollution should form an integral component in operations geared toward combating these potentially health-threatening occurrences.

In light of the proposed recommendations, communities frequently do not have the necessary structural facilities available to execute these recommendations, themselves. Thus, development and planning departments have colossal power to determine the short and long term levels of environmental quality and associated public health status.

Furthermore, for communities to recognise the potential environmental health implications associated with disaster such as that of flooding and pollution, it is proposed that settlement upgrade initiatives become a key component in addressing such community issues. Initiatives should aim at improving community knowledge of the relationship between the environmental conditions and exposures, and health and well-being. This aspect has been receiving increased attention from international organisations such as the World Band and the World Health Organisation (1989; 1991; 1997). Nevertheless, this aspect is not being adequately addressed at national, regional and local levels.

In conclusion, if authorities such as the Department of Health, local councils and metropolitan bodies aim to minimise health implications, then the old adage that "prevention is better (and cheaper) than cure" should be affixed to any recommendation to better environmental quality and associated public health.

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ADDENDA

ADDENDUM A

Dear Respondent

The objective of the following questionnaire is to gather information pertaining to the potential effects of flooding and pollution on your health and the health of the environment. Your participation is entirely voluntary and the information will be treated as strictly confidential. The data will be used for academic purposes and nobody will be identified by name in the results.

The responses will form a fundamental part of research conducted by Yumna Hendricks of the Department of Geography and Environmental Studies at the University of the Western Cape.

It will be highly appreciated if you can complete the questionnaire.

Thanking you in advance for your co-operation.

Geagte respondent

Die doel van die volgende vraelys is om informasie te versamel rondom die verhouding tussen die gebeurtenis van oorstroming en waterbesoedeling, en die moontlike invloed op U gesondheid en die welstand van die omgewing. U samewerking is vrywillig en die inligting sal met vertroulikheid onthaal word. Die data sal vir akademiese doeleinde gebruik word en geen mens sal geidentifiseer word in die uitslae.

Die vraelys vorm 'n belangrike deel van 'n navorsingprojek waaraan Yumna Hendricks van die Departement Geografie en Omgewingstudies aan die Universitiet van Wes-Kaapland, werk.

Dit sal hoogs waardeer word indien U die vraelys kan beantwoord.

By voorbaat dank vir U samewerking.

ID Number: ..... Town/Site: .....

Date of interview: ..... Fieldworker:.....

SOCIO-ECONOMIC FACTORS/SOSIO-EKONOMIES FACTORE

1. How many people live in this house/Hoeveel mense bewoon hierdie huis?

Total adults/ Getal volwasse	Total children/ Getal kinders

2. How long have you lived in this settlement/Hoe lank woon U hier?
Years/jare ☐

3.1 Sex/Geslag: Male/Manlik ☐ Female ☐

3.2 Marital status/Huwelikstaat:

Single/ Enkel	Married/ Getroud	Divorced/ Geskei	Widowed/ Weduwee/naar

3.3 Education/Opvoeding:

No schooling/ Geen opleiding	Highest standard attained/ Hoogste standaard behaal

4.1 Who is the breadwinner of the household/Wie is die broodwinnaar van die huishouding?

_____

4.2 Are you currently employed/Het U werk? Yes/Ja ☐ No/Nee ☐

4.3 What is your household's average income per month/Wat is U maandlikse inkomste?

(i) >R500 ☐
(ii) R500 – R 800 ☐
(iii) R801 – R1000 ☐
(iv) R1001 – R1500 ☐
(v) R1501 – R2000 ☐
(vi) <R2000 ☐

5. From which building materials is your house constructed/Met watter boumaterial is U huis gebou?

(i) Brick/Baksteen ☐
(ii) Wood/Hout ☐
(iii) Zinc/Sink ☐
(iv) Zinc and wood/Sink en hout ☐
(v) Other/Ander ☐

RIVER USAGE/RIVIER VERBRUIK

6.1 Would you classify the Kuils/Eerste River as important/Beskou U die Kuils/Eerste Riviere as belangrik? Yes/Ja ☐ No/Nee ☐

6.2 If yes/no, explain/Indien ja/nee, verduidelik

_____

_____

7.1 Do you think that the river environment adds beauty to this residential area/Dink U dat die rivier en sy onmiddellike omgewing die area mooi maak?
Yes/Ja ☐ No/Nee ☐

