THE DEVELOPMENT OF SUSTAINABILITY CRITERIA TO FACILITATE THE SELECTION OF SANITATION TECHNOLOGIES WITHIN THE BUFFALO CITY MUNICIPALITY (EASTERN CAPE PROVINCE, SOUTH AFRICA)

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ABSTRACT

Two and a half billion people mostly in sub-Saharan Africa and southern Asia remain without improved sanitation facilities despite the Millennium Development Goal 7's target to halve this number by 2015. While it might be tempting for developing countries such as South Africa to implement the cheapest and most rapidly constructed sanitation services simply to meet the desired target, this could have significant negative implications on human health and the environment over the long-term. As a result, there is a need to ensure that the most appropriate sustainable sanitation technologies are selected during the planning stage. The purpose of this research was therefore to document the development and pilot application of a flexible context-specific decision-support tool for sustainable sanitation technology selection within Buffalo City Municipality (BCM) in the Eastern Cape Province of South Africa. The first step in the development process was to ascertain the current status of sanitation within the municipality, with a specific focus on the main challenges related to the provision, maintenance and performance of these technologies. Thereafter, a participatory approach was employed involving BCM stakeholders to develop a series of sustainability criteria and indicators that took into consideration economic, social, environmental and technical concerns as well as legal requirements. The development process resulted in a list of 38 BCM sustainable sanitation selection criteria that were applied in a pilot study involving rural, urban and peri-urban communities within BCM. Certain criteria related to topographical features and the availability of piped water and land were considered useful for 'coarse screening' while others were applied during 'fine screening'. In order to enhance the context specificity of criteria, each was weighted, through consultation with key BCM stakeholders. This research confirmed that the sanitation situation in BCM was poor and preliminary evidence indicated that sanitation systems were negatively impacting on the quality of water resources within BCM justifying the need for a sustainable sanitation decision support tool. Based on the pilot application of the BCM Sustainability Selection Criteria List, the urine diversion technology was considered the most sustainable technology option in each study site. There were however, certain social criteria that received relatively low sustainability scores and these would need to be addressed prior to the approval of this technology for implementation. The approach adopted in this thesis was considered highly context-specific yet flexible and appropriate for adoption not only by BCM but other municipalities on a range of spatial scales.

DECLARATION

The work described in this research project was carried out in the Department of Environmental Science, Rhodes University, Grahamstown, under the supervision of Dr Kevin Whittington-Jones, in fulfilment of the academic requirements for the degree of Master of Science. This study represents original work by the author, and opinions expressed and conclusions arrived at are those of the author. The author has read and accepted the Rhodes University plagiarism policy. Where use has been made of the work of others it is duly acknowledged.

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LIST OF ABBREVIATIONS

ADM – Amatole District Municipality

AII – Actual Importance Index

BCM – Buffalo City Municipality

BCM IEMP – Buffalo City Municipality Integrated Environmental Management Programme

BOD – Biological Oxygen Demand

CCED – Collins Concise English Dictionary

cfu – colony forming units

COD – Chemical oxygen Demand

CON – Conservancy Tank

DEAET – Department of Economic Affairs Environment and Tourism

DWAF – Department of Water Affairs and Forestry

EIA – Environmental Impact Assessment

EnTA – Environmental Technology Assessment

FSC – Forestry Stewardship Council

GDP – Gross Domestic Product

GIS – Geographical Information System

HWR – Human Waste Report

IWA – International Water Association

LM – Local Municipalities

MCDA – Multiple Criteria Decision Analysis

MDB –Municipal Demarcation Board

MDG – Millennium Development Goal

ML/DAY – Mega litres per day

NICD – National Institute of Communicable Diseases

NSSD – Natal Strategy for Sustainable Development

P/F – Pour Flush Latrine

RDP – Reconstruction and Development Plan

RSA – Republic of South Africa

S/T – Septic Tank

SDF – Spatial Development Framework

STLV – Small Towns and Large Villages

TA –Technology Assessment

UD – Urine Diversion

UN –United Nations

UNDESA – United Nations Department of Economic and Social Affairs

UNEP – United Nations Environmental Programme

UNESCO – United Nations Educational, Scientific and Cultural Organisation

UNFPA - United Nations Fund for Population Activities

UNICEF – United Nations Children's Fund

VIDP – Ventilated Improved Double Pit

VIP – Ventilated Improved Pit Latrine

W/B – Waterborne

WHO – World Health Organisation

WSSCC - Water Supply and Sanitation Collaborative Council

WSSD – World Summit on Sustainable Development

WWTWs – Wastewater Treatment Works

Yrs – Years

ZINWA – Zimbabwe National Water Authority

CHAPTER 1: OUTLINE OF THE STUDY

1.1 INTRODUCTION

The United Nations Department of Economic and Social Affairs (UNDESA, 2007) global estimates indicate that in the next 40 years an additional 3.1 billion people will live in existing towns and cities, mainly in developing countries, and will require much needed water and sanitation facilities. These figures demonstrate the remarkable trend towards urbanisation which is set to continue, with the greatest urban population growth predicted to occur in Africa, Asia, Latin America and the Caribbean. The United Nations Environmental Programme (UNEP) recognizes that the increasing global population tends to concentrate in urban communities. This concentration results in densely populated areas that require sanitary collection, treatment and disposal systems for their waste (UNEP, 2001). These systems control the transmission of waterborne diseases and contribute to the prevention of irreversible degradation of the environment and aquatic systems. Increased urbanisation and population growth already place huge demands on scarce water resources. However, according to Mara (2003), we are currently living in a "water desperate" world and the extensive use of surface water is leading to clashes between urban and rural users as well as overexploitation of these resources (Narain, 2002).

Surface and ground water resources are also under threat from inadequate and inappropriate sanitation. Jenkins & Curtis (2005) state that, nearly half the world's population lack the basic sanitation necessary to protect the environment from contamination by human excreta. Sanitation – defined by the Water Supply and Sanitation Collaborative Council (WSSCC) as "*reducing people's exposure to disease by providing a clean environment in which to live, including measures to break the cycle of disease*" (WSSCC, 2000) when inappropriate has caused a reduction in water quality and quantity and as a result many rivers today have been polluted due to domestic sewage flowing into them from cities (Dewulf & Van Langenhove, 2005). Surface water systems have also been transformed into open sewage drains as a result of unsustainable disposal of anthropogenic waste.

