ENVIRONMENTAL RISK ASSESSMENT ASSOCIATED WITH UNREGULATED LANDFILLS IN THE ALBERT LUTHULI MUNICIPALITY, MPUMALANGA PROVINCE, RSA

by

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Submitted in fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in the subject

ENVIRONMENTAL SCIENCES

at the

UNIVERSITY OF SOUTH AFRICA
(UNISA)

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August, 2008

DECLARATION

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I hereby declare that “Environmental risk assessment associated with unregulated landfills in the Albert Luthuli Municipality, Mpumalanga Province, RSA ” is my own research work and that all sources that I have used have been indicated and acknowledged by means of complete references.

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ABSTRACT

Integrated management of municipal and hazardous waste is one of the challenges facing the new municipalities in South Africa, especially those located in previously disadvantaged rural areas. However, much of the research on solid and hazardous waste management in South Africa has examined waste management problematics in urban areas, the majority of which are located within the jurisdiction of local governments which are comparatively effective in terms of providing adequate disposal services. By contrast, this study has examined the environmental risk assessment associated with unregulated landfill sites in the Albert Luthuli municipality, in the Mpumalanga province. The determination of the environmental risk was achieved by the use of questionnaire surveys and landfill analysis forms in selected study areas.

The findings have highlighted a very high environmental risk, nearly four times and above, the threshold limits set by the Department of Environmental Affairs and Tourism (DEAT, 2005:15) for all of the landfill sites examined. Several exposure pathways stemming from associated environmental impacts have also been identified for the study. The higher environmental risk determined for the problem sites is ascribed to numerous factors, including their ill-planned location, the sensitivity and vulnerability of the natural environment and adjacent rural settlements, the lack of appropriate waste pre-treatment processes prior to disposal, and most significantly, the lack of regulatory and control measures to contain the myriad of environmental problems generated. In conclusion, it is recommended that several measures (including closure) should be taken in order to reduce and contain the magnitude of environmental risks involved.

ACKNOWLEDGEMENTS

I am indebted to my research supervisors, IT Rampedi and M Jordaan, in the Department of Environmental Sciences at UNISA, for their guidance and constructive criticism throughout the course of the research period. Lynne Meyer, also in the Department of Environmental Sciences at UNISA, is kindly acknowledged for preparing and finalising some of the sketches and figures used in the presentation of this thesis.

I would also like to express my sincere thanks to Mnisi family members, particularly my wife, Mrs G Mnisi, my parents, Mr P Mnisi and Mrs LZ Mnisi, and my brother, TG Mnisi, for their unfailing support, encouragement, and assistance during the course of the study.

I further acknowledge the financial support received from Isaiah Dladla and Evelyn N
Manamela. Special thanks also go to Wisdom Mnisi and Naledi Mnisi for the contributions they have made regarding the success of the research project. Similarly, members of the Environmental Health Department, at Embhuleni Hospital, HD Manganyi; NOS Ngubane, and MJ Ngoepe, who assisted in the study are gratefully acknowledged.

Finally, and most significantly, I acknowledge the providence, grace and peace stemming from the Almighty God, the Father of our Lord Jesus Christ, for keeping me sane and industrious during the duration of the research project and the compilation of the dissertation.

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CHAPTER 1

RESEARCH BACKGROUND

1.1 INTRODUCTION

One of the development and environmental challenges facing the new and often poorly-resourced local municipalities in South Africa relates to solid waste management in previously disadvantaged rural areas. Solid waste refers to refuse and other discarded materials and semi-solid material emanating from households, industrial, commercial, as well as agricultural activities (Hill, 2004). The generation of solid waste is bound to be of concern to all of us due to the unfavourable environmental consequences such as unpleasant smells, fire potential, contamination and the possible transfer of pathogens. Solid waste that is not properly managed, therefore, can pose greater environmental risk, with negative implications for human life and environmental sustainability (Kum *et al.,* 2005). Unfortunately, most of the research on solid and hazardous waste management in South Africa has focussed on urban areas that are located within the jurisdiction of local governments, which are relatively efficient and cost-effective in terms of centralised disposal services (Van der Merwe & Steyl, 2005; Dalvie & Ehrlich, 2006)

The reasons why urban areas, especially in provinces like Gauteng, the Western Cape, and Kwa-Zulu Natal, receive more attention in terms of research and resource commitment, stem from the fact that they have a massive stream of solid and hazardous waste generated by a rapidly growing number of households, polluting manufacturing industries, as well as commercial activities. There is also scarcity of land for providing waste disposal services in mostly urban environments (Kutlaca, 1994).

By contrast, too little attention is focused on the rural areas where the waste management system is fairly typical of the situation in developing countries. This is characterized by highly inefficient waste collection practices, variable and inadequate levels of service due to limited resources, indiscriminate and illegal dumping, widespread littering and scavenging, and most of all, poor environmental and waste awareness of the general public (Matete & Trios, 2007).

Against this backdrop, the waste management framework in South Africa is founded on a range of legislation, which is intended to manage and prevent environmental pollution, the most relevant among them being the laws on the disposal and treatment of hazardous substances (Hazardous Substances Act 1973 (RSA Act No 15, 1973). Other relevant legislations include the Environment Conservation Act 1989 (RSA Act No. 73, 1989); and the National Environmental Management Act 1998 (RSA Act 107, 1998). Furthermore, the Local Government: Municipal Systems Act 2000 (RSA Act 32, 2000) requires that waste management services be provided to all local communities in a financially and environmentally responsible manner, in order to promote basic service accessibility as well as sustainable waste management services.

However, as already intimated, in South Africa there is a dichotomy regarding the implementation and regulation of waste management systems based on these legal instruments, with urban areas receiving relatively greater attention than rural areas although nearly 40 per cent of the South African population still resides in rural areas (Van der Merwe & Steyl, 2005). There is, therefore, a growing research need to examine waste mismanagement in mostly small countryside towns and rural settings, where the need for reliable, effective, and sustainable waste management has been predominantly neglected.

This research need augers well with the so-called Millenium Development Goals that are aimed at, amongst other things, reversing the loss of environmental resources and biodiversity, improving the proportion of people with access to safe drinking water as well as the reduction of areas with slum living conditions (United Nations, 2008). Consequently, the current research has examined the neglected state of solid waste management and associated environmental risks in at least three unregulated landfill sites in the Albert Luthuli Municipality in the Gert Sibande District, Mpumalanga Province.

1.2 RATIONALE AND MOTIVATION FOR THE STUDY

According to Mpumalanga Department of Agriculture and Land Administration (Mpumalanga DACE, 2003), Mpumalanga Province is the largest producer of hazardous waste in South Africa because of the historical existence of coal-fired power stations and the relatively high number of petro-chemical factories. In addition, the amount of municipal solid waste generated by various land-users has been increasing rapidly in recent years given the growth of polluting industries and the development of informal settlements in the province.

The development of informal settlements in this province, as in other parts of South Africa, especially since the abolition of influx control measures during the period 1986-1994, has invariably led to new focal areas of accelerated population growth. Unfortunately, these areas are often inhabited through informal processes of land invasion, characteristic of certain urban centres in some of the provinces of South Africa (Krige, 1998). Such processes have resulted in the erection of shacks in areas without basic infrastructure for the provision of municipal services, including waste management.

The widespread lack of formal collection and management of waste in such areas within under-resourced municipalities sometimes give rise to outbreaks of diseases such as cholera and typhoid fever, with horrendous negative impacts on human well-being and environmental sustainability.

The Albert Luthuli Municipality is one of the new local municipalities established in the Gert Sibande District, which is predominantly rural in terms of the scope of economic activities. This municipality has to deal effectively with the poor waste management practices prevailing in its area of jurisdiction. However, this is not always feasible without the design and implementation of a sound and integrated waste management framework. This shortfall is evidenced by the sporadic development of unregulated and improperly managed landfill sites in the associated municipal areas.

Moreover, site inspections during the fieldwork of the current research project have revealed several signs of environmental neglect at these landfill sites, whose geographical location and management is poorly planned. In terms of morphology and shape, the landfills are in the form of freshly dug circular and linear trenches while others occur on open spaces, very close to residential areas, wetlands, streams and underground water sources. Generally, the solid waste dumped in these landfills appears to be a mixture of bio-degradable and non-biodegradable forms of waste from neighbouring households, hospitals and clinics, schools, the informal business sector, formal commercial enterprises and other industries. More seriously, sporadic fires and associated smoke have been observed in these landfill sites (*see* Plate 1.1).

Plate1.1 **Elukwatini landfill site**

Worldwide, landfills are known to release a broad range of harmful pollutants such as leachate, gases and particle matter with great potential to cause human illness and contamination of the air, soil and bodies of water (Koshy *et al.*, 2007). Furthermore, other studies have shown that the location of landfills cannot be a random process and neither can it be driven by sheer socio-economic imperatives (Lerche & Paleogos, 2001; Slack *et al.*, 2005). The design of modern landfills is carried out in such a way that they are as self-containing as is technologically feasible, although it is acknowledged that at some time some leakages may occur (Koshy *et al.*, 2007). During site inspections in the current research, it was observed that the landfills in the Albert Luthuli Municipality are not fenced off from the general public, thus allowing for a situation in which anyone can drop off waste material regardless of its nature and without any precautionary treatment. Moreover, groups of pickers or reclaimers, some with visible signs of skin lesions, roam the landfill sites in the Albert Luthuli municipal areas, to select and collect recyclable material, as well as spoiled pieces of food for direct consumption. The degree of environmental risk posed by these landfill sites is drastically increased if the quantities of waste generated from various sources and their likely environmental impacts are not known. Without a proper scientific knowledge of what is going on in these landfill sites and adjacent settlements, the prospect of successfully implementing an effective waste management strategy in the rural areas of Mpumalanga Province, remains bleak.

1.3 RESEARCH HYPOTHESIS

The research hypothesis is as follows:

> The uncontrolled and illegal dumping of various forms of waste materials at the unregulated landfill sites in the Albert Luthuli municipality has potential to pose greater environmental risk to neighbouring land-users and the natural environment.

Environmental risk assessment attempts to characterize the potential negative impacts of human exposure to environmental hazards (Sykes *et al.*, 2007). Risk assessment involves a process of identifying the number and characteristics of current environmental hazards, establishing the probability and magnitude of the likely environmental harm, and determining what should be done to reduce or eliminate the risk (Environment Agency, 2005).

1.4 RESEARCH AIMS AND OBJECTIVES

The primary aim of the current research was to assess the environmental risks associated with three unregulated landfill sites under the jurisdiction of the Albert Luthuli Municipality. This research aim was addressed by means of the following objectives, namely to:

1) Identify the different sources of waste materials entering unregulated landfill sites of the Municipality;
2) Classify and evaluate the type of waste disposed at the landfill sites;
3) Identify different exposure pathways of environmental hazards;
4) Characterize and quantify the magnitude of environmental risks associated with the identified hazards;
5) Suggest possible mitigations measures to implement a sustainable and integrated waste management strategy for the municipality.

1.5 SCOPE OF THE RESEARCH

Although this study was conducted in the Mpumalanga Province, the research only focused on the Albert Luthuli Municipality in the Gert Sibande District. The three unregulated landfill sites, as well as the contributing land-uses, constituted the study area for the research. The local municipality has already expressed the intension to close some of the problem landfill sites such as Ekulindeni and eMpuluzi, while those in Badplaas, Carolina and Elukwatini are earmarked for licensing should they comply with regulatory standards. The latter three landfill sites were selected for a detailed study in order to investigate their base-line status and associated environmental risks.

1.6 RESEARCH METHODOLOGY

In order to achieve the objectives of the research, various sources and generators of solid waste and the three unregulated landfill sites in the Albert Luthuli Municipality were selected for an in-depth study. Both qualitative and a quantitative study designs were adopted for the research. This research design replicates procedures followed in other studies of solid waste management and associated landfill sites. For example, in a study of households' perspectives of the effectiveness of the private sector in the management of solid waste in Dar es Salaam, this approach involved the use of questionnaire surveys (Kassim & Ali, 2005).

Questionnaires were used to study different perspectives of households and private solid waste collectors involved in the solid waste management problem. Their sample was drawn from nearly 300 households, about 100 people from each municipality. In addition, various criteria served to select the locations in order to conduct the survey (Kassim & Ali, 2005). Aspects such as the following were included in the surveys: collection methods, awareness of the problem of solid waste, and the effectiveness of the services rendered. Furthermore, questionnaire interviews were conducted with stakeholders in the private sector who had formal contracts with the Dar es Salaam local municipality.

Another important aspect of the approaches followed was observations relating to the various aspects of the solid waste management problem in the study area. Subsequently, these approaches were adapted for the study of solid and hazardous waste mismanagement in the Albert

Luthuli Municipality, with some modifications in that other target groups such as hospitals, hotels, abattoirs were also surveyed in order to gauge not only their perspectives but also the type of waste they generate. Furthermore, the three landfill sites were assessed by means of site analysis forms.

1.6.1 Population and samples

The entire study included two major sources from whom and where data would be collected. The first data source was comprised of the general public (n=375) who consisted of the directly affected residents located within a radius of about 5 km from the landfill sites, commercial institutions and health care institutions within the area wherein refuse collection services are rendered by the municipality. Representative samples were drawn by means of a stratified random sampling technique and comprised of at least 20 % of the entire population. The second population group consisted of the three selected landfill sites (n=3) in Badplaas, Carolina and Elukwatini.

1.6.2 Data collection

Questionnaires were applied to collect data from possible waste generators. This data was analysed by means of descriptive statistics. Site analysis forms were used to collect data from the three selected landfill sites. Secondary data was also used in the study and it was based on water quality, air pollution and health-related problems reported for the study areas. Accordingly, the risk assessment was broken down into three components, namely toxicity assessment, exposure assessment and risk characterization. These components were used to calculate quantitatively the risk related to each landfill site. Thereafter, the risk values obtained were used to compute risk levels using a grading system of risk analysis (DEAT, 2005:15)

1.7 LIMITATIONS OF THE STUDY

The study was confined to Albert Luthuli municipal boundaries and to the exclusion of areas beyond this. Furthermore, the study did not involve laboratory analysis of samples except where secondary data was available.

1.8 STRUCTURE AND PRESENTATION OF THE DISSERTATION

The chapters of the thesis to follow are:

Chapter 2: Literature review
Chapter 3: Demarcation of the study area
Chapter 4: Research methodology
Chapter 5: Research results and discussion
Chapter 6: Conclusion and recommendations

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL TRENDS IN WASTE MANAGEMENT

Solid and hazardous waste cannot be managed efficiently and effectively, unless its origin or sources, composition, quantities, processes and the associated environmental risks are thoroughly understood (Kum *et al.,* 2005). The improper management of waste materials is a global environmental challenge arising from unrestrained human activities. This challenge affects various communities and environmental quality in developed as well as developing countries. However, the challenges faced by the developed countries are not necessarily the same as those experienced in the developing countries. The differences between these countries are mainly attributed to discrepancies in their socio-economic status, levels of industrialisation, urbanisation and levels of education (Kassim & *Ali*, 2005).

2.2 WASTE MANAGEMENT TRENDS IN DEVELOPED COUNTRIES

The inappropriate management of solid and hazardous waste does not only affect developing countries such as those located on the African continent. For instance, nearly 500 years ago, European cities were spawned with outbreaks of cholera, typhoid and plague epidemics resulting from widespread accumulation of waste along roadsides (Yong-Chung *et al.,* 2005). Moreover, some of the developed countries find it difficult to establish new landfill sites due to land scarcity and large-scale opposition from the general public because of the negative perceptions associated with landfill sites and other waste disposal sites (El-Fadel *et al.*, 1995).

However, most developed countries such as the United States of America (USA) still dispose about 95 per cent of their solid waste by means of landfills, while approximately 80 per cent of the waste is hazardous (El-Fadel *et al.*, 1995). In the USA, landfill sites continue to be the most convenient and cost effective method for waste disposal despite the history of environmental disasters that have negatively affected some of the populations living there (Yong-Chung *et al.,* 2005 & El-Fadel *et al*., 1995). Inevitably, some of the developed countries, like Japan and Canada, are gradually shifting their waste disposal practices from establishing landfills towards incineration.

In general, incinerators are used for the treatment of hazardous waste substances, mainly toxic industrial and healthcare waste. Although, incineration has become a popular means of waste disposal, especially in countries where land is scarce, it is also accompanied by the release of high levels of carbon monoxide, hydrogen chlorine, metallic (e.g. lead, arsenic, cadmium & mercury) and particulate matters into the natural and human environment. These by-products result mainly from incomplete combustion in incinerators. The emission, movement, and circulation of these pollutants in the biosphere often produce negative environmental and health impacts. Furthermore, the release of greenhouse gases from incinerators is currently contributing to climate change in the form of global warming, which has adverse effects for human settlements and environmental quality. More seriously, such pollutants have been negatively implicated in a variety of acute, chronic and/or sub-chronic illnesses because they have the properties of carcinogens, teratogens as well as mutagens (Yong-Chung *et al.,* 2005).

Beyond the use of landfills and incinerators, the global trend in waste management is towards sustainable waste management with an emphasis on recycling, reusing, reduction, and prevention of waste materials. However, only a few developed countries have witnessed considerable progress in this practice. For instance, Denmark is reputed to be the first country in the world to launch a comprehensive waste taxation scheme in their waste management policy in order to inculcate the reusing and recycling of waste as early as the mid-1980s (Middleton, 2004). This trend is also apparent in countries such as Switzerland and Germany, whereby there are successful initiatives to recycle bottle containers. In fact, the average recovery rate for the recycling of glass containers has increased from 22 per cent in 1980 to 32 per cent in the late 1980s, for most of the OECD countries. In addition, many countries worldwide are now attempting to reach waste prevention in their different manufacturing industries through an emphasis on cleaner production. This is achieved through processes that are summarised by Middleton (2004:248) as:

- Conservation of energy and raw materials
- Reduction in the use of toxic or environmentally harmful substances
- Reduction of the quantity and toxicity of wastes and pollutant discharges
- Extension of product durability

2.3 WASTE MANAGEMENT TRENDS IN SUB-SAHARAN AFRICA

In the sub-Saharan African region, the rate of solid waste generation exceeds the management capacities of municipalities. However, only 35 per cent of the population lives in urban areas where refuse removal services are rendered.

