# “An Assessment of Waste Management Practices in South Africa: A Case Study of Mariannhill Landfill Site, eThekwini Municipality”


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# Declaration

**Submitted in partial fulfilment of the requirements for the Masters degree of Town and Regional Planning, in the Graduate Programme in the School of Architecture, Planning and Housing, University of KwaZulu-Natal, South Africa.**

**I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. I confirm that an external editor was used and that my Supervisor was informed of the identity and details of my editor. It is being submitted for the degree of Masters Town and Regional Planning in the Faculty of Humanities, Development and Social Science, University of KwaZulu-Natal, South Africa. None of the present work has been submitted previously for any degree or examination in any other University.**

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# Abstract

A number of environmental, social and economic problems are associated with waste disposal in landfill operations. The potential hazards associated with landfill operations are numerous and include fatal accidents, infrastructure damage, pollution of the local environment, harmful air emissions, to simple nuisance problems – such as dust, odour, vermin, and noise pollution. Further challenges include the availability of land and lack of municipal or other financing in the face of rising operation costs.

Landfilling is, however, seen by many as an environmentally responsible and cost-effective solution to waste disposal. It is acknowledged however to lead to waste of resources by burying valuable materials that could have been reutilized. Careful engineering can resolve this shortcoming, yet the associated challenges and costs can become prohibitive. The regulatory environment also affects the prospects for adopting this approach to landfill site management in different contexts.

The Mariannhill landfill site in eThekwini Municipality, South Africa, provides an opportunity to investigate both the range of challenges which these type of sites encounter, and the solutions which have been developed as a response. The central questions which this research seeks to answer are whether the practices adopted by the Mariannhill landfill site are replicable in other solid waste landfills around eThekwini and whether it can be viewed as an example of best practice in landfill site management more generally.

The research finds that the main barrier to easy replication of systems followed at Mariannhill in other landfill sites is the difficulty in replicating the specific structures and character of management. Another key determining factor found is the prevailing attitudes to recycling and the environment in general in the society. Consumers choices are seen to be critical to the prospects for recycling of solid waste, including the size, degradability and recyclable potential of products purchased.

In considering the potential for replication of the Mariannhill model as an example of best practice, it becomes clear that the technical aspects of operations at Mariannhill are the most easily replicable, yet other and equally important determinants of success are not easily replicable. These include the existing regulatory environment and prevailing societal attitudes towards recycling.

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# Abbreviations & Acronyms

| | |
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| CDM | Clean Development Mechanism |
| CER | Certified Emissions Reductions |
| $CH_4$ | Methane gas (refer to GHG) |
| $CO_2$ | Carbon Dioxide (refer to GHG) |
| CSW | Cleansing and Solid Waste unit (within DSW) |
| DAEA | Department of Agriculture and Environmental Affairs |
| DEAT | Department of Environmental Affairs and Tourism |
| DMOSS | Durban Metropolitan Open Space System |
| DNA | Designated National Authority (for CDM projects) |
| DSW | Durban Solid Waste (renamed: eThekwini Department of Cleansing and Solid Waste) |
| DWAF | Department of Water Affairs and Forestry |
| EIA | Environmental Impact Assessment |
| GHG | Green House Gas emissions |
| HFC's | Hydrofluorocarbons (refer to GHG) |
| IDP | Integrated Development Plan |
| IPC | Integrated Pollution Control |
| IWMP | Integrated Waste Management Plan |
| Kv | Kilovolt |
| KZN | KwaZulu-Natal |
| LFG | Landfill Gas |
| MW | Mega Watt |
| $N_2O$ | Nitrous Oxide (refer to GHG) |
| PCF | Prototype Carbon Fund |
| PPP | Polluter Pays Principle / Public Private Partnership |
| PRUNIT | Plant and Rescue Unit |
| UKZN | University of KwaZulu – Natal |
| WB | World Bank |
| WSSD | World Summit on Sustainable Development 2002 |

# Chapter One: Case Study and Research Questions

## 1.1 Research Problem, Objectives and Questions

Waste management is a vastly challenging problem, most acutely felt in the rapidly growing urban centres of developing countries. Prevailing production and consumption patterns result in waste that can harm human health and the general environment (SIDA, 2006). Waste disposal also gives rise to allocation issues when it comes to sharing the burden of disposal and the associated environmental, social and economic externalities. In the context of these challenges, authorities have had to provide innovative solutions and adequate management systems in order to lessen the environmental, health and safety hazards associated with waste disposal.

This research seeks to investigate the challenges associated with waste disposal in an urban and rapidly developing context, here the eThekwini municipality in the province of KwaZulu-Natal, South Africa. The Mariannhill Landfill Site is chosen as an example of a waste disposal site which encounters many of the challenges common to solid waste sites globally. The eThekwini municipality provides an opportunity to investigate the approaches adopted as a response to these urgent and challenging circumstances. The Mariannhill Landfill Site is generally viewed as a successfully managed landfill which employs various effective systems, including a "closed-loop" system designed to minimise loss of recyclable materials and release of harmful gases.

Through this study, the practices adopted at the Mariannhill Landfill Site will be assessed in the context of challenges faced and expectations brought to bear on site management from relevant regulations and societal expectations and subsequently assessing whether it is replicable in other solid waste landfilling contexts around eThekwini. The research questions will be interpreted through the theoretical and conceptual lens of environmentally sustainable development as sustainability is seen as a good indicator of management competency and innovation towards greater efficiency and responsibility in landfilling operations.

The Key Questions which this research seeks to answer are:

**Key Question 1)** What determines sustainability of practices undertaken at Mariannhill Landfill Site? Sustainability of site practices is to be determined by the following sub-questions;

- What are operational objectives of the site within a municipal context?
- How environmentally sustainable is the site?
- How economically sustainable is the site?
- What is the role for management and innovation in achievement of site objectives?

**Key Question 2)** Are the approaches undertaken at Mariannhill Landfill replicable in other settings? This is investigated through the following sub-questions:

- Can practices followed at Mariannhill Landfill be considered as examples of best practice?
- What are some of the barriers to replication of site activities in other solid waste landfills in eThekwini?

## 1.2 Methodology

### Approach and Method of Analysis

The research seeks to place the Mariannhill Landfill Site case study within a relevant international, national and municipal framework of environmental conventions and regulations in order to define the expectations brought to bear on the site and relative success of their achievement. The range of established international, national and municipal environmental standards, technical approaches, and models of best practice are similarly analysed in order to assess the case and its replicability.

A qualitative approach was used for the research design. Qualitative data collection is defined as: “if the purpose of the study is primarily to describe a situation, phenomenon, problem or

event, the information is gathered through the use of variables measured on nominal or ordinal scales" (Kumar, 1999: 10).

The interview candidates were selected via a purposive sampling method which falls under the broader umbrella of non-probability sample designs (Nachmias; et al, 1982: 299). Non-probability sampling designs are used when "a population cannot be defined because of factors such as a non-available list of the population" (Nachmias; et al, 1982: 299). The selection or sampling process was dependent upon the availability and willingness of respondents to participate in the study. According to Neuman (1997: 206) purposive or judgmental sampling may be defined as follows: "Purposive sampling is an acceptable kind of sampling for special institutions. It uses the judgment of an expert in selecting cases or it selects with a specific purpose in mind. […] the researcher never knows whether the cases selected represent the population". When sampling, "a researcher gets a set case, or a sample, from sampling that is more manageable and cost-effective to work with than the pool of all cases" (Neuman, 1997: 201).

Ten in-depth individual, open- and closed-ended, structured, qualitative interviews were conducted face-to-face with respondents. The respondents represented a mixture of those with expertise in the relevant areas of inquiry. The interviews were often longer than planned due to the vast amount of information provided. In 70% of the interviews, comment was given on every single question even if the technical answer was not known by the respondent. The privacy of sensitive information was respected at all times and respondents were not forced to answer questions they were not at liberty to answer. Interviews were transcribed, with findings analyzed and synthesized. During the reporting process and steps that followed, it became clear that the in-depth qualitative approach chosen was best suited to this largely social science assessment of a very technical and scientific process. The personal bias of the respondents' answers occasionally proved hard to deconstruct without challenging the views or arguments of other respondents.

It must be noted though that there was a general consistency in understanding of the technical and other substantive issues which should create confidence in the validity of responses generally. In analysis of the content of interviews, no specific method was used except for identifying trends and themes that best answered the research questions, with the most accuracy, effectiveness and background understanding that added more depth to the research. Data collected was hence analyzed for patterns in the hope of explaining, expanding upon, supporting or opposing already established theories or assumptions.

## 1.3 Key Concepts

For the purposes of this research, it is important to define the following concepts: waste management; sustainability; environmental management; and what is seen as best practice.

**Waste Management**

Hester & Harrison (2002: 2; 3) argue that municipal solid waste (MSW) management in terms of options at the international level may be defined as follows: "[Including] waste arising from private households to that collected by or on behalf of local authorities from any source. MSW therefore includes a proportion of commercial and non-hazardous industrial waste".

**Sustainability**

Sustainability may be defined as "[involving] the role of current and future generations to achieve a decent standard of living for all people within the constraints and limits of a natural system" (Berke & Conroy, 2000: 22). Greene (2001: 392) further explains the root of sustainability within the concept of sustainable development:

> The concept of "sustainable development" was crystallized and popularized in the 1987 report of the UN World Commission on Environment and Development (the Brundtland Commission), which drew upon long established lines of thought that had developed substantially over the previous 20 years. The Brundtland

> Commission's shorthand characterization of "sustainable development" is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

**Environmental Management**

Environmental management incorporates many elements of sustainability, in particular in terms of the emphasis placed on minimizing waste generation. A typical definition of environmental management is "All efforts closely related to or influencing manufacturing that also reduce chemical loss or waste generation" (Overcash; et al, 1997: 1299). Most definitions of environmental management involve an approach towards cleaner technologies in a specific process, such as the landfilling process. If a process can be understood as involving a series of chemical and energy inputs. At certain locations, some materials may begin to diverge from the specific sequence and will ultimately become wastes. Overcash et al (1997: 1299) explain how these nodes (not often known precisely), where loss first occurs, offer the maximum potential for pollution prevention or the adoption of cleaner technology. That is, there are three general prevention principles that can be invoked at these loss nodes: (1) keep the chemicals and materials in the main manufacturing process; (2) establish a recycle mechanism to improve the overall use; and (3) use as a by-product. This definition provides an explanation of how sustainability is a by-product of the management of environmental factors.

**Best Practice**

According to Allison & Behn, cited in Hannah (1995: 217) the approach to defining "effective practice" or best practice is as follows:

> If you want to develop a theory about effective practice you have to understand a lot of observations of effective practice. If you really want to know the best way to lead an organization to the top of sand dunes, you have to observe a lot of organizational efforts to climb sand dunes. And then you have to cull out the commonalities of success – at least of particular kinds of success in particular

conditions –and attempt to develop a theoretical framework to explain such limited and conditional successes.

It is difficult to establish what constitutes best practice in the particular context studied, as it is a specific case. However, success factors of the Mariannhill Site can be ascertained through assessing the achievement of specific objectives. The case study is located within a particular geographic and social context – the eThekwini municipality in KwaZulu-Natal – and as such the definition of best practice must take on the context-specific requirements brought to bear on the activity of landfill waste disposal. In the South African context, the Department of Environmental Affairs and Tourism (DEAT) maintains that "good practice" is contingent on achieving the 3R's in the national waste hierarchy: Re-duce; Re-use; and Re-cycle. These objectives include the following:

- promoting measures towards establishing a concrete material-cycle society;
- promoting appropriate treatment and waste reduction; and
- aiming to create a regulatory environment;
- providing poverty relief and job creation;
- encouraging consumers to adopt "green purchasing" and "eco-labelling";
- promoting further research and technological development towards improving the 3R's; and lastly
- creating an establishment for the prevention of illegal trans-boundary movement of hazardous wastes within the African network – both on land and out at sea (Mvuma, 2005).

There is a suggested fourth "R" in the waste hierarchy: "Re-pair", viewed as part of the new "Zero Waste" initiative in solid waste management of particularly electronic waste ("e-waste") (Guidelines On Recycling Of Solid Waste, 2005: 5).

The example of waste disposal in Curitiba, Brazil provides an international model against which to further assess the success of the Mariannhill Landfill Site in fulfilling its intended roles. Curitiba is generally accepted as an example of best practice in a setting not dissimilar from that which prevails in the eThekwini municipality.

## 1.4 Case Study

Mariannhill Landfill was opened in July 1997 as a "New Generation" landfill[1]. The site is an operating large landfill, registered as class "G:L:B+" (general large site), accepting approximately 850 tonnes of municipal solid waste daily (Jewaskiewitz, 2007: 7). The site is part-owned by the eThekwini Municipality and Durban Solid Waste (DSW), itself a semi-public company. Site management has significant autonomy in control over daily site operations, and is free to supplement funding from municipal structures with outside sources of financing, and operation improvements in efficiency and other measures (refer to Figure 1 below).

**Figure 1: Mariannhill Landfill Site**

(Source: http://www.resource-india.net/CivilEngNov2007.pdf)

The site's gas extraction scheme produces 170m$^3$/hr landfill gas. The scheme was partially funded by the Carbon Fund, a World Bank fund intended to capacitate the Kyoto Protocol

[1] A "Next Generation" landfill includes a combination of the following processes: an Anaerobic Bioreactor, Aerobic-Anaerobic Bioreactor and a Facultative Bioreactor – all of which are operating at the Mariannhill Landfill, such as the Sequential Bach Reactor. Mariannhill's "Next Generation" status is further enhanced by projects such as the generation of electricity from methane gas extracted via gas wells in the ground (Wienand, 2007).

(Strachan; et al, noted in Strachan; et al, 2004). The site further comprises of various activities, including waste-sorting and picking, recycling, recovery of used landfill as forested and re-vegetated areas, and also landfilling itself. The site is covered in more detail in Chapter Three.

## 1.5 Conclusion

No single definition exists for the concepts of waste management, environmental management, sustainability, and best practice. However, the practices adopted at the Mariannhill Landfill Site serve as a model for investigating how these various concepts related to waste management are brought to bear in a specific case and context. Assessment of the site relies on the concept of sustainability applied to waste and environmental management. This in turn allows for an assessment of best practice in landfill site activities.

# Chapter Two: Literature Review

The key objectives of this research are to interrogate the environmental and economic sustainability of Mariannhill Landfill Site's waste management practices, and to understand how the Mariannhill example may be replicated in other eThekwini municipal landfills. This chapter examines the literature applicable to sustainability, environmental management; and overall solid waste management. International, national and municipal environmental and waste regulation is also examined to ascertain the regulatory framework within which the site operates. The city of Curitiba in Brazil is presented as an example of successful waste management in a setting with some similarities to eThekwini. The elements of this theoretical and conceptual lens are here presented in detail.

## 2.1 The Origins of Environmental Regulation

Gorman (1999) argues that residents of the more affluent societies of North America and Europe began, in the 1960s, to place more value on clean water and air than their predecessors had. Attention began to be directed to the quality of the environment due to rising pollution of rivers and the air, urban smog, contamination of food, and a rapid increase in waste production (Gorman, 1999: 34). The relative lack of environmental regulatory mechanisms at that time meant that little could be done to prevent these issues from worsening, and efforts were made to forge a new guiding ethic for regulation based on environmental values. Such an ethic began to emerge in the 1970s, evidenced by a new raft of regulations and an accompanying set of environmental institutions such as the United States Environmental Protection Agency (EPA) which began its operation in 1970 (Gorman, 1999: 35). The publication of " The Limits to Growth" in 1972 by the "Club of Rome", an informal organisation of "scientists, educators, economists, humanists and industrialists" was a highly influential account of the pollution problem which helped to advance the debate over human impacts on the environment (Meadows et al, 1972). This organisation had as its objective to examine the "complex of problems" faced by the world's societies, conceived of as five factors which determine and limit growth: population, agricultural production, natural resources, industrial production and pollution (Meadows et al, 1972: 12).