7.2 If yes/no, explain/Indien ja/nee, verduidelik _____

_____

_____

8.1 Do you or any member of your household use the river for recreation/Gebruik U of enige lid van U huishouding die nabygelee rivier vir ontspanning?
Yes/Ja ☐ No/Nee ☐

8.2 If yes, specify/Indien ja, spesifiseer _____

9.1 Are you involved in farming activities/Is U by boerdery betrokke?

Yes/Ja ☐ No/Nee ☐

9.2 If yes, indicate below/Indien ja, dui asseblief aan:

(i) Cattle/Beeste ☐
(ii) Crops/Gewasse ☐
(iii) Pigs/Varke ☐
(iv) Sheep/Skape ☐
(v) Other/Ander ☐

9.3 Is it commercial or subsistence farming/Is dit kommersiele of bestaans boerdery?

Commercial/Kommersiele ☐ Subsistence/Bestaansboerdery ☐

10.1 Do you use the river water for crop irrigation/Gebruik U die water van die rivier vir besproeing? Yes/Ja ☐ No/Nee ☐

10.2 Do you use the river water for stock watering/Gebruik U die water van die rivier as drinkwater vir U vee? Yes/Ja ☐ No/Nee ☐

FLOODING ISSUES/VLOEDINGSVRAE

11.1 Are you aware that you are situated on a floodplain/Is U bewus daarvan dat U op 'n vloedvlakte gelee is? Yes/Ja ☐ No/Nee ☐

11.2 If yes/no, explain/Indien ja/nee, verduidelik

_____

_____

12.1 Has a flood ever resulted in property damage/Was daar enige beskadiging aan eiendom as gevolg van 'n vloed? Yes/Ja ☐ No/Nee ☐

12.2 Do you take any precautions to prevent potential flood damage to your home/Neem U enige voorsorge om moontlike oorstroming in U huis te verhinder? Yes/Ja ☐ No/Nee ☐

13. Do you think that there will be another flood while you are (living) here/Dink U dat daar nog 'n oorstroming sal gebeur tydens U verblyf in hierdie huis?
Yes/Ja ☐ No/Nee ☐

14.1 If local authorities were to organise environmental health safety schemes and flood management courses in your settlement, would you attend/As die plaaslike owerheid omgewingsgesondheid en vloed-ramp-beheerkurses aanbied, sal U bereid wees om dit bytewoon?

Yes/Ja ☐ No/Nee ☐

14.2 If yes/no, explain/Indien ja/nee, verduidelik

_____

_____

_____

WATER SUPPLY AND SANITATION/WATERVOORADE EN SANITASIE

15. What is your household's principle source of drinking water/Wat is U huishouding se hoof drinkbare waterbron?

(i) In-house piped water/ Binnehuis waterpype ☐

(ii) Outdoor private tap/ Buitenhuis private krane ☐

(iii) Communal tap/ Gemeenskaplike kraan ☐

(iv) No formal water provided/ Geen formele watervoorsiening ☐

16. Do you and/or your family ever drink water from open waterways, such as the Kuils/Eerste River /Het U of enige van U familie al ooit water van die Kuils/Eerste Riviere gedrink?

(i) Sometimes/soms ☐ (iii) Frequently/dikwels ☐

(ii) Never/nooit ☐ (iv) Unsure/onseker ☐

17.1 What type of toilet facility do you have/Watte tiepe toiletfasiliteite word gevind in U huis?

(i) In-house flush toilet binnehuise toilette ☐ (ii) Outdoor flush toilet/ buitenhuis toilette ☐

(iii) Bucket system/ emmer ☐ (iv) Pit latrine/ pit latrine ☐

(v) None/geen toilette ☐

17.2 If no toilet facility is available, where do your household members defecate/As geen toilet fasiliteit beskikbaar is nie, waar ontlas die mense in U huishouding?

_____

WATER POLLUTION ISSUES/WATER BESOEDELING

18.1 Are you aware of the problem of water pollution in the area/Is U bewus van besoedeling van die rivier in die gebied?