Currently, thousands of tons of solid waste are generated daily in the region and the highest amount of the waste produced ends up in open spaces and neglected street corners. The rate at which solid waste is generated in developing countries ranges between 0.5 to 0.8 kilograms per person per day, as compared to 1 to 2 kilograms per person per day generated in the developed countries.

Generally, high waste generation is commonly associated with the throwaway culture associated with rapid urbanization, accelerated economic and population growth (Middleton, 2004; Yong-Chung *et al.,* 2005). Unfortunately, the general waste streams frequently contain hazardous waste materials, often emanating from local industries, health care facilities, commercial and residential institutions. As a result, toxic and infectious materials are discarded along with general waste throughout the region. The presence of hazardous waste materials in the general waste streams is a critical issue that complicates the management of solid waste, especially with regard to land filling. In the rural and poor communities of the African continent, uncollected solid wastes accumulate illegally along roadsides whilst another fraction is burnt within household yards. This trend has the potential to reduce environmental quality in neighborhoods and can also pose a threat to public health and the environment.

At present, only a small amount of solid waste is disposed of safely in sanitary landfills, while most of the waste is deposited in open dumps, semi-controlled and unlined landfills which do not have access control, groundwater protection measures, leachate management and/or gas collection. More disturbingly, most of the waste dumps are located in ecologically sensitive areas whereby toxins may find their way into groundwater resources.

Consequently, if the existing solid waste practices in the region do not improve, the following associated environmental and health risks may be experienced continuously (Jung *et al.,* 2005):

- Foul smells,
- Dust emissions,
- Environmental nuisances,
- Pollution of ground and surface water,
- Attraction of vermin, vectors and/or pests,
- Chemical instability on affected sites,
- Emission of landfill gases (methane gases) and other green house gases,
- Severe health risks to human beings and animals.

2.4 WASTE MANAGEMENT TRENDS IN SOUTH AFRICA

South Africa is one of the countries experiencing faster economical growth rates in the SADCC region. Unfortunately, economic growth is always accompanied by the generation of large quantities of solid waste. As a result, it is estimated that an amount of 42 230 000 cubic meters of solid waste is generated per annum in South Africa (Table 2.1). However, from the total solid waste quantities generated per annum in the country, about 3 831 000 cubic meters of the waste is produced in Mpumalanga Province (Mpumalanga DACE, 2003).

Table 2.1: South Africa's waste quantities

Province	General waste		Hazardous waste	
	m³/annum	%	m³/annum	%
Mpumalanga	3 831 000	9.1	3 039 873	31.8
Eastern Cape	2 281 000	5.4	52 088	0.5
Free State	1 675 000	4.0	30 530	0.3
Gauteng	17 899 000	42.4	2 829 643	29.6
KwaZulu-Natal	4 174 000	9.9	1 702 934	17.8
North West	1 625 000	3.8	1 618 383	16.9
Northern Cape	733 000	1.7	1 149	0.0
Limpopo	1 470 000	3.5	5 814	0.1
Western Cape	8 543 000	20.2	283 887	3.0
TOTAL	**42 231 000**	**100%**	**9 564 301**	**100%**

Adopted from Mpumalanga DACE (2003: 53)

The country also disposes about 99 per cent of its solid waste through landfill methods. In this instance, different ways of waste disposal by land are used, the most common being trenches, open dumps, unprotected landfill and sanitary landfill methods. Indiscriminate dumping of waste in neglected open spaces also occurs in small, resource-poor rural municipalities (Mahlangu, 2007). Even so, sometimes the municipalities themselves are responsible for the indiscriminate dumping of waste. Presently, South Africa has about 1 200 landfill sites of which 86 per cent are operated by municipalities, while 14 per cent are privately owned (McLean *et al.,* 2003). However, about 88 per cent of the landfill sites are not legally permitted to exist and are, therefore, not operated according to statutory requirements (DWAF, 1998b; McLean *et al.,* 2003; Mahlangu, 2007).

Based on the quantities of solid waste generated for general and hazardous waste in South Africa, as well as the existing status of landfill sites, there is no doubt that the overall management of solid waste in the country has not reached satisfactory standards (DEAT, 1999). Thus, South Africa is faced with a serious challenge of delivering efficient and effective solid waste services to needy communities, in both urban and rural areas. Due to this challenge, large quantities of solid waste are dumped on open spaces as well as along street corners within settlements, than at landfills. This trend is especially true for vulnerable rural and urban settlements, who often bear the brunt of the negative impacts associated with improper and unsafe disposal of toxic waste (DEAT, 1999).

In the current South African government, the primary responsibility of solid waste management lies with the local government sphere or municipalities. However, the management of hazardous waste remains a competency of the provincial government (DWAF, 1998b). However, an estimated amount of 9 564 301 cubic meters of hazardous waste materials are presently generated in South Africa per annum. From the total quantities of hazardous waste generated in the country, 3039873 cubic meters of this waste is generated from Mpumalanga Province (Mpumalanga DACE, 2003). This shows that the Mpumalanga Province is the highest producer of hazardous waste material in South Africa.

Furthermore, of the 3 039 873 cubic meters of hazardous waste generated in the province per annum, only 2 923 cubic meters of the waste actually reaches a hazardous waste site. This accounts for 0.1 per cent of the total hazardous waste generated in the province, while the remainder portion of 99.9 per cent is disposed somewhere in undocumented areas (Mpumalanga DACE, 2003).

Inevitably, this huge quantity of hazardous waste makes a significant contribution to the burden of solid waste management in the municipalities within the province. In fact, health care risk waste is the most common type of hazardous waste that is dumped with general waste in most parts of the province, while the other types of waste are transported to the Gauteng Province for disposal (Finlay, 2007). Improper management of health care waste has a negative impact on the manageability of landfill sites in the South African municipalities (Slack *et al.,* 2005; GSDM, 2006).

The other type of hazardous waste often found mixed with municipal solid waste is household hazardous waste. These waste materials are often present in smaller quantities and result from household appliances, sprays, body lotions, furniture polish, vehicle batteries and other household accessories (Nriagu *et al*., 1997; Rosqvist *et al*., 2003; Slack *et al.,* 2005). General waste materials can be sub-categorized as:

- Domestic or household waste: Waste generated on premises used for residential purposes and community amenities and which is collected as part of a routine service provided by the municipality;
- Commercial / Business waste: Waste generated in office blocks, retail stores, restaurants and other commercial properties;
- Industrial waste: Waste generated by industries which is largely determined by the type of industry where it is generated, and may be hazardous or non-hazardous;
- Rubble: Waste generated where construction and road building activities are undertaken. Generally, contractors remove this waste to disposal sites and are often

suitable for daily cover at landfill sites where sufficient quantities of soil cannot be obtained;

- Garden refuse: This waste is generated when maintaining gardens or cutting grass, trimming trees, shrubs and is typically collected in a mixture of domestic waste as part of the routine collection service.

Similarly, hazardous waste materials can be categorized into the following nine sub-categories or classes:

- Class 1: Explosives,
- Class 2: Gases,
- Class 3: Flammable liquids,
- Class 4: Flammable solids or substances,
- Class 5: Oxidizing substances,
- Class 6: Toxic and infectious substances,
- Class 7: Radioactive substances,
- Class 8: Corrosives,
- Class 9: Miscellaneous substances.

When all these materials react physically and chemically during decomposition processes, a heavily mineralized liquid flow known as leachate occurs. The uncontrolled flow and circulation of this fluid in unprotected landfill sites, poses greater environmental risk to the environment and human health (Thomson, 1999). In addition, hazardous waste materials are also grouped into four toxic or hazard levels (DWAF, 1998a):

- Hazard rating 1: Extreme hazard
- Hazard rating 2: Highly hazard
- Hazard rating 3: Moderate hazard
- Hazard rating 4: Low hazard

When examining the impact of hazardous waste in relation to the definition of hazardous and general waste, general waste is regarded as the waste materials that do not pose a significant threat to health or the environment, if managed properly. However, hazardous waste has the potential, even in low concentrations, to have a significant adverse effect on public health and the environment because of its inherent toxicological, chemical and physical characteristics (DWAF, 1998a).

2.5 WASTE MANAGEMENT PROBLEMATICS IN THE ALBERT LUTHULI MUNICIPALITY

In the Albert Luthuli Municipality, solid waste management is a competency of the Department of Community Health Services, which is one of the administrative units of the Municipality. The Department is meant to handle only general waste. Currently the Municipality has only 22 employees, while 31 posts are vacant. As an alternative, the Municipality outsources refuse removal services to private contractors.

However, the Municipality is able to provide a similar service to Carolina and Badplaas by means of municipal trucks and tractors, while contractors collect refuse from the Elukwatini, Ekulindeni and eMpuluzi townships. Unfortunately, other areas of the municipality do not have access to refuse removal services. These areas are primarily low income and informal residential areas. Some of these areas are provided with bulk refuse containers, which are removed on an *ad hoc* basis. Solid waste removal services are only accessible to 11 per cent of the total households within the municipal area of jurisdiction. According to the study conducted by the Gert Sibande District Municipality (2006: 47): "the Municipality acknowledges that there is a lack of communication and understanding between them and the contractor (Beauty Construction)". To this extent, it has been established that the contractor does not dispose waste in all of the allocated areas probably due to capacity constraints.

2.5.1 Waste minimization in the municipal areas

A study conducted by the district municipality revealed that a number of re-claimers frequently sort and collect waste materials at the Carolina landfill. During the interviews carried out by the district consultants, the re-claimers indicated that they had been working on the neglected site for about three weeks and were paid 30 cents per kilogram of reclaimed plastic and tins (GSDM, 2006). In addition, a team of other re-claimers, who collected metals, indicated that they sold it to the local scrap contractor in town. According to one of the local scrap yard contractor, ABCON Metals, the reclaimed goods bought from reclaimers are further sold at approximately 30 tons of steel to *Highveld Steel* in Middelburg at least once a month (GSDM, 2006).

However, the re-claimers were unable to provide the quantities of recycling material collected, as they did not keep records. Re-claimers also indicated that their recycling undertakings are limited as the landfill is at times set alight, thus placing them in a vulnerable position (GSDM, 2006). In the district study, it was reported that: “a municipal foreman has confirmed that there is always smoke coming from underneath the site, suggesting that the site was set alight or uncontrolled fires occur and that these developments are not supported by the municipality” (GSDM, 2006: 49). Furthermore, the re-claimers did not make use of any personal protection equipment when entering the landfill sites.

2.5.2 Waste treatment by the Municipality

The Municipality does not practice any formal waste treatment nor does it have an infrastructural and human capital capacity to deal effectively with solid waste treatment. The only treatment facility in the Albert Luthuli municipal area is the incinerator at the Carolina and eMbhuleni hospitals that are also not capable of burning at the highest temperature that is required to destroy toxic or infectious waste materials.

2.5.3 Management of hazardous waste

The management of hazardous waste is a responsibility of the provincial government (Mpumalanga DACE, 2003). However, it is the responsibility of the local municipality to ensure that general landfills are correctly managed and that human health and the environment are not negatively affected by poor management of solid waste.

The municipality has the responsibility to ensure that all potential hazardous waste generated in its area of jurisdiction comply fully with the relevant legislation and statutes. In order to achieve its obligation, Albert Luthuli Municipality must ensure that:

- Waste is correctly segregated into hazardous and non-hazardous waste streams to ensure that the hazardous waste does not end up in the general waste stream,
- Hazardous waste is stored correctly and safely on site,
- Hazardous waste is removed on a regular basis and is not allowed to accumulate on site,
- Hazardous waste is handled, classified, treated and disposed of by a registered person or institution,
- All hazardous waste generators must have a proof that their hazardous waste collecting person has a Safe Disposal Certificate.

The greatest challenge facing the local municipality currently is that there is no adequate information relating to the generation, disposal and management of hazardous waste within its area of jurisdiction. Despite the fact that the Municipality does not have capacity and the authority to handle or dispose of hazardous waste, it was identified during the study by the district that there is an area adjacent to the main landfill at Carolina which is used for the disposal of animal remains. Veterinary waste such as animal remains, is classified as hazardous waste and may have a significant adverse effect on public health and/or the environment (McLean, *et al*., 2006). Due to the lack of security at the problem landfills, unregulated reclaimers often dig up the remains of the buried animal carcasses for direct consumption.

2.5.4 Municipal solid waste facilities in affected municipal areas

The majority of residential, commercial and industrial waste is collected and disposed of at the general landfill sites. The general condition of the landfills, as observed during the site visits by the district, is not satisfactory. None of the landfills in the Albert Luthuli Municipality are permitted and are not formally classified. This cannot be achieved as none of the landfill sites within the Albert Luthuli Municipality have any weighbridges. General waste disposal sites only receive general waste. However, it is required by existing legislation that prior to waste being accepted at a landfill site, suitably qualified staff must monitor the site for compliance. However, this is not undertaken at any of the landfill sites. Furthermore, it has been reported that the landfills experience problems with the illegal disposal of hazardous waste (GSDM, 2006).

In addition, tyres are burned on the landfill site, while daily compaction and covering is not done due to lack of machinery. The Municipality does not have any transfer station. The plan of the Municipality is, however, to have only two landfill sites, Carolina and Elukwatini, where all the waste generated in the municipal area will be disposed of, and to construct transfer stations at some of the other towns (GSDM, 2006). The waste generated per household, when taking into account the population growth rate, is 1 per cent where the calculation of the waste volume (in tons per month) is based on the assumption that each person in the formal areas of Albert Luthuli generates 1.2 kilograms of waste per day and each person in the informal settlements in Albert Luthuli generates 0.3 kilograms of waste per day. It must be noted that most of the informal areas in Albert Luthuli do not have a refuse removal service and their waste is not disposed on the landfill sites. Most of the informal settlements handle their own waste by digging and burning it (GSDM, 2006).

2.6 THE SOUTH AFRICAN REGULATORY FRAMEWORK

A few national statutes relevant and most pertinent to solid and hazardous waste management are briefly summarized in Table 2.2. According to Section 24 of the Constitution of the Republic of South Africa (Act 108 of 1996):

> Everyone has a right to an environment that is not harmful to health or well being. The Government is, therefore, obliged to act reasonably to protect the environment by taking appropriate measures to prevent pollution of all types, and to ensure that polluting agents take precautionary measures to balance industrial development with environmental protection to the mutual and socio-economic benefit of all stakeholders involved.

To achieve this goal, the National Environmental Management Act (NEMA of 1998) provides an over-arching framework towards the attainment of integrated and co-operative environmental governance. Furthermore, this Act supersedes several sections of the Environmental Conservation Act of 1989 and it includes the so-called "Polluter must Pay Principle" as well as the remediation of environmental damage (South Africa Year Book, 2000/01). In particular, the Hazardous Substance Act (RSA 1973) as well as the Environmental Conservation Act (RSA 1989) provides for the control of substances which may cause injury or human illnesses due to their toxic and corrosive nature; as well as the regulating of dumping of waste in registered landfill sites, respectively.

In addition, the National Environment Management: Air Quality Act (RSA, 2004), provides national norms and associated standards in order to control and regulate air quality monitoring, management of all government spheres involved, the goal being to achieve environmentally sustainable development (Mc Clean, *et al*. 2003). Other relevant legislations are succinctly summarised in Table 2.2.

Table 2.2: Regulatory framework

Constitution of the Republic of South Africa Act 108 of 1996	The Constitution, as the principal piece of legislature in South Africa, obligate all activities to take place in accordance with environmentally sound practices to prevent the violation of the environmental right. Local government has to do refuse removal, waste/refuse dumps and disposal.
National Environmental Management Act 107 of 1998	The National Environmental Management Act (NEMA) provides for co-operative governance. Chapter 3 makes specific reference to the responsibilities of local government with respect to waste management. Chapter 7 imposes a duty of care in respect of pollution and environmental degradation.
National Waste Strategy and Action Plans	The overall strategy is to reduce the generation of waste and the impact on the environment of all forms of waste. Again, concepts such as Integrated Waste Management planning, Waste Minimization and Recycling are emphasized repeatedly.
National Environmental Management: Waste Management Bill 2007	The Bill has a significant impact on Waste Management in South Africa. It requires municipalities to have a comprehensive integrated waste management plan, and industries to develop an industry waste management plan.
DWAF Minimum Requirements for Landfill, 2nd Edition, 1998	The Minimum Requirements provide applicable waste management standards or specifications that must be met, as well as providing a point of departure against which environmentally acceptable waste disposal practices can be assessed.
Environment Conservation Act 73 of 1989	The Act specifies the requirement of a permit to establish and operate any waste disposal. The permit sets conditions pertaining to the design, construction, monitoring and closure of a waste disposal site. In Section 20 specific reference is made to waste management, including the establishment and operation of waste disposal sites.
Municipal Systems Act 32 of 2000	The Act regards Municipalities as service authorities, responsible for the effective delivery of services and must provide appropriate policy and regulatory frameworks.
National Environmental Management: Air Quality Act 39 of 2004	The Act deals with the control of ambient air quality. It clearly spells out the responsibilities of each sphere of government in ambient air quality management.
National Water Act 36 of 1998	The Act contains provisions directly addressing waste management operations that impact on a water resource.
White Paper on Integrated pollution and Waste Management for South Africa, Notice 227 of 2000	In this document the focus is shifted towards integrated pollution and waste management, as well as waste minimization. Concepts such as cradle-to-grave, waste minimization at source and integrated waste and pollution management are emphasized throughout.