This growing emphasis on environmental regulation and the role of pollution or waste has taken place both within individual countries around the world, and on the international stage in the form of a growing number of international conventions such as the Kyoto Protocol of 1997.

> The Kyoto Protocol, which came into force in 2005 with the ratification of Russia, distinguished between different categories of countries in a way that provides for common but differential responsibilities. Developed countries and countries with economies in transition (primarily former Iron-curtain countries) are required to reduce levels to specified targets between 2008 and 2012, while developing countries (including countries such as China and India, and South Africa) are not subject to the same requirements. The Protocol also provides for mechanisms such as clean development mechanisms, emissions trading and carbon sinks (Kidd, 2008: 56).

## 2.2 Planning and Urban Growth Management

Beall (2000: 440) has noted that: "[cities] are spatial arenas in which who gets what is determined by the collusion and collision of contested social relationships and identities". Special significance is given to these social relationships and identities in the South African context. During the Apartheid era, the government constrained the movement of peoples and maintained a reasonably slow rate of urbanization whilst creating racial inequalities structured along geographic lines. In post-Apartheid South Africa, many of these barriers have come down, with a consequent movement of large numbers of people seeking to live in urban rather than rural areas in the hopes of a better quality of life, employment and better service provision. In a context where public service provision such as transport, electricity, water, sanitation and waste have been historically run by parastatals, a shift towards privatization in the last 5 years has presented new challenges (Potts, 1997: 479). This has led to greater pressures on service provision in terms of higher running costs, less social welfare and resulting "disaster management". Existing infrastructure in urban areas is however already largely oversubscribed and can collapse under pressure, adding to health and safety risk issues (Beall, 2000:440). Another environmental risk which exists in municipalities is that interventions required in the long-term exceed available municipal budgets. This issue of scarce resource allocation is exacerbated in situations where basic social needs are particularly pressing. In these situations, aspects of the environment will usually be seen as less of a priority over services such as water,

housing and sanitation – even waste may be forsaken until a health pandemic arises (SACR, 2008). Survivalist strategies in urban spaces often lead to illegal accessing of services where there is a lack of public provision, or where affordable provision is not to be found (Beall, 1997: 438). There are legal, social, health and safety implications to rapid urbanisation:

> Urban areas around the world are ecologically unbalanced, and most are environmentally challenged. In the developing world, urban areas are increasing in population at a rate faster than can be accommodated by the infrastructure of housing, schools, hospitals, and roads. As a result, many of the urban areas around the world have an undernourished, unemployed, and inadequately sheltered underclass" (Spengler; et al, 1997: 33).

In the context of these challenges, Adebayo (2002: 355) argues that "[…] forward planning and realistic master plans measured against resources, capacity building and development should be the priority for the future, otherwise on the basis of current African cities, there seems to be little reason to be optimistic". Without adequate urban growth management of cities, public service provision to rate payers diminish with the resulting effects usually felt disproportionately by a city's urban poor. Inadequate service provision affects electricity, water, sanitation and waste management services. Besides social impacts of a degradation of social services, added pressure is placed upon the environment to absorb a municipality's shortcomings. The environment may in turn be slow to recover or may be incapacitated in terms of its ability to provide other environmental goods and services such as clean water and recycling of elements.

This, admittedly, pessimistic outlook is a possibility which informs the need to carefully examine the ways in which municipal service provision can successfully respond to these challenges and risks. South Africa and the eThekwini municipality are good examples of the challenges facing local municipalities in rapidly urbanising contexts characterized by increasing pressure on local service providers, including waste management services

## 2.3 Sustainability and Urban Management

Allowing free access to resources without foresight and management can lead to a "tragedy of the commons"[2] – a term coined by Garrett James Harding relating to the human tendency to use up the easily available resources in a given area to serve an individual's need, without thought given to the communal or long-term interests. In contrast to this eventuality is the concept of sustainable development, defined as: "economic and social development that meets the needs of the present without compromising the ability of future generations to meet their own needs; programmes which maintain an appropriate balance between economic development, social development, and environmental protection" (Greene, 2001: 411). In the case of waste disposal, sustainability is conceptualised as the shift from simple landfilling to a focus on recycling and eliminating waste. Sustainability also informs the longevity of such strategies as an urban poverty reduction mechanism (Glasmeier; et al, 2003; and Murray, 2002). Financing of waste disposal initiatives is a key deciding factor in both a project's viability and environmental sustainability. Finance for waste disposal and other environmental-related projects has been institutionalised at the international level through the Clean Development Mechanism (CDM), a World Bank funded initiative intended to finance the implementation of the Kyoto Protocol.

## 2.4 Waste and Urban Management

Urban management plays an integral role in city waste management. It is therefore important to closely examine waste management to ascertain the shortcomings in urban management. According to Hester & Harrison (2002: 2; 3) municipal solid waste (MSW) forms a small part of solid waste, and may be defined as:

> [Including] waste arising from private households to that collected by or on behalf of local authorities from any source. MSW therefore includes a proportion of commercial and non-hazardous industrial waste. Depending on the country, the definition can include some or all of [the following]:

[2] The tragedy of the commons may be defined as: "the over-exploitation of open-access resources by users "rationally" pursuing their individual interests" (Greene, 2001: 411).

- Household waste (collected waste, waste collected for recycling and composting, and waste deposited by householders at household waste disposal sites);
- Household hazardous wastes;
- Bulky wastes derived from households;
- Street sweepings and litter;
- Parks and garden wastes; and
- Wastes from institutions, commercial establishments and offices.

It is important to note that municipal waste is a management concept and that the varying definitions of solid waste around the world and hence the varied amounts of municipal solid waste and differing associated collection activities, principles and statistics may not be comparable across contexts (Hester & Harrison, 2002: 3). Even though there is no "blue-print" for every disposal situation, the European Union has set broad principles upon which its approach to waste management is modelled (Hester & Harrison, 2002: 3). In the European Union (EU) countries and most of the developed world, formal legislation exists to guide, support and control emissions of and combustion from landfill gases. In the process of landfill gas combustion, methane (highly flammable and difficult to extinguish) is converted to carbon dioxide (Strachan; et al, 2004). Even though this sets an example to be followed, many developing and developed countries do not have such strict legislation. Therefore, the obligation to comply with global "best practices" such as combusting landfill gas and preventing landfill gases from venting into the atmosphere – towards reducing the impact of global warming, is not necessarily supported as it should (Strachan; et al, 2004). As a partial explanation, it has been found that municipal waste management budgets are often too small to consider more environmentally friendly alternatives that may, at inception have high running costs, but which have long-term positive financial, environmental and social benefits. These benefits are seen to accrue with the design, approval and construction of Mariannhill Landfill's gas-to-electricity project.

## 2.5 General Environmental Impacts of Solid Waste Landfill Disposal

At the international level, landfilling remains the most popular method of waste disposal, accounting for 95% of the waste disposed globally. It is therefore important to note the potential hazards commonly associated with this practice (Mato, 1999:1 & 2). The inevitable consequences of solid waste disposal in landfills include gas and leachate generation, primarily due to microbial decomposition. The migration of gas and leachate from within landfill boundaries into the surrounding environment presents serious environmental concerns. Other hazards include fires and explosions, vegetation damage, unpleasant odours, groundwater pollution, air pollution and global warming (El-Fadel; et.al, 1997:17). Although dumping is the general method for solid waste disposal it remains unhygienic and poses risks such as: insect-, worm-, and rat infestations – all causes of ill-health (Sida, 2006). Landfill sites, especially in urban areas are widely perceived as being unsightly – exacerbated by waste being spread by wind and other weather elements. A less orthodox yet still legal alternative to this approach is dumping into drainage systems, which leads to blockages and worsening sanitary management (Sida, 2006). Further disposal methods include burning waste, which only adds to existing air pollution (Sida, 2006). Natural processes involving the breakdown of the organic components of solid waste cause simultaneous breakdown of organic matter – all adding to leachate and methane gas, potentially released into the surrounding soil and air from landfill sites (Sida, 2006). Methane gas poses an additional problem as it easily causes fires which are more difficult to extinguish. Since methane is one of the stronger greenhouse gasses, its impacts are viewed as far worse than carbon dioxide ($CO_2$) (Sida, 2006). The above mentioned are all associated with environmental consequences resulting from dumping (Sida, 2006).

It is important to note that in addition to disposal methods used at a landfill site, the attitudes and perceptions of people influence views on waste, influencing the production and handling of waste (Sida, 2006). An example of these perceptions influencing an approach to livelihood strategies is that of "scavengers" (better known as garbage pickers). Such poor people often live either on or nearby landfills, where they make a living through sorting, recycling and selling waste. This has become a form of informal and unskilled job creation (Sida, 2006). It may be argued that the conditions under which these 'scavengers" operate could be better managed so as to reduce health risks and increase support of this informal part of the economy as part of the municipalities; investment in local economic development (LED) (Sida, 2006).

Problems associated with waste in developing countries such as South Africa may arguably be characterized as follows: solid waste management in developing countries suffers from inadequacies such as "highly inefficient waste collection practices, variable and inadequate levels of service due to limited resources, lack of environmental control systems, indiscriminate dumping, littering and scavenging and, most of all, poor environmental and waste awareness of the general public" (Matete and Trois, 2007). Furthermore, Matete and Trois (2007) note that South Africa is an emerging nation faced with the near unattainable challenges of meeting high demands for service delivery in waste management with limited financial and capacity resources. The realities of post Apartheid South Africa include disparities in services coverage found in governmental fund allocation and between communities in the same area. Therefore, "[...] environmentally and socially unacceptable practices characterize many aspects of waste management in many of those urban areas that have always had poor delivery" (ibid). It has been noted that the most common method of waste management in South Africa is that of disposal. As set out by the Department of Environmental Affairs and Tourism (DEAT) at a Waste Management Conference (2007), some of the challenges facing waste management in South Africa, include the fact that there are 1327 known waste disposal sites of which 639 are not officially permitted – with a further 58 of these unpermitted sites being highly hazardous. The most well known and amongst the largest of the permitted solid waste disposal sites are Mariannhill, Bisasar and Shongweni (eThekwini Online, 2008). Furthermore, in light of the ongoing battles over illegal dumping, a lack of cradle-to-grave control as well as waste minimization not being mandatory, the South African waste management vision and strategy seems poor and by comparison and still lags behind international cases such as Curitiba, Brazil (DEAT, 2007)

## 2.6 International Example: The City of Curitiba, Brazil

The Brazilian city, Curitiba employs sustainable urban management practices which include internationally recognised examples of best practice. Curitiba's reputation for sustainable urban management improved rapidly during the 1990s when it became known as a model for urban ecology planning. Soon thereafter it was labelled an international archetype of environmentally friendly urban development and a model for efficient city planning (Macedo, 2004: 537).

Observing Curitiba's overall urban growth management successes as a global city requires an understanding of its history and the planning that went into its design. Historically, Curitiba's urban form forced planners to follow topographical features for its settlement patterns. Many years of development and investment paid off in the 1940s with "real" economic development – because of Curitiba's vested interest in the coffee produced up North. By 1943 the plan for the city was drawn. The population numbers grew from 1800 00 in 1950 to 1.6 million at present (Macedo, 2004: 538). Dudeque noted in Macedo (2004: 540), that "most early planning in Curitiba was motivated by the necessity to provide reasonably sanitary conditions" to rising population numbers and rapid urbanization in Brazil during the late 19th century. Curitiba's creative planning and management approaches towards architecture, the environment, social services and infrastructure brought about waves of continuing success, inspiration and motivation for continual improvement. Curitiba's innovative successes and replicable ideas are evident in their long-term results and approaches. Its concomitant and dedicated relationship to "local values such as accessibility, transparency, social justice and poverty reduction and efficient resource management are what resulted in Curitiba's sustainable development, which is more than simply 'environmental'" – because its planning principles considered social-political needs and issues, as well as the natural environment (ICLEI, 2005). For example, integrated transportation and land-use were pivotal to the city's development, controlling growth, cutting pollution and enhancing the life of residents" (ICLEI, 2005). Curitiba's creative approaches and cost effective solutions saved money and were better suited to the city than more expensive approaches such as having residents recycle at home rather than employing an expensive separation plant. Through its sustainability successes, Curitiba helped formulate key replicable factors or principles and guidelines for future running of cities.

Curitiba further prides itself on its sustainable and cost-effective multipurpose approach to job creation; recycling and waste recovery management. The successes of these alternative approaches lie not only in their unique foundational ideas but also in their evidential long-term functioning sustainability (ICLEI, 2005). Brazil's approach towards waste management has been successful largely due to its recycling aspects which may be seen as examples of best practice. Curitiba's efforts in the area of recycling have been especially successful however, through its extended recycling initiative which includes both construction and demolition waste recycling centres (Nunes; et al, 2007: 1531). Even though its governing roots lie within the

Brazilian military, Curitiba's governance remains interventionist in approach. Management initiatives proposed are often followed through. Although Curitiba has been governed by the same political party for over 40 years and planning is sometimes used as a political tool, it has brought consistency in the delivery of the city's master plan which helps to elevate Curitiba to global best practice status (Macedo, 2004: 541). Despite Curitiba's "First World City" status, like most developing countries, it too faces the mammoth urban management task of providing housing and livelihood strategies to its ever increasing urban poor, many of whom live in informal settlements. Intensifying pressure on the city infrastructure has made safe and adequate service provision and sewage collection and treatment increasingly difficult (Macedo, 2004: 542). Despite these challenges, Curitiba has been able to provide effective and practical solutions to the issue of waste disposal and recovery in landfill sites. These include strict control systems to prevent the dumping of forbidden wastes and an extensive system in place to ensure that most recyclable items are recovered before actual landfilling takes place. The recovery of recyclable materials in Curitiba is made possible through a fostered culture of waste separation within households, business and schools, a system for collecting recyclable materials for resale to the industrial sector, and a "Garbage Trade Program" which allows people in lower income communities to trade wastes for food (Guillen, 1993:88). Curitiba has also been able to successfully convert old landfills into new land use areas, such as the Botanical Gardens located on an old landfill site last used in the 1970s (ibid).

There are both similarities and differences in the circumstances faced by eThekwini and Curitiba in the area of waste management. KwaZulu-Natal has not only the legacy of Apartheid planning but also colonial physical structures and long standing social inequalities to contend with, whereas Curitiba was able to introduce a more rational approach to city planning from the inception. Municipal fund shortages are common in eThekwini where social problems such as health and housing are more pressing in terms of short-term survival. Similarly to Curitiba, eThekwini faces the overwhelming task of housing provision to informal settlement dwellers within an urban context, which places increased pressure on existing infrastructure - resulting in management challenges. Although Curitiba's landfills are built and owned by municipal governments, they are operated and monitored by private contractors (Johannessen and Boyer, 1999: 34). Mariannhill Landfill is owned and operated by DSW and therefore subject to eThekwini's municipal budget. The necessity for Mariannhill to locate additional funding to

continue developing and implementing innovative solutions outside of municipal budgets (such as through CDM projects) illustrates the array of competing demands for existing budget. Whereas the management structure in place for the city of Curitiba as a whole is longstanding and has incorporated a focus on forward-thinking, practical and cost-effective approaches to the range of urban management tasks, the eThekwini municipality has been in place for a shorter period, and is still grappling with the formulation and replication of its waste management practices. From the comparison of Curitiba with eThekwini, it may be argued that what is required for effective waste management is an effective system for waste sorting, collection and recovery which operates at the level of the society as a whole, as well as the mandate to develop solutions and the time to improve the system through monitoring. The Mariannhill Landfill Site may prove to have developed certain of the solutions to waste management required in eThekwini at this particular juncture, and therefore further study of the site may encourage replication of this model in other solid-waste landfill sites within the municipality.