Yes/Ja ☐ No/Nee ☐

18.2 If yes, have you reported or complained about it/Indien ja, het U dit gerapporteer of klagtes daaroor ingedien?

Yes/Ja ☐ No/Nee ☐

18.3 If yes, to whom/Indien ja, aan wie? _____

18.4 Was any action taken in response to your complaint/Was daar enige reaksie na aanleiding van U klagtes?

Yes/Ja ☐ No/Nee ☐

19. Would you describe the river passing through the area, as/Hoe sou U die toestand van die rivier wat deur die area deurloop beskryf:

(i) Clean/Skoon ☐

(ii) Relatively clean/Taamlik skoon ☐

(iii) Dirty/Vuil ☐

(iv) Hazardously dirty/Gevaarlik vuil ☐

20. Do you (or anyone you know of) use the river as a dumping site/Gebruik U (of enigiemand wie U ken) die rivier as 'n stortingsterrein?
Yes/Ja ☐ No/Nee ☐

21. Do you think that the Zandvliet Treatment Works and Macassar Sewage Plant has any negative effect on the health status of the river/Dink U dat die Zandvliet en Macassar rioolwerke enige negatiewe invloed op die toestand van die rivier het?
Yes/Ja ☐ No/Nee ☐

22. Does the river emit any foul smells in the residential area/Is daar enige slegte reuke wat van die riviere afkomstig is?
Yes/Ja ☐ No/Nee ☐

23.1 Do you experience fly or insect infestation in your home/Is daar enige vlieg or insek infestasie in U huis?
Yes/Ja ☐ No/Nee ☐

23.2 If yes, during which month(s) is/are they most prevalent/Indien ja, in watter maande is dit die mees opvalend?

(i) Summer/somer ☐ (ii) Autumn/herfs ☐

(iii) Winter/winter ☐ (iv) Spring/lente ☐

HEALTH INDICATORS/GESONDHEIDSAKE

24.1 Have you had any illnesses or complaints recently/Het U enige kwale in die afgelope tyd gehad? Yes/Ja ☐ No/Nee ☐

24.2 If yes, what is the nature of your illness/Wat is die oorsaak van U siekte?

_____

25.1 Do you suffer from any long-term ailments/Verduur U enige lang-termyn siektes? Yes/Ja ☐ No/Nee ☐

25.2 If yes, what kind of ailment(s) is/are they/Indien ja, watter soort siektes?

_____

26. Have the members of the household ever been sick as a result of/Was daar enige van U familielede wat siek geword het, as gevolg van die volgende:

(i) Asthma ☐ Possible cause/
Moontlike veroorsaking:_____

(ii) Diarrhoea ☐ Possible cause/
Moontlike veroorsaking:_____

(iii) Cholera ☐ Possible cause/ Moontlike veroorsaking:_____

(iv) Typhoid ☐ Possible cause/ Moontlike veroorsaking:_____

(v) Legionella ☐ Possible cause/ Moontlike veroorsaking:_____

(vi) Tuberculosis ☐ Possible cause/ Moontlike veroorsaking:_____

27.1 Have any of the children in this household been ill during the past three weeks/In die afgelope 3 weke, was enige van die kinders in die huishouding siek?

Yes/Ja ☐ No/Nee ☐

27.2 If yes, what is the nature of your illness/Indien ja, wat is die oorsaak van U siekte?

_____

28.1 Is there a medical health facility in the area/Is daar enige gesondheidsfasiliteit in die area?

Yes/Ja ☐ No/Nee ☐

28.2 If yes, is it easily accessible/Indien ja, is dit toeganklik?

Yes/Ja ☐ No/Nee ☐

29. Does the service offered at the medical or health facility meet your needs/Is die diens wat aanbebied word, voldoene?

Yes/Ja ☐ No/Nee ☐

Thank you very much for your co-operation.

Baie dankie vir U samewerking.

CHECKLIST (OBSERVATIONAL DATA)

- To be recorded at the end of the interview

ID Number: .....

1. **Water supply and storage:**

1.1 Type of container used to transport water to the home:

Hand-carried container ☐ Rolling drum ☐

Other (specify) .....

1.2 Water stored in home

Yes ☐ No ☐

1.3 Type of containers used to store water:

Plastic ☐ Tin/metal only ☐

Metals and plastic ☐ Other (specify) .....