Adopted from Govan Mbeki Municipality (2003:100)

2.7 INTEGRATED WASTE MANAGEMENT

According to Slack *et al.* (2005), the adverse impacts of waste management are best addressed by establishing integrated programs for solid waste management. In these programs, all types of waste and all facets thereof are considered together. Slack *et al.* (2005) further highlights that despite the importance of the programs, limited resources can prevent or hamper the implementation of such programs. The long-term goal should be that each municipality develops an integrated waste management plan (IWMP). Integrated waste management ensures that the management of solid waste is planned cross-sectorally and in advance. Thus, the objectives of integrated waste management planning are as follows (Slack *et al.,* 2005):

- Optimization of waste management;
- Minimization or total mitigation of environmental impacts;
- Minimization of environmental costs and maximizing environmental savings or income generation;
- Capacity building amongst communities to develop proactive plans for efficient management of waste;
- Establishment of waste information systems within municipalities; and
- That sound financial planning is practiced and implemented.

According to the guidelines of the Department of Environmental Affairs and Tourism (DEAT), an integrated waste management plan should consider, *inter alia,* the following aspects (Slack *et al.,* 2005):

- Identification of national, provincial and local statutes that are governing waste management within municipalities;
- Demographic information of municipalities;
- An assessment of quantities and characteristics of waste generated, collected, recycled, treated and disposed of within the municipalities;
- An assessment of existing waste management strategies, systems and practices within municipalities;
- Economical and financial costs of waste management;
- The waste management organizational structure within the municipalities;
- Identification and prioritization of community needs;
- Strategies for waste prevention, minimization and recycling;
- Implementation of a program for IWMPs; and
- Mechanisms for monitoring performance in respect of targets and strategies set.

An integrated waste management system is one of the national principles that regulate environmental matters (National Environmental Management Act 107 of 1998).

The principle also requires that waste should be avoided, or where it cannot be altogether avoided, it should be minimized and reused or recycled, where possible and otherwise treated and/or disposed of in a responsible manner (Jain *et al.,* 2005). Thus, integrated waste management involves the following four priorities (*see* figure 2.1) in order of preference (Slack *et al.,* 2005):

- Waste avoidance;
- Waste minimization: reduce, re-use and recycling.
- Waste treatment;
- Waste disposal.

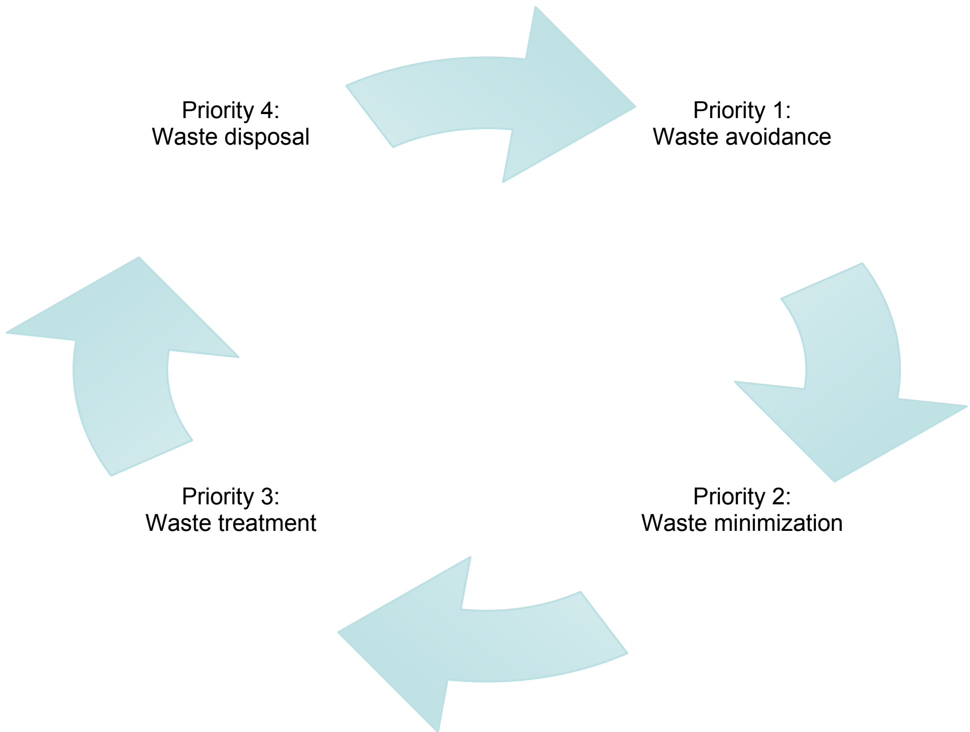

***Figure 2.1:* Integrated solid waste hierarchy**
(Adopted from DEAT, 2002a)

Integrated waste management promotes integrated planning for solid waste management and prioritization of waste management hierarchy. The main aim of integrated waste management strategy is to reach the objective of Integrated Pollution and Waste Management, which is the national police regulating pollution and waste management. It also aims at achieving world-class commitments on sustainable development as in the Polokwane Declaration of September 2001, which works towards a waste free environment (DEAT, 2002b). In terms of the integrated pollution and waste management, solid waste management priorities are geared towards preventing waste generation and pollution, waste reduction, material recovery and reclamation of waste material (DWAF, 1998b). The implications of these approaches are serious if it is considered that it has been predicted already that the generation of waste will exceed existing landfill capacity in five of the nine provinces of South Africa, by up to nearly 70 per cent before the year 2010 (South Africa YearBook, 2000/01).

2.7.1 Waste avoidance

Waste avoidance can be achieved in different ways, such as the prevention of waste at a point of generation through cleaner production or cleaner technology. These technologies mainly involve the use of good quality raw materials and the generation of very small amounts of by-products or no by-products at all. It is also achieved through strong legislative measures for waste reduction (Jain *et al.,* 2005). Waste avoidance is a first step and a priority in the waste management hierarchy. Priority should be given mainly to the avoidance of waste generation, and it must be a priority before the other three measures that can be applied to ensure the best management of waste, while waste disposal is the last priority (Sugni, *et al.,* 2005).

2.7.2 Waste minimization

Waste minimization simply means reduce, reuse and recycle. The primary goal of waste minimization is to reduce waste quantities that could otherwise be transported and disposed of in the landfill sites. Waste minimization is also called resource recovery or waste reclamation (DEAT, 2002a). Traditionally, the practice focused more on material reclamation from disposed waste in the landfill sites. This was uncontrolled, and informally done by reclaimers who were mainly from economically disadvantaged communities. There is an indication; however, that municipalities, private industries, and communities are starting to give support to initiatives of resource or material recovery. This involves amongst others, biodegradation, biostabilization, biodrying, composting and energy generation from landfill gas, as well as other advanced technologies (DEAT, 2002a).

Recovery of waste at the source is strongly recommended, but it can also be done during transportation or at the disposal site. However, the earlier the separation, the cleaner the material, and ultimately, the higher its quality and the economic value of recyclables. When waste recyclers are allowed access to landfill sites, significant amounts of material are recovered. However, because they interfere with efficient operation of dumps and landfills, recyclers are usually prohibited, yet in turn it leads to lowering recovery rates and causing severe economic hardship in local communities. Some sites provide a measure of structured access, for instance at the Bisasar Road landfill in Durban, where registered recyclers are allowed onto the site after hours. This allows recycling to help build capacity among local micro-enterprises and to reduce the waste handled by landfills and dumps (Adani *et al.,* 2004; Jain *et al.,* 2005; Sugni *et al.,* 2005).

Hence, different waste reduction or recovery projects are emerging. One of the recent technologies is the use of landfill gas for energy generation either through incineration of waste or direct extraction of methane gas from the landfill site (Jain *et al.*, 2005).

South Africa does not only recycle solid waste but also other types of waste such as liquid and gaseous waste (DEAT, 2002b). This is in keeping with the integrated pollution and waste management policy (reduce, reuse, recycle & repair), which encourages waste minimization and resource recovery (DEAT, 2002a). Subsequently, South Africa is the seventh highest per capita emitter of carbon dioxide in the world. Consequently, there are efforts to reduce emissions. For instance, eThekwini Municipality is the first municipality in South Africa to generate electricity from landfill gas. This initiative helps to reduce green house gas such as carbon dioxide and others, which in turn addresses the challenge of global warming (Strachan, *et al.*, 2007).

This literature review revealed that different countries use different methods to recover and reduce waste quantities. The focus is often to reduce waste quantity or quality. Quantity reduction measures are aimed towards minimising the amount of waste generated, while quality reduction ones attempts to lessen toxic levels (Kassim & Ali, 2005; Sugni *et al.,* 2005). Whereas the emphasis in most countries is to recycle only general waste, industrialised countries such as Korea, also attempt to recycle hazardous waste. For example, some of the health care waste, such as human placentas, are recycled in Korea and are used as raw material in the production of pharmaceutical products (Yong-Chung *et al.,* 2005).

2.7.3 Waste treatment

Waste treatment is the third priority in the waste management hierarchy. It follows *waste minimization* and precedes *waste disposal,* the fourth and the last step in the waste management hierarchy. Different methods are used by countries for waste treatment ranging from chemical treatment, thermal treatment, sterilization and many more. Waste treatment is also used as waste disposal and hence the two waste management steps are dealt with concurrently in order to create good coherence. Although practices for solid waste treatment or disposal also vary from country to country, the most common method for waste disposal are landfill sites. Japan, China, Sweden, Denmark and some other countries use incineration as a preferred method for waste treatment and/or disposal. This method is mainly used in developed countries, especially in countries where land is scarce. Incineration is a waste treatment method that uses high temperatures to combust waste. This method is both a treatment and disposal method. During the incineration process, waste materials are converted into gas, heat, emissions and residual ash (Middleton, 2004). The use of incinerators, chemical treatment, physical treatment, immobilization, solidification and encapsulation are some of the methods that are often used for solid waste treatment in the country. However, given the negative environmental impacts associated with incineration processes, this form of waste treatment is discouraged (McLean *et al.,* 2003).

2.7.4 Waste disposal

After the first three priorities of the waste management hierarchy are applied, the final and last option in the hierarchy is waste disposal. Waste disposal is done in various ways, such as the landfill method, incineration, encapsulation and others.

According to El-Fadel *et al*. (1995), landfill sites are historically the most used method for waste disposal in the world. Some activities in the waste management priorities also fall between waste treatment and waste disposal, because they have the potential to treat and also finally deal with waste as a disposal facility (McLean *et al.,* 2003). Despite the challenges facing the country, there has been a remarkable improvement in both regulatory framework and implementation of developmental plans for solid waste management. Disposal of waste by landfill is the most economic way of waste disposal for many developed and developing countries (Middleton, 2004; Kum *et al.,* 2005). Landfill sites continue to be the most convenient method for waste disposal (El-Fadel *et al*., 1995). Numerous developed and developing countries still rely on the landfill method for waste disposal since approximately, 95 per cent of the world's solid waste is disposed of through the landfills (El-Fadel *et al*., 1995).

In Africa, most solid waste is disposed of indiscriminately and in an environmentally unacceptable manner through open or controlled dumps. The ultimate goal for waste disposal by landfill is to separate disposal of hazardous and non-hazardous materials, and to construct clean and properly sited landfills with diligent management, including leachate and methane management, during operation and after closure. When these conditions are met, the landfill becomes a sanitary landfill.

2.8 CONCLUSION

The review of relevant literature on waste management shows that it is not only a technical problem for the municipalities, but that it involves other aspects, such as the social, political, economical considerations and others. In the review of legislation, it was highlighted that the disposal of waste is a listed legally regulated activity in terms of South African law. This implies that the undertaking of this activity by any person or an organ of state is prohibited, unless authorized by the Minister through the Environmental Impact Assessment regulations. There is sound evidence available from waste management studies involving different approaches or new technologies of minimizing waste and the conversion of waste material to useful resources.

CHAPTER 3

DEMARCATION OF THE STUDY AREA

3.1 MPUMALANGA PROVINCE

The Mpumalanga Province (as illustrated on *Figure 3.1*), meaning "*place of the rising sun",* lies in the northern eastern region of South Africa (Mpumalanga DACE, 2003:1). The capital of the Province is Nelspruit, which is located 450 km east of Johannesburg. The Province occupies 6.5 per cent of the total surface of the Republic of South Africa and has a population of approximately 3 million people (Mpumalanga DACE, 2003:1).

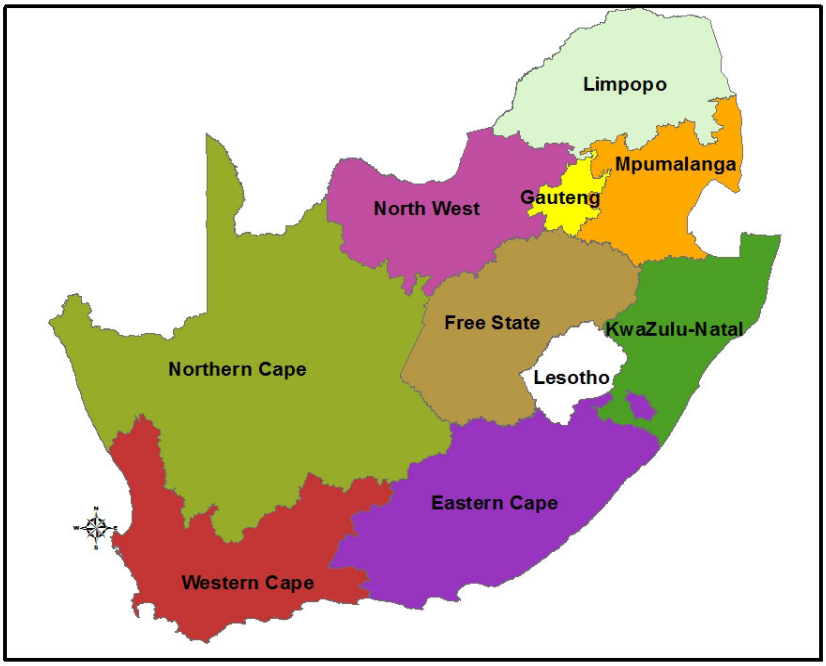

Figure 3.1: **South African provinces**

(Constitution Act 108 of 1996)

The population is dominated largely by siSwati- and isiNdebele-speaking people, although language groups of Xitsonga, seSotho, isiZulu, Afrikaans and English are also prominent in the province (Mpumalanga DACE, 2003:1). The province is divided into three districts, namely Ehlanzeni, Nkangala and Gert Sibande. The study was conducted in one of the seven local municipalities in the Gert Sibande District Municipality (GSDM). The district municipality is located on the eastern Highveld of the province, bordering the KwaZulu-Natal Province, Gauteng Province, Free State Province and Swaziland. The district has a total of 25 landfill sites, yet in all seven local municipalities only two of the landfill sites are licensed. Presently, there are plans to develop four regional landfill sites for the district (Mpumalanga DACE, 2003).

3.2 ALBERT LUTHULI MUNICIPALITY

Albert Luthuli Municipality as part of the Gert Sibande district comprises of the towns of Carolina, Badplaas, Elukwatini, Ekulindeni and eMpuluzi (*Figure 3.2*). The main town in Albert Luthuli Municipality is Carolina, which hosts the municipal headquarters. The municipal area consists of the following: 42 settlements, which have been categorized into 22 wards. The area stretches from Diepdale and Ekulindeni along the Swaziland border. It also borders South Africa in the east towards Hendrina and to the west from Nooitgedatch and Vygeboom dams in the north to Warburton in the south. Three provincial routes, namely R33, R36 and R38 pass through this area.

The municipal land occupies an area of about 557 279 hectors. Albert Luthuli is predominately rural in the degree of functional specialisation, with small scale socio-economic activities. There are numerous development-related concentrations scattered across the region that can be categorized into five sub-regions namely, Carolina/Silobela, Elukwatini, eMpuluzi, Ekulindeni and

Tjakastad/Badplaas (Albert Luthuli Municipality, 2006). Approximately 80 per cent of the total area is used for agriculture with limited fragmented human settlements scattered throughout the region (Mpumalanga DALA, 2006).