## 2.7 Legislative Framework

This section will look at the various laws, policies, bills and regulatory standards involved in solid waste management, internationally and in South Africa at national, provincial and local levels. Also examined are the international conventions relevant to South African waste management. It will further explore international selection standards and impact assessments for landfill sites, South Africa's waste related legislation, and the general environmental impacts of solid waste landfill disposal. It is important to note the international laws that broadly apply to waste management, so as to better understand South African laws on waste management. Establishing the existing set of regulations applied to solid waste disposal also facilitates understanding of solid waste landfill site's objectives, and assists in the assessment of success in achieving these objectives in the case of the Mariannhill Landfill Site.

### 2.7.1 Background on Waste Generation and Disposal in South Africa

Roughly 300 million tons solid waste is generated in South Africa every year, with most disposed of at landfill sites (Glazewski, 2005: 533). There are monitoring and managing systems in place to control this process in the form of "[…] licenses, permits, permit exemptions and directions in terms of various acts, especially the National Water Act, 1998 (Act 36 of 1998) and

the Environmental Conservation Act, 1989 (Act 37 of 1989)" (Bredenhann, 2003). Benchmarking approaches to aid in the control of waste disposal in South Africa have legally been established and formalized as Best Management Practices, Environmental Management Programme Reports (EMPR's) and Minimum Requirements (MR's). Despite the legal guidance and backing of the Integrated Pollution Control and Waste Management Policy, as well as the National Waste Management Strategy, the importance and value of waste prevention, recovery and re-use is not stressed enough and simple disposal of waste remains the dominant activity in South Africa (Bredenhann, 2003). According to the 1998 Baseline Studies, 760 disposal sites were recorded in South Africa – of which a total of 528 were controlled via permits, exemptions and Directions (also known as general authorizations) (Bredenhann, 2003). There is therefore a shortfall in the municipal system of optimum waste management. In response to this shortfall in comprehensive control measures, in place for waste disposal, the Department of Water Affairs and Forestry (DWAF) in 2002 launched a project geared towards formulating Minimum Requirements for the upgrading of Disposal Sites around the country (Bredenhann, 2003). Through this approach, a gradual shift from the simple provision of permits towards increased compliance with permit requirements is hoped to decrease the levels of simple disposal of waste (Bredenhann, 2003).

### 2.7.2 International Laws, Policy and Regulatory Guidelines

Generally, the definition of waste is defined according to the type of waste being disposed by the possessor. The basic requirements are usually licenses for the disposal of any kind of waste, at specified sites (Garbutt, 1995: 123). It is however found that, even at international level, it is hard to give a clear-cut definition of waste. Home (2007: 14) argues that even at international level waste management has proved a "hard task to master", noting that this issue has for a long time been a major part of the European Union (EU) environmental policy - with the longest section in the Handbook for Implementation of EU Environmental Legislation. There exist many anomalies, influencing not only the disposal of waste in terms of its management but also its written definition. This is reflected in the amount of caution with which it is viewed by policy writers and law enforcers (Home, 2007: 14).

According to Louka (2006: 425) international law on waste management is set-out as follows: "Landfill disposal, is still used because it is less expensive than recycling and waste

minimization. Technological and other standards preventing contaminants from reaching the groundwater have been developed. These technological standards have made landfill disposal a sounder waste management method". The landfill selection process and authorization of operations include an extensive Environmental Impact Assessment (EIA) and must within the approval process meet certain basic criteria. Some of these include isolation of a site via engineered barriers such as liners and other leak collection systems- controlling and preventing contamination of the surrounding environment and groundwater. Groundwater as well as surface water must be monitored *ad infinitum*. The structure of a site is very important and must make allowance for pre-and-post closure management systems (Louka, 2006: 425).

The downside to stringent national regulatory standards on disposal and treatment of waste have in the past led to waste exports to countries with less stringent laws but with that also lacked the infrastructure to deal with the waste they were "taking on" (Louka, 2006: 446). There is a general attitude that "waste management is an allocation issue in terms of sharing the burden of an externality. Most countries view waste as the by-product of an industrial activity [and seldom as a resource]" (Louka, 2006: 92). Hence each state must become self-sufficient in waste management and keep to the polluter pays principle (PPP). This has been supported by the European Court of Justice (ECJ) – based on environmental considerations but rejected by the U.S. Supreme Court – based on "nationhood" in the United States (Louka, 2006: 447).

### 2.7.3 International Standards and Impact Assessments of Landfill Sites

International comparative standards aid in guiding local assessments as an indication of what management of a landfill site should include. Any landfilling operation and general solid waste management in South Africa including the local context of eThekwini, is subject to all national and local laws and regulations. These legal frameworks are hierarchically informed by international laws and standards, not only as guiding examples but also through binding treaties and conventions such as the Kyoto Protocol of 1997, signed by South Africa. Hence it becomes imperative to briefly illustrate international law, to be able to comprehend the legal framework within which South Africa negotiates and manages its environmental and solid waste landfilling practices. By understanding the abiding laws, the bases for assessing best practices in relation to sustainability, environmental management and solid waste landfilling site management, is facilitated.

Landfill site selection is a step-by-step process, in which environmental, engineering and economic criteria are applied. An environmental impact assessment (EIA) constitutes the first and most crucial stage in the selection process – with the aim of quantifying the impacts according to the natural characteristics of the sites. The method selected to facilitate the proper selection of a landfill site for municipal waste follows specific principles, called "selection criteria", the aim of which are to compare the considered sites to a hypothetical "ideal one" (Frantzis, 1993). Studies on many landfill sites in the Unites States, yielded several models and methods being developed "to simulate or assess the probability, magnitude and potential consequences of the leakage of aqueous environmental contaminants from solid waste landfills and similar facilities" (Nixon; et al, 1997). A commonality amongst all the models is that they incorporate climatology and geology as factors to be considered. Unfortunately, it must be noted that no two models would be able to give the same guiding assessment of a landfill and more importantly no one model has been granted validation in terms of predicting long-term landfill performances (Nixon; et al, 1997). This raises the question as to whether there is one single approach to best practice for solid waste management. If each landfill site is different and requires varying management approaches, can Mariannhill Landfill Site be assessed as to whether the best possible approaches have been taken considering the specific context? Furthermore, this research seeks to answer the question, whether the Mariannhill case is replicable at other eThekwini landfills?

Through the fieldwork it will be assessed how Mariannhill achieved its status as best practice model for sustainability, environmental management, landfill conservation and solid waste management – covered in more detail in Chapter Four.

## 2.8 South African Waste Management Legislation

### 2.8.1 National Legislation and Management Systems or Objectives

*The Constitution of the Republic of South Africa Act 108 of 1996* instructs and informs all other legislative laws and policy guidelines, by setting "[...] the framework for the administration of environmental laws by national, provincial and local spheres of government" (Glazewski, 2005: 68).

Section 24 of the Bill of Rights contained within the Constitution, states that everyone has the right:

> (a) to an environment that is not harmful to their health or well-being; and (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that – (i) prevent pollution and ecological degradation; (ii) promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development (Glazewski, 2005: 67).

This forms the legal backbone of all the legislation, policies and bills discussed below –at national, provincial and local level. The provisions set out for environmental-related rights are those which national, provincial and municipal regulations must work to ensure. The activities undertaken by municipalities, such as landfilling, can be assessed for how closely they adhere to the upholding of these rights.

### 2.8.2 National Waste Management Policy

Glazewski (2005) gives a detailed breakdown of South Africa's national Environmental laws. For the purposes of this thesis, laws relating to waste- and environmental management shall be discussed. A National Waste Management Strategy for South Africa (*the National Waste Strategy*) - published after the White Paper and outlined as an integrated approach to pollution and waste management, is described as:

> […] a holistic and integrated course of action, which [specifies] the institutional, infrastructural and technological support, as well as human and financial resources required to establish and implement an integrated waste management strategy which commits all the people of South Africa to preventing and minimizing waste generation at source in order to protect human health and the environment and to develop resources in a sustainable manner (cited in Glazewksi, 2005: 553).

The policy framework that guides waste management in South Africa is called the National Waste Management Strategies and Action Plans for South Africa (1999) (subtitled: National Waste Management Strategy). The aim of the associated reports and policy is to address

management structures on a long-term basis, gearing them towards more holistic integration of functions. There still remains a gap however between formulation and implementation.

### 2.8.3 Landfill Site Design Requirements

The Department of Water Affairs and Forestry's **(**DWAF) *Local Minimum Requirements for Waste Disposal by Landfill* (1998) include a number of specific technical requirements to guide landfill design in South Africa generally. The legal governance in terms of a control authority for authorisation and control over disposal sites, has however recently been shifted from DWAF over to DEAT (Department of Environmental Affairs and Tourism) (Kidd, 2008: 159). Municipal landfill sites are expected to proceed with site design based on these requirements. However, enforcement of technical requirements is uneven based on local enforcement capacity and asymmetrical information across the parts of waste management infrastructure, resulting in only partial take up of all technical requirements at any one site (Kidd, 2008: 161). Hence the shift in governing bodies. The set of requirements does however give an indication of the technical and other requirements which "well run" waste landfill sites must take into consideration, especially within a well resourced and managed municipal context. The Mariannhill Landfill Site can be considered well run and located within such a well resourced and managed municipality (UN-HABITAT, 2008).

### 2.8.4 National Bills

The *National Environment Laws Amendment Bill* was in November 2008 before the National Council of Provinces (NCOP) to seek approval that all forms of pollution would be deemed a criminal offence, and that recycling as well as a healthy lifestyle amongst citizens be promoted. Recent debate relating to the Bill, by the Deputy Minister of Environmental Affairs and Tourism, Ms Rejoice Mabhudafasi, was quoted saying that "'scavengers" should be trained to become good recyclers […] We need to turn our waste into wealth" (Parliament of RSA in Session, 2008: 19). Furthermore, the "Chairperson of the Select Committee on Land and Environmental Affairs, Reverend Peter Moatshe said reforming waste-regulating laws would help give effect to Section 24 of the Constitution which provides for an environment that is not harmful to the health and well-being of citizens" (Parliament of RSA in Session, 2008: 19). A strength attributed to this Bill is the "clout" with which the South African government aims to back it, granting environmental management inspectors (EMI's) the authority and duty to inspect,

investigate, enforce and administer the new legislation. Once the Bill has been passed into law it will strengthen the 2001 Polokwane Declaration (signed at the first National Waste Summit in Limpopo). In the 2001 Polokwane Declaration South African government, civil society and the business sector vowed to 'stabilize waste generation, halve waste disposal by 2012 and develop a plan for "Zero Waste" by 2022" (Parliament of RSA in Session, 2008: 19).

These developments indicate how waste minimization, recycling, efficiency, and sustainability are all concepts which are entering national and local policy-making discourse. I argue that these developments are consistent with developments internationally where environmental considerations have been steadily gaining in importance in most states across the globe and can be seen in international conventions (Kyoto Protocol etc.). I argue that these developments at the international scale can be reasonably assumed to materialize in both national and local policy and regulation. South Africa is a fully-fledged member of the international community, and as such is subject to the same emphasis on environmental regulation as many of its international partners.

### 2.8.5 Local Legislation, Policies and Municipal Bylaws

Many local authorities have municipal bylaws which deal with solid waste management issues (Kidd, 2008: 161). Local eThekwini Cleansing and Solid Waste (DSW), by-laws say little about landfill site management and solid waste disposal at landfill sites. Instead it relates more to service delivery conduct, and the relationship between DSW and the private-public individual (eThekwini online, 2009). According to the "Guidelines On Recycling Of Solid Waste" (2005: 6) waste management is generally dictated to by municipal by-laws and seeing as each municipality institutes its own by-laws, there is often enforcement, administrative and regulatory discrepancies between municipalities with each province. Hence the Department of Environmental Affairs and Tourism have devised minimum standards for recycling of solid waste in South Africa. Consequently each municipality is required in terms of the Municipal Systems Act to compile an Integrated Development Plan (IDP). The IDP must include an Integrated Waste Management Plan in-accordance with the National Waste Management Strategy; and promote recycling when setting tariffs for waste management services (Guidelines On Recycling Of Solid Waste, 2005: 6).

### 2.8.6 White Paper on Integrated Pollution Control (IPC) and Durban's Local Agenda 21: Pollution and Waste Management

There is a recent call to shift from the White Paper on integrated pollution[3] and waste management for South Africa, towards a media-specific pollution control Act (the Air Quality Act) (Kidd, 2008: 175). The White Paper on integrated pollution and waste management is an encompassing and integrated process which aims at preventing pollution; minimizing waste; integrating across media; involving all sectors of society in pollution and waste management; and lastly, integrating all institutional departments and spheres of government both vertically and horizontally. This presents a paradigm shift from only dealing with waste after its generation ("end-pipe"), towards a "cradle-to-grave" approach in a more integrated approach to environmental management (Kidd, 2008: 175).

The national Department of Environmental Affairs and Tourism (DEAT) developed an Integrated Pollution and Waste Management (IP&WM) Policy. KwaZulu-Natal further developed its own Integrated Waste Management Policy within "Durban's Local Agenda 21". The Metropolitan Environmental Policy has to be informed by the aforementioned broader policies (Roberts & Diederichs, 2002: 179). It is clear from this example that overall policy or strategy documents such as the IPC White Paper do have an influence over other policy documents and other forms of regulation.

## 2.9 Conclusion

Issues of environmental sustainability in the range of activities which local governments undertake has taken on much greater significance over preceding decades for many countries around the world. This is due to a growing awareness of the need to regulate for those activities which impact on the environment. Waste and pollution can have serious impacts on a local area, which provides the incentive for environmental regulation at the local level. The shared challenges which are faced around the world from waste, pollution and other forms of environmental degradation become the driving forces behind regulation. The challenges and

[3] "The concepts of "pollution" and "waste" are closely related, but not synonymous. Waste can be defined as that which "we do not want or what we fail to use, with the proviso that "failure to use" includes "failure to use for its proper purpose"". Pollution need not necessarily be caused by waste, in the sense that it is defined here. On the other side of the coin, if waste is handled and disposed of correctly, it need not cause pollution" (Kidd, 2008: 127 & 128).

potential opportunities within planning and urban growth management, as well as sustainability and urban management, are interconnected. If one of these areas is not properly attended to, the results may impact negatively across the whole chain of urban management areas.

South African urban planning focuses more on the social aspects of livelihood strategies, urbanization, employment, housing, health, and service provision than issues around waste management, due to the historically inherited challenges stemming from Apartheid planning. A city cannot be planned nor function adequately without proper waste management strategies. The strength of one service is dependent upon another. The spiralling effect of inadequate planning will reflect in the sustainability of a city's urban management.

South African legislation on waste management does not explicitly address waste minimization, re-use or recycling. Kidd argues that despite this shortcoming in South African waste law, recycling is in a "healthy state": approximately 45% of recyclable paper was recycled in 2006 and two thirds of all steel cans are currently recycled, with these figures comparing well to first world countries (Kidd, 2008: 161). There still remain policy gaps however in the current legislation and municipal waste management practices at national and local level. Much of the effectiveness of environmental legislation depends upon its authorization, permitting or the licensing of persons to carry out certain activities (Kidd, 2008: 208). With the power to grant authorization must come the power to withdraw if *inter alia*, it is not found in public interest to continue such activities (ibid). Kidd (2008: 176) noted that due to the Constitutional allocation of powers within governmental spheres, together with concurrent legislative and administrative competence it "[…] means that institutional fragmentation will always be part of the South African environmental legal landscape, not only in the field of pollution and waste. It is important, therefore, that every effort is made to prevent this becoming an obstacle to effective pollution control and waste management". The ability to effectively monitor and evaluate waste disposal activities of different kinds is vital to an effective waste management system, and relevant authorities should be properly empowered to enforce those changes necessary for the public interest to be upheld in line with existing legislation.

According to Du Plessis (2007: 16) improper disposal of waste and insufficient monitoring and management is a problem in all South African provinces:

> By 2004, only 28.5% of nearly half of the 1321 waste landfill sites in SA are unauthorized [and] should be closed – 60 [are] hazardous. [Based on the] DEAT State of Environment Report of 2006: as many as 15,000 unrecorded communal waste sites [were] in rural areas. Within the national municipal infrastructure grant system waste has an allocation of 5% in the category termed "other". [Some] IDP hearings in 2005 [made it clear that]: municipalities in SA have little environmental management capacity-national average of less than one engineer per local authority in 2006. No information available on the expenditure by local government on environmental management functions of which waste is a prominent part.