There are a multitude of ecological, social and economic consequences of pollution from poor sanitation practices, the majority of which affect the poorest in society, particularly women and children in developing countries. According to the World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF) (2000), four million people die annually from diarrhoeal diseases such as cholera and typhoid fever which are transmitted by water contaminated with faeces. The WHO and UNICEF (2000) further estimates that 1.5 billion people are infested with parasites due to inadequate disposal of faeces and refuse. Morris (2004) has termed the poor water and lack of sanitation provision as a "*Silent emergency*" and Bartram *et al.* (2005) have called it "*A silent humanitarian crisis.*" The latter further state that, "*more people endure the largely preventable effects of poor sanitation than are affected by war, terrorism and weapons of mass destruction combined. Nevertheless, these issues catch the public and political attention in a manner that water and sanitation issues do not.*"

Based on the above, it is clear that there is an urgent need to develop methods for protecting communities and the environment from the largely preventable impacts of poor sanitation provision. There is a need for the principles of sustainable development to merge with sanitation provision. If the risks and impacts of environmental pollution are to be minimised, and the goal of sustainable development achieved, appropriate sanitation technologies have to be selected right from the planning stage. Loetscher & Keller (2002) defined a comprehensive list of 83 different types of existing sanitation technologies – emphasising the great variety of sanitation technologies available, each with its own advantages and disadvantages in a given context. As such, before selecting and investing in a sanitation technology, it is always preferable to investigate whether the sanitation technologies are environmentally sustainable, appropriate to the intended local conditions, acceptable to the intended users, and affordable to those who have to pay for them.

Bracken *et al.* (2005) highlighted the fact that decisions regarding the selection of sanitation technology have in the past frequently been based on financial and technical factors, whilst largely neglecting the issues of the environment and human health. As a result, many sanitation systems within communities have resulted in pollution of water resources with associated negative impacts on the health of communities. As sustainable development in a sanitation context requires balancing different aspects such as environmental impacts, social acceptance, economic feasibility and technical viability of alternatives, rational guidance is necessary to achieve sustainability. Sustainability criteria can support rational decision-making by assisting decision-makers to examine and consider the balance between the above-mentioned aspects of sustainable development.

South Africa provides an opportunity for the investigation into the development of sustainability criteria within a developing country context. Its population of 49.4 million consists of an estimated 13.4 million people without access to improved sanitation (DWAF, 2008). Providing sustainable sanitation to these individuals will require careful planning and co-ordination by the South African government to ensure that the different aspects contributing to sustainability are achieved. The development and use of sustainability criteria to support local government decision-making was investigated in the Buffalo City Municipality (BCM) in the Eastern Cape Province of South Africa.

1.2 SANITATION PROVISION IN BUFFALO CITY MUNICIPALITY

Of the nine Provinces in South Africa, the Eastern Cape is the second largest covering a total area of 168 966km^2 with a population of 6 49 453 people (DWAF, 2008). It is however the poorest province, with an unemployment rate of 32% and a large rural population, currently estimated to be 63% (DWAF, 2008). Apartheid deprived the Eastern Cape community of services including health, education, housing and sanitation (Woolard, 2002).

Due to the lack of employment opportunities and basic human needs, in the Eastern Cape Province and particularly in the rural areas, many municipalities are experiencing rapid urbanisation in the form of rural to urban drift. The Buffalo City Municipality (BCM) located within the Amathole District Municipality in the Eastern Cape Province of South Africa has also experienced this scenario – whereby many rural people have the impression that the urban areas of BCM can provide employment and better access to social and health support. The BCM covers a total area of 2510km^2 with a population of 722,603 people (DWAF, 2008), with an urban population of 79.6% and rural population of 20.4% (BCM, 2006).

Approximately 296 788 residents of BCM are considered economically active (population above the national school going age of 18 and below the retirement age of 65). Of the economically active, approximately 53% are unemployed and only 34% of those who are employed earn above the basic national average of R1500.00 per month. The inevitable consequence of the high rate of rural to urban drift and increased urbanisation is the parallel increase in requirements for services such as water and sanitation (BCM, 2006). With the current BCM housing backlog estimated to be 206 454 accommodation units (DWAF, 2008), estimates of population statistics show that 20% of the BCM population live in mushrooming informal settlements (slums) with limited access to infrastructure, water and sanitation (BCM, 2005; DWAF, 2008).

Indeed rapid urbanization and growing urban population in BCM have resulted in poor sanitation provision. The BCM State of the Environment Report (BCM, 2005) identifies the contamination of water resources from the lack of sanitation services in peri-urban and informal settlements as one of the most significant environmental and health issues. Unprocessed sewage is being discarded into the environment which is not only adversely affecting the ecosystem, but also is creating unhygienic conditions that are conducive for the transmission of diseases in the densely populated informal settlements.

The current sanitation situation in BCM according to DWAF (2008) estimates that 92 055 BCM residents and 26 306 BCM households still require access to safe sanitation. The different sanitation technologies employed in BCM are waterborne flush toilets connected either to a sewer system or containment tanks, Ventilated Improved Pit latrines (VIPs) (single and double), unventilated pit latrines, composting toilets (Enviro-loos) and bucket latrines (BCM, 2006). The municipality is currently in the early stages of piloting a project for urine diversion toilets.

The approach currently taken by BCM when selecting sanitation technologies for target communities has been short-term and based primarily on cost and engineering considerations. Environmental and social considerations have largely been ignored. This thesis therefore aims to develop an integrated list of sustainability criteria that takes into account environmental, socio-economic and technical considerations which can be used by the BCM decision-makers when assessing the available sustainable sanitation technologies which could help improve the current BCM sanitation situation.

Provided in Sections 1.3 and 1.4 that follow are the objectives of this research and the questions that needed to be answered in order to meet these objectives respectively.

1.3 RESEARCH OBJECTIVE AND QUESTIONS

1.3.1 Research objective

Based on the discussion in Section 1.2 above, it is clear that in light of the "sanitation crisis" BCM is facing, there is a need to develop an integrated decision support tool that takes the environmental, socio-economic and technical criteria into consideration. Therefore, the primary objective of this research was the development of sustainability criteria that can be used for the selection of appropriate and sustainable sanitation technologies within BCM, specifically within low-cost housing developments and informal settlements.