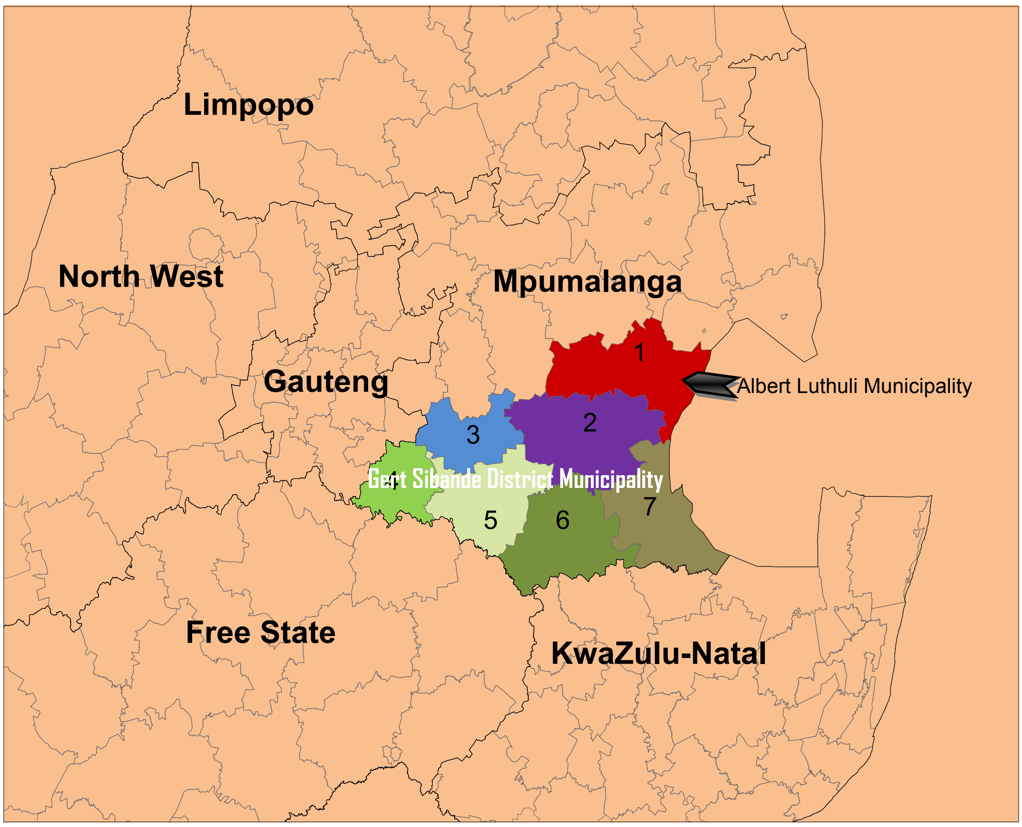

Figure 3.2: **Location of the district and local municipalities**

3.2.1 Demographic status

The Municipality has a population of 187 936 based on the 2001 census, which constitutes 98.2 per cent Africans, 0.2 per cent Coloureds, 0.1 per cent Indians and 1, 5 per cent Whites (Albert Luthuli Municipality, 2006: 9).

The gender balance of the population is represented by 54 per cent females and 46 per cent males, while approximately 98.5 per cent of the population is from previously disadvantaged groups (Albert Luthuli Municipality, 2006). At present, approximately 61.4 per cent of the inhabitants of the municipal area are living below the reconstructive development program (RDP) standard of sanitation, with the exception of Carolina, part of Badplaas, Elukwatini and Mayflower (Albert Luthuli Municipality, 2006). The socio economic data reflecting employment, employment per economic sector, annual income and per capita income are presented in Figure *3.3* and *Table 3.1*.

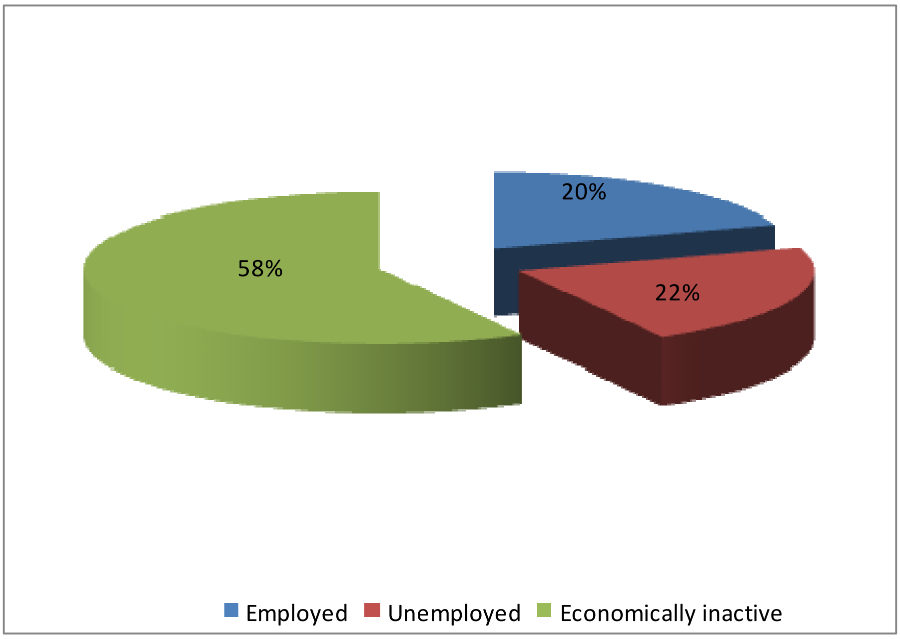

***Figure 3.3*: Economic activities for the communities**
(Albert Luthuli Municipality, 2006: 33)

Table 3.1: Annual incomes

Income	Households	
	Households	*%*
None	12 357	30.0
R1 – 4 800	6 352	15.4
R4 801 – 9 600	10 132	24.6
R9 601 – 19 200	5 998	14.6
R19 201 – 38 400	3 268	7.9
R38 401 – 76 800	1 795	4.4
R76 801 – 153 600	770	1.9
R153 601 – 307 200	257	0.6
R307 201 – 614 400	75	0.2
R614 401 – 1 228 800	51	0.1
R1 228 801 – 2 457 600	93	0.2
Over R2 457 600	38	0.1
TOTAL	**41 186**	**100**

(Taken from Albert Luthuli Municipality, 2006: 33)

3.2.2 Environmental features

The Albert Luthuli municipal area spans the eastern part of Mpumalanga within the Highveld, Lowveld and eastern region. It has a sub-tropical climate with hot summers and mild to cold winters. The average daily temperature in summer is 24°C, while in winter the average day temperature is 14.8°C (Mpumalanga DACE, 2003). The average rainfall is 767 mm per annum, with approximately 10 times more rainfall in summer than in winter. The rainfall increases from West to East from as little as 600 mm to more than 1600 mm annually (Mpumalanga Province DALA, 2006).

A total area of 5600 km^2 is covered by grass land with patches of forest in the lower lying areas. Bodies of water cover 2 968.3 ha, wetlands 555.7 ha, the urban or residential area is 5 900.7 ha, mines and quarries cover 183.7ha and the remainder is utilized for other activities (*Plates 3.1, 3.2, 3.3*).

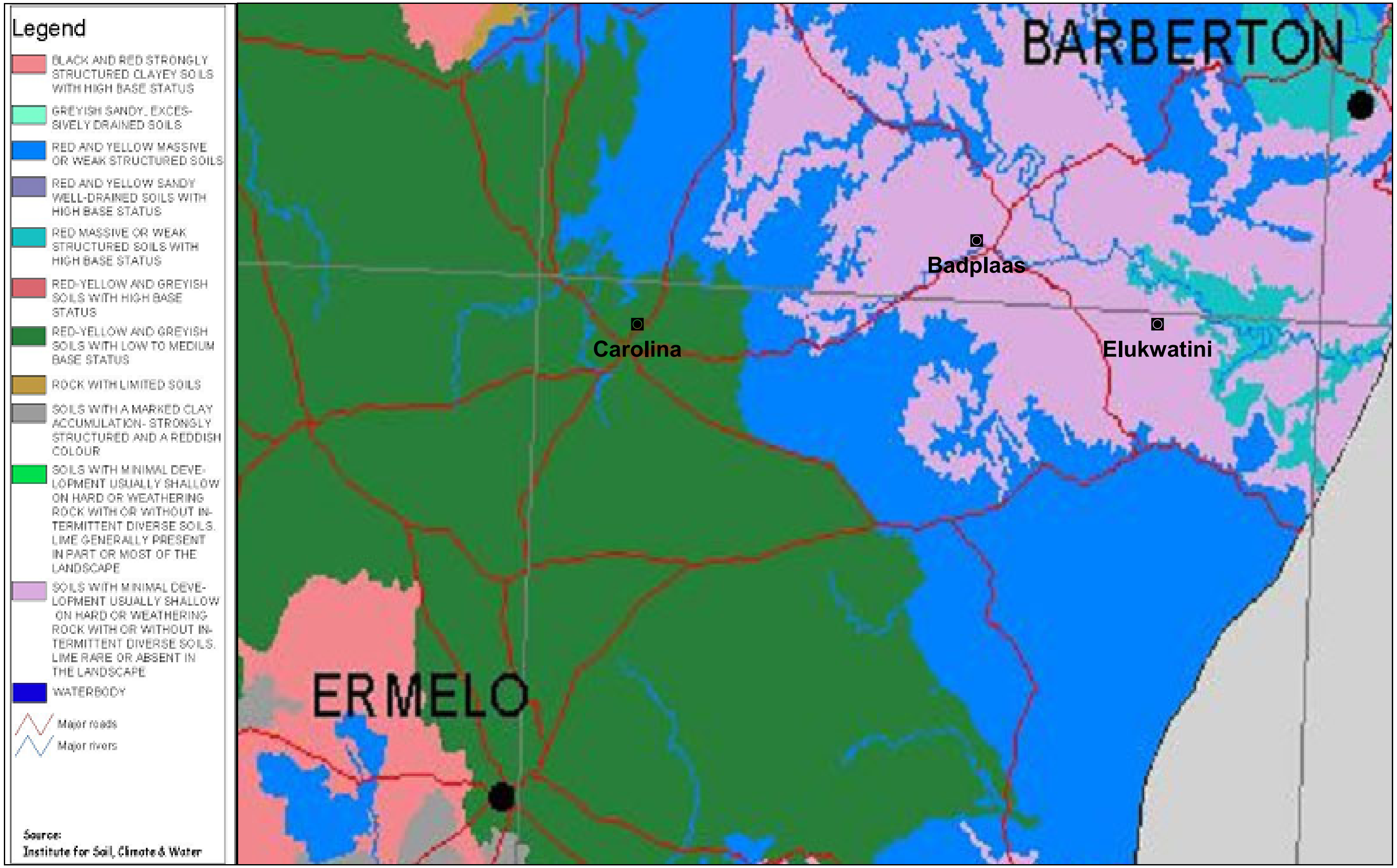

***Plate 3.1*: Soil types**
(Adapted from the Institute of Geo-Science, 2007: 13)

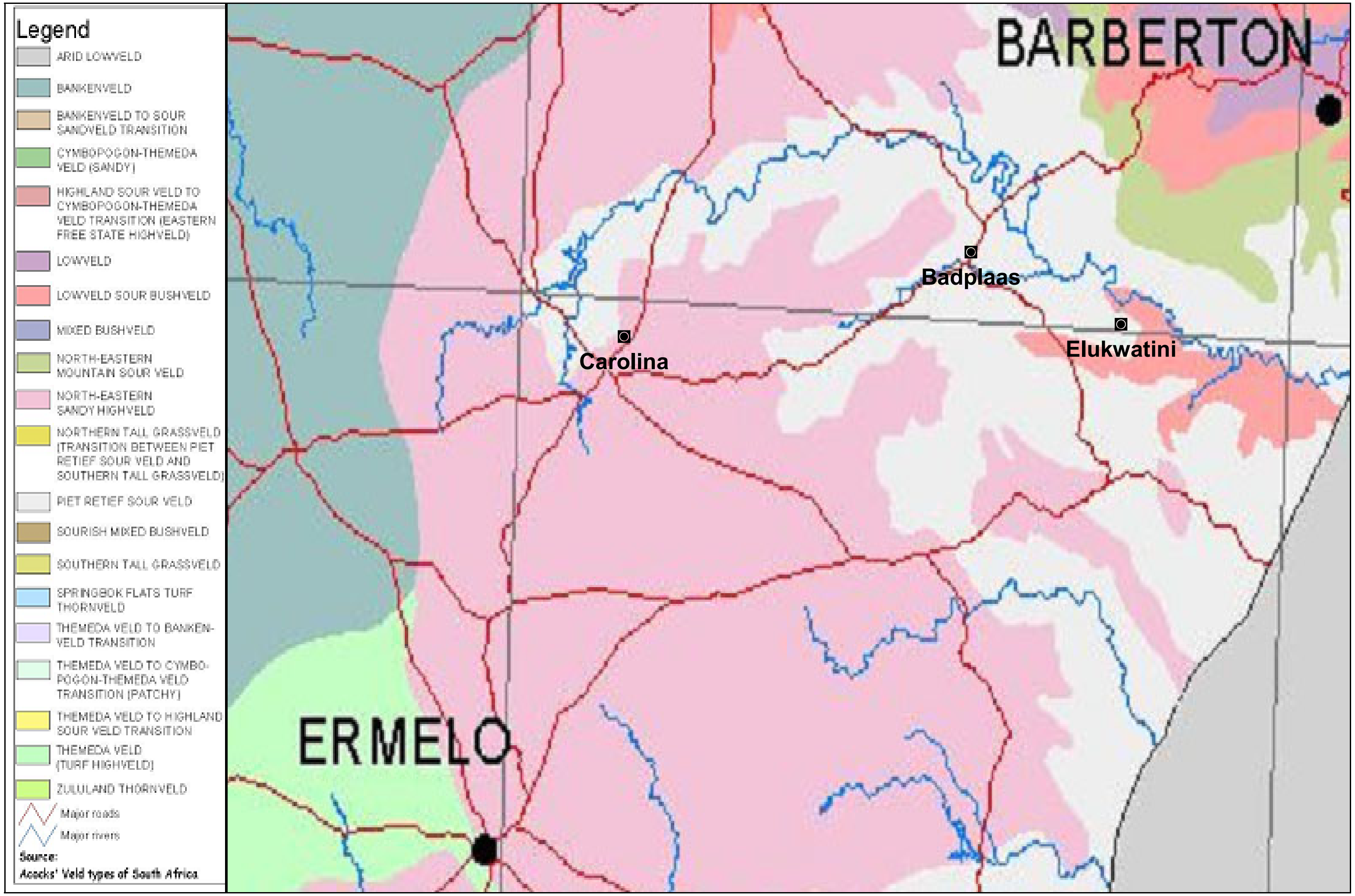

Plate 3.2: **Vegetation type**
(Adapted from the Institute of Geo-Science, 2007: 13)

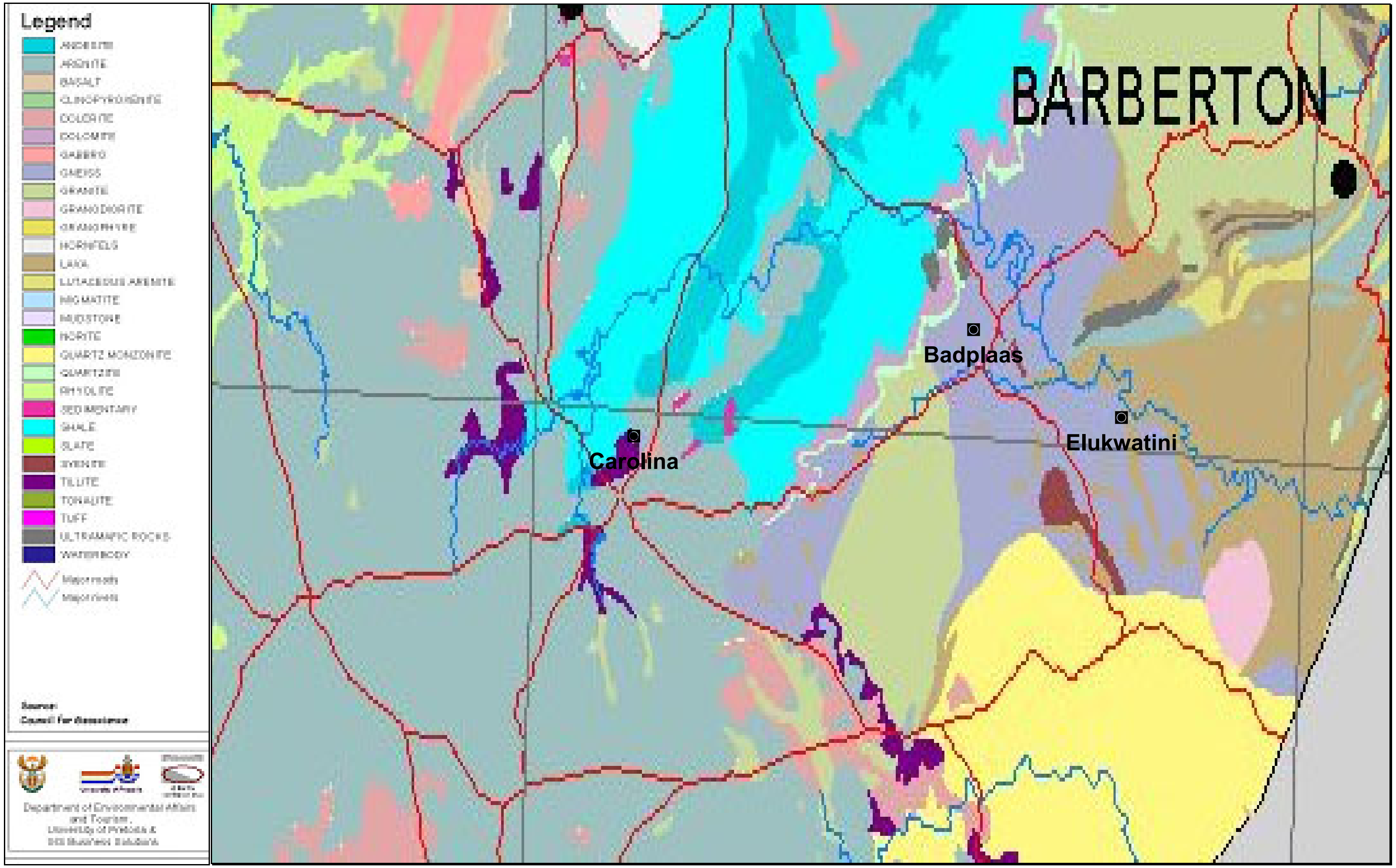

Plate 3.3: **Geology map**
(Adapted from the Institute of Geo-Science, 2007: 14)

3.2.3 Water supply

The Albert Luthuli Municipality has provided communities in the deep rural areas with 180 boreholes, while several bulk water supply schemes exist at different localities. The Department of Water Affairs and Forestry currently own the existing water supply schemes, with the exception of the Carolina treatment plant. The following are the water supply schemes that exist in the municipal area:

- Elukwatini water scheme supplies water to Elukwatini, Nhlazatshe, Mooiplaas, Arnhemburg and Avontuur with its catchment area downstream from the Badplaas old and new landfill sites, as well as the private landfill sites of the Badplaas Aventura Hotel;
- Badplaas water scheme supplies Badplaas with its catchment area upstream;
- eMpuluzi water scheme supplies Izindonga, Dumbarton, Mayflower, Glenmore, Dundonald 1 and 2, Zwallusnest, Bettysgoed and Robbins dale.
- Ekulindeni supply scheme supplies water to Ekulindeni/Kromdraai, Moddergat, Rossville, Steynsdorp, Vlakplaas, Kalwerskraal, Kranskop, Maanhaar, Nhlaba and Ngonini. Ekulindeni water supply scheme also fetches its water at about 4km downstream of Elukwatini landfill site and 8km of the Badplaas landfill sites.
- Carolina water scheme supplies the town of Carolina, Silobela Township and Caro Park.