There are many examples of international laws which act as guidelines to the formulation of South African solid waste- and environmental regulations. There are also many binding international conventions which can be seen to affect the formulation of environmental policy in South Africa. South Africa's laws and regulations for solid waste management and the environment have evolved rapidly since 1994 which indicates the influence of South Africa's re-entry to the international community. It may be argued that the growing awareness of environmental problems and the need to regulate for them which can be seen in many countries around the world, has led to a form of global consensus around certain environmental issues. This consensus can be seen at work in the formation of global treaties such as the Kyoto Protocol. It may further be argued that this filters down into the language, or discourse, of environmental policies and regulations in specific countries. It can be clearly seen from a review of environmental and waste-related legislation in South Africa and eThekwini, that there is a strong focus on the concepts of preserving and sustaining the environment. "Sustainable development" is a recurring theme in much of South Africa's legislation, and many policies contain elements of sustainability of various kinds, including sustainable livelihoods. At the national level, as well as in the eThekwini Municipality, certain of the policies and regulations which apply to waste disposal espouse a form of environmental ethos which, more often than not, centres on the concept of sustainability. These policies and regulations include parts of the Constitution, the Waste Management Strategy and Durban's Local Agenda 21 policies. Certain policy documents are only very loosely related to regulations, and are more conceptual in nature,

intended to guide the ethos of a particular element of government. The "Waste Hierarchy" and Zero Waste initiative are examples of these policies which are influential in the regulatory environment in eThekwini Municipality. It may therefore be argued that the Mariannhill Landfill Site operates within a regulatory framework which emphasises sustainability and a responsibility towards the environment and the wider community. Regulated for technical requirements would have an obvious and direct influence over the activities undertaken at Mariannhill Landfill. In addition, it can also reasonably be assumed that the environmental ethos that is found in many of the relevant policies and regulations would also have influence over activities undertaken at Mariannhill Landfill Site.

# Chapter Three: Research Findings

This chapter provides a background on Mariannhill Landfill Site as a model for environmental management and sustainability, and assesses whether aspects may be replicable at other eThekwini landfill sites. This will be achieved by presenting the data compiled from fieldwork interviews, synthesizing the main points, and analyzing the data with the aid of the research questions. These questions are restated here:

**Key Question 1)** What determines sustainability of practices undertaken at Mariannhill Landfill Site? Sustainability of site practices is to be determined by the following sub-questions;

- What are operational objectives of the site within a municipal context?
- How environmentally sustainable is the site?
- How economically sustainable is the site?
- What is the role for management and innovation in achievement of site objectives?

**Key Question 2)** Are the approaches undertaken at Mariannhill Landfill replicable in other settings? This is investigated through the following sub-questions:

- Can practices followed at Mariannhill Landfill be considered as examples of best practice?
- What are some of the barriers to replication of site activities in other solid waste landfills in eThekwini?

The field work included conducting ten in-depth interviews with key respondents in the field of solid waste disposal in order to assess the key questions. The broader themes under which these key questions were explored during fieldwork are: An Overview of Mariannhill Landfill Operations (3.1); Gas-to-electricity Project at Mariannhill (3.2); Site Roles and Objectives within a Municipal Context (3.3); Field Work Findings: Environmental and Economic Sustainability of Marianhill Landfill (3.4). These themes include the various aspects of solid waste disposal – its laws, policies and regulatory standards in eThekwini; the notion of best practice; sustainable waste management practices; broader environmental management and conservation issues; broader planning issues; barriers and opportunities; local economic development (LED) and the

informal economy; as well as the replicability of solid waste disposal practices at Mariannhill Landfill Site. All references made in this section are to interviewee responses (refer to Table 1 below).

**Table 1: List of Respondents**

| Respondent Name | Job Title / Employer | Date Interviewed |
|---|---|---|
| Costley, S. | Department of Agriculture and Environmental Affairs (DAEA), Deputy Manager: Waste & Chemicals Management | 19/08/2008 |
| Edward, B. | Project Executive Development Planning & Environment Management | 30/09/2008 |
| Govender, M. | Site Supervisor, Mariannhill, DSW, eThekwini Municipality | 04/07/2008 |
| Home, R. | Chartered Town Planner and Professor in Land Management. Anglia Law School, Anglia Ruskin University | 18/08/2008 |
| Lakhani, M. | Waste Activist | 25/07/2008 |
| Lindsay, J. | Pinetown Counsellor (for environmentally related matters) | 07/07/2008 |
| Moodley, L. | Operations Engineer DSW, eThekwini Municipality Cleansing and Solid Waste Division | 29/07/2008 |
| Moodley, S. | EThekwini Policy Unit | 30/07/2008 |
| Parkin, J. | Deputy Head – Plant & Engineering, DSW, eThekwini Municipality | 02/07/2008 |
| Petterson, T. | EThekwini Municipality:<br>Development Planning, Environment & Management Unit<br>Environmental Management Department | 17/09/2008 |
| Stewart, T. | Conservator Overseeing: Umbilo, Umhlatuzana zone for eThekwini Municipality | 09/07/2008 |
| Strachan, L. J. | Carbon Reductions, Executive Director, KZN | 01/08/2008 |
| Winn, R. | Environmental Assessment Manager, contracted to DSW, eThekwini Municipality | 03/07/2008 |

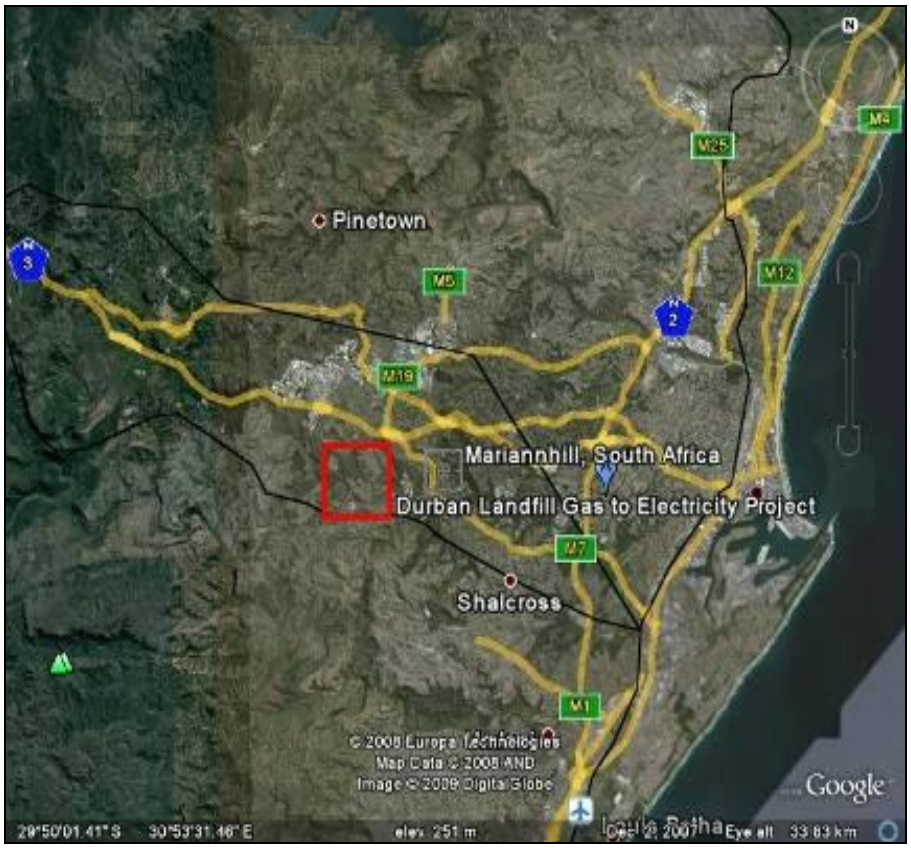
## 3.1 An Overview of Mariannhill Landfill Site Operations

Mariannhill Landfill was opened in July 1997 as a "New Generation Landfill" for Durban Solid Waste (DSW). Mariannhill receives solid waste from the entire Inner West region of eThekwini (refer to Figure 2 below). The site is an operating large landfill, registered as class "G:L:B+" (general large site)[4], accepting approximately 850 tonnes of municipal solid waste daily" (Jewaskiewitz, 2007:7). According to eThekwini Durban Solid Waste's Integrated Waste Management Plan (IWMP) and in accordance with the National Waste Management Strategy

[4] Also refer to eThekwini online, 2009

(NWMS) the waste types accepted at the Mariannhill Landfill via permit is classified as general waste. The general waste accepted consists of: solid waste: garden refuse, building rubble, mixed loads, very light items, light items, whole tyres, cover material (onsite and imported building rubble), condemned foods, and special waste.

**Figure 2: Geographical location of Mariannhill Landfill Site (indicated by red square)**

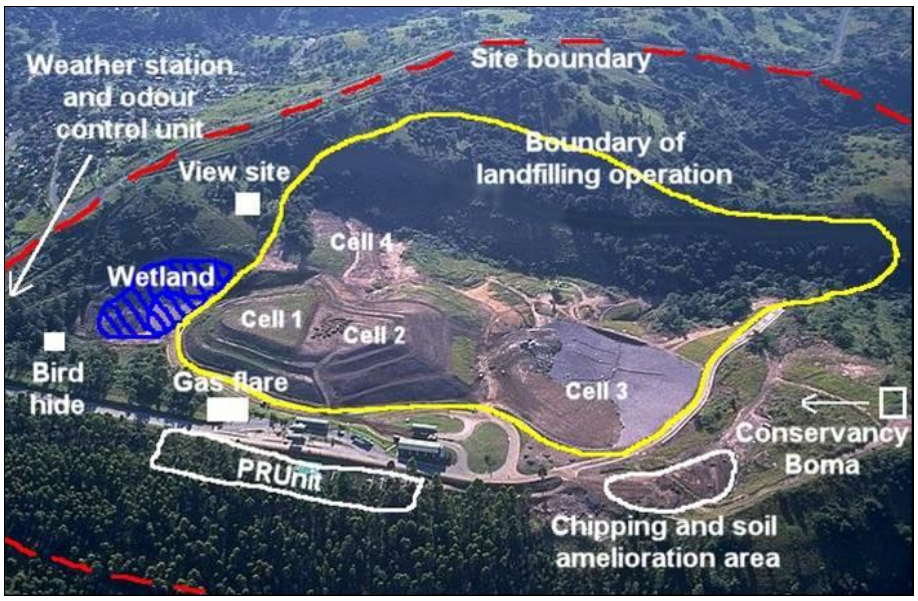



(Edited and sourced from: Google Earth, 2009)

Mariannhill Landfill covers 45ha of land space, of which approximately 20 ha is used for landfilling with the remainder functioning as a mandatory buffer zone. Landfilling capacity at the site is around 4.5 million $m^3$ (Strachan; et al, noted in Strachan; et al, 2004). At the site, waste is landfilled via constructed cells and compaction, and first goes through a wash-bay or weighbridge. Rehabilitation is done through the on-site Plant Rescue Unit (PRUNIT) as old cells are closed up (IWMP, 2004: 4). Management of litter and pollution takes place and includes leachate treatment and control, as well as flaring of gas emissions. On the outskirts of the site there is a 200m buffer zone separating the site from its surroundings (refer to Figure 3

below). There are currently a handful of nearby communities, but no business or industrial activity takes place in areas bordering the site (Mariannhill Park and Nazareth) (IWMP, 2004: 4).

**Figure 3: Aerial view of Mariannhill Landfill**




(Source: Richard Winn)

Mariannhill receives an average of 750 tonnes of solid waste daily, of which 200t are sent to the recycling plant. A further 25-30t is recovered in general landfilling processes. The majority (around 70%) of waste received is landfilled. The table below reflects the tonnages and types of waste received on an annual basis, which can be extrapolated to the structure of average daily waste intake (refer to Table 2 below). Mariannhill Landfill receives the second highest volumes of solid waste in eThekwini behind the Bisasar Landfill site. The Mariannhill Landfill Monitoring Committee together with DSW, are applying for a further 120Ha to be able to increase capacity, or "air space", in line with increasing volumes of solid waste.

**Table 2: CSW Landfill Tonnages from 01-01-2007 until 31-12-2007**

| | Types of General Waste | Bisasar Road Landfill | Mariannhill Landfill | Wyebank Landfill | Buffels-draai Landfill | Total Tonnage per annum (TPa) |
|---|---|---|---|---|---|---|
| 1 | DSW | 417,265.97 | 87,980.51 | 0.00 | 27,201.83 | 532,448.30 |
| 2 | GENERAL SOLID WASTE | 67,089.61 | 33,072.32 | 0.00 | 19,452.16 | 119,614.09 |
| 3 | GARDEN REFUSE | 39,919.78 | 9,729.98 | 3,421.33 | 1,046.00 | 54,117.09 |
| 4 | BUILDERS RUBBLE | 72,438.29 | 12,136.11 | 0.75 | 2,526.25 | 87,101.40 |
| 5 | MIXED LOADS | 12,734.40 | 1,840.24 | 0.00 | 309.02 | 14,883.66 |
| 6 | SAND & COVER MATERIAL | 380,872.68 | 47,480.60 | 0.00 | 751.54 | 429,104.82 |
| 7 | PURCHASE COVER MATERIAL | 1,776.54 | 568.72 | 0.00 | 8.86 | 2,354.12 |
| 8 | TYRES | 186.34 | 225.98 | 0.00 | 2.40 | 414.72 |
| 9 | LIGHT TYPE REFUSE | 53,969.93 | 2,181.14 | 0.00 | 87.62 | 56,238.69 |
| 10 | OTHER | 93,513.83 | 28,804.54 | 0.00 | 14.32 | 122,332.69 |
| | LESS: SAND & COVER MATERIAL | 382,649.22 | 48,049.32 | 0.00 | 760.40 | 431,458.94 |
| | TOTAL ETHEKWINI WASTE GENERATED | 757,118.15 | 175,970.82 | 3,422.08 | 50,639.60 | 987,150.65 |
| | LESS: PUBLIC WASTE (DSW) | 417,265.97 | 87,980.51 | 0.00 | 27,201.83 | 532,448.30 |
| | TOTAL: PRIVATE WASTE | 339,852.18 | 87,990.31 | 3,422.08 | 23,437.77 | 454,702.35 |

[Edited table; source: Parkin, 2008)]

The Mariannhill Landfill Site boasts very rich original soils, and through management practices aimed at conserving this natural asset, has establishment the onsite Plant and Rescue Unit (PRUNIT) (refer to Figure 4 below). The aim is to not only manage the immediate environment (ensuring the landfill's longevity) but through preserving indigenous plants and soil, create opportunities for local economic development (LED) (Moodley, 2007: 70).

**Figure 4: Plant Rescue Unit (PRUNIT) pilot project at Mariannhill duplicated at other eThekwini landfill sites**


(Source: the author)

Previously disadvantaged and unemployed people (some from the nearby community) grow and nurture plants and soil removed for landfilling purposes in a storage nursery (Moodley, 2007: 70). Further local employment is created by the large amount of alien vegetation removed from the landfill (Moodley, 2007: 71). The nursery aids in the rehabilitation of operational cells (defined areas where waste is disposed), transforming them into forested areas once a new cell has been excavated. According to statistics leading up to 2007, the environmental monetary values of these plants had far exceeded R 2 million (Moodley, 2007: 71). By 2007 a conservation area had been established consisting only of indigenous plants across the 30 hectares buffer zone. This area also includes wetlands, forests and diverse bird life habitats[5] (Moodley, 2007: 71) (refer to Figure 5 below). Mariannhill Landfill's best practice methods in this area have not only benefited the site, but have been replicated at the Bisasar Road landfill site, deemed the busiest in Africa, to help rehabilitate it through the PRUNIT programme (Moodley, 2007: 71). Mariannhill's landfill conservancy comprises several wetlands, which are important to preserve as they boast 118 recorded bird species, making them recognized birding spots. Wetlands have been described as the "kidneys of the earth" – stripping out toxic materials; breaking storm water flow energy and preventing soil erosion.