1.4 Containers:

Covered ☐ Uncovered ☐

2. **Waste disposal:**

2.1 Method of storing household waste:

Plastic bags ☐ Plastic/metal bins ☐

None ☐ Other (Specify) .....

3. **Sanitation:**

3.1 General condition of latrine: .....

3.2 Faecal matter visible: Yes ☐ No ☐

3.3 Average number of flies ☐

4. **Proximity to river and principle water source:**

4.1 Average distance from river: .....m/km

4.2 Average distance from principle water source: .....m/km

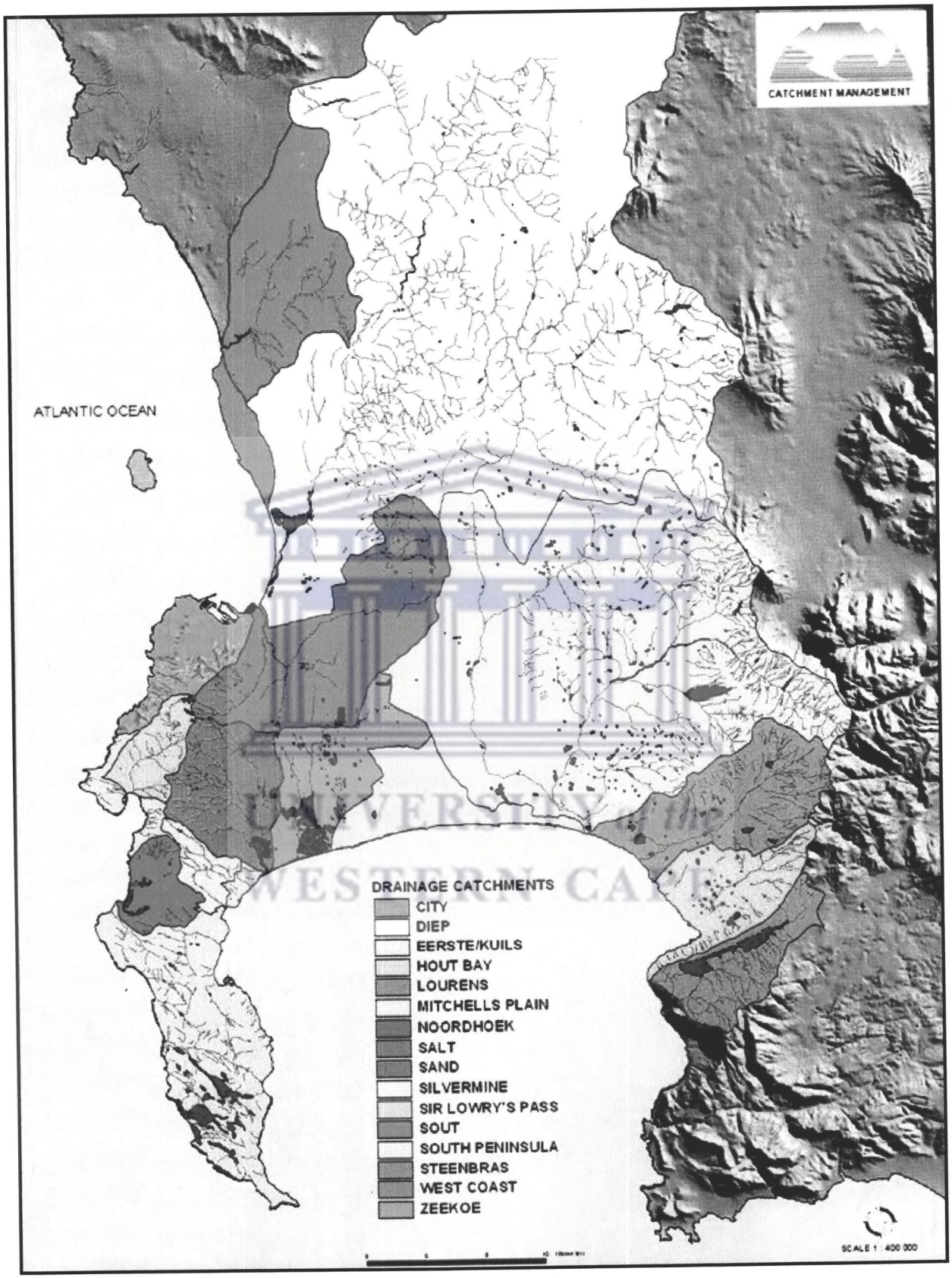

FIGURE 2: LOCATION MAP INDICATING THE CATCHMENTS OF THE WESTERN CAPE

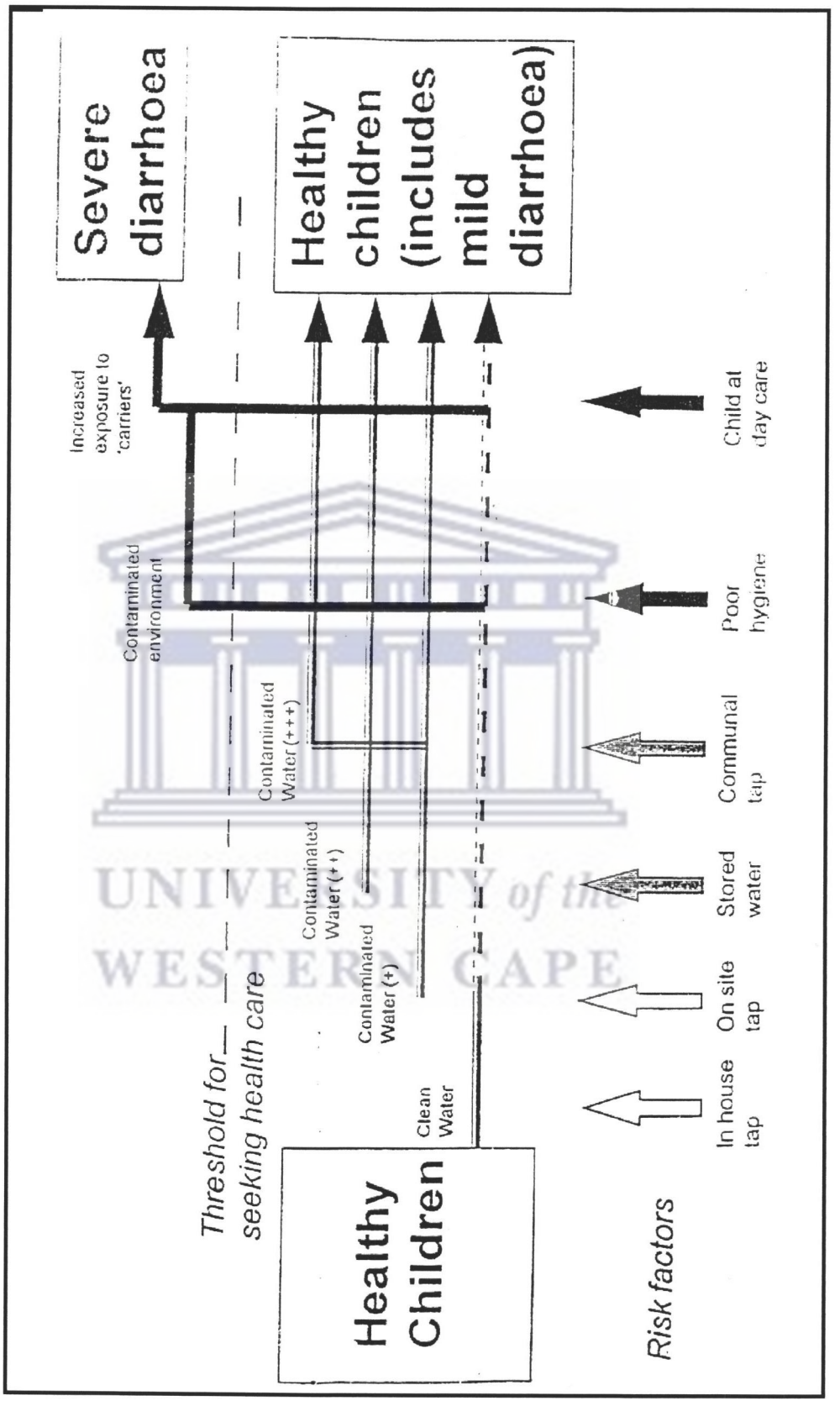

FIGURE 3: SIMPLIFIED MODEL OF THE EFFECTS OF WATER QUALITY ON DIARRHOEA IN CHILDREN