3.2.4 State of three landfill sites

3.2.4.1 Badplaas township/landfill site

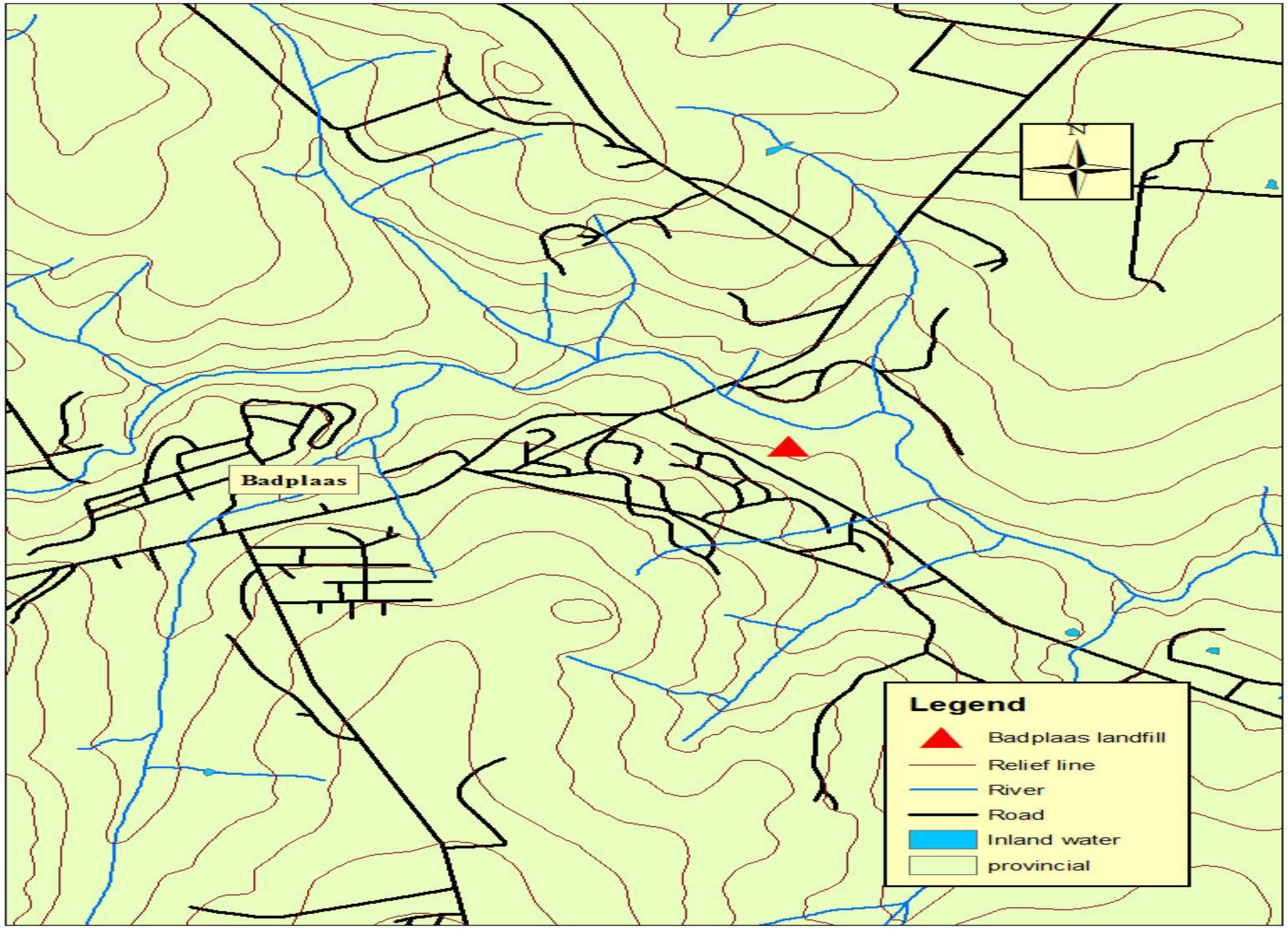

Figure 3.4: **Map of the Badplaas Township**
(Institute of Geo-Science, 2007: 15)

Asbestos structures were found disposed at the new landfill site established in October 2005. As is evident in *Plate 5.1*, reclaimers or scavengers are without proper protective equipment. They are in direct contact with broken asbestos structures. The landfill site is located adjacent to Nkomati River, which is approximately 100 m from the landfill site and flows to Elukwatini. Nkomati River is also bordered by a private landfill site, which belongs to Badplaas Aventura Hotel. The Badplaas landfill site is not permitted, nor fenced, nor lined, no leachate collection system is in place and there is no access control. The old Badplaas landfill site was closed two weeks after this study was initiated. It was closed without proper rehabilitation and no closure plan or permit was issued. The old Badplaas landfill site was not originally made for waste disposal, but was a borrow pit. It was located approximately 10m from households, adjacent to and opposite the New Badplaas clinic, Manzana cultural village and 100m from the Badplaas Aventura Hotel. The same landfill site, located within a wetland, was not fenced, with no gas or leachate collection systems, no covering of refuse after disposal and many more challenges. Even though the site is now closed, there is no monitoring or auditing. The type of waste buried in the landfill site is not well known.

It is evident, according to the details in *Figure 3.4,* that at the new Badplaas landfill site, electronic waste is within a distance of approximately 100m from the residential areas. During site visits, it was established that material recovery is done throughout the day at all times, seven days a week. However, the lack of personal protective clothing is a challenge at all landfill sites. In the new landfill site, the Municipality is applying a trench method for waste disposal.

3.2.4.2 Carolina landfill site

The Carolina landfill site is located approximately 100m from the residents of Caro Park (*Fig. 3.5*). Smoke is visible in the air and the prevailing wind blows in the direction of the residents of Caro Park.

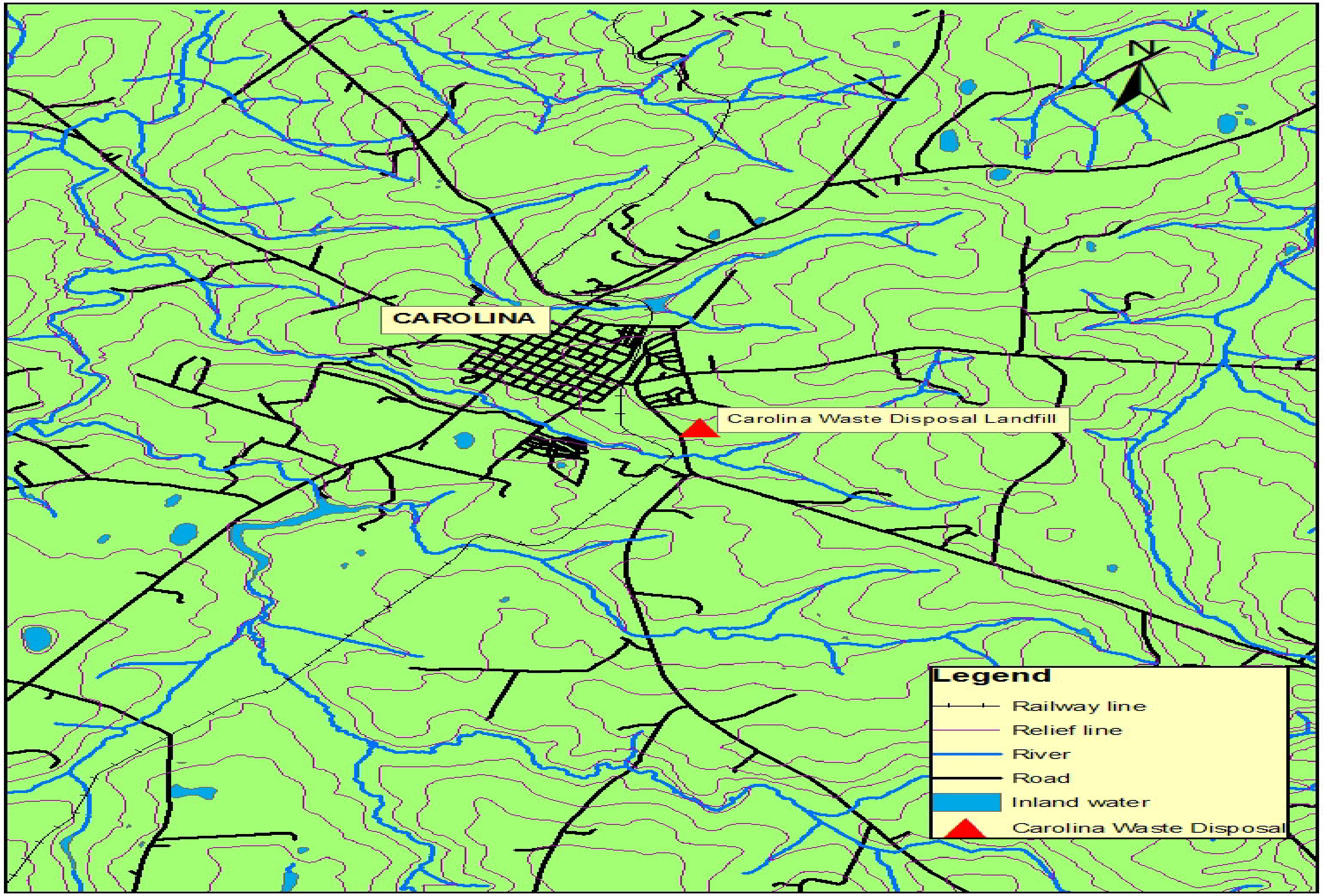

***Figure 3.5*: Map of the Carolina Township**

(Institute of Geo-Science, 2007: 15)

3.2.4.3 Elukwatini township

The *Figure 3.6*, illustrates the activities that are undertaken at Elukwatini landfill site and the state of the landfill site. Elukwatini landfill site is not fenced, there is no access control, nor is a gas or leachate collection system in place and it is located ±500m from the catchment and drainage area of Nkomati River. Elukwatini landfill site is located in an ideal position, away from residential areas, with a buffer zone and it is not close to bodies of water.

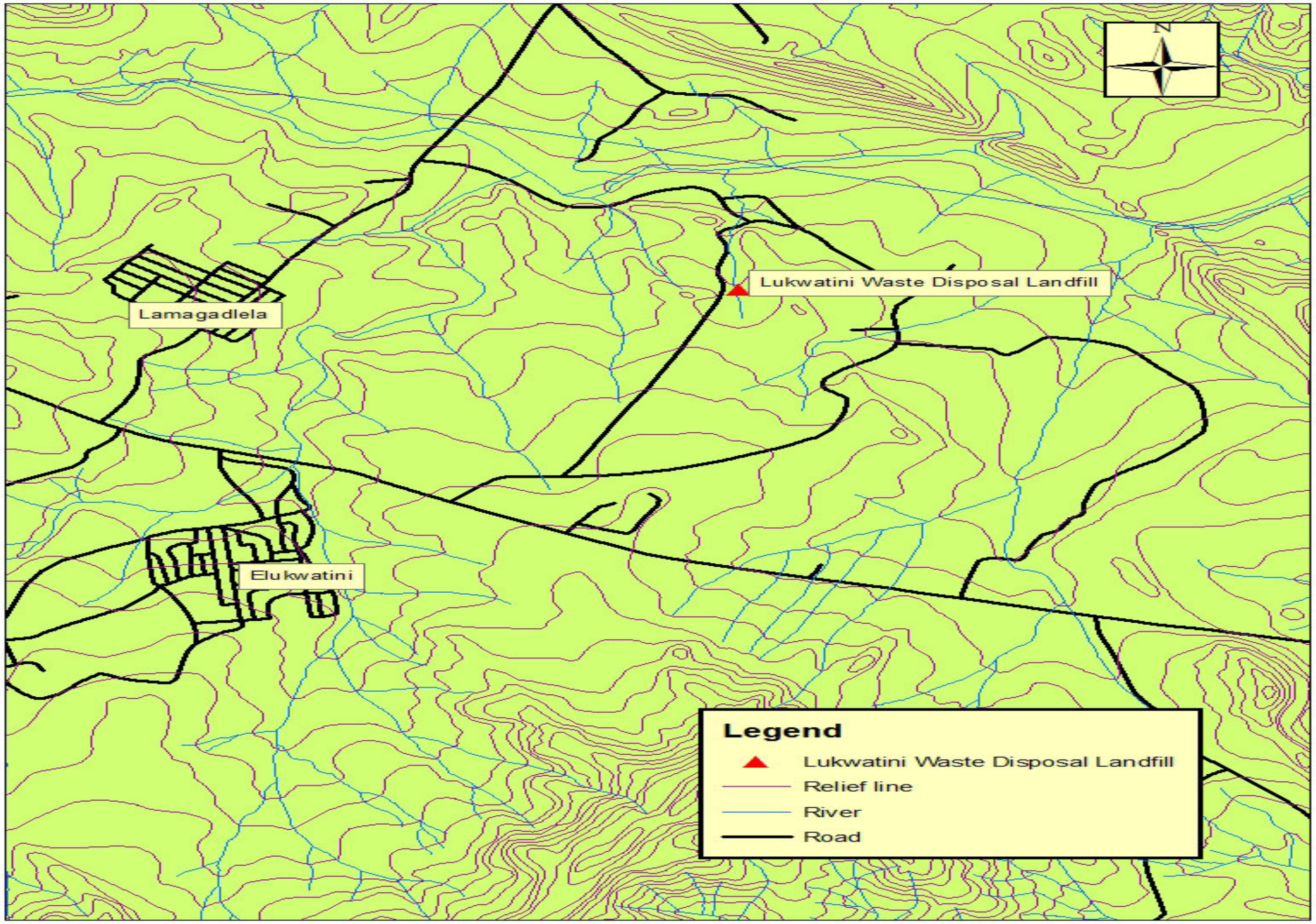

***Figure 3.6*: Map of Elukwatini Township**

(Institute of Geo-Science, 2007: 15)

3.4 CONCLUSION

This chapter has described the demographics of the Municipality, its location within South Africa, Mpumalanga Province as well as the Gert Sibande District Municipality. Details of the size of the area, population dynamics, the locations of the three landfill sites, affected rivers and communities have been provided. Furthermore, significant environmental features of the area have also been highlighted.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

This study aimed to investigate the solid and hazardous waste disposal trends and the associated environmental risks in the Albert Luthuli Municipality. In order for the study to achieve set objectives, a triangulated research design was followed. A triangulated research design is a concurrent combination of qualitative and quantitative research designs (White, 2003). According to Babbie (1998) the motivation for the use of this research design is to enable the study to provide multidimensional perspectives about the research phenomena in question. The qualitative aspect of the design attempted to holistically examine the environmental and health risks associated with unregulated landfills. The methods used for primary data collection involved site visits with the purpose of gathering data by means of observation, photos and landfill analysis forms. The purpose was to capture the base-line state of unregulated landfills, environmental degradation and the associated environmental risks (Nissim *et al.*, 2005). The quantitative aspects of the research design focused more on the specific aspects of the research problem. It is descriptive in nature; hence it attempted to provide further insights about the research problem, mainly in respect of toxicity assessment, exposure assessment and risk characterisation. In this study surveys were used to investigate the existing and potential risks that are associated with unregulated landfill sites. This methodology was also used by Mutuki *et al.* (1997) to investigate solid waste management challenges in Tanzania.

However, in the current study, primary data was collected through site analysis forms and questionnaires. Biophysical data on water quality aspects was obtained from the Municipality. The information was used to draw inferences about the inherent environmental and health risks. In particular, a stratified random sampling technique was used to select participants or respondents from the total population group (*see* figure 4.1). A total of 400 questionnaires were administered to participants (Huysamen, 1998). The research was purely non-experimental and descriptive in nature. The primary goal was to examine the prevailing environmental conditions, practices, attitudes, as well as processes and impacts related to the unregulated landfills in the Municipality (Nachmias *et al.,* 1992).