**Figure 5: Mariannhill Landfill's 30Ha conservation area and buffer zone consisting of grasslands, wetlands and forests**


(Source: the author)

[5] These include: Sacred ibis, storks, herons, duiker antelope, water mongoose, and Natal francolin (Daily News, 29/11/2002).

In terms of waste disposal and the management thereof, the Mariannhill Landfill has a full on-site leachate treatment plant known as a Sequencing or Sequential Batch Reactor (SBR). Lindsay (2007: Page number unknown) has noted that: "[…] leachate produced in the landfill is treated in a Sequential Batch Reactor (SBR) to a standard acceptable for reintroduction to the environment, which is then used for dust suppression and irrigation of the vegetation in the conservancy (refer to Figure 6 below). This conserves potable water and saves the city substantial costs". From plant recycling to actual waste materials recycling, all take place at an on-site pilot recycling facility which recycles various materials (Moodley, 2007: 71). The formation of toxic gases is an inevitable consequence of prolonged dumping, with these gases harvested: "Once the operational cell has reached capacity, extraction and treatment of harmful landfill gas takes place" (Moodley, 2007: 71).

**Figure 6: Aerial view of Mariannhill Landfill Site's Sequential Batch Reactor**

(Source: http://www.resource-india.net/CivilEngNov2007.pdf)

In addition to the production of gas, solid waste dumping at the Mariannhill Landfill Site also produces large quantities of leachate, produced by the natural breakdown of organic matter, which has the potential to pollute groundwater and nearby streams.

## 3.2 Gas-to-electricity Project at Mariannhill

Amongst the disposal strategies adopted by the Mariannhill Landfill, which are commonly practised around the world, include flaring (burning) some of the greenhouse gases (methane in particular) which emanate from the landfill, and by so doing limit their escape into the atmosphere (Moodley, 2007: 71). In addition, the Mariannhill Landfill Site has adopted the practice of converting a large portion of these gases into electricity. It is hoped that the approach adopted here and at the Bisasar Road landfill site will be replicable as a model for best practice throughout South Africa and the African continent as a whole. The benefits associated with this approach include the reduction of harmful green house gases (GHG) released into the atmosphere, and helping to "[…] reduce dependence on fossil fuels and pump the electricity generated back into the city's electricity grid" (Moodley, 2007: 71). This energy saving environmentally geared initiative contributes to eThekwini's Local Economic Development (LED) objectives by increasing Durban's revenue through the sale of this electricity as well as the sale of carbon credits to industrialized countries. It is hoped that eventually 10MWs (Mega Watts) of electricity a year will be produced from this alternative to traditional fossil fuel energy production (Moodley, 2007: 71). (refer to Table 3, below).

**Table 3: CER in tonnes $CO_2$ equivalent for eThekwini**

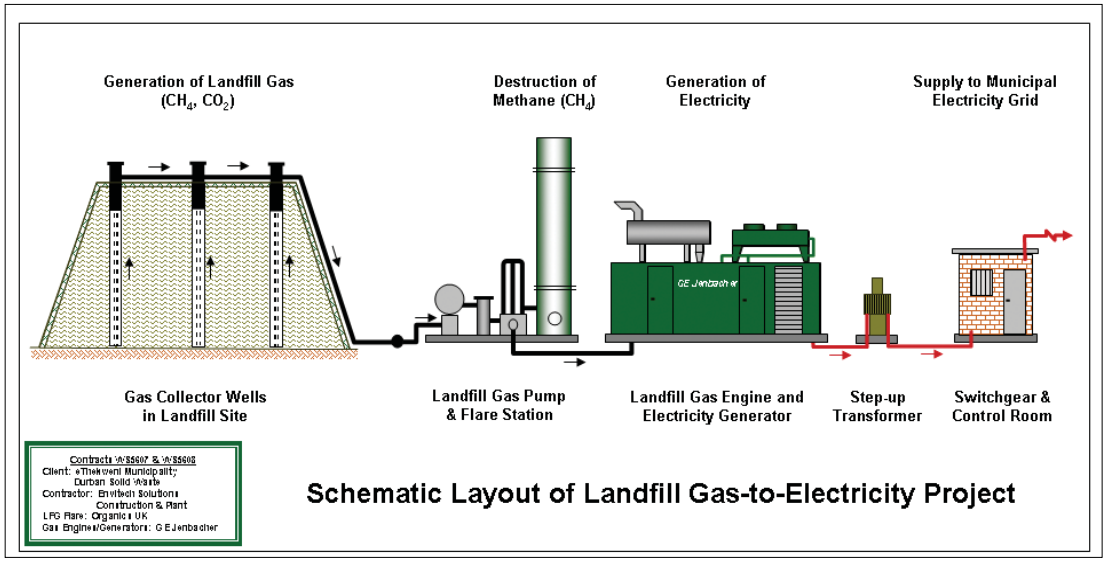
| Site | Methane Destruction | Electricity generation | Total |
|---|---|---|---|
| Bisasar Road | 5 295 296 | 800 704 | 6 096 000 |
| Mariannhill | 1 112 568 | 112 344 | 1 224 912 |
| La Mercy | 488 972 | 24 511 | 513 483 |
| Total | 6 896 836 | 937 559 | 7 834 395 |

(Source: Strachan; et al, 2007:12).
(Note: Expected carbon emissions reductions generation over a lifespan of some 21 years has been assessed. Calculations allow for early closure on the Bisasar Road landfill.)

Gas production at Mariannhill Landfill is measured using two gas generation models developed in the United Kingdom, "Environment Agency GasSim" and the "Enviros" model (Strachan; et al, 2004). The rate at which gas is produced at any given time is variable as a result of influencing factors such as composition and density of the waste; temperature within the landfill; availability of nutrients; [and the] pH/alkalinity of leachate (ibid). Predictions of gas production volumes is dependent upon the accuracy of monitoring systems for waste risings, moisture

content, compaction, infiltration, and other factors (ibid). The two models, therefore varied by 30% (the "Enviros" model being higher than the "GasSim" model). Consequently, the "GasSim" model is used more frequently for its conservative attributes. It is used in predicting gas production from on-site waste, and calculates projected gas-to-electricity generation at the Mariannhill Landfill Site, for better monitoring. This ensures maximum quality electricity is yielded at the end of the monitoring and generating process (Strachan; et al, 2004). (Refer to Figures 7 & 8 below)

**Figure 7: The gas-to-electricity generating process in the LFG CDM project**




(Source: Strachan; et al, 2007:9)

**Figure 8: Gas-to-electricity plant at Mariannhill Landfill Site**

(Source: the author)

Gas extraction and flaring at Mariannhill arose from eThekwini's recognition of the potential income that lay within selling Certified Emissions Reductions (CER's). CERs are a tradable certificate, just like a stock. The formation of international markets for "carbon credits" has followed developments such as the formation of the Kyoto Protocol. CERs are granted by the Clean Development Mechanism (CDM) Executive Board to projects in developing countries to certify they have reduced green house gas emissions by one tonne of carbon dioxide per year. The rationale behind this carbon credit trading regime is that the market and its associated functions (e.g. CDM projects) will help to mitigate the effects of climate change and preserve the environment. It is estimated that "Overall credits equivalent to nearly 4 million tonnes of [Carbon Dioxide] will be sold" in KwaZulu-Natal over the lifetime of the CDM projects (Robinson and Strachan, 2007: 2).

Funds for green-house gas reducing projects in countries around the world come from the Prototype Carbon Fund (PCF), a partnership between seventeen companies and six governments, and managed by the World Bank. The PCF became operational in April 2000 subsequent to the World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa. The stated objective of the Fund is to pioneer the market for project-based greenhouse gas emission reductions while promoting sustainable development and offering a learning-by-doing opportunity to its stakeholders. The Fund had a total capital of $180 million in 2008 (The World Bank Carbon Finance Unit, 2008). The eThekwini cleansing and solid waste department, DSW, has entered into a contract with the International Bank for Reconstruction and Development as a trustee of the Prototype Carbon Fund to reduce the emission of greenhouse gases. The gas is now used to drive spark ignition engines to generate electricity for the eThekwini supply grid (refer to Figure 9 below).

**Figure 9: Gas blower and flare station section of the gas-to-electricity project**

(Source: the author)

A combustion flare is required as a back-up to the generation system. Landfill gas at Mariannhill is collected from a system of gas wells sunk into the landfill body and a gas blower that exerts negative pressure. The gas is discharged to a flare stack where it is incinerated and the combusted gases are discharged. Landfill gas is also led to gas-fuelled engines driving generators, designed as an "embedded system". The electricity generated is transferred via step-up transformers and switchgear to the local grid. The contract provided for a one megawatt generator at Mariannhill, to be augmented later by further engines. The transformers deliver an 11 kilovolt [Kv] current to the local grid" (Strachan; et al, 2007: 7 & 8). EThekwini became the first South African municipality to be approached by the World Bank (WB) for this project, with Mariannhill becoming the fore-runner of subsequent gas-to-electricity projects and CER projects (Strachan; et al, 2004).

## 3.3 Site Roles and Objectives within a Municipal Context

Waste disposal in eThekwini forms part of the overall urban planning for the municipality, which is undertaken as part of a vision which includes seeking a sustainable city; a caring city; a smart city; an equal and democratic city; and a financially successful city (Innovations, 2006). The eThekwini Planning and Policy unit has cooperated with other stakeholders to develop planning in the fields of water and waste management (Innovations, 2006).

It is important to delineate the regulatory and legislative context within which the Mariannhill Landfill Site operates in order to understand the set of requirements which site management must adhere to, and the relative success of the site at achieving its objectives within a specific set of constraints on site activity. Dr Shauna Costley at the provincial Department of Agriculture and Environmental Affairs (DAEA) (19/08/2008) describes how South African waste disposal requirements have inherited knowledge and expertise developed over time in other parts of the world, by integrating international standards and examples of best practice into local legislation where applicable:

> Specific legislation and policies are vital to ensure proper and controlled waste management. Prior to the development of the minimum requirements, disposal was simply a method of "dig a hole and dump the waste"; the potential impacts of the waste on the surroundings were not considered. Laws, policies and guidelines give direction as to what are the minimum requirements for waste disposal and outline how waste disposal should be conducted. They are vital to ensure protection of the environment. South African legislation is drafted taking into account international standards where applicable. Often international standards are a starting point when developing new standards providing guidance to "best practices" in waste management (Costley, 19/08/2008).

Costley outlines the following policies, acts, and government bodies that have influence over solid waste operations at the Mariannhill Landfill as elements of the eThekwini Municipality's mandate on waste management:

> Policies - National waste management strategy; White paper on integrated pollution and waste management; KZN waste management policy
> Acts - National Environmental Management Act; Draft NEM: Waste Management bill
> Government bodies - DEAT as the national permitting authority; DWAF as the lead authority on water issues; and the DAEA the provincial authority on environmental issues, including waste (19/08/2008)

The following acts and policies, impact upon and manifest in the management of the Mariannhill Landfill, in the following ways:

- The Environmental Management Plan (EMP) impacts upon Mariannhill, by dictating how the site must be operated and achieves this through the site specific operations plan; emergency plan; and rehabilitation plan.
- The National Environmental Management Act of 1998 (NEMA) impacts Mariannhill site operations through its polluter pays principle, duty of care and public participation – which not only Mariannhill but Durban Solid Waste (DSW) must follow in all their activities. NEMA aids in landfill permit clearance, also referred to as a Solid Waste Facility Permit (SWFP) (Parkin, 02/07/2008).
- The Integrated Pollution Control (IPC); National Waste Strategy; and Waste Management Policy (WMP) are included in eThekwini Municipality's waste management plan for DSW. EThekwini's Integrated Development Plan (IDP) for the municipality - at a broader level, also includes management responsibilities for DSW which inadvertently applies to Mariannhill Landfill. Seeing as eThekwini municipality uses Mariannhill Landfill as a benchmark example, the IDP is not very impacting upon the Mariannhill Site as it is upon eThekwini itself (Parkin, 02/07/2008).
- According to the Constitution (1996), the responsibility of the eThekwini Municipality, relating to Durban Metropolitan's solid waste management, is to provide basic refuse removal for all communities (Costley, 19/08/2008).

These national, provincial and municipal laws, policies and standards provide the overall regulatory framework which guides the operation of the Mariannhill Landfill Site. "Legislation requests government, to wherever possible avoid, and where not to reduce, and where not to re-use, and where not to recycle, and lastly to safely dispose – relating to the waste hierarchy" (Lakhani, 25/07/2008).

This framework can also be seen as providing a mandate, or set of objectives which Mariannhill must operate according to. Essentially, the landfill site is mandated to receive and dispose of waste safely. Reducing the amount of waste sent for landfilling is a preferred strategic approach

to waste management adopted by the eThekwini municipality and formulated as the "Waste Hierarchy" or "3Rs" (reduce, re-use, re-cycle).

## 3.4 Field Work Findings: Environmental and Economic Sustainability of Mariannhill Landfill

Field work findings are presented here under different themes. These themes are derived from the research questions and relate broadly to the questions of sustainability and replicability of activities undertaken at the Mariannhill Landfill Site. Main themes are indicated by numbered headings. Sub-themes are indicated by non-numbered headings.

The issue of sustainability of the practices undertaken at Mariannhill is central to the discussion of the role of the site within its municipal setting and of the replicability of the model. Solid waste management in eThekwini forms part of the broad and long-term strategic component of the municipality's five year Integrated Development Plan (IDP). Moodley (30/07/2008) explains that environmental management activities undertaken within the eThekwini municipality centre on sustainability in order to achieve operational and departmental level goals. Site design is also largely engineered around sustainability in the form of processes relating to cell lining, gas capturing and leachate treatment (Parkin, 02/07/2008). The concept of sustainability is here understood as sustainability of the landfilling process itself and the economic sustainability of the site's processes as a whole.

### 3.4.1 Environmental Sustainability at Mariannhill

The environmental sustainability of Mariannhill is seen to be determined by a number of factors. Levels of daily waste in-take and the size of land available are of course primary factors, and respondents referred to the availability of land as a crucial determinant of the ability of the site to sustain its intake of solid waste. Indeed, the record of waste intake at Mariannhill is the most direct evidence of the sustainability of landfilling practices undertaken at the site. Mariannhill has been able to sustainably (thus far) receive the second highest volumes of solid waste in eThekwini, narrowly behind the geographically much larger Bisasar landfill site (Parkin, 02/07/2008). The site has a volume of 4.5 million cubic metres of landfill space, with two additional areas remaining for landfilling activities (Parkin, 02/07/2008). Parkin argues that landfilling operations may continue until 2018 at 70% landfilling ratios (02/07/2008). Parkin

further states that the site may be able to sustain intake capacity through to 2021-2024 contingent on a 28% reduction in volumes for landfilling – deemed feasible by the current municipality through a combination of process improvements in landfilling operations and societal improvements in waste reduction and sorting (Parkin, 02/07/2008). In this section, those factors over which landfill site management have control are investigated.

In the case of the landfilling process, respondents noted that sustainability is achieved partly through effectively containing the contents of the landfill and thereby sustaining the environment and its ability to continue accepting waste: "The acceptance of waste at Mariannhill is sustainable until the site is full as the designated area is lined and through the operational management process the area is basically cut off from the environment and therefore does not impact on it" (Parkin, 02/07/2008). The approach to containing waste at the Mariannhill Landfill Site is referred to as a "closed-loop" solid waste disposal system, which comprises a number of elements. Firstly, as John Parkin (02/07/2008) describes, the "closed-loop" system implies that Mariannhill Landfill tries to not allow anything to leave the site. This is in turn enabled through a series of practices. Richard Winn's (03/07/2008) description of this system involves a process of "lining, covering and containing". This encompasses the overall approach to waste management at the site through lining active landfill cells, compacting through addition of waste, and capping with an appropriate material. Both Stewart and Winn refer to landfill cells as "bath tubs" in keeping with the concept of a properly lined landfilling space which effectively contains its contents.