1.3.2 Research questions

In order to meet the research objective stated in Section 1.3.1 above, the following research questions had to be answered:

1. What is the current state of sanitation in BCM?
2. Is there evidence that a lack of adequate sanitation is having adverse impact on the natural environment, specifically water resources?

3. On what basis are sanitation technologies currently chosen within BCM and what are the key challenges facing the implementation and ongoing operation and management of these systems?
4. What criteria should be considered when selecting sanitation technologies for BCM to maximise the likelihood that these technologies will be sustainable?
5. To what extent do existing sanitation systems within the low-income and informal settlements of BCM meet the criteria of sustainable sanitation with respect to the newly-developed sustainability criteria?

CHAPTER 2: LITERATURE REVIEW

2.1 SANITATION AND SUSTAINABLE DEVELOPMENT IN THE DEVELOPING WORLD

"Sustainable Development" means different things to different individuals and therefore there are a myriad of definitions for this term. The definition has been "evolving" since the publication of the book *Silent Spring* authored by researcher Rachael Carson in 1962. This book was considered by the academic society of the time as "*integral to understanding interactions between the environment, economy and social well-being*" (WCED, 1987). In the decades that followed, many literary milestones have marked the journey toward defining sustainable development, and in 1987 a "universally" agreed upon definition was published in *Our Common Future* (also known as the Brundtland Report) (WCED,1987). The definition stated that:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

At the United Nations Earth Summit held in 1992 in Rio de Janeiro, Brazil, world leaders used the Brundtland Report as a basis to create agreements and conventions on critical environmental issues between nations, as well as drafting a broad action strategy known as Agenda 21 (Seyfang, 2003). The subject of sustainable development has dealt mainly with 'green' issues such as biodiversity and global warming which are the 'sustainable' components of development; however the 'brown' agenda which translates to "meeting the needs of the present", the 'development' component of sustainable development that entails resolving problems such as water supply, sanitation, and housing conditions for the world's population, specifically the poor has been neglected (Beall *et al*, 2000).

Steps to address the "brown issues" were taken at the Millennium Summit held in New York in 2000 and the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002 where a series of Millennium Development Goals (MDGs) were developed. The intention of the MDGs was to achieve sustainable development by increasing access to basic needs such as clean water, sanitation, energy, healthcare, food security, poverty eradication and protection of biodiversity (Jenssen *et al.*, 2004). The explicit target set for the provision of water supply and sanitation (MDG 7) was to "*halve the proportion of people without access to safe drinking water and adequate sanitation by 2015*" (Seyfang, 2003). However, according to Morris (2004), progress towards the 2015 target has been "lamentably slow" that at the current "pace", Africa will take more than 30 years to achieve the water target and will never achieve the sanitation target.

Ever since the UN Earth Summit in 1992 there has been serious discussion and consideration surrounding environmental pollution, overpopulation, exploitation and limitations of natural resources within a global context. The WHO/UNICEF Global Water Supply and Sanitation Report (WHO/UNICEF, 2000) states that, during the period 1990-2000 the global population increased by an estimated 15%, from 5.27 to 6.06 billion and that during this time frame the global urban population increased by one quarter, while the rural population only increased by less than 8%. The report also states that due to the global population increase of the 1990s, an estimated 620 million people gained access to water supply facilities and 435 million people gained access to sanitation facilities by the year 2000 as work of a high standard was being performed in the sector to serve this ever-increasing global population. Nevertheless, in spite of all the efforts made and the results achieved thus far, there still remains a massive backlog. According to the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation Report (WHO/UNICEF, 2008), the latest global estimates indicate that approximately 1 billion people lack access to improved water supply and 2.5 billion people do not have access to improved sanitation. The report also states that although the MDG target for water supply is on track and may be met, the MDG target for sanitation is not on track and will be missed by an estimated 700 million people in 2015 (WHO/UNICEF, 2008).

In addition to the above, the WHO and UNICEF set an objective to provide water and sanitation for all by the end of 2025 (Mara, 2003). However, for this objective to be met 2.9 million people will need improved water supplies and 4.2 billion people will need improved sanitation (WHO/UNICEF, 2000). These figures convert into 310,000 people needing improved water supplies and 460,000 people needing improved sanitation per day throughout the next 19 years to 2025 (Mara, 2003). As with the MDGs, the water target can be met, but it is highly unlikely that the sanitation target will be achieved.

Achieving the WHO, UNICEF and MDG objectives is severely threatened by the fact that countries implement sanitation systems with little consideration for the type of system employed. In essence, sanitation technologies are not subjected to assessment prior to implementation in order to assess the suitability or viability of the technology within a specific context. As a result, systems often function sub-optimally, leading to significant ecological, social and environmental problems later, threatening the target of ever reaching the ideal of "sustainable development." Section 2.2 that follows discusses the need for "sustainable development" to merge with the provision of sanitation in order to ensure that the WHO, UNICEF and MDGs are achieved.

2.2 WHAT IS SUSTAINABLE SANITATION?

The phrase "sustainable sanitation" is used extensively in existing literature but without an accompanying definition (Bracken *et al.*, 2005). However, according to Collins Concise English Dictionary (CCED) 1993), sanitation can be been defined as "*the study and use of practical measures for the preservation of public health and refers to actions taken to avoid the spread of diseases and encourage public and private health.*" Additionally the Water Supply & Sanitation Collaborative Council (WSSCC) of the WHO (WHO/UNICEF, 2000), defines sanitation as the contribution to "*reducing people's exposure to disease by providing a clean environment in which to live, including measures to break the cycle of disease.*" The Human Waste Report (HWR) prepared by WaterAid (2002) provides a more limited definition of sanitation, defining it as, "*...access to excreta disposal facilities. In the developing world, this often means access to an improved latrine.*"

In order, to understand the components of "sustainable sanitation" it is important to first define "improved sanitation", "adequate sanitation" and "basic sanitation." According to the WHO and UNICEF 2004 MDG progress report (WHO/UNICEF, 2004), "improved sanitation" is defined as, "*a connection to a public sewer or septic tank or access to a pour flush latrine, simple pit latrine or VIP.*" According to the WHO/UNICEF (2008), "adequate sanitation" is defined as, "*facilities that provide for the controlled disposal of human excreta in ways which avoid direct human exposure to faeces, or contamination of food and local water supplies by raw faeces.*" The WHO (2008) states that suitable facilities might range from simple but effective pit latrines, to flush toilets with sewerage, and that for facilities to be effective, "*they must be correctly constructed and properly maintained and available within the home or within 50 metres of the home.*" As far as the definition goes, shared or public toilets are normally not considered to be adequate. In addition, according to WaterAid (2002), "adequate sanitation" means "*a clean, private environment, as well as knowledge and understanding about the connection between hygiene and disease.*" The WHO/UNICEF (2008) defines "basic sanitation" as, "*the lowest-cost technology ensuring hygienic excreta and sullage disposal and a clean and healthful living environment both at home and in the neighbourhood of users.*"