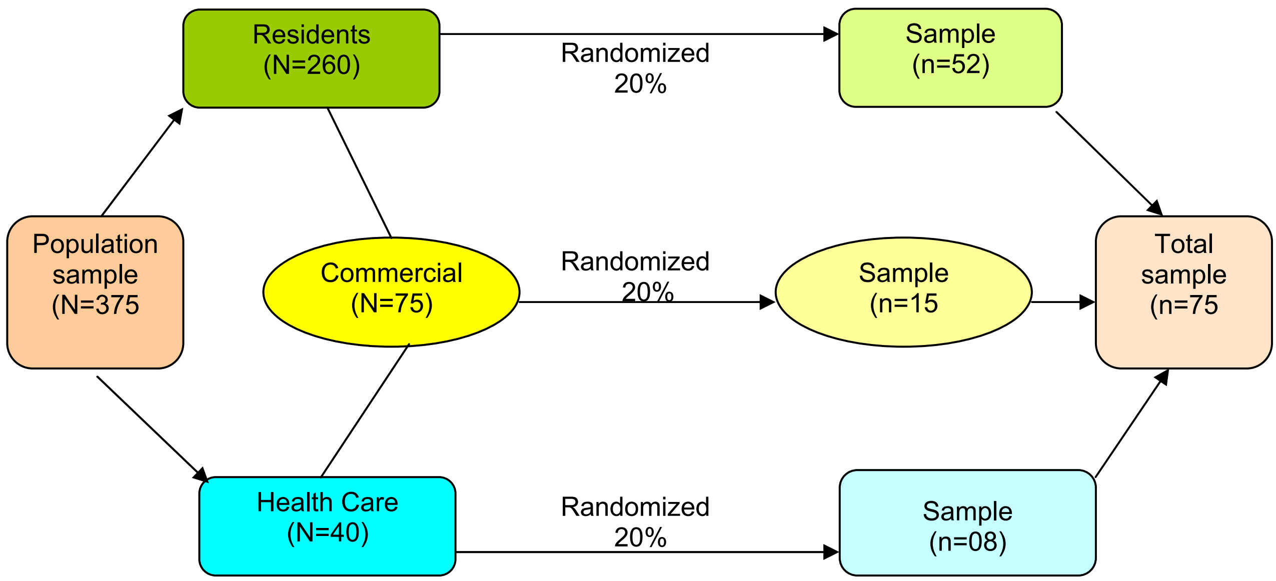

Figure 4.1: **Stratified random sampling plan**
(Adapted from White, 2003:5

In order to adequately address the set study objectives, the methods used are outlined below.

4.1.1 Research method for Objective 1:

The purpose with this method was to identify different sources of waste materials entering unregulated landfills of the municipality. In Annexure A and B, the data collection tools used are presented which, amongst other things, required the following information:

- The types of waste generated by the local communities,
- The waste materials collected by the Municipality,
- Whether or not all waste collected by the Municipality is disposed at the landfills under the study,

- Whether waste materials are sorted into general or hazardous,
- Whether waste generated from hazardous waste producing institutions was collected by the Municipality and/or not,
- Whether the hazardous generating institutions disposed their waste at the municipal landfills.

4.1.2 Research method for Objective 2:

The purpose with this method was to classify and evaluate the types of waste that are disposed in the landfills. To achieve this goal, three groups of participants were classified into hazardous or general waste producing institutions according to the industrial group list approved by the Department of Water Affairs and Forestry (Table 4.1 & 4.2). This list classifies the type, category and hazard rating of all waste produced by different industries.

Table 4.1: Industrial groups

Industrial group	Industrial process
A: Agriculture, Forestry & Food Production	• Agricultural, plant and animal production as well as forest management, fisheries and manufacturing of animal feed
B: Mineral Extraction & Upgrading	• Quarrying of metallic and non-metallic minerals
C: Energy	• Gas works, coking, petroleum and production of electricity
D: Metal manufacturer	• Ferrous and non –ferrous metallurgy • Foundry, metal working operations, metal finishing and electroplating
E: Manufacture of Non Metal Mineral Products	• Construction materials, ceramics, glass, salt recovery and refining • Asbestos goods and abrasive products
F: Chemical & Related Industries	• Petrochemicals, feed stock and production of inks, varnish, paint & glue • Fabrication of photographic products • Production of pharmaceuticals and cosmetics • Rubber & plastic materials • Production of explosives and propellants • Production of Biocides • Waste & water treatment • Analytical, biochemical and chemical laboratories
G: Metal Goods, Engineering & Vehicle Industries	• Mechanical, electronic & electrical engineering • Manufacture of motor vehicles & parts
H: Textile, Leather & Wood Industries	• Textile, clothing & footwear industry • Hide & leather industry • Timber, wood & furniture industry
J: Manufacture of Paper Products, Printing & Publishing	• Paper & cardboard Industry • Printing, publishing & photographic laboratories
K: Medical, Sanitary & Other Health Services	• Health, hospitals, medical centres & laboratories • Veterinary services
L: Commercial & Personal Services	• Laundries, dyers & dry cleaners • Domestic services & cosmetic institutions

(Adapted from DWAF, 1998a)

Table 4.2: Hazardous substance classes

Class	Description
Class 1	• Explosives
Class 2	• Gases: compressed, liquefied or dissolved under pressure.
2.1	• Flammable gases
2.2	• Non-flammable gases
2.3	• Poisonous gases
Class 3	• Flammable liquids
3.1	• Low flashpoint group of liquids, flashpoint below – 18°C
3.2	• Intermediate flashpoint group of liquids, flashpoint of – 18°C up to, but not including 23°C c.c.
3.3	• High flashpoint group of liquids flashpoint of 23°C up to, do including, 61°C c.c.
Class 4	• Flammable solids or substances
4.1	• Flammable solids
4.2	• Flammable solids liable to spontaneous combustion
4.3	• Flammable solids, which emit flammable gases when in contact with water.
Class 5	• Oxidizing Substances
5.1	• Oxidizing agents
5.2	• Organic peroxides
Class 6	• Poisonous (toxic) and infectious substances
6.1	• Toxic substances
6.2	• Infectious substances
Class 7	• Radioactive substances
Class 8	• Corrosive
Class 9	• Other miscellaneous substances, that is any other substance which experience has shown, or may show, to be of such dangerous character that the provision of this Section should apply to it.

(Adapted from DWAF, 1998a)

4.1.3 Research method for Objective 3:

The purpose in this instance was to identify different exposure pathways related to the waste hazards, which were identified in research objective 1. Furthermore, the following issues were addressed:

- The landfill designs, location, leachate and gas management, as well as the proximity of the landfills to water bodies, communities and sensitive environmental resources,
- The landfill operation such as waste sorting, pre-treatment of waste, scavenging, waste burning, presence of explosives in the waste stream, and
- Possibilities of environmental and human exposure through inhalation, ingestion, contact/skin and/or non-dietary digestion.

4.1.4 Research method for Objective 4:

The goal was to characterize and quantify the environmental risks associated with the current disposal practices. The outcomes of the previous three methods are used to synthesize possible environmental risks to the natural environment and to human health. This is done by combining:

- identified sources of hazardous waste entering the landfills,
- possible exposure routes,
- public perception about the landfills, and
- possible environmental and health risks associated with the existing hazards and exposure routes.

4.2 DATA COLLECTION

Two data collection tools were used for the study namely; a questionnaire and a site analysis form (Annexure A & B). The tools were designed taking into consideration the "*Minimum Requirements for Waste Disposal by Landfill"* (DWAF, 1998b). In the study, only one participant was selected in each sampled waste generating institution. Data collectors were environmental officers, who were responsible for the completion of site analysis form during each visit to site landfills. In this manner every landfill was visited and assessed at least three times per year.

The same team collected data by means of a questionnaire and site analysis form. A questionnaire was given only to a participant in charge of a waste generating institution, which was sampled to participate in the study, such as chief executive officers, directors, managers, or their delegates. In the case of residents, only participants aged 18 and above were allowed to participate. Participation was limited to participants residing within the area of study (Albert Luthuli Municipality, 2006).

4.3 DATA ANALYSIS

The results were descriptively analysed. The descriptive analysis helped to reduce the large amount of data or numbers and also to easily draw conclusions using numbers. The analysis involved the use of frequency distribution of scores converted to percentages (White, 2003). At the end, all the replies to questions were grouped into three risk assessment components namely, toxicity assessment, exposure assessment, and risk characterisation.

4.4 RISK ASSESSMENT

Risk is the likelihood that an adverse outcome can occur. Thus, risk assessment is a process that seeks to evaluate the risk levels posed by the landfills to the environment and human health and then compare them with acceptable or tolerable risk levels. It is also called an organized quantitative or qualitative process of ascertaining risk levels and evaluating risk tolerability (Butt & Oduyemi, 2003). Risk assessment is also viewed as a scientific quantification or qualification of risk from data and understanding the processes involved. It is a process that gathers all relevant information and identifies substances that are hazardous to health or the environment (Butt & Oduyemi, 2003).

Consequently, the data was converted into risk assessment scores for quantitative calculation of the inherent risk. According to DEAT (2002b), it is advisable to integrate all three types of risk assessment when conducting a risk assessment study in order to obtain comprehensive results. Such types of risk assessment are namely:

- *Baseline risk assessment* is the first type of risk assessment to be conducted in a facility that focuses on assessing risk in relation to a specific landfill.
- *Issue based risk assessment* is a risk assessment that is focused on a specific issue or activity within the operation of a landfill.
- *Continuous risk assessment* is the most important day-to-day function of management to continuously assess the risks associated with the daily operations of the landfills.

From this observation, it was also taken into account that risk assessment is a minimum requirement for waste disposal sites, hence certain requirements for conducting risk assessment on the landfills had to be followed. In the study, three risk assessment components are used as illustrated through Figure 4.2 (DWAF, 1998c).

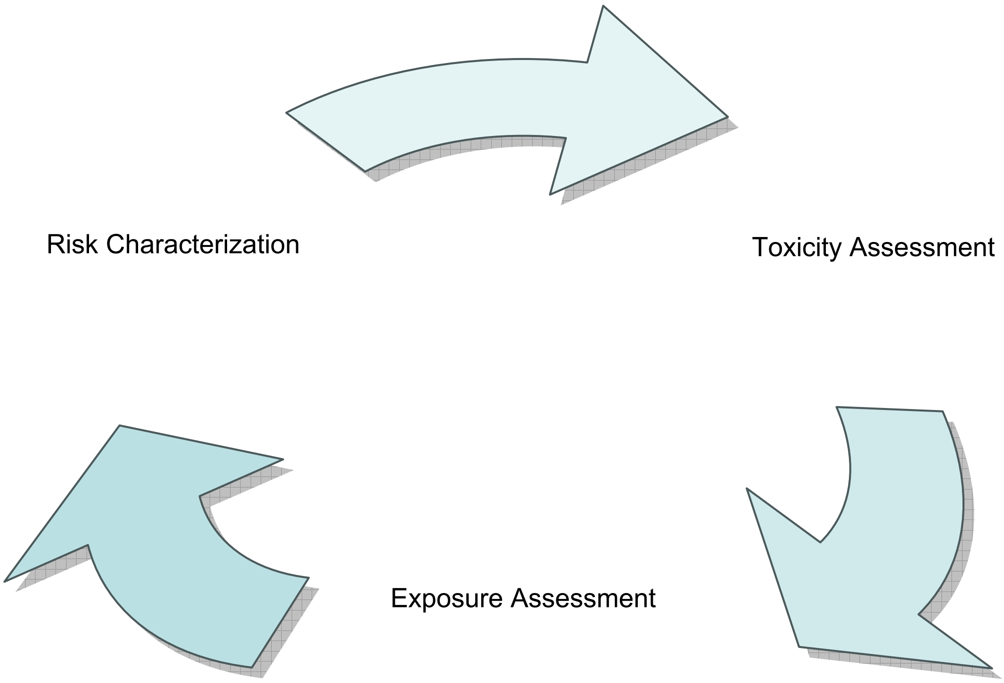

Figure 4.2: Risk assessment model
(Adapted from Butt & Oduyemi, 2003: 15)

4.4.1 Toxicity assessment (TA)

Toxicity assessment is the first step of risk assessment, which integrates hazard identification (HI) and dose-response assessment (DA). It concerns the agent or hazard and its adverse effects and the correlation of the dose and the response thereof.

It uses various kinds of studies, such as epidemiological, biological, physiological and toxicological, to identify and assess hazards. It also establishes the relationship between the dose and the extent of an adverse response quantitatively (Paustenbach, 2000).

4.4.2 Exposure assessment (EA)

The focus of this EA component is to establish the existing and anticipated exposures, exposure pathways and levels of the identified hazards towards environmental and human health (De Rosa *et al.,* 1997). This stage often involves epidemiological, biological, physiological and toxicological studies. Exposure assessment is a key component of risk assessment and is also an area of many uncertainties, mainly due to the dynamics involved such as, the exposure rate, duration of exposure, contact agent, location of the agent, its exact availability and other factors (De Rosa *et al.,* 1997).

In human beings, exposure to toxins occur through three major routes namely, inhalation (respiratory system), dermal (integumentary system) and oral (digestive system). Adding to the three major exposure routes, there are two methods of measuring exposure, which also play a critical role during exposure assessment exercise (direct & indirect). These methods involve physiologically based pharmacokinetic (PB-PK) modelling and environmental sampling (Paustenbach, 2000; De Rosa *et al.,* 1997). The two methods differ in that the direct measurement method (DMM) focuses on measuring the concentration of substances by taking a specimen or sample from the environment or human body, while an indirect measurement method (IMM) measures the concentration of an agent outside the human body (ambient concentration of substances). It further assumes that ambient substances are readily available for absorption into the environment.

Although there are different advantages and disadvantages of both measurement methods, a combination of both methods was adopted in this study (Schoeman & Schroder, 1994).

4.4.3 Risk characterization (RC)

As alluded to earlier, risk assessment is a process of gathering data and making assumptions to estimate the nature, severity, and likelihood of harm to human health or the environment. Therefore, risk characterization (RC) is the last step of the risk assessment process that summarises all data from the previous steps (De Rosa *et al.,* 1997). It is a stage of risk assessment at which conclusions are drawn based on the strength and weight of evidence about the hazard. This stage relies on the quality of the information about the potency of the effect caused by the hazard, population affected, types of health and environmental effects, the likelihood of exposure and public concerns over the issue in question (Paustenbach, 2000).

Furthermore, risk assessment involves identifying hazards and evaluating the nature and severity of risks. According to De Rosa *et al.* (1997:38) the following aspects are critical when conducting risk assessment:

- Estimate environmental and health problems associated with the status conditions and operations of the local municipal waste disposal sites;
- Estimate and compare the risks associated with upgrading, developing new sites, closure of the existing sites and using the waste sites with the present existing conditions and operational practices;

- Evaluate and compare different techniques, methods and proposals for reducing or eliminating the risk from the condition, operations of the waste facilities and the classes of the waste disposed;

- Identify and select conditions and operations, which are potentially hazardous in the waste facilities;

- Evaluate and set priorities for the management of various environmental and health risks.

The combination of all components of risk assessment, all studies involved, health perceptions and other relevant information are used to establish the extent of risk involved in the study areas (Mehta, 2007). The extent of the risk depends on the severity of harm to the environment, public health and the number of those who are affected by the hazards of the landfill sites. All data gathered from toxicity assessment (TA) and exposure assessment (EA) were combined, analyzed, quantified or qualified, and meanings extracted or contracted (Janis, 2001).

4.5 CONCLUSION

In this chapter, research methods, data collection tools and data analysis and risk assessment models were elucidated. The chapter illustrates the relationship between the rationale of the study, statement of research problem, as well as the aims and objectives. It also explained the research methods used to address each research objective. Furthermore, the three risk assessment components were also discussed and how they are linked to the research objectives. The categories of participants, size of the population, sample size, sample frames and units were also detailed. The next chapter will present research results and findings.

CHAPTER 5

RESEARCH FINDINGS AND DISCUSSION

5.1 INTRODUCTION

Out of the 400 questionnaires administered to respondents, at least 380 were returned. However, out of this total five were not completed accurately. As a result, the final number of questionnaires analysed was 375. In addition, for each of the three landfills, three site analysis forms were completed during the survey, which resulted in the total of nine forms analysed. All responses from the questionnaires and site analysis forms were clustered into two groupings, namely, demographics and risk assessment components. The risk assessment components are (1) toxicity assessment, (2) exposure assessment and (3) risk characterisation. These components as well as the demographics of respondents were analysed by means of descriptive statistics and through tables and figures – an analytical procedure undertaken in other studies of risk assessment (De Rosa, *et al*, 1998; Huysamen, 1998; Paustenbach, 2000; Kassim & Ali, 2005).

5.2 DEMOGRAPHICS

The findings regarding the different demographics in the study areas are depicted in figure 5.1. On this figure it can be seen that there are about seventy five (75) different institutions (including households) that are implicated in the production of the different types of waste materials reaching unregulated landfill sites. These institutions can be divided into three categories, namely, residences, commercial enterprises, and health care facilities. At the Badplaas study area, 87 per cent of the respondents were residential households whilst 13 per cent was comprised of commercial enterprises.

This means that Badplaas had no responses in the category of healthcare facilities. This can be ascribed to the fact that this study area has a very low number (about two) of such facilities, and given the sensitive nature of the topic under consideration it appears that some respondents were not ready to provide the information required. Regarding the demographics prevailing in the Carolina study area, responses from residential households constituted 62 per cent whilst those from commercial enterprises were 34, 5 per cent. The responses from health care facilities were at 3, 5 per cent, slightly higher than at Badplaas. However, the number of health care facilities at Carolina is nearly 10, suggesting the significance of this study area as a source of health and medical-related waste. At the Elukwatini study area, the magnitude of responses from the residential households, commercial enterprises, and health care facilities was 61 per cent, 9 per cent, and 30 per cent, respectively.