This standard process is supplemented by removal of leachate, which is then recycled & reused for irrigation or dust control - by spraying roads & waste to prevent debris from becoming air-borne. An additional practice implemented at the site is the management of gas produced through the chemical decomposition of waste. This is achieved through flaring activities which, whilst not being a perfect solution, does reduce the amounts of Carbon dioxide ($CO_2$) and Methane ($CH_4$) potentially released into the atmosphere (Winn, 03/07/2008). The methane gas is further disposed of through conversion to electricity in Mariannhill's gas-to-electricity project, the first of its kind in Africa (Winn, 03/07/2008). The electricity generated from this project is fed back into the electricity grid. According to Lindsay (07/07/2008), the capacity of the site is extendable through changes to the recycling and composting activities undertaken at the

Materials Recycling Facility (MRF) located on the site. Once solid waste reaches the site, the "tipping" process starts with the site manager and the weighbridge operator, as they are the first to "receive" the waste onto site (Winn, 03/07/2008). A volume of items are immediately recovered for alternative uses. This includes material such as rocks, tyres, and shipping rope, the recovery of which saves landfilling space – increasing the operating life-span of the site and decreasing pressure on the receiving environment. Together, the processes outlined above complete the "closed-loop" system (Winn, 03/07/2008). These processes taken together can be viewed as a system which is sustainable over time, as each process serves to minimize waste in a particular area.

### 3.4.2 Economic Sustainability of Landfilling Activities

An important component of sustainability of the site in general is the economic sustainability of the various practices undertaken. Certain practices can be seen to be driven by the need to comply with regulations, and may not in fact enhance economic sustainability, such as the act of landfilling itself, which is not an activity which necessarily generates a monetary return. The site cannot be seen as a private enterprise, mandated to generate profits, as it is a municipal undertaking, and so is run within the municipal funding framework. The economic sustainability of the site is nevertheless an important issue, as it relates to future developments in the area of landfilling, both within the eThekwini municipality and in other contexts in which landfilling is undertaken. The economy of landfilling also relates to the entire question of "sustainability" in a developmental context, something which is of great relevance at present due to increasing demands placed on societies around the world to minimize waste and maximize efficiency.

In investigating the question of economic sustainability of practices undertaken at Mariannhill the introduction of gas extraction and its conversion to electricity at Mariannhill is an important development which provides the opportunity to test the economic viability of such an activity, its sustainability and replicability in other settings. Removal of recyclable materials from waste intake is another key area which can be assessed for its economic sustainability.

### 3.4.3 Sustainability of Gas-to-Electricity Activities at Mariannhill

There is an ongoing debate around the financial benefits of CDM projects which generate Certified Emission Reduction (CER) credits, or Carbon Credits, for sale on international carbon

credit markets. The Durban city manager, Mike Sutcliffe and others predicted that, whilst initial profits would be modest for the Mariannhill Landfill gas-to-electricity project, they would gradually increase to constitute significant revenue for the eThekwini municipality through the offsetting of around 80,000 tonnes of carbon per year (Parkin, 02/07/2008). The sale of CER credits is set to provide financial security for the Mariannhill and other landfill sites over the medium-term (Robinson and Strachan, 2007). This partial dependence on outside sources of financing both indicates the scarcity of municipal funding in the face of myriad demands on available budget, and the change in the way waste is viewed – not as mere waste but as a source of income: "Waste can be a resource and not just a costly liability. Recycling can cover all aspects of waste production and an excellent place to start is with projects to productively use methane gas from landfill sites to generate power" (cited in Robinson and Strachan, 2007).

Moodley (29/07/2008) argues that the gas-to-electricity project will mean that less natural resources will be extracted and processed for energy requirements, and that the project and its associated activities may generate employment for 50 surrounding community members over the coming years. Moodley argues that the project will aid government in achieving many of its environmental and developmental goals, as well as meeting public expectations. Both Moodley and Parkin (02/07/2008) agree that the gas-to-electricity incorporation with the CDM project will produce less greenhouse gasses and yield income for the site, generated from the carbon credits sold via generated electricity to the World Bank and Eskom.

Wienand (2007) noted that the Mariannhill Landfill gas project (LFG) which was audited by instruction of the World Bank and granted its CDM certification in 2007, was supported by the private sector and Durban City Manager and Mayor, but was not funded by Durban Solid Waste (DSW), the municipal waste disposal company. Mariannhill Landfill relied upon an initial financial "injection" from the World Bank via its Carbon Fund – as part of the worldwide World Bank public private partnerships (PPP). At present Mariannhill Landfill utilizes Carbon Finance in part to operate its gas-to-electricity project. This partial reliance on external financing through the World Bank's Carbon Finance indicates the difficulties, at least initially, in capitalizing and sustaining such a project. Since South Africa's signing of the Host Country Agreement for the acceptance of Clean Development Mechanism (CDM) projects, it has enabled other African

countries to access finance towards landfill gas utilization projects through its status as the Designated National Authority (DNA) for granting qualification for CDM projects.[6]

The sustainability of the gas-to-electricity project can also be argued to depend partly on the way it is viewed by the society within which it is located. In the case of the Bisasar Landfill site's electricity generation project, a prominent local environmental activist, the late Sajida Khan, was able to convince the World Bank to retract their funding in 2006 (Bond & Dada, 2007). This may have spelt the end of the project had not the eThekwini Municipality stepped in to secure international and private funding (John Parkin, 02/07/2008).

At the Mariannhill and La Mercy landfills, however, flaring would suffice for methane gas harvesting because of its reasonably spacious proximity to nearby residential areas. Due to the fact that the gas holds a certain energy potential and that some of that goes lost during conversion from gas-to-electricity, Mariannhill would need to rather use the gas in direct applications – such as gas for household cooking and for industrial applications (Lakhani, 25/07/2008).

On the question of whether the gas-to-electricity project is the best approach to be undertaken, Lakhani argues that there are questions over how to maintain activities in the long run, and states that a preferred solution would be a gas pipe-line to pipe methane gas to the national energy company, Sasol. Such an approach, Lakhani maintains, would be uncomplicated, would yield the most thermal efficiency and that end-of-life factors would not be as much of an issue (25/07/2008).

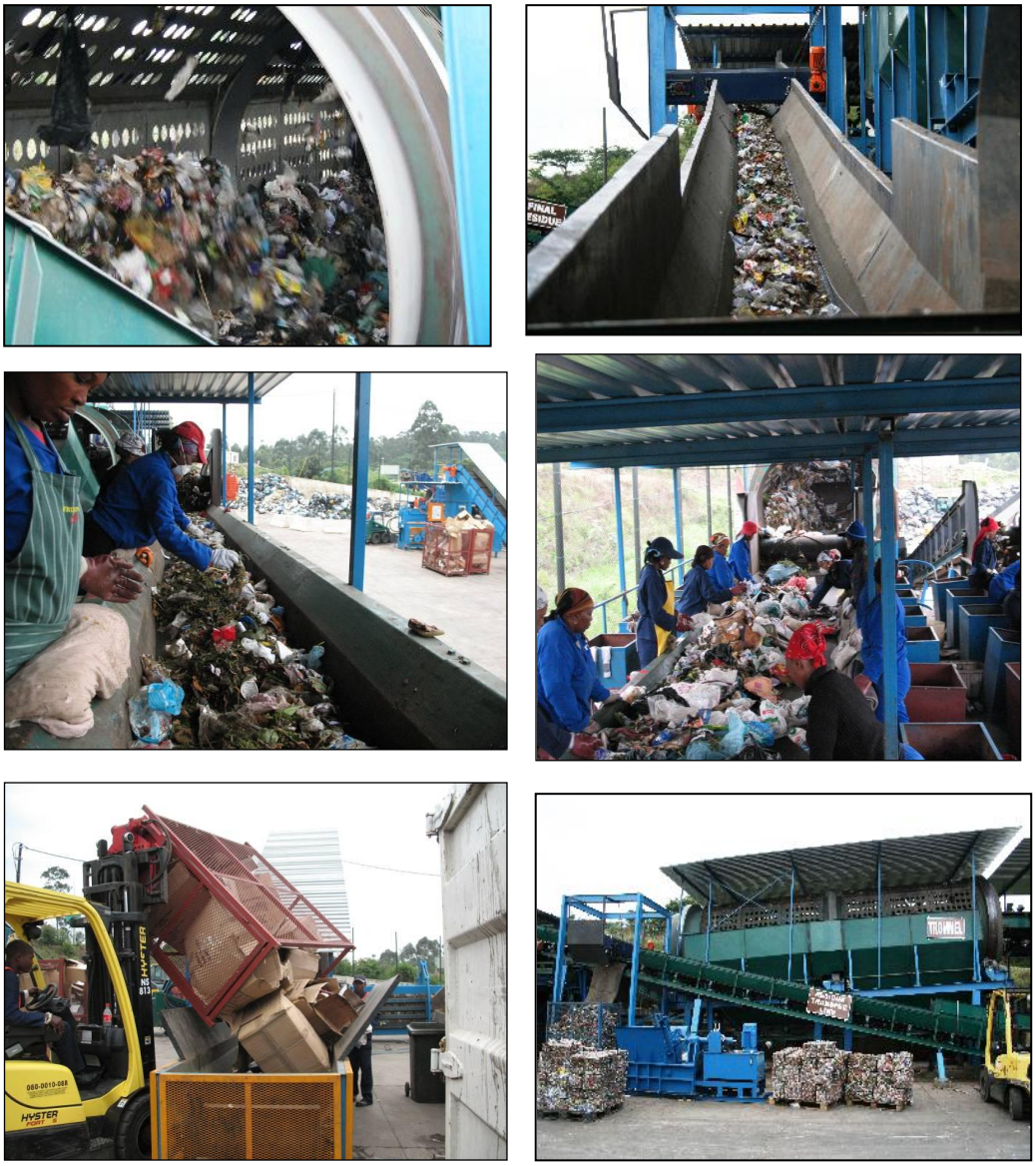
A key issue which informs the overall utility of the gas-to-electricity project is that of the contribution made to eThekwini's overall electricity needs. The project currently produces 1MW/hr whilst eThekwini utilises 750MW/hr on average during the day. This seemingly small contribution should be viewed in light of the eventual maximum envisaged production of 10MW/hr as the rate of gas extraction rises to full capacity, and the fact that current production is sufficient to power 10-15,000 low cost homes (Moodley, 29/07/2008).

[6] Also refer to Cities Network, 2007

### 3.4.4 Sustainability of Recycling Activities at Mariannhill

Assessing the recycling activities undertaken at Mariannhill can provide some insight into the economic prospects for recycling within eThekwini as recycling is not mandatory at the site, but is an initiative specifically intended to be self-supporting. In order to provide a measure of economic sustainability of recycling activities at Mariannhill, numbers of staff which the unit can sustainably employ is observed, as well as experiences at the Bisasar solid waste disposal site in eThekwini. Parkin (02/07/2008) described how employment is provided to 45-50 former waste pickers and unemployed people from the surrounding community in the Mariannhill area, to work in the on-site waste separation plant named the "Materials Recycling Facility" (MRF) established in 2007 (refer to Figure 10 below). This number may reduce in the coming years in line with the experiences at the larger Bisasar Road landfill, which used to have 350 "waste scavengers", but which has since reduced this number to 30 in 2008 (Parkin, 02/07/2008 & Moodley, 29/07/2008). Management at the Bisasar Road landfill site maintain that the shift to a more formal approach to waste-picking, whereby each waste-picker must be registered with a specific buyer, dictates that this reduced number is what the site can sustain (Moodley, 29/07/2008).

**Figure 10: Materials Recycling Facility (MRF) employs pickers and sorters from the surrounding community**




(Source: Sharon Purchase, 2008)

Those factors which reduce the prospects for economic waste-picking and recycling at eThekwini solid waste landfills are here conceptualised as barriers. A large number of these barriers are seen to be exogenous factors which originate in the wider social context. Both Parkin (02/07/2008) and Moodley (30/07/2008) argue that the prospects for economic waste-picking and recycling activities are determined in large part by whether or not a market exists for recycled or recyclable goods. Moodley argues that a major reason for the difficulties experienced in providing jobs for waste-pickers at the site is the "lack of sustainable markets with proper rebates" for recyclable products in eThekwini. Moodley (30/07/2008) and Parkin

(02/07/2008) conceptualise of these exogenous barriers as stemming primarily from issues of funding in a developing city, where issues of service delivery backlogs, health, housing and other, seemingly, more pressing social demands often out-compete issues of waste management and the environment for funding. The problem is complicated further by the range of "hidden costs" of recycling alluded to by Parkin (02/07/2008) and which include "the transport of waste, disinfecting, washing, melting and so forth" which accompany the recycling process undertaken at Mariannhill. According to Parkin, "continuous strong funding infrastructure is needed to make it (recycling) efficient and worthwhile" (02/07/2008). In instances of municipal funds shortages, (taking into account the three tiers of government), procedure requires provincial level to step in, and so forth. However this does not occur. Often Municipal Metropolitan level, is left to "fit the bill" or 'save the day" because of its higher competency based on responsibilities towards funders (Parkin, 02/07/2008).

In the case of Mariannhill the question of economic viability of recycling is particularly pressing as the site has built its reputation partly on its recycling systems, which allow the site to claim success in the area of environmental sustainability. The funding for ongoing recycling efforts at the site have however not come purely from municipal funding, nor from resources generated from the recycling itself, but are also largely dependent on outside funding. These considerations raise the question as to the sustainability of waste recycling at Mariannhill, and point to the challenges of easily adopting recycling processes on this scale generally.

Parkin (02/07/2008) argues that key to overcoming some of these barriers have been the actions of site management, and not support in the way of funding from the municipality or economic viability of the process: "The management team of the Mariannhill Landfill has ensured sufficient funding to run the landfill site according to required standards. Mariannhill's saving costs lie with its management strategy. The site can run on its own and carry on but funding can be an issue due to externalities. Ideal if it could operate without reliance on outside finance (tariffs, rates, taxes)". Mariannhill may only be able to continue recycling activities for as long as it is able to acquire funding (Parkin, 02/07/2008).

Others such as Winn (03/07/2008) argue that the site may be able to function indefinitely, given the application of adequate technologies and changes in waste disposal behaviour in the society

generally. Winn argues that the site's sustainability is reliant upon the off-site involvement of DSW in educating the public on re-using and recycling before sending for landfilling – which would increase the operating "life-span" of the site (saving "air-space"), decrease the impact on the receiving environment, beyond landfilling operations (03/07/2008). Even after the site has technically been closed and fully rehabilitated, the site would still remain open for recycling or shredding, as well as for gas- and leachate treatment – as part of post-site waste management (Winn, 03/07/2008). Stewart argues that solid waste disposal at the Mariannhill Landfill Site will remain sustainable for 5-6 years before coming to an end in 2024 at the most, with some hopefuls placing it at 2030 (Stewart, 09/07/2008; Moodley, 29/07/2008). Should two more cells be made available as extensions to the existing cells, then the Mariannhill Landfill Site will eventually be re-integrated into the Durban Metropolitan Open Space System (DMOSS)[7] (Stewart, 09/07/2008; Moodley, 29/07/2008). This will take on forms of a proposed golf-course and nature reserve, with hiking trails and all current conservancy initiatives such as the bird hide and wetland for bird watching, still in self-sustaining operation long after waste landfilling operations have ended (Stewart, 09/07/2008; Winn, 03/07/2008; Lindsay, 07/07/2008).

### 3.4.5 Role of Management and Innovation

As has already been alluded to in previous sections, the role of management is shown to be key in determining the operational successes of the Mariannhill Landfill Site. Interview responses indicated that the specific management team in place at Mariannhill, and the consistency in staff retention, have been crucial determinants of any success achieved: The Environmental Assessment Manager for DSW states that this aspect of the operation of Mariannhill is crucial to its success and should be maintained: "[The] city would need to keep the current Mariannhill team for the long haul, for consistency and adequate hand-over when such time arrives. The team combines innovation, forward thinking and has helped to change the perception of a landfill ("dump") site in South Africa" (Winn, 09/07/2008).