From this array of definitions of sanitation, "improved sanitation", "adequate sanitation" and "basic sanitation", two strong themes come through. These are, "human health" and a "clean environment" and the interactions thereof. In the developing world, sanitation has come to mean excreta disposal facilities and, in particular, refers to the methods of hygiene relating to the safe collection, removal and disposal of human excreta and wastewater (Nadkarni, 2004). The South African National Sanitation Policy (RSA, 1996a) considers sanitation to be, "*principles and practices relating to the collection, removal or disposal of human excreta, refuse and waste water, as they impact upon users, operators and the environment.*" In order to alleviate the "silent emergency" described earlier, the concept of "sustainability" needs to be combined with current "sanitation" practices and thinking in order to provide adequate sanitation in a way that does not threaten sustainability.

Bracken *et al.*, (2005) define a sanitation system as, "*users of all parts of the system along with the collection transport and treatment of human excreta, grey water, solid waste, industrial waste water and storm water and the management of the resulting end products.*" They further emphasise that, a sustainable sanitation system, "*protects and promotes human health, does not contribute to environmental degradation or depletion of the resource base, is technologically and institutionally appropriate, economically viable and socially acceptable.*" This research will make use of the latter definition of "sustainable sanitation" as it encompasses the main aspects of both sustainability as defined by the Agenda 21 principles (Beall *et al.*, 2000) and sanitation as defined by the WHO (2000).

The impacts of 'unsustainable sanitation' are truly dire in consequence. The sanitation practices currently encouraged in developing countries are either based on hiding human waste in deep pits ('drop-and-store') or flushing it away and diluting it in rivers, lakes and the sea ('flush-and discharge') (DFID, 1998). The latter frequently includes wastewater from industry and domestic households as well as storm water. The environmental and health impacts of these 'unsustainable sanitation practices' are seen and felt on a daily basis. Effluent from sanitation potentially contains nutrients from urine, faeces and industrial processes such as nitrates, phosphates and ammonia which may cause the eutrophication of rivers (Krebs & Larsen, 1997). Industrial effluent can also contain heavy metals, toxins and complex compounds that can cause severe health problems. To address these problems, leaders, professionals and communities in developing countries are presently faced with two options; the first is to expand existing sanitation approaches together with their associated limitations and weaknesses. However, the existing approach to sanitation is not viable or affordable to the majority of people neither does it offer communities an approach towards a sustainable society (Bracken *et al.*, 2005). The second option is to seek completely new solutions (DFID, 1998).

The impact of inadequate and unsustainable sanitation services falls primarily is felt primarily by the poor people in rural and peri-urban areas of developing countries (Bracken *et al.*, 2005) particularly women and children due to the fact they are usually detached from public services (DFID, 1998). Diarrhoea causes two million deaths per year globally, generally among children under the age of five in developing countries (WHO/UNICEF, 2000). According to POSTnote (2002), in 2002 there were 106,547 cases of cholera worldwide and a total of 3,155 reported deaths however, improved water and sanitation may reduce it by an estimated 77%. Intestinal worms infect about one third of the population in developing countries, but improved sanitation would control their transmission (POSTnote, 2002).

In light of the above, the phrase "Sustainable Sanitation" would appear to be an oxymoron, especially in developing countries. Statistics from developing countries show a state of sanitation provision that is far from sustainable. Discussed in Section 2.3 that follows is the current sanitation provision in developing countries and the progress that these countries have made thus far towards meeting the MDG target of "*halving the proportion of people without access to adequate sanitation by 2015.*"

2.3 SANITATION COVERAGE IN DEVELOPING COUNTRIES

According to WaterAid (2002), poor and inadequate sanitation is the "*heart that regulates cycles of disease, poverty and powerlessness in developing nations.*" Efforts have been undertaken towards improving sanitation in order to empower the poorest people to escape poverty. The State of the World Population 2007 Report prepared by United Nations Fund for Population Activities (UNFPA) (2007) states that, by 2008 more than 3.3 billion people will be living in towns and cities (urban areas). Predictions in the report are mainly projected for a 30 year period (2000 to 2030). The greatest urban population growth is predicted to occur in Africa and Asia where the urban populations are expected to double from 294 million to 742 million and 1.36 billion to 2.64 billion respectively (UNFPA, 2007). Latin America and the Caribbean urban populations are also expected to expand from 394 million to 609 million, but at a slower rate. Consequently, developing regions will have 80 per cent of the world's urban population in 2030 (UNFPA, 2007). By then, Africa and Asia will comprise approximately seven out of every ten urban inhabitants in the world and this may well have significant implications for the provision of adequate sanitation.

According to the WHO/UNICEF (2008), only 62% of the world population has access to any type of improved sanitation facility. Therefore, more than 30% of the world population, do not have access to basic sanitation. While the 62% sanitation coverage figure shows an increase in sanitation coverage from 49% in 1990, great efforts need to be made to expand coverage to the MDG target of 77%. The main challenge being in developing regions, which have an average sanitation coverage of 53% with the lowest coverage reflected by Sub-Saharan Africa (31%) and Southern Asia (33%). It is interesting to note however, that although in these countries rural sanitation coverage consistently lags behind urban coverage (WHO/UNICEF, 2008), rural populations are migrating to urban areas which, coupled with urban growth, will add to the number of urban unserved .

Table 2.1 provides the latest 2006 global sanitation statistics and also provides an indication of each region's progress towards meeting the MDG (WHO/UNICEF, 2008) and a detailed discussion on sanitation coverage in Africa follows.