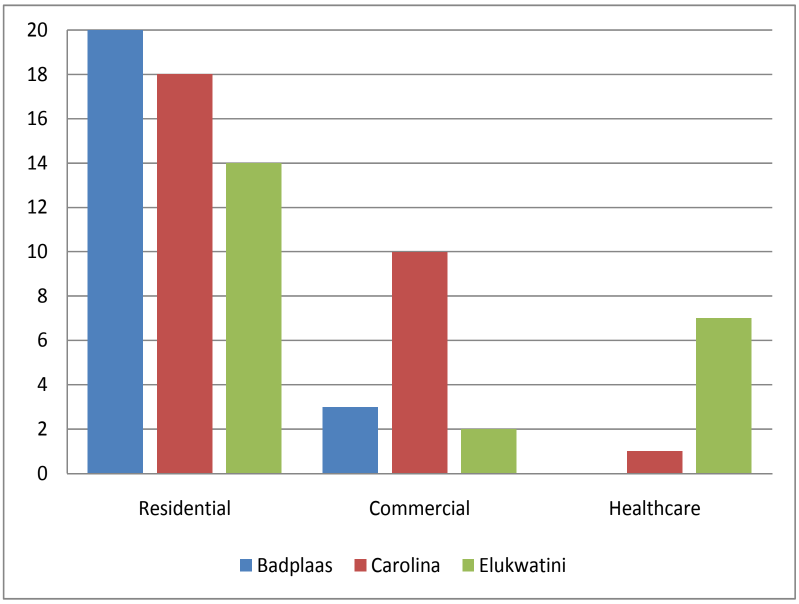

Figure 5.1: **Profile of the number of participants per study area**

Table 5.1: Number of respondents per study area

Landfill sites	Residents	Commercial institutions	Health care institutions	Total
Badplaas	(39%) 20 (87%)	(20%) 3 (13%)	0	23 (30.5%)
Carolina	(35%) 18 (62%)	(67%) 10 (34.5%)	(12.5%) 1 (3.5%)	29 (39.0%)
Elukwatini	(27%) 14 (61%)	(13%) 2 (9%)	87.5%) 7 (30%)	23 (30.5%)

Out of the total respondents who participated in the study, 13 percent of them were head of households, 21 per cent were tenants, and 28 per cent occupied management roles in the different organisations in the vicinity of the study areas. Responses from the youth sector were 38 per cent. These numbers imply that over 72 per cent of responses were obtained from the different households in the study areas. Regarding gender composition, 58 per cent of respondents are women whilst 42 per cent are men.

All the respondents included in the survey have indicated that they do receive waste collection services from the local municipality; although about 40 per cent of them mentioned that the services provided are not regular, thus forcing many to dispose of their own waste. The latter situation appears to be rampant amongst the different industries involved in the selected areas, as well as in the informal settlements. Given that this category of waste is simply dumped in open spaces and without any pre-treatment nor steps to contain the movement of particulates and associated fluids, this poses an environmental threat of various dimensions in the selected study areas.

5.3 RISK ASSESSMENT

5.3.1 Sources of waste material disposed of in unregulated landfills

Observations made during fieldwork and data collected by means of landfill analysis forms have revealed the different sources of the type of waste commonly found at the unregulated landfill sites. Based on the type of waste materials disposed of in the different sites, the following patterns can be highlighted. At the Badplaas landfill site, the largest contributors were residential households and commercial enterprises at 48 per cent and 34 per cent, respectively. Although no responses were received from the health care facilities, there was evidence in the form of discarded needles, bottles, tissues, gloves and plastics which shows that such facilities also contribute to the waste stream in this study area.

At the Carolina landfill site, it was found that the different waste categories emanated from residential households, commercial enterprises and health care facilities in the proportion of 25 per cent, 39 per cent, and 36 per cent, respectively. Thus, commercial enterprises and health care facilities are the largest contributors of waste in the landfills around Carolina. By contrast to the other landfill sites, the biggest sources of waste at Elukwatini are residential households (48 per cent) and health care facilities (34 per cent). Commercial enterprises constitute only 18 per cent of the total waste stream. Figure 5.2 depicts the total proportions of sources of the different waste materials disposed of in the landfill sites. According to this figure, residential households contribute about 41 per cent of the waste materials generated from the local municipality whereas the role of commercial enterprises and health care facilities is nearly the same at 30 per cent and 29 per cent, respectively.

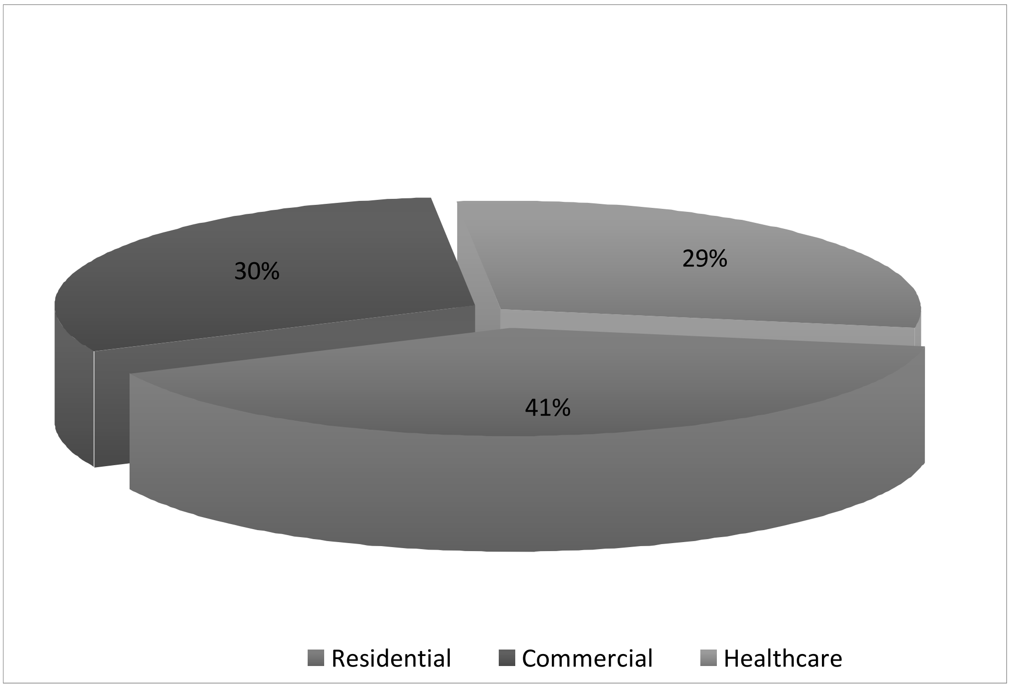

Figure 5.2: **Total proportions of the different sources contributing to the waste stream reaching the unregulated landfill sites.**

5.3.2 Classes and types of waste disposed of in the landfill sites

Given that the mass of waste observed at the disposal sites emanates from various sources, it can be stated that these sites contain both household solid waste and potentially hazardous waste fractions, originating from industries and health care facilities. By definition, the class of waste usually categorised as solid waste, mainly refers to municipal solid waste comprised of food remains; packaging materials in the form of cardboards, tins, and bottles; discarded writing materials and newspapers; plastic bags, clothing, batteries, wooden waste, garden waste, appliances; and a variety of household chemicals, discarded paint; as well as electronic waste (Hill, 2004).

Figure 5.3 shows that households in Badplaas and Elukwatini rank superior (at 48 per cent) in terms of the provenance of waste dumped in their landfill sites, although a larger fraction of this waste could even be deemed as hazardous. In this instance, the most environmentally hazardous items included, amongst other things, asbestos fibres, glasses, batteries, discarded paint, and electronic waste. However, besides this type of municipal solid waste, another type of waste encountered was the potentially 'hazardous' fractions emanating mostly from polluting industries such as abattoirs, agricultural enterprises, fuel stations, and medical facilities in the study areas. In order to summarise the waste categories observed in the study, figure 5.3 shows the relative quantities of each type of waste per each landfill site.

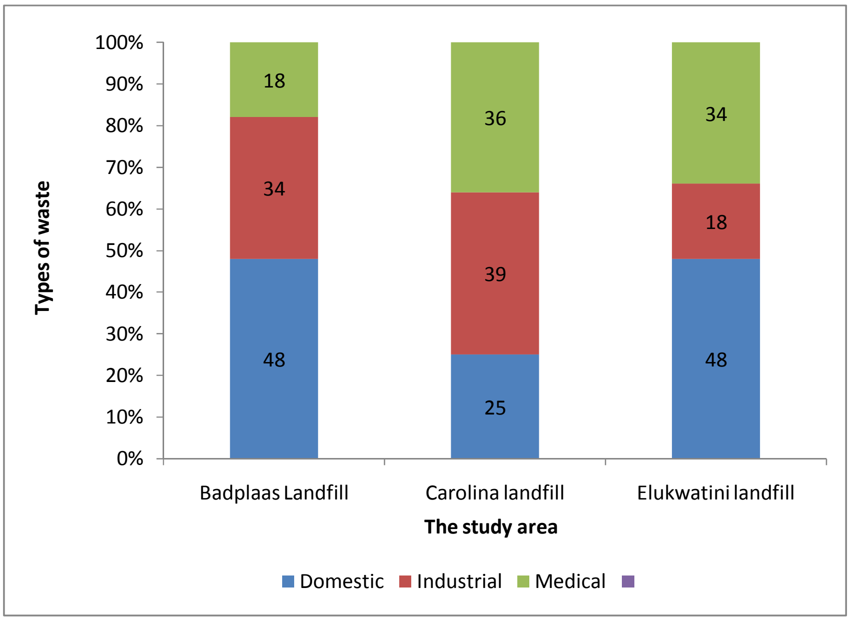

Figure 5.3: **Types of waste disposed of at the municipal landfills**

Based on figure 5.3, Carolina and Elukwatini landfills appear to have high quantities of medical waste. In particular, this waste was comprised of used syringes, leaking blood residues, sharp instruments, gloves, pharmaceutical waste and plastics. However, of major environmental concern is that this waste was discarded without any pre-treatment nor precautionary measures been taken. According to DWAF (1998a), medical waste is classified as toxic and infectious (class 6: hazardous substances). Although it may form a smaller fraction of the total waste load discarded, it is likely to pose danger to humans and livestock around affected sites.

Furthermore, the landfills at Carolina and Badplaas received significant quantities of industrial waste, estimated to be 39 per cent and 34 per cent, respectively. This waste was comprised of the following classes, as deduced from the categories provided by the Hazardous Substances Act (Act 15 of 1973):

- Class 1: Explosives
- Class 2: Gases
- Class 3: Flammable liquids
- Class 4: Flammable solids or substances
- Class 5: Oxidizing substances
- Class 6: Toxic and infectious substances
- Class 7: Radioactive substances
- Class 8: Corrosives
- Class 9: Miscellaneous substances

Even more hazardous, is the fact that these substances provide an environmental setting conducive to the outbreak of sporadic fires and flow of leachate that results from the physical and chemical disintegration of various waste substances. Moreover, when fires break out they generate large quantities of smoke which escape into the surrounding atmosphere and neighbouring informal settlements whilst the unrestricted flow of leachate has potential to contaminate adjacent geological and soil formations as well as surface water bodies and wetlands.

5.3.3 Exposure pathways in and around the landfill sites

Given the types of waste identified in the current research and the contribution made by the different economic sectors towards the local waste streams, some exposure pathways were identified in the affected sites. In general, exposure pathways may occur across different routes from the source of pollution to receptors (Paustenbach (2000). According to Hill (2004), and DEAT (2002a) exposure pathways occur in various forms, including inhalation, dermal contact, oral route, and environmental routes. Furthermore, exposure pathways may also be divided into primary and secondary exposures.

Primary exposure has to do with contamination through direct contact with pollutants. This may occur through the consumption of contaminated water, inhalation of hazardous substances, and skin infections due to air and water-borne irritants.

The natural environment may also be vulnerable to primary exposures due to the release of toxins directly into the soil, atmosphere, and water bodies. In contrast, secondary exposure relates to the indirect effects of environmental contamination. For instance, when livestock ingests contaminated material in the landfill sites, the consumption of such livestock by humans may provide a secondary route of infection.

Regarding the exposure of humans to health-threatening substances in the study areas, three pathways were identified, namely, oral, dermal and respiratory routes:

- Oral route - could be through dietary and non-dietary ingestion. The dietary route refers to ingestion of substances such as food reclaimed by informal pickers in the landfill sites. The non-dietary fraction is comprised of unintentional ingestion of substances due to explosions, contaminated hands and other indirect sources.

- Dermal route – occurs mainly through the skin and may lead to the development of skin problems such as eczema or psoriasis and other complications. This exposure pathway involves direct contact between contaminants and the skin. Furthermore, it may be worsened by injuries sustained around the landfill sites as well as the use of contaminated reclaimed materials. The impacts of these exposure pathways in the selected landfills were manifested by festering wounds, scars and marks of insects bite, observed on the skin of some of the reclaimers.

- Respiratory route – affects neighbouring rural communities and the receiving natural environment through the movement and settling of airborne emissions such as landfill gas, fumes, and particulates. Residents who reside within 200 m of these landfills and informal pickers who visit these sites are at greater environmental risk.

By contrast, environmental contamination arises from point and non-point pathways. In the current study, routes implicated in the dissemination of toxins include emissions into the surrounding airscape and the fall-out of landfill gases as well as the underground flow of leachate. Unrestrained movement of leachate has the potential to contaminate the different layers of the soil, geological strata, ground water bodies, as well as adjacent wetlands. Given the fact that a significant fraction of the inhabitants of rural communities in the study areas rely on the use (44 per cent) of untreated water from local streams and boreholes (4 per cent) (*see* figure 5.4), the environmental impacts of leachate flow can be expected to be greater. Equally disastrous, however, is the fact that the headwaters of most streams located in close proximity to the Badplaas and Carolina landfill site can also be polluted by direct surface wash triggered by rainwater and indirect run-off stemming from problem sites.

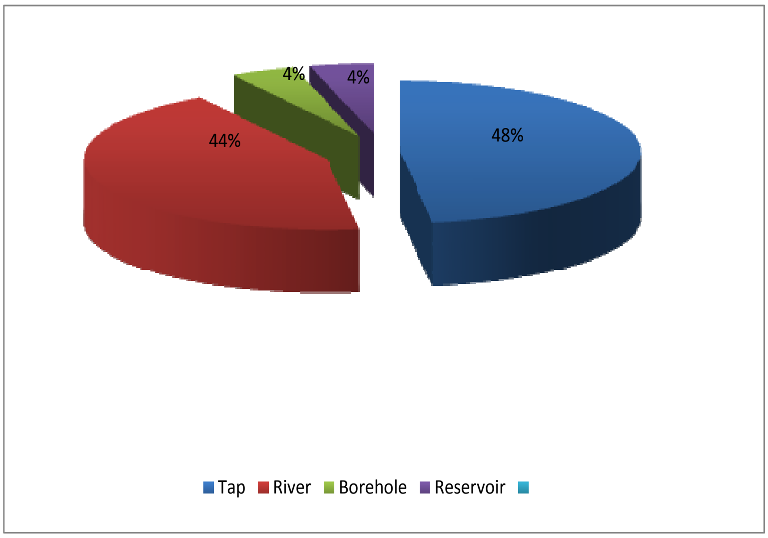

Figure 5.4: **Domestic water supply for the communities**

Furthermore, the analysis of bio-physical data pertaining to water samples obtained from local streams indicates undesirable chemical and microbiological properties. These properties were quantified through measures such as *Escherichia coli* counts and p H levels (see table 5.2). The *Escherichia coli* counts were found to be far above the maximum tolerable limits, and pH values signified an acidic medium. Moreover, the p H value recorded for Carolina site was 3.1, characterising a strongly acidic environment. The danger associated with highly acidic water is that it has the propensity to release heavy metals such as aluminium, copper or iron and is, therefore deemed to be hazardous for human consumption and ecosystem processes (DWAF, 1998c).

Table 5.2: Portability of untreated water samples

Parameter	Maximum limit	Badplaas	Carolina	Elukwatini
Escherichia coli	0-10/100ml	200	11000	320000
pH	6.5 -8.2	4.3	3.1	6.8

5.3.4 Assessment and characterization of the environmental risks associated with unregulated landfill sites

In view of the different sources, classes, and types of waste materials highlighted, as well as exposure pathways in and around unregulated landfill sites, the associated environmental risks were determined for the study.

By definition, environmental risk is the likelihood that the health of receiving communities and the different components of the natural environment may be adversely affected. In other words, the assessment and characterization of risk has to do with determining the severity and extent to which hazardous waste materials can cause harm to human health and the environment (De Rosa *et al*., 1998).

Subsequently, the data analysed in the current study was used to determine frequencies or the number of exposures as well as the percentages characterising the severity of associated environmental impacts. In this section, an attempt has been made to characterise existing environmental risk at unregulated landfill sites. This analysis utilised the information regarding the location of affected human populations, associated health and environmental effects as well as public perceptions, in keeping with related studies conducted by Paustenbach (2000), Mehta (2007), as well as Janis (2001).

In the characterization of the inherent environmental risks, specialist studies suggest the following guidelines (De Rosa *et al*. 1998; Paustenbach, 2000). *Firstly*, the different sources, classes and types of waste materials are identified. In the context of the current study, sources of waste materials that were dumped in the landfills are threefold, namely, residential households, commercial enterprises and healthcare facilities. In addition, the waste materials disposed of in the landfills were categorized into both general waste types and hazardous ones. Moreover, the materials recorded in landfill analysis forms included all the nine hazardous waste classes. According to DWAF (1998a) guidelines, hazardous waste materials are rated, in order of severity, from one to four. In this study, over 65 percent of the materials identified were classed as extremely and highly hazardous to local public health and ecosystem processes.

Secondly, the conditions and operations that are potentially hazardous in the landfill sites are identified (see *for instance* Plate 5.1, 5.2, and 5.3). In the current study, such conditions and operations relate to the careless disposal of potentially hazardous solid waste materials and the lack of landfill liners or geomembranes as well as collection systems to contain the flow of leachate. In addition, the degree of environmental risk is heightened by factors such as lack of access control at landfill sites, the existence of nearly 60 informal waste pickers who collect contaminated food remains and the fact that they wear no protective clothing, and the occurrence of fires, smoke, as well as chemical explosions.