[7] "The Durban Metropolitan Open Space System (D"MOSS) was designed and launched in 1989 in the Durban Municipal Area. As a result, a network of open space conservation and recreation areas, linked by open space corridors, was created in the previous municipal area. The aim of D"MOSS is to preserve the city's ecological diversity and enhance living environments. The D"MOSS system was updated and extended in 1998 to include the whole metropolitan area through the development of a D"MOSS Framework Plan" (Durban Local Agenda 21). (Also refer to: Roberts & Diederichs, 2002)

This point is also made by Petterson (17/09/2008):

> By instigating a high level of best practice, constant monitoring and maintaining a high standard of operation. It should also be iterated that a cardinal factor in this is the attitude of those in administration of the site. That they are open and receptive to new ideas and following "best practices" is a huge advantage and little more than upholding the minimum legislative requirements would have resulted from a less enthusiastic staff.

A key factor which seems to have informed the management successes at Mariannhill has been the willingness to innovate within the existing regulatory framework in order to meet, and in some instances exceed, the mandated objectives of the site. Parkin (02/07/2008) argues that this innovation has been, in many instances, driven by the "failures" of DSW's waste management disposal methods. What Mariannhill has been successful at is reformulating these methods to achieve the same objective, thereby not risking non-compliance with regulations, but rather pursuing outcomes over and above the minimum expected. Strachan (01/08/2008) describes, how "constant complaints" in the early years of the landfill site's operation led to the formation of expert problem solving skills which were constantly put to the test and forced Mariannhill to excel beyond normative landfilling standards.

Parkin (02/07/2008) argues that innovation should in fact be an automatic component of landfill site management, as every site and its context are different, and management is realistically to be expected to use what tools and resources it has at its disposal:

> As problems arise, they are dealt with the best technology available and whichever techniques work, are implemented at Mariannhill. Each site is unique: terrain, weather, surrounding communities. It is important to pick-up on issues and to solve them. As part of Mariannhill's initial planning stages, it used old site's mistakes and problems to think about what should be done.

This willingness to and success achieved from innovation points to an interesting observation regards the role for legislation and regulation in this particular area of waste management. Legislation and regulation provide a framework to guide the development and operation of the

landfill site. This framework does not however provide direction on every aspect of plant operations, and Mariannhill is noted for developing its own operating standards, many of which DEAT & DWAF use as benchmarks for its conservancy standards, regulations, policies and laws (Parkin, 02/07/2008). In the case of the Mariannhill Landfill Site, this regulatory framework can in fact be seen as both a positive and negative influence. Should compliance with mandated minimum standards not be achieved, enforcement would need to take place through the various municipal structures, yet the need to enforce regulations at the site have been minimal due to Mariannhill's efficiency and ability to exceed requirements for operations such as landfilling safety and recycling since "day one" (Parkin, 02/07/2008). This does not however mean that Mariannhill has significant leeway to manage its operations as it sees fit, with municipal policies forcing the site to follow certain set procedures which are in some cases less preferable to alternatives (Parkin, 02/07/2008). Some of the logistical administrative requirements can place strain upon engineers who have to "waste time with paperwork" (Parkin, 02/07/2008). Parkin argues that there should be some flexibility within the municipal system to allow for non-compliance with laws and policies where the attainment of overall mandated objectives is enhanced by alternative measures adopted. Parkin further states that, in the case of Mariannhill Landfill Site, this is effectively the case, with no one getting into "trouble" where efficiency and other enhancements are made not strictly in line with mandated approaches, partly because "there are always loop holes and little authority" behind these "solid" laws (Parkin, 02/07/2008). Laws are often used by the engineers to justify funding, "however the implementation of laws is still up to the interpretation of engineers, emphasizing what is important and what is not" (Parkin, 02/07/2008).

According to Parkin (02/07/2008) the Municipal Finance Management Act (MFMA) and Supply Chain Management Policy (SCM) apply more to the operating of the Mariannhill Landfill than the Municipal Systems Act. Its enforcement at the site has however been minimal because of Mariannhill's efficiency since "day one". It still forces Mariannhill Landfill to follow set procedures which sometimes renders a somewhat less desired result despite better knowledge - because some laws are less appropriate or inadequate to deal with solid waste management and consequently quality becomes compromised. Some of the logistical administrative requirements often place financial strain upon engineers, rather than bringing "gain", who then have to waste time with paperwork (Parkin, 02/07/2008).

### 3.4.6 Replicability of the Mariannhill Landfill Site Model

#### a) Barriers and their Solutions

Winn argues that education at community and business levels become imperative in terms of following eThekwini's goals for waste management – of reducing; reusing and recycling before landfilling takes place (Winn, 03/07/2008) "Policy makers are not "brave enough" to implement definitive waste strategy and increasing the authority of non-compliance" (Winn, 03/07/2008).

Parkin (02/07/2008) argues that although these barriers present themselves at municipal level, Mariannhill on the other hand does not face the same barriers and the only one worth mentioning is that rate payers may complain about the rates associated with waste disposal. This, however, may be remedied by increasing recycling enforcement at household level, which would reduce rates (Parkin, 02/07/2008) (refer to Figure 11 below).

**Figure 11: Public recycling drop off and storage area**


(Source: the author)

#### b) Logistical and operational shortcomings as barrier

"Delivery of waste to the site cannot [however] be guaranteed as promised, for example blue bags are often mixed with black bags upon collection as well as waste content, where black bags are filled with garden refuse" (Winn, 03/07/2008) (refer to Figure 12 below).

**Figure 12: Landfilling, cell re-enforcements and bank stabilization in progress**

(Source: the author)

There are also realistic challenges to some of the waste initiatives such as "zero waste" and the gas-to-electricity project. Parkin and Lindsay argue that the "zero waste" initiative is in fact a "pipe dream" due to the logistics concerned; available capacity; quality in production; not excluding the need for affordability; as well as the public's apathetic attitude, poor interest, and lack of education (02/07/2008 & 07/07/2008) .

A further obstacle in the way of solid waste management success at Mariannhill and other DSW landfill sites is that even though "zero waste" is conceptually and practically feasible, it does not have a supportive legislative driving force beyond the capacity of a policy objective. Lakhani, however, disputes that until EPR is not incorporated within the Waste Bill and given adequate legislative backing, "zero waste" will remain a "pipe dream" "betrayed" by the "hollow threat of a toothless legislation", when companies are still being granted exemptions (25/07/2008). Furthermore, recycling is arguably a diversion from EPR and hence "designed" to fail. Recycling materials are not always sustainable such as the various types of plastic, as well as the logistics and human error associated with separation (Lakhani, 25/07/2008).

Lakhani (25/07/2008) highlighted a possible point for investigation through his argument which stated that apart from the "inability to think" logically and practically, the public lacks the ability to anticipate alternative measures being as viable, efficient and convenient as current operating systems – due to lack in education and reluctance in cooperation beyond the rate payers" comfort zones.

Furthermore, poor plastic bags will be able to rule out contamination, either - resulting in the same problem only disguised in a different bag (Govender, 04/07/2008). The only alternative offered is education at household level, encouraging the re-use and recycling of waste materials which will reduce the amount sent to the landfill. These "home-solutions" include making mulch and compost from organic waste. It is hoped that should these alternatives be followed closely, the site air-space and life-span will be increased and hence the quality gas-to-electricity generated.

**c) Replicability and Current Practices**

The responses detailed below are to the question of how replicable the practices employed at Mariannhill are at the eThekwini municipality level.

The operations at Mariannhill Landfill Site are similar to those of other eThekwini landfill sites as it functions according to the general landfill operating requirements as set out by eThekwini Municipality and Durban Solid Waste. These standards, as described by Melvan Govender (04/07/2008), require that all sites adhere to minimum legal principles and standards which include the prohibition of scavenging and ensuring that each waste disposal cell is lined at its base to contain leachate and control the impact upon the receiving environment (refer to Figure 13 below). There are, however, a number of differences to be found in Mariannhill's practices when compared to other landfill sites in eThekwini. Richard Winn highlighted some of these differences, noting that Mariannhill Landfill Site's management is different because of the driving forces behind its operations such as laws; the monitoring committee; and the "PRUNIT" (Plant Rehabilitation Unit). The effectiveness of these driving forces is determined by the people who administrate and operate within these parameters.

**Figure 13: Site scavenging is prohibited at Mariannhill Landfill**


(Source: the author)

Bisasar Road landfill is similar but was opened in 1980s when the understanding of waste management was limited compared to the changes that have subsequently taken place since 1994. It is, however, impossible to replicate all of Mariannhill's best practice landfilling methods at Bisasar Road to the same extent - such as re-shaping community perceptions, because of the area's strong Apartheid[8] legacy and Bisasar Road landfill was already 14 years in operation (Parkin, 02/07/2008). Hence replicability would be possible as far as the basic principles are concerned but not to the extent of the exact measures employed at Mariannhill Landfill. For near complete replicability to be possible, a site would need to be adequately managed from the day of "opening" (Parkin, 02/07/2008).

There are still some similarities to be drawn, as Parkin (02/07/2008) argued that eventually the new Buffelsdraai landfill will be run in much the same way as Mariannhill Landfill– where appropriate and possible, and will also receive a conservancy title.

[8] Also refer to Freund, 2007

The replicability of some of Mariannhill's best practice initiatives such as the gas-to-electricity and "zero waste", in other eThekwini municipal solid waste landfills may be challenged with the following concerns as argued by Dr Shauna Costley (19/08/2008):

> Many of the municipalities in KZN are challenged by the lack of sufficient budget and capacity to adequately manage their landfills. In many instances there is no dedicated post for a landfill manager hence the function becomes an added responsibility to others e.g. health officer who does not necessarily have the required training in landfill management. Furthermore the landfill is more like a "dump" i.e. the site is poorly managed and gas emissions are uncontrolled. As such it would be very difficult to try implement a "gas-to-electricity" project without first getting the site managed and operated properly! I believe the MRF (Materials recycling facility) could be replicated at other landfills in the Province, although in the smaller municipalities (with smaller budgets) the facility would be smaller and more hands on. My concern would be the location of markets for the recycling material in relation to the municipality and the associated costs with transportation of the waste. I would also be concerned about the general health and safety of the employees at sites where management is poor.

A major concern held by DSW is the rising need for more commitment from the municipality towards stricter recycling regulations at household level and at all eThekwini landfill sites[9]. As it stands increased waste generation rates, render Mariannhill Landfill's life span short. These life-span saving and air-space increasing initiatives will require education at household level as well as at municipal solid waste management level. It would further require a change in public perception and an encouraging driving force from eThekwini towards a new philosophical approach and ethos surrounding solid waste disposal (Costley, 19/08/2008; Lindsay, 07/07/2008; Govender, 04/07/2008).

There is currently no other more successful DSW landfills within eThekwini – as Mariannhill is revered as the flagship site for other sites to follow, because technologies are tested at the

[9] Costley, (19/08/2008) explains that: "In the eThekweni metro landfilling is the only alternative for waste disposal. Although there are some recycling initiatives in place e.g. drop-off centres, garden waste sites, recycling is not a common practice by the general public. Drop off centres are generally inaccessible and require 'effort' by citizens to drive to and drop off their separated waste"

Mariannhill Landfill and those successful are then replicated (refer to Figure 14 below). However, Buffelsdraai with a much larger geographical size and capacity (and 800Ha buffer zone) seems to have all its "bells and whistles" in check and will have a more long-term scope (Winn, 03/07/2008; Moodley, 29/07/2008; Govender, 04/07/2008).

**Figure 14: Site activities piloted at Mariannhill for replication around DSW eThekwini**


(Source: the author)

Some alternatives to solid waste management as previously mentioned, would include Extended Producer Responsibility principles. This would imply a shift to "out designing" undesirable or unsustainable processes and products, and rather towards redesigning infrastructure into a decentralized model – because waste problems must be dealt with at a local level first (Lakhani, 25/07/2008).

The umbrella solution includes a system of control over the amount of waste received and sent for landfilling at the site. The reduction and re-use of waste by means of instituting different coloured bags from household level up to commercial activities (for the separation of garden refuse and plastic materials) have been suggested to the eThekwini municipality. At present only the separation of paper is practiced which does keep the paper free of contaminants for optimal recycling, but is, however, not enough and only voluntary. Should the different coloured bags be instituted, the waste would still be loaded into one mixed solid waste disposal truck destined for the same landfill (separation area).

With reference to the "zero waste" initiative, varied views are shared regarding its success. It is a replicable technology, however, its success would be reliant upon waste volumes, the area, locality, and types of waste - "Any delivery would need to be on a large scale for the sake of cost-effectiveness" (Govender, 04/07/2008). Other opinions include that it is an ideal theory or concept, however realistically there will always be a waste residue (Moodley, 29/07/2008).

Further impacting replicability in and around other eThekwini landfill sites face barriers of political will; power of industrial lobbying; the lack of understanding within which context solid waste can be managed; and overall mental colonization found in generic terms of reference, associated with solid waste and environmental management issues (Lakhani, 25/07/2008).

Some of the available opportunities involved in implementing these alternatives in other local municipal landfills in eThekwini, may, however, include greater economic prospects; lessening social impacts such as health and environmental degradation (Lakhani, 25/07/2008).

"Mariannhill is not viewed in isolation and is seen as a learning tool for the whole of DSW, therefore the same principles are applied at all the other DSW landfills – depending on the stage of landfilling, capacity, closure procedure; environmental factors, etc." (Winn, 03/07/2008) [10].

The realistic challenges and prospects associated with the replicability of some of the following initiatives, in other eThekwini solid waste landfills, have been discussed by Govender, 04/07/2008 in tabular format (refer to Table 4, below).

[10] "Although the Municipality's Environmental Management Department has not had a direct input into Mariannhill it has been involved with the landfill gas project of which Mariannhill is a participant. This, however, will change in future as the EMD now has a Capital Projects Environmental Officer whose function it is to deal with the internal regulation of all of the Municipality's Capital Projects, which would include the establishment of future land fill sites within the Municipality" (Petterson, 17/09/2008).

**Table 4: The Challenges and Prospects for Replicability of Best Practice Initiatives in other Municipal Solid Waste Landfills in eThekwini**

| Initiatives | Challenges | Prospects |
|---|---|---|
| Zero-Waste | Pilot project. Sorted through the negatives and implemented at other sites, e.g. Bisasar. | Will be 4x bigger at Bisasar due to capacity and volume waste received. |
| Gas-To-Electricity | Tender process becomes tricky and influenced by various experience of contractor. | Bisasar is an old landfill, releasing plenty gas. The project was commissioned two months ago (May 2008) and the landfill site tested for over 5years viability. Although the project is new, the site is old and could supply a 4MWengine per/hr with gas to electrify the Moses Mabida 2010 Stadium. |
| Waste Recycling | Without sorting & cleaning recyclables before sent for landfilling, would mean more odours; more dirt at the materials recycling facility and possibly more waste being sent for landfilling. This initiative goes hand-in-hand with the ZERO WASTE vision. | There is the possibility of job creation for +- 60 unskilled and unemployed local people in the surrounding area. This further decreases the impact upon the lining system and receiving environment – saving the environment and increasing landfill air space and consequently its lifespan. Further up the chain, less resource extraction means requiring less production, also saving water; time; and money. Would be easier to monitor bad medical waste disposal practices with the help of the waste sorters the source could be located. An example would be where Doctors do not follow adequate procedure and try sneaking medical waste together with solid waste. |
| Methane Combustion/ Flaring | Same as Bisasar landfill but Buffelsdraai still too new and small in its operation to take-on combustion/flaring because only receives 10 tonnes a day. | |
| Plant Rehabilitation ("PRUNIT") | Already in-place at all eThekwini landfill sites. Buffelsdraai has been assessed to have an 80-100 year life-span and therefore a leachate treatment plant/Sequential Bach Reactor can be implemented from the get-go. | Able to rehab the full cells with same plants found at the site whilst landfilling on next cell continues. This saves money; impact upon receiving environment and creates more immediate stable rehabilitated environment. |

(Source: Govender, 04/07/2008)

## 3.5 Conclusion

One may ask whether a future without landfilling is possible and if so at what cost and at whose expense? If landfilling continues, will it really be sustainable for human and environmental survival? One must bear in mind that there cannot be any human activity without having an impact upon the environment. Consequently for health and safety reasons, waste has to be disposed. The example of Mariannhill Landfill indicates a way forward in future landfilling activities; where initiatives such as the Sequential Bach Reactor (SBR), Materials Recycling Facility (MRF), Plant Rescue Unit (PRUNIT) and the Gas-to-Electricity project, all combined add to less waste being landfilled. This not only decreases the direct impact upon the receiving environment but also lengthens the operating life-span of sites to gain time in seeking better alternatives in the future and in doing so also decreases the demand upon scarcely available and developable land.