Table 2.1: Global sanitation statistics

Region	Sanitation Coverage (%)		Required coverage to be on track to meet MDG in 2006(%)	2015 MDG Target Coverage (%)	Progress so far
	1990(%)	2006 (%)			
Western Asia	79	84	86	90	On Track
Latin America and the Caribbean	68	79	78	84	On Track
Northern Africa	62	76	74	81	On Track
South-eastern Asia	50	67	64	75	On Track
Eastern Asia	48	65	65	74	On Track
Developed regions	99	99	99	100	On Track
Commonwealth of Independent States	90	89	93	95	Not On Track
Oceania	52	52	69	76	Not On Track
Southern Asia	21	33	46	61	Not On Track
Sub-Saharan Arica	26	31	50	63	Not On Track
Developing Regions	41	53	60	71	Not On Track
World	54	62	69	77	Not On Track

Source: WHO/UNICEF (2008)

2.3.1 Africa

Sanitation coverage in Africa is very poor, with only Asia having lower coverage levels. Africa has 28% of the world's population without access to improved water supply and 13% of people without access to improved sanitation worldwide (WHO/UNICEF, 2000). In 1998, 308,000 people in Africa died as a result of war, yet nearly two million died of the effects of diarrhoeal diseases linked to the lack of improved sanitation. Africa is divided into two regions, North Africa which is made up of seven countries and Sub-Saharan Africa which is made up of 42 countries. Each region shall be discussed below in terms of the current provision of improved sanitation, the current progress towards meeting the MDG target and the projected progress required to meet the MDG in 2015.

Countries in the North African region are Algeria, Egypt Libya, Morocco, Sudan, Tunisia and Western Sahara. Improved sanitation coverage is estimated to be 76%. The required coverage to be on track to meet the MDG in 2006 was 74%, which places North Africa on track to meet the 2015 MDG of 81% coverage. However unlike North Africa, the situation in Sub-Saharan Africa is not as promising in terms of meeting the MDG. The region consists of 42 countries that are sub-divided into Central Africa, East Africa, Southern Africa, West Africa and African Island Nations. The total coverage for the region is 31% which is the lowest coverage in the world and most certainly far from the required 50% to be on track to meet the MDG in 2006 and even further from the 63% coverage required to meet the MDG in 2015. According to Waterkeyn & Cairncross (2005), sanitation coverage in sub-Saharan Africa has not kept pace with population increase and has dropped. Angola, Burkina Faso, Chad, the Democratic Republic of the Congo, Eritrea, Ethiopia, Madagascar, Mauritania, Rwanda and Sierra Leone have less than 50% sanitation coverage and this problem is expected to worsen with population growth and urbanisation.

In general, the Developing Regions have a total improved sanitation coverage of 53% which is 7% less than the required 60% coverage of 2006 needed to be on track to reach the MDG in 2015 set at 71%. With progress towards the MDG target described by the WHO/UNICEF (2008) as, "*not on track*", great strides need to be made if the target is to be reached. In many developing countries, sanitation systems have been installed but some sanitation systems are better than others in terms of meeting the MDG objective of "adequate sanitation."

Section 2.4 that follows provides a discussion on centralised and decentralised sanitation systems and the technology options, with reference to developing countries. The advantages and disadvantages of the technology options and their suitability/adequacy in terms of the definition of "sustainable sanitation" are also discussed.

2.4 CENTRALISED AND DECENTRALISED SANITATION IN DEVELOPING COUNTRIES

There are two main categories of sanitation systems in developing countries namely, "centralised" and "decentralised" systems. Within each category, there are number of different types of technologies. Centralised sanitation systems are connected to a sewerage reticulation system whereby domestic wastewater is flushed to a centralised treatment facility, hence the term 'centralised'. Decentralised sanitation systems treat or store domestic wastewater onsite using a variety of methods. Existing literature extensively the different sanitation technology options in developing countries falling into the above-mentioned "centralised" and "decentralised" categories (Mara, 1985, 1996, 2005; DWAF, 2002a; Tandia, 2004; Winblad & Simpson-Hébert, 2004). For the purpose of this thesis, it was necessary to review these technology options in more detail, looking specifically at the advantages and disadvantages of each. The different sanitation technology options that have been identified and that will be described below are summarised in Figure 2.1.

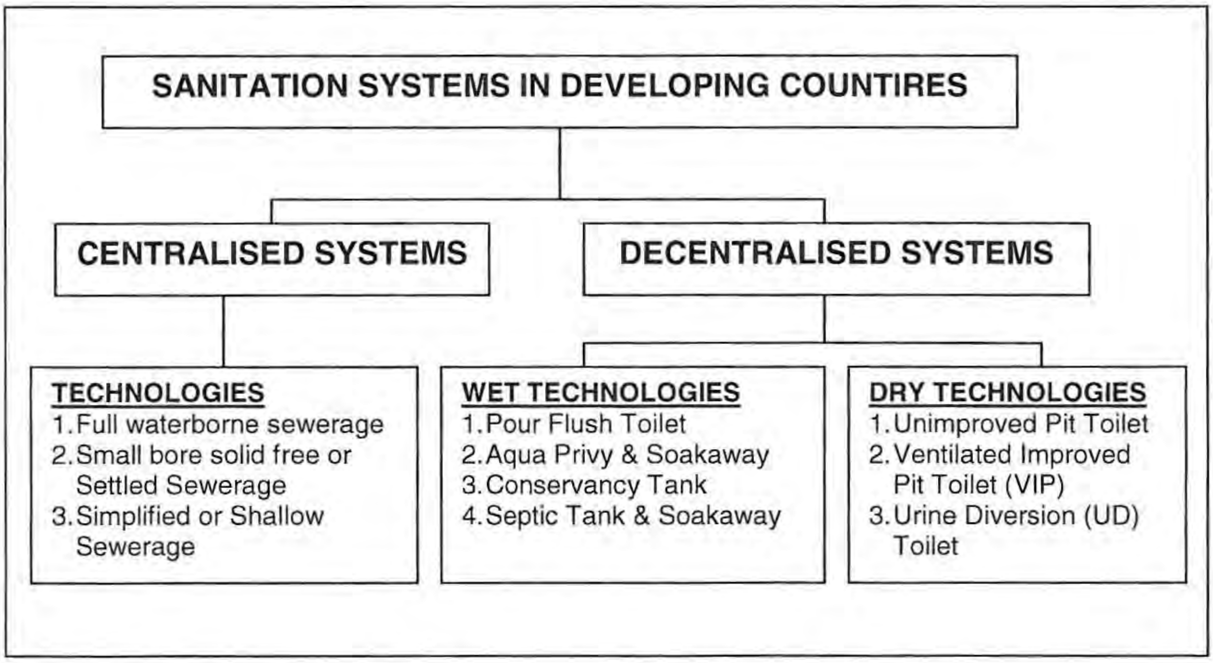

Figure 2.1: The different types of sanitation systems available in developing countries

2.4.1 Centralised Systems

Full Waterborne Sewerage:

This technology is known as "flush-and discharge" and consists of single toilet units found either in private houses or in communal facilities which are linked to centralised treatment works by pipelines. The effluent from this technology is often combined with wastewater from industry, domestic households and storm water collected at a central treatment works and treated to a high standard prior to discharge into the aquatic environment (DWAF 2002a).