Thirdly, it is imperative to estimate the frequencies related to the different exposure pathways involved (De Rosa *et al*. 1998; Paustenbach, 2000). Accordingly, the occurrences of exposure pathways were calculated through an examination of the number of all instances that have potential to cause environmental hazards per study area. These instances were determined by analysing the data on the completed questionnaires. For instance, at Badplaas, the frequency with which various exposure pathways occurred was found to be 53, implying just how often the public and the environment is susceptible to existing waste-related hazards. At Carolina and Elukwatini, the frequencies of exposure were found to be 58 and 37, respectively. It can be seen that, in order of severity, the landfill sites at Carolina and Badplaas have the highest exposure frequencies.

Plate 5.1: Sporadic fires and other waste materials at Elukwatini landfill

Plate 5.2: Some of the reclaimers at the Badplaas landfill

Plate 5.3: Waste materials dumped at the Carolina landfill

Fourthly, the probabilities for the occurrence of risk are determined. In the current research, risk probability was determined by analysing questionnaire responses which dealt with aspects such as the proximity of residential households and water bodies to landfill sites, the consumption of discarded food by reclaimers, the percentage of respondents relying on water from contaminated streams, the potential for the bio-accumulation of hazardous substances in living organisms as well as along food webs, and the frequency of personal injuries commonly associated with the problem landfill sites. It was found that at Badplaas and Carolina the proportion of respondents affected by existing hazards were 40 per cent and 63 per cent, respectively. At Elukwatini this figure was 45 per cent. These percentages maybe regarded as an indication of the magnitude of the severity of environmental impacts associated with the unregulated landfill sites. According to the guidelines provided by DEAT (2005), environmental risk can be estimated by multiplying the frequency of exposures by the severity of environmental impacts. This relationship or formula is illustrated as follows:

Environmental risk = Frequency of exposures **x** Severity of environmental impacts

Source: Adapted from DEAT (2005:15)

The computations performed based on this formula, have revealed that the environmental risk associated with the three unregulated landfill sites is 2 120, 3 654, and 1 665 for Badplaas, Carolina, and Elukwatini, respectively. Table 5.4 illustrates further, how these calculations were performed whilst table 5.5 shows categories for risk classification (DEAT, 2005: 17).

Based on table 5.5 the scores associated with the individual risks in the respective landfill sites were found to exceed a risk value of 400, which is interpreted to imply very high environmental risky situations. With these high levels of risk, the environmental management decision to be taken involves immediate discontinuation of existing landfill operations in order to reduce the magnitude of public vulnerability and drastic decline in environmental quality and sustainability.

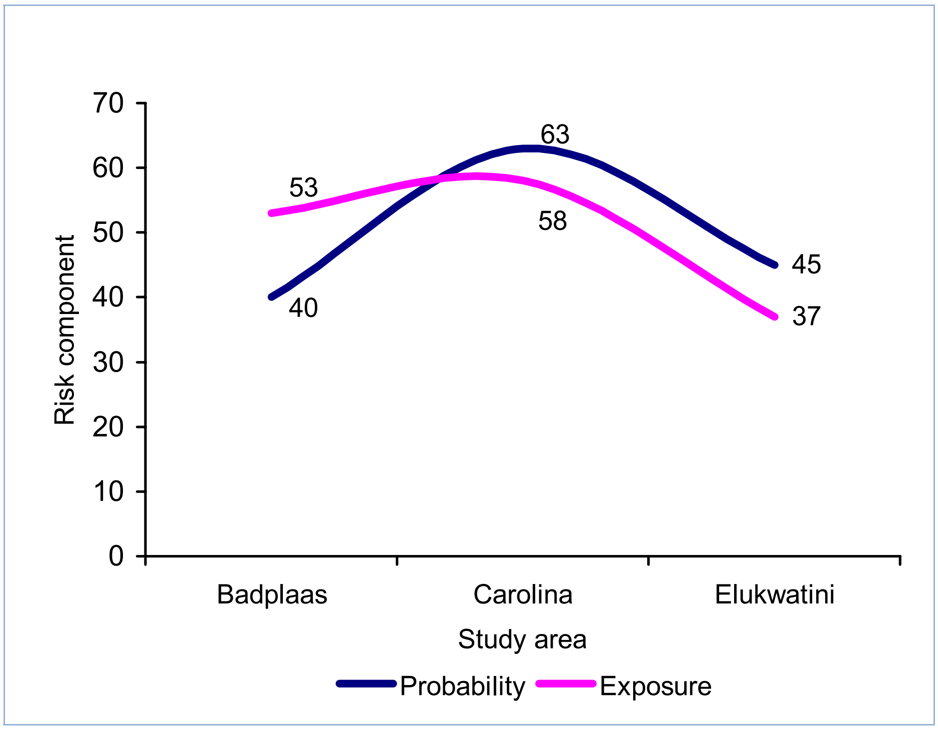

Figure 5.5: **Public perceptions on the probability of the various exposure pathways**

***Table 5.3:* Quantitative risk assessment**

Landfill site	Calculation	Assessment
Badplaas	40 x 53 = 2120	Extreme risk
Carolina	63 x 58 = 3654	Extreme risk
Elukwatini	45 x 37 = 1665	High risk
Formula R = F x S;	R= Risk; F=Frequency or Probability; S= Severity	

Source: Adapted from DEAT (2005:15)

Table 5.4: Risk classification

Risk classification	Risk scores	Environmental management decision
Very high risk	Over 400	Discontinue the operations
High risk	200-400	Immediate corrective action
Substantial risk	70-200	Correction needed
Possible risk	20-70	Attention is needed
Low risk	Under 20	Risk perhaps accepted as is

Source: Adapted from DEAT (2005:15)

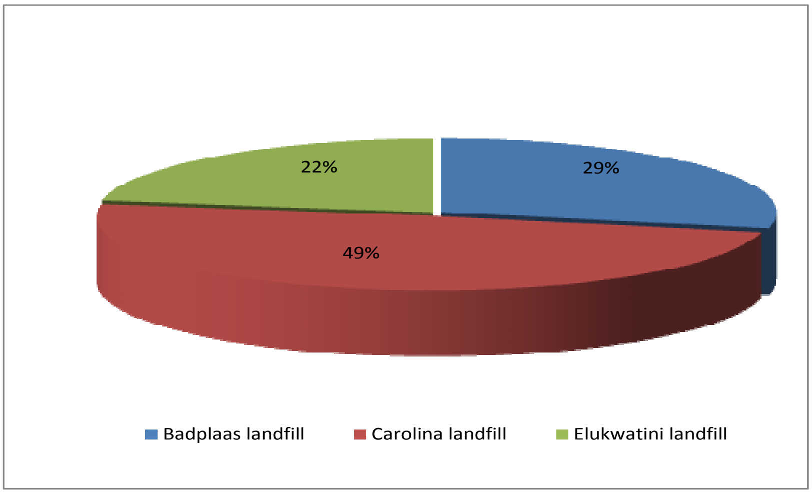

Figure 5.6: **Risk distribution in the landfills of the municipality**

Given the inherent risks determined per landfill site, it can be seen on figure 5.6 that the Carolina landfill site contributes 49 percent of the total health and environmental risk determined at the selected study areas. This high level of risk is possibly accentuated by the fact that this landfill site receives a larger proportion of hazardous waste material from local industries and the fact that the town itself is undergoing rapid commercial and residential growth. This trend is less conspicuous at Elukwatini and Badplaas landfill sites, which have contributed 28 per cent and 22 per cent, respectively, to the total environmental risk (Figure 5.6).

However, the higher risk profile of landfill sites at Elukwatini deserves to be highlighted and it is attributable to the relatively higher number of existing healthcare facilities (see Table 5.1 & Figure 5.1). It can, therefore, be stated that the magnitude of environmental risk in selected study areas is considerably high and it is possibly accentuated by the failure of the current management system of the local municipality to deal effectively with streams of waste from local industries and health care facilities, as well as residential households – despite the plethora of existing environmental legislation (*see* Table 2.2) intended to control and contain waste mismanagement. Consequently, the research hypothesis in the current study – that the uncontrolled and illegal dumping of various forms of waste materials at the unregulated landfill sites in the Albert Luthuli municipality has potential to pose greater environmental risk to neighbouring land-users and the natural environment - is accepted.

Without such a base-line characterisation of environmental risk in the affected areas, the provision and delivery of sustainable waste management services will remain elusive in the foreseeable future for the municipality and affected stakeholders.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUDING REMARKS

The current research has identified and quantified the environmental risks associated with the unregulated landfill sites in the Albert Luthuli municipality, thus contributing to the research pertaining to waste problems in rural areas where disposal facilities often engender environmental nuisances due to poor environmental planning. In all cases examined for the municipality, it has been established that environmental risk is extremely high. Without such risk characterisation, it would be impossible to provide informed perspectives towards the development of an integrated waste management strategy to deal with the problem landfill sites. Chief among the multiple sources of negative environmental impacts in the disposal sites include waste materials such as:

- Broken asbestos structures, electronic cables and toxic waste containers at the Badplaas landfill.
- Healthcare waste in Carolina and Elukwatini and burning fires, with reclaimers picking left overs.
- Different types of industrial waste, including plastics and other discarded containers.

As outlined earlier, the movement of these materials into the biosphere, hydrosphere, atmosphere, geosphere and the human environment, through a myriad of exposure pathways, may lead to unfavourable human illnesses as well as impaired ecosystem processes. The exposure pathways summarised in chapter 5 illustrate the baseline environmental status as well as the unfavourable repercussions arising from substandard and shoddy operational practices unfolding at the problem landfills sites. In view of these ramifications, as well as the magnitude of the environmental risk computed, the current research hypothesis has been accepted

6.2 RECOMMENDATIONS

From an environmental viewpoint, the goal to be achieved in the Albert Luthuli Municipality waste management problematics should to minimise and ultimately eliminate the environmental risks involved. As a result, some guidelines are recommended and they are at three levels or categories.

6.2.1 Priority 1: Strategic issues

Since the Albert Luthuli Municipality does not have its own solid waste management plan, the municipality is advised to adopt the existing integrated waste management plan developed by the district (GSDM, 2006). The adoption of the district IWMP plan will assist in helping the municipality to address key waste management problematic landfill sites in a holistic manner. For instance, in the integrated waste management plan, issues of recycling and reclamation of waste materials from the source, transfer stations and the reduction on the number of landfills are outlined in order to reduce management challenges. However, human and financial resources must be allocated in the integrated development planning because it appears the municipality does not have adequate resources to deal with these challenges. Furthermore, there is a need for the municipality to develop waste management by-laws which must be enforced.

6.2.2 Priority 2: Operational issues

The findings of the study also showed that all landfills in the study areas are not legally commissioned and operated. However, in South Africa, development actions involving the handling, transportation, treatment and disposal of waste materials are classified as scheduled activities which require formal environmental impact assessment (EIA) authorisations and other precautionary measures. The purpose of the EIA is three fold. Firstly, to identify any potentially negative environmental impacts of a development project or programme. The aim being to avoid and reduce all undesirable environmental consequences (Lee & George, 2000). Secondly, to ensure and guarantee that any identified environmental consequences are taken into account during the planning and designing phase. Thirdly, to influence environmental decision making processes throughout the entire project or programme life cycle.

Beyond EIA compliance, a long term environmental management plan (EMP) as well as a monitoring plan are required. An EMP will describe all the appropriate actions that the development proponents must take during the construction and development phase of proposed actions during the implementation, construction, and decommissioning phases. In drawing these plans, a summary of all potentially significant adverse impacts can be obtained directly from the completed EIA report (George, 2000). In addition, the environmental monitoring plan should provide information on aspects such as the following (UNEP, 1996):

- The nature of problems encountered
- Magnitude of impacts

- Their geographical extent
- Time scale
- Probability of occurrence

According to Arts and Nooteboom (1999:1) there are a range of possibilities for monitoring nuisances such as landfill sites and these include measures such as the (1) specification of procedures for handling of the waste, (2) provisions for spillages, (3) maintenance of protection measures and facilities, (4) registration of generated waste and how it is disposed of, and lastly (5) regular registration of material flows in order to curb point and non-point contamination.

The lack of these environmental planning imperatives in the Albert Luthuli Municipality has led, unfortunately, to a situation of extremely high environmental risks to nearby vulnerable populations and the environment. In order to help ameliorate the impacts associated with these higher risks, it is recommended that all the problem landfill sites should be closed immediately. However, given the rapidly accelerating streams of waste from the various areas of the municipality, at least one of these landfill sites can be allowed as an interim measure whilst the other two are regarded as transfer or recycling stations. The Elukwatini landfill site can be left to continue since it is located relatively distant from human settlements and there is also a buffer zone away from possible receptors. This will enable the municipality to only permit one landfill site and manage it effectively. This will in turn help improve legal compliance and reduce permitting constraints as well as operational costs.

6.2.3 Priority 3: General issues

It is equally imperative to recognize the fact that dealing with environmental problematics such as those examined in the current research requires meaningful stakeholder engagement. Stakeholder engagement or public participation is an indispensable phase of environmental planning in South Africa and abroad. Moreover, there are numerous benefits associated with stakeholder engagement, apart from merely communicating the inherent environmental risk associated with the problem landfill sites in the Albert Luthuli Municipality. These benefits include the possibility of affording interested and affected parties an opportunity to know more about local environmental concerns, integrating stakeholder knowledge and views in project planning and implementation, and solving problems and issues at an early stage in order to avoid decelerating project development (George, 2000). Recognition of these benefits by the Albert Luthuli Municipality will prevent conflict with interested and affected stakeholders and will instead promote win-win scenarios.

Furthermore, if the affected communities can be involved meaningfully, legitimate ward waste management councils and recycling forums can be established. This will assist the municipality to reduce waste quantities, formalize recycling and reclamation of waste materials, and improve the environmental conditions of the municipal area. Nevertheless, there is also a need to engage the local business sectors, as there are considerable market and industrial opportunities if some of the waste can be reclaimed through environmentally sound operations.

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ANNEXURE A: SITE ANALYSIS FORM

This tool will be completed by the researcher or the research team and the information collected shall be used only for academic purposes. Anonymity is guaranteed to all participants , according to DWAF, (2001)

To be completed by the researcher or his research team	
1. Name of the waste disposal site	
2. Locality of the waste disposal site	
3. Responsible person/ authority	
4. Certificate of registration/ approval	
5. Date of on which operations commenced	

6. What is the distance from the waste facility to the nearest residential area	
7. What is the distance from the waste facility to the nearest industries	
8. What is the distance from the waste facility to the nearest water bodies	
9. List or mention the names of the nearest facilities in (6,7 & 8)	

10. Is the waste facility located within or close to the following features? (state yes/ no)						
10.1 A drainage area						
10.2 An area with a shallow or visible water table						
10.3 100m of source of surface water						
10.4 1km from a wet land or within a wetland						
11. What type of waste reclamation activities that take place at the waste facility (mark with an ***x***)						
• At source			• No salvaging			
• Recycling installation			• Formal salvaging			
• Contractor			• Informal salvaging			
12. Is the waste disposal site lawfully permitted or registered?						
13. Has risk assessment (RA) or EIA been once conducted on the waste disposal site?						
14. If yes to question 13, give the year and the person/ authority that performed the exercise						
15. Is waste covering done after disposal?					Yes	no

16. If yes, how often?	Daily	Weekly	Monthly	Annually	During decommissioning

17. Is sufficient cover material available	Yes	no
18. Is buffer zone sufficient or provided	Yes	no
19. Is the geographical formation of the underlying site known	Yes	no
20. Was the waste site designed specifically for waste disposal	Yes	no

21. Which of the following substances were identified during the survey or observations?				
• Explosives			• Toxic & infectious substances	
• Gases			• Radioactive substances	
• Flammable solids			• Corrosives	
• Flammable liquids			• Miscellaneous substances	
• Oxidizing/organic peroxides				

22. Indicate the period of most rainfall during the course of the year	Nov-Apr		May-Oct	
23. Indicate the direction of the prevailing wind				
24. Indicate the direction of the nearest residents				
25. Indicate the direction to the nearest industries:				

26. What is the estimated population that is served by the landfills site? (Mark with an ***x)***							
0-499		500-999		10 000-19 9999		200 000^{+}	
27. Indicate the types of waste identified within the landfill site mark with an **x**							
Industrial toxic		Industrial non toxic		Medical/HCW		Insect/pesticides	
House hold refuse		Electronic waste		Garden refuse		Building rubble	

ANNEXURE B: RESEARCH QUESTIONNAIRE

This tool will be completed by various role players as specified in each part, and the information collected shall be used only for academic purposes. Anonymity is guaranteed to all participants, according to DWAF, (2001)

To be completed by the respondents from one of the three strata selected										
1. Locality/ township										
2. Type of an institution										
3. Total population (family)										
4. Capacity of the respondent										
5. Gender of the respondent										
6. Age range of respondent	18-25		26-33		34-41		42-49		50+	
7. What type of services or operations is performed in your institution?	Health care		Veterinary services							
	Industry		House hold/residential							
	Laboratory		Other (specify) :							
8. What type of waste items are produced in your institution or household?										

9. Indicate you answer to the following statements by filling Yes or No on the appropriate spaces	
10. Does the municipality collect waste from your residence?	
11. Does the municipality collect waste from your industries?	
12. Does the municipality collect waste from your health care institutions?	
13. According to your knowledge, does the municipality collect waste from the nearest hospitals, clinics or mortuaries?	
14. According to your knowledge, does the municipality collect waste from the nearest industries?	
15. What type of water supply is used by you/your local community?	
16. Reticulated/ tap water supplied by the municipality	
17. Spring/river waster	
18. Bore hole	
19. Tankers/reservoirs	
20. Combination of various waster sources	
21. Do you know or have heard of any person injured at the dumping site?	
If yes, what type of problem/injury:	
List the composition or items that form part of waste generated in your institution	
What is the situation of waste management in your local municipal area or township?	
What improvements would you recommend for your local area/municipality/dumping sites?	
Give any waste related information that you feel it can contribute to this study …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… ……………………………………………………………………………………………	