# Chapter Four: Analysis and Conclusions

This chapter will synthesize the findings from the literature review and field work findings to provide analysis of the research questions. Recommendations for further research will also be proposed. The two key questions are restated and re-examined here in more detail.

**Key Question 1)** What determines sustainability of practices undertaken at Mariannhill Landfill Site?

**Key Question 2)** Are the approaches undertaken at Mariannhill Landfill replicable in other settings?

## 4.1 Determinants of Sustainable Solid Waste Management at Mariannhill Landfill Site

It is clear from the field work that Mariannhill Landfill has a number of systems in place which each individually contribute to the overall sustainability of the site. Many of these in fact go beyond both the requirements of the municipality, and the activities more traditionally associated with landfilling. As Parkin (02/07/2008) indicates, landfilling is commonly viewed as a cheap form of waste disposal which lessons the need for recycling or sorting of waste. Mariannhill has certainly fulfilled the requirements of effectively containing or converting to a safe form all of the material that enters the site, which is the paramount role for the site within its municipal context. Part of the reason for this very effective containment and conversion of materials is the range of activities undertaken at the site which exceed regulated requirements. The range of activities, such as waste-picking and sorting, recycling, and the gas-to-electricity project are activities which, whilst not regulated for, do feature prominently in the general texts of national and provincial policy documents and perhaps in the mid to long-term, such activities will be progressively more regulated in eThekwini as they are in many other parts of the world.[11]

A focus on sustainable development and more efficient use of limited resources is a trend which is gaining in importance internationally. This quite strong emphasis on sustainable and environmentally conscious municipal guidelines and policy points in eThekwini certainly has

[11] There is an increased trend towards more highly regulated environmental-related areas in countries around the world (Louka, 2006: 445).

had an influence over the initiatives undertaken at Mariannhill Landfill and the way the site is run generally.

Another factor affecting the sites movement towards a very sustainable and multi-function landfill site have been exogenous “push factors” or incentives including the provision of outside financing from the Prototype Carbon Fund and the provision of Certified Emission Reduction (CER) credits to trade on international carbon credit markets.

## 4.2 The Role of Management at Mariannhill Landfill Site

The impetus for implementing systems such as the Materials Recycling Facility (MRF) and the complex reclamation process which uses recycled leachate as water must come in large part from the management itself, as this aspect to the site's operations is not regulated for. Management seems to have taken pride in pursuing excellence and in adopting many innovative and effective systems which are focused around recycling of materials. This recycling takes the form of both recovery of material from waste in-take, and from conversion of materials to useful forms. The formation of combustible gas, its transport and combustion to form electricity is an example of a process which in fact combines the two forms of recycling into a profit-forming system. The profitability of the more traditional waste-sorting, picking and recycling system is less certain the medium to long-term. Management therefore must be motivated by more than the wish to make profit.

It may be argued that the management at Mariannhill have been motivated to achieve success in every aspect of the site's operation, and to act according to an environmental ethos informed in part by the approach to environmental issues within eThekwini Municipality. This environmental ethos and professional pride have also served to ensure remarkable continuity of management personnel over the duration of the site's operation. Key environmental structures within the municipality have also remained fairly consistent over the time period. The eThekwini Municipality has acquired a “character” of pursuing environmental excellence over a period of time which has affected the prospects for a site such as Mariannhill to operate in the way which it does. The range of policies and regulations related to the environment and waste disposal in eThekwini are much centred on sustainability, both of the environment and of development. The focus on job creation and inclusive development at the national level, which

have been consistent goals of the government since 1994, exert an influence over choices made at the site. The influence of this strong emphasis on sustainable development (environmental and economic) can be seen in activities which provide employment and are focused on waste-minimization, recycling, conversion of materials and other activities which enhance sustainability. These include the Plant Rescue Unit (PRUNIT), leachate Sequential Batch Reactor (SBR) treatment plant, and the Materials Recycling Facility (MRF). These activities are not specifically regulated for, and so must be partially influenced by the more general principles contained in policy and regulation.

## 4.3 Replicability of The Approaches Undertaken at Mariannhill Landfill in Other Settings

The main barrier to easy replication of systems followed at Mariannhill in other landfill sites is the difficulty in replicating the specific structures of management and its character. As indicated above, the set of factors which served to motivate and guide management's decisions at Mariannhill were largely spontaneous and contingent upon a particular contextual and time setting. These exogenous factors are difficult to replicate unless certain basic pre-conditions are met. Just as quickly as such a particular management ethos and its associated structures can form, so conditions can change, ushering in a different set of objectives and competencies.

Another key exogenous factor is the prevailing attitudes to recycling and the environment in general in the society. Various respondents argued that a lack of education within DSW departments and at household level becomes a governing and decisive factor in Mariannhill Landfill's managing successes and prevailing shortcomings. Realistically the current possibility of full recycling in South Africa has been estimated to be at an average of only thirty percent (30%) over a nine-year period (Matete & Trois, 2007). However, without proper education and enforcement of waste separation and minimisation at household level, the integrity of the type and volume of recyclable materials become compromised. Household waste management starts at the point of purchase; hence consumer choice-power comes into play. By consumers making informed decisions about their choice in products and the types of materials involved in the packaging thereof, the home owner as a consumer, already decreases the amount of waste sent to the landfill and may increase the amount of waste re-usable at household level without being sent for landfilling. Such packaging materials include plastic and polystyrene, which is either toxic to

the environment and or in-disposable during its waste life cycle and should therefore not be used in packaging processes. Further household incentives stood to be gained include benefits from organic waste such as mulch used as compost in gardens and as sustainable sources of fuel. "One way of generating energy from waste is to convert it into Refuse Derived Fuel (RDF). Pellets are made from combustible waste material and can be used in industrial boilers in place of or as a supplement to fossil fuels (oil and coal). Roughly 25-30% of household waste is suitable for conversion into RDF" (Household Waste, 2008).

Consumers need to make informed choices regarding product packaging, pertaining to types of materials used in packaging; the size; degradability; and recyclable potential. Materials such as plastics and polystyrene are not only non-biodegradable but are also non-recyclable due to porous nature and varying chemical compositions that may prove lethal in re-using to package food or medicine. Furthermore, the types of chemicals used in producing food and medicine as well as the precarious conditions and labour contracts under which products are produced or manufactured and packaged, delves further into the intricate dark heart of consumerism, the "relationships and connections" globalization forges and the choices the public should be made aware of – as previously suggested by Parkin (02/07/2008); and Lakhani (25/07/2008). These choices impact upon the physical and natural environment – biodiversity and eco-systems, as well as our human health and safety. Perhaps encompassing cohesion may be reached on this dilemma by introducing a kind of an Integrated Product Policy (IPP) – to better inform and closely monitor the means, logistics, and technologies involved in production, manufacturing, and packaging of goods. This would determine whether potential waste or re-introducible materials are being "produced" with minimal impact upon the receiving environment – for overall better and more sustainable solid waste management (SWM), at both local municipal level in eThekwini and at a foreseeable national level of South African solid waste landfill management. The overall community perception of Mariannhill Landfill, as argued by Moodley, is good and ascribed by some, to the sites" high-science methods of waste disposal (2007: 71).

All these environmental and economic cost saving efforts, decrease energy consumption and raw materials extraction, ranging from transport to manufacturing, to re-using and recycling. However for such basic efforts at household level to become a reality and everyday solid waste management practice, better municipal infrastructure would be required. However, for

consumers to make a more informed and "environmentally friendly" decision, their choice in products and packaging materials need to be increased. Furthermore, the price of such associated commodities would need to reflect and encourage consumer demand, in order to create and sustain economically viable and lucrative markets. The price of packaging materials manufactured and quality of products produced are coiled in the relationship between South African government and South African business owners – in keeping with local laws and standards. This may further be affected by global trends of consumer demand and trade tariffs attached to sought after products and materials. Trade agreements with other nations may further dictate what enters the local South African market – determining the range of consumer choice. However through strong local policies and complying with high international standards related to "clean" production, the market control may be negotiated within the trade agreement's obligations and boundaries.

In trying to determine the replicability of activities undertaken at Mariannhill, it is useful to try to identify those areas that can be considered examples of best practice as possible areas to replicate in other settings. As mentioned in Chapter One, it is difficult to ascertain what best practice is in an isolated case, as success factors in one setting may not necessarily translate into others. However, based on the definition given by the Department of Environmental Affairs and Tourism (DEAT) which centres on the Waste Hierarchy, several of the activities undertaken at Mariannhill do constitute examples of "good practice" or best practice. The Waste Hierarchy, which centres on the "3 Rs", "Reduce, Re-use, Recycle" is also however located within a specific context (South Africa) and so takes on some of the specificities of its setting. Mariannhill has certainly integrated activities which fulfil the 3 Rs. These include the reduction of waste through waste-picking and sorting, re-use of materials such as the use of treated leachate to irrigate and reduce dust, and recycling initiatives which take place at the Materials Recycling Facility (MRF). Other considerations, such as sustainable job-creation which forms part of the Waste Hierarchy, are also partially met at Mariannhill through the aforementioned activities. The Mariannhill Landfill Site can, I argue be considered an example of best practice within its particular municipal setting as it satisfies the principles upon which good, or best practice is determined in the particular setting, by the eThekwini Municipality itself. Mariannhill has far exceeded landfilling standards and legal expectations. Replication therefore may be most

easily undertaken within the same or similar municipal settings in South Africa, as in the other eThekwini solid waste landfills.

However in considering the difficulty in replication of the Mariannhill model as a whole, I argue that it is the technical aspects of operations at Mariannhill Landfill that are the most easily replicable aspects of Mariannhill's operation in other settings which may not necessarily operate within the same set of societal needs or obligations.

## 4.4 Recommendations for Further Research

There are, however, some areas for improvement such as a free onsite public recycling drop-off area that will further encourage pre-separation of waste at household level and hopefully further encourage the reduction and reuse of waste before discarding it as waste for landfilling. Pre-separation of waste will increase not only the amount of recycling but also the variety and quality of recyclable materials. The drier and less contaminated waste is, sent for landfilling, the better and more improved quality gas-to-electricity is generated – increasing the power supplied back into the eThekwini electricity grid.

According to 1994 and 1996 statistics, places such as Chile, Brazil, Argentina, Mexico, Malaysia and Hong Kong, were recorded to have already either through higher landfill site tipping charges or via the amounts of waste received, generated between 4, 300 – 22, 010 US $ Per Capital. South Africa lagged behind with 3,140 US $ Per Capital (refer to Table 5 below).

**Table 5: International Correlation Between Tipping Charges and GNP Per Capital**

| Country | Tipping Fees US$/tone (app. Range) | 1996GNP Per Capita(US$) |
|---|---|---|
| Argentina | 5-18 | 8,410 |
| Chile | 5-17 | 4,920 |
| Brazil | 5-18 | 4,360 |
| Malaysia | 1.2 | 4,300 |
| South Africa | 12 | 3,140 |
| Peru | 5 | 2,410 |
| Colombia | 11 | 2,190 |
| Philippines | 9.7 | 1,190 |
| Indonesia | 1.3 | 1,090 |
| China | 2.5 | 750 |
| Hong Kong | 10 | *22,010 |

(Source: Johannessen and Boyer, 1999: 3)

These countries have since then gone from strength-to-strength in their waste disposal revenues. It would be useful to examine in certain of these examples, the role for management in particular in determining the landfill sites' operational successes.

EThekwini and South Africa should more adequately use existing laws to guide and support management innovations and environmental conservancy efforts such as site entry charge fees for unsorted waste and enforce pre-sorting at household level. When considering that most of the current disastrous environmental problems created by landfills, have been as a result of disposal activities by unpermitted and privately owned landfills, there is scope to investigate what role regulation and institutional structures play in determining effective landfill management in a specific area (Parkin, 02/07/2008).

This may be encouraged and achieved by better planning integration into the policy writing process, relating to trade tariffs, resource extraction, manufacturing and production. The result and or catalyst for such regulatory policies may be found in urban planning design strategies and regulations, as seen in the city of Curitiba where old buses are converted into office spaces.

Although Mariannhill is a good example of what can be achieved in terms of sustainability and achievement of operational excellence, there is no guarantee that such an example will be repeated in the eThekwini municipality, or indeed in any municipality in South Africa. Innovations and best practice examples of recycling, leachate treatment and production of gas for combustion are all systems which may have potential for integration into environmental regulations in South Africa.

Indeed, these activities should become more important over time as certain resources become scarce, or development leads to increasing volumes of waste. There is a great need therefore to investigate how to introduce regulation in these areas in the most effective way. Options for regulating for waste management may include increasing penalties – raising fines and including jail sentences for non-compliance, which will demand a paradigm shift from voluntary participation towards forced adherence.

Furthermore, it must be noted that it is possible to overcome the "grips" of apartheid planning as seen in the construction of new and better landfill sites such as Buffelsdraai, by applying innovative and groundbreaking technologies such as piloted at the Mariannhill ("flagship") site. Just because the environment does not have an audible human "voice", does not mean it will not "lash out". Should that "voice" be too soft to keep up with ever increasing population, urbanization, globalization, and consumerism demands, then hopefully environmental activists, conservationists, and engineers like Muna Lakhani, Jean Lindsay, Richard Winn and Lindsay Strachan, will slam on the brakes.

# Appendix 1

***List of Key Informants***

1. Costley, S.; Deputy Manager: Waste & Chemicals Management, Department of Agriculture and Environmental Affairs (DAEA); Dated: 19/08/2008.

2. Edward, B.; Project Executive, Development Planning & Environmental Management, eThekwini Municipality; Dated: 30/09/2008.

3. Govender, M.; Site Supervisor, Mariannhill, DSW, eThekwini Municipality; Dated: 04/07/2008.

4. Home, R.; Chartered Town Planner and Professor in Land Management. Anglia Law School, Anglia Ruskin University, Bishop Hall Lane, Chelmsford, Essex CM1 1SQ, UK; Dated: 18/08/2008.

5. Lakhani, M.; Waste Activist; Dated: 25/07/2008.

6. Lindsay, J.; Pinetown Counsellor, eThekwini Municipality; Dated: 07/07/2008.

7. Moodley, L.; Operations Engineer, Durban Solid Waste, eThekwini Municipality Cleansing and Solid Waste Division; Dated: 29/07/2008.

8. Moodley, S.; eThekwini Policy Unit; Dated: 30/07/2008.

9. Parkin, J.; Deputy Head – Plant & Engineering, Durban Solid Waste, eThekwini Municipality; Dated: 02/07/2008.

10. Petterson, T.; Environmental Management Department, eThekwini Municipality; Dated: 17/09/2008.

11. Stewart, T.; Conservator Overseeing: Umbilo, Umhlatuzana zone for eThekwini Municipality as part of Parks Department; Dated: 09/07/2008.

12. Strachan, L.J.; Executive Director, Carbon Reductions (Pr Eng, MSc Eng); Dated: 01/08/2008.

13. Winn, R.; Environmental Assessment Manager, contracted to Durban Solid Waste, eThekwini Municipality; Dated: 03/07/2008.

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