The advantages of Full Waterborne Sewerage use are; the convenience of having the toilet located inside the house which provides the household ownership, accessibility, convenience, privacy and safety during its use and there is no direct handling of the human excreta as it is flushed away immediately into the sewerage system.

The disadvantages of using the Full Waterborne System relate to the need for a reliable and uninterrupted household water connection that is aligned in spatially regular permanent settlements (DWAF 2002a). However, according to the WHO (2000), in developing countries this has proven to be impractical as it is difficult to provide potable water to a tap at a stand pipe for drinking purposes, let alone for flushing toilets with a reliable and uninterrupted water connection. The design criteria required by the sewerage network is very specific, and skilled, organised and effective operation and maintenance capability is necessary for the full functioning of the sewers and wastewater treatment facilities (DWAF 2002a). An important operational requirement is that the system requires appropriate anal cleansing material is used so it does not block the sewerage system and cause backflows and sewage spills. In the event of a spill and disposal of poorly treated wastewater into aquatic environments, the human and ecological health consequences are devastating. Additionally, DeWulf & Van Langenhove (2005) ascertained that, sewage treatment facilities often fail to treat the effluent from flush toilet (waterborne) systems to the desired standard due to misuse, mismanagement, overloading and high operational costs. This has resulted in over 90% of untreated sewage being discharged into the environment. Furthermore, the use of significant quantities of potable water to convey human excreta to a central sewage treatment facility is not appropriate in arid or water-stressed regions of the developing world, such as sub-Saharan Africa. The cost of a centralised sewerage system has been considered to usually be more than four times that of on-site decentralised alternatives. Furthermore the sewage requirement of a piped water supply precludes its adoption in many communities in developing countries that lack adequate sanitation (Franceys *et al.*, 1992).

The system is widely used internationally and is the common sanitation system option that the majority of citizens in developing countries aspire to. However, as is evident from the discussion above, the disadvantages of this system greatly outweigh the advantages of its use in developing nations and for this reason, the sustainability of Full Waterborne System use in developing regions must be questioned.

Shallow Sewerage

This technology type is used in areas where there are significantly lower loads of effluent than that of conventional full waterborne sewage. Waste is collected from toilet units and possibly domestic wastewater (depending on design) and flushed into an on-site sewerage system and progressively washed down to either a dedicated treatment facility or into street sewers and eventually into a major treatment works (DWAF, 2002a). The toilet is usually located in the household and the effluent is flushed into smaller diameter sewers laid at flatter gradients and shallower depths between dwellings.

The advantages of the Shallow Sewage technology are that it can be laid out in less formal and spatially irregular settlements and it has less design specific criteria than full waterborne systems. The use of this technology has indicated savings of up to 50% over conventional sewerage capital costs (DWAF, 2002a) in addition to also allowing the toilet to be located inside the house thereby affording the household ownership, accessibility, convenience, privacy and safety during use as for full waterborne sewerage systems. In addition, the toilet is more likely to be properly operated and maintained by the household if it is located inside and used for private use.

The disadvantages of this technology are that it requires reliable household availability of water and connection to the sewerage system (DWAF, 2002a). Water is required as a medium to transport effluent to storage and treatment facilities. Furthermore, even though the technology has fewer stringent design criteria; it requires organised and effective operation and maintenance capability, preferably to be conducted by a skilled person. Although it is possible that this can be delegated to residents for on-site sewers, it is critical that there is significant user education and acceptance of shared management of the entire system.

According to DWAF (2002a), the Shallow Sewerage system has reported success under a wide range of conditions in a number of South American countries as well as in Ghana, Pakistan and Greece. In South Africa, pilot projects have been completed in the cities of Durban and Free State, with ongoing monitoring to resolve its overall success and sustainability.

Small-bore Sewer

This technology is also termed Settled Sewerage or Solids-free Sewerage in some developing countries and known as Small-diameter Gravity Sewerage in the United States of America or Septic Tank Effluent Drainage in Australia. This technology only conveys septic tank effluents that do not contain solid material (Mara, 2005). Since the effluent is solid-free, the sewer is designed differently from the Full Waterborne and Shallow Sewerage systems, which as discussed above convey both sewage effluent and wastewater solids. The small-bore sewer technology operates by collecting toilet and domestic wastewater from individual housing units or a small group of neighbouring houses. The wastewater is then flushed into a settling chamber inside a septic tank, where it is retained for a period of at least 24 hours (Mara, 2005; DWAF, 2002a). This allows the waste to settle and the process of biological digestion to occur. Partially treated liquid effluent is transferred from the tanks and discharged into small-diameter (75 mm) plastic sewers laid at shallow depths which roughly follow the ground contour. The liquid effluent is then conveyed to a communal treatment point, which may be an off-site treatment works reached either by existing sewerage or by tanker (DWAF, 2002a). Solids in the form of digested sludge remain in the septic tank and require that they are eventually emptied, collected, transported to, and treated at a wastewater treatment facility.

The Small bore Sewer technology has the advantage of being an in-house toilet system that affords the household access, convenience, privacy, safety and ownership of the toilet. Another advantage is that the technology demands les water requirements and design criteria than that of the other centralized system technology options (DWAF, 2002a). In addition, the technology does not directly release effluent and sludge into the environment before it is properly treated at a treatment facility. Skilled labour is required to maintain and operate the collection, transport and disposal of the wastewater and sludge which supports potential employment opportunities for members of a target community.

Although the Small bore Sewer technology requires less water to operate, it still needs household water and septic tank connections. Therefore, it is highly unlikely that it is suitable for poor and very poor households in developing countries. Furthermore, the tankers need clear road access to the septic tanks for emptying (in the case of vacuum pump tanker collection), or a sewer network connected to a treatment facility for effluent disposal, which may not be available in many developing country settlements (DWAF, 2002a). Additionally, the technology requires essential routine maintenance of the pipe network which needs to be carried out by skilled labour (Mara, 1985; 1996)

According to Mara (2005), the Small-bore Sewer technology is best applied in areas already served by septic tanks and is therefore not widely used in developing countries, except where according to DWAF (2002a), existing septic tank and soakaway systems have been converted for convenience and or environmental reasons.

A discussion on the technology options of "decentralised" sanitation systems focusing specifically on the advantages and disadvantages of each follows.

Decentralised (on-site) Systems

According to Tandia (2004), Decentralised Sanitation Systems refer to the actions related to the treatment and disposal of human excreta and domestic waste water on-site. Provision of on-site sanitation was listed by the WHO Expert Committee on Environmental Sanitation, in 1954, as being among the initial basic steps that should be taken towards guaranteeing a safe environment (WHO, 1954).

Many types of on-site latrines exist and they have the potential to improve living conditions of populations and solve sanitation needs in developing countries. It has been realised that conventional waterborne sewerage systems are incapable of meeting populations' needs in these countries due to the systems being imposed onto communities (Tandia, 2004). As there are a number of different on-site sanitation technologies in use, it is necessary to provide a brief description of common or potentially important systems. These systems are further split into two categories which are wet and dry technologies. Wet technologies include pour flush toilets, aqua privy and soakaways, conservancy tanks and septic tanks and soakaways and dry systems include unimproved pit latrines, ventilated improved pit latrines(VIPs), ventilated improved double pit latrines (VIDP), composting toilets and Urine Diversion (UD) toilets. Apart from the latrines described above, there are other on-site facilities. The technologies mentioned above are each discussed in detail below with particular focus on the advantages and disadvantages of their use in developing countries.

Wet Technologies

Pour Flush Latrine

The Pour Flush Latrine consists of a toilet, a water tank (cistern) for flushing purposes, a discharge pipe with a water-seal arrangement, a pan trap fitted into the floor slab and a short stretch of pipe or channel that empties into a pit. The pit is designed both for solids digestion and storage and infiltration of urine and flush water (DWAF, 2002a). After toilet use, the latrine is flushed with approximately 2-4 litres of water previously poured into the water tank (Mara, 2005; DWAF, 2002a). The wastewater travels to the pit via the discharge pipe where the sludge biologically degrades and the sewage effluent infiltrates into the soil and subsequently the environment. The sludge and effluent can also be emptied. The water retained in the pan provides a seal against smell, flies and mosquitoes from the pit (Mara, 1996; DWAF, 2002a).

The advantages of using this technology are that it is appropriate for small volumes of water and can accept domestic greywater which is usually carried by hand to the latrine (DWAF, 2002a). The technology also provides an onsite alternative that can potentially be located inside the house providing the household access, convenience, privacy, safety and ownership of the toilet. In addition, the technology does not require expensive water and sewer connections to the household thereby making it a feasible option in poor settlements. Furthermore, greywater from domestic household use can be used to flush the toilet in an attempt to conserve and recycle water – a scarce resource in many developing countries.

The disadvantages of the technology include the inconvenience of having to re-fill the cistern after every flush of the toilet, the technology requires road and site access to the pit for mechanical emptying of contained sludge, which may not be available in poorly planned and located settlements (DWAF, 2002a) and there is a high reliance on the subsoil environment to be suitably drained to make the pit effluent harmless so it does not pollute and contaminate the environment. In addition to the above, the technology needs sludge collection treatment and disposal which may be a service that is not offered or which is too expensive for many communities in developing countries. The technology is also prone to blockages due to the use of inappropriate cleansing material (DWAF, 2002a), which renders the toilet inoperable. The technology also requires intensive user education for proper operation and maintenance and is very prone to poor design and construction issues if the building contractor is not experienced and skilled in its construction.

According to Mara (2005), Pour Flush Latrines are only applicable in low-density Small Towns and Large Villages (STLV) if they are cheaper than simplified sewerage. However, DWAF (2002a) noted international acceptance of the technology where water is used for anal cleansing and users' squat. Nevertheless, experiences in South Africa have seen failures due to the lack of user education, poor design and construction and use in areas where inappropriate and limited provision of affordable emptying services are available.

Aqua-privy

An Aqua-privy consists of a latrine built above, or next to, a waterproof tank that contains liquid effluent (Franceys *et al.*, 1992). Excreta is flushed into the tank through a vertical or curved chute running from the seat to below the water level in the tank. The pipe should extend at least 75 mm into the liquid so that a water seal is formed (DWAF, 2002a). To maintain the water seal, the pipe must continuously be submerged by liquid, therefore, a bucketful of water needs to be poured into the tank each day to compensate for evaporative losses. The means of containment of the waste may vary from a sealed container to a solids collection system or an effluent soakaway.

The advantages of this type of latrine are that it has a very low water usage and the volume of effluent discharged from the tank is small (Franceys *et al.*, 1992). However, the discharge is very concentrated. The system also has the advantage that it can accept domestic wastewater which can be carried by hand to the latrine (DWAF, 2002a). This further reduces the reliance on piped clean water for flushing purposes and promotes the use of domestic wastewater.

The disadvantages of this system are that the tank needs to be periodically desludged and there needs to be a sludge treatment and disposal facility to accommodate for this. A removable cover for the tank must be provided to desludge the tank, but this cover is prone to vandalism and there are risks that the tank may provide a breeding ground for mosquitoes and pose a health and safety hazard unless it is properly sealed from the external environment (DWAF, 2002a; Franceys *et al.*, 1992). Furthermore, in the instance of the effluent soaking away, there is a high reliance on the surrounding soil environment to render the effluent harmless. In addition, the costs of constructing and operating an aqua-privy are high and it needs to be well designed and maintained to ensure that it has an adequate design life (Franceys *et al.*, 1992).

International acceptance of this system has been demonstrated especially in countries where water is used for anal cleansing and users' squat like in the Asia (DWAF, 2002a). Nonetheless, blockages occur through the use of inappropriate anal cleansing material. Experiences from South Africa have seen failures due to the lack of user education and poor design and construction. Additionally, the systems in South Africa failed due to their implementation in areas where there was inappropriate and limited provision of affordable emptying services.

Conservancy Tanks

Conservancy Tanks are sealed tanks that store wastewater from low-flow or full-flush toilet systems. The wastewater is flushed into the tank where it is contained in isolation from the surrounding environment before removal by tanker for treatment (DWAF, 2002a). The conservancy tank size is dependent on flush volumes, domestic wastewater levels and frequency of emptying. The system however requires access for mechanical emptying and availability of treatment and disposal facilities.

The advantages of the system are that it encourages water conservation to ensure that the tank does not fill up unnecessarily and require frequent emptying. It also contains the contents of the tank until it is collected and treated preventing pollution of the environment (DWAF, 2002a). The tank also allows for the toilet system to be installed inside the household and provides the benefits of a safe and private environment for users and ensures frequent and appropriate operation and maintenance of the toilet.

The disadvantages of the system are that it is very prone to vandalism and can be sabotaged by puncturing a hole into the bottom of the tank. This will drain the liquid effluent out into the environment and leave the solids therefore the tank fills up slower and requires emptying and disposal at a slower rate (DWAF, 2002a). Another disadvantage is that the system is reliant on emptying for treatment and is not treated at the source as is the case with septic tanks.

Conservancy tanks are widely used on an international scale, especially in more sensitive soil and geohydrological environments (DWAF, 2002a).

Septic Tank and Soak Away

The Septic Tank and Soak Away consists of an in-house full flush-toilet connected through plumbing fixtures to an underground watertight settling sludge digesting chamber that is connected to a liquids outlet to a subsoil drainage soakaway system (DWAF, 2002a). Toilet waste and domestic wastewater is flushed into the settling chamber where it is kept for at least 24hrs to allow settlement and biological digestion as in the Small Bore system, only the partially treated liquids then pass out of the tank and into the subsoil drainage soakaway system and not a sewer pipe (DWAF, 2002a). The digested sludge that gradually builds up in the tank requires eventual removal by tanker.

The advantages of using the system are that it provides a high level of service and user convenience. It also provides a primary treatment of the wastewater before it is released into the environment through the subsoil.

The disadvantages of the system are that it requires a reliable household water connection and is only applicable in areas of low settlement density and where soils have a high ability to drain effluent away (DWAF, 2002a). The system also requires that there is access for tanks by vacuum tanker, as well as availability of sludge treatment and disposal which is not readily available in most developing regions. The system is also installed in areas where the soils are not well drained and this leads to pollution of ground water sources and the environment by the effluent. In addition, specific design criteria must be applied to the settlement tank and soakaway system for it to function optimally.

This system is used extensively used by formal rural households and farming areas in developing regions, where reliable water supply is available. The failures of the system have been due to poor design and construction, and use of inappropriate anal cleansing material that cause blockages in the plumbing between the toilet and the septic tank. The soakaway system is particularly prone to failure in the long-term if detailed soil testing is not carried out prior to installation.

Dry Technologies

Unimproved Pit Latrine

An unimproved pit latrine refers to a simple wooden or concrete slab installed over a pit of 2m or more in depth. The support usually stands on a sufficiently waterproof edge of the pit to avoid surface water (runoff and grey water) entering and destroying the system (Tandia, 2004). The pit is usually lined with impermeable lining in case of unstable soil where there is a risk of walls collapsing and seepage of pathogens and nutrients may occur. Excreta fall directly into the pit through a drop hole or a seat. A structure is built around it and this provides privacy and protection.

The advantages of the pit latrine system are that it is relatively cheap to operate in contrast to other sanitation systems and it can be constructed by the user (Tandia, 2004). This provides a sense of ownership and opportunities for capacity building (DWAF, 2002a). Natural resources can be used to line the pit (like clay bricks and wooden poles) which reduces the costs considerably (Tandia, 2004). However, the main advantage of this system is the fact that it does not require water to function.

The disadvantages of the latrine system are that is provides a breeding ground for flies and mosquitoes which pose great health risks to the communities these toilets are used in (DWAF, 2002a). Unlined or poorly lined pits may allow seepage of pit contents into the adjacent environment, thus leading to pollution of soil and downstream and underground water sources (Tandia, 2004). It is unhygienic, time consuming and expensive to empty the pits and this needs to be done with good health awareness and education programmes which are not typically available in developing regions (DWAF, 2002a). Another disadvantage of the latrine system is that other forms of waste are frequently put into the pit thus filling the pit up much earlier than it should be (Tandia, 2004). The main disadvantage of the pit latrine is that is strongly linked to faecal oral route diseases that are prevalent in developing regions.

Pit latrines are used internationally, however they have the worst reputation for causing disease (DWAF, 2002a). They are not considered an adequate form of sanitation in South Africa, however many are still in operation in rural areas within the country.

Ventilated improved pit (VIP) latrine

Ventilated improved pit latrines were developed in rural Zimbabwe (Morgan & Mara, 1982) and have also been used in low-density low-income urban areas in Botswana (Van Nostrand & Wilson, 1983). The design is essentially a top-structure constructed over a single pit, similar to unimproved pit latrines in that waste drops into the pit where organic material decomposes and liquids seep into the surrounding soil (DWAF, 2002a). However, the distinguishing feature of a VIP as opposed to an unimproved pit, is that the pit is aerated by a pipe over which a fly-screen is fixed. The main location aspects taken into consideration are the potential of storm water ingress into the pit as well as the local groundwater contamination, use and conditions. In addition, a VIP may be altered to accommodate a single top-structure over two pits, side by side. This alteration is termed a ventilated improved double pit latrine (VIDP). Each pit is vented by a pipe protected with a fly screen and only one pit is in use at any time. The pits are lined and have a central wall separating them that is fully sealed to ensure isolation of one pit from the other. The pit is used until filled to within about half a metre of the top, then the defecation and vent pipe holes are completely sealed and the other pit used (DWAF, 2002a). The contents of the first pit are then dug out after a period of at least two years, once the contents have become less harmful.

The main advantages of a VIP and VIDP are that they have ventilation pipes that allow continuous airflow through the top-structure, the pit and the external environment. This helps remove smells and vents gases out into the atmosphere. This ventilation encourages the digestion of the pit contents by naturally occurring bacteria. The interior of the VIP and VIDP top-structures are deliberately kept darkened to encourage insects (especially flies) entering the pit to be attracted towards the strongest light source at the top of the vent pipe where they are trapped by the fly screen (DWAF, 2002a). This is to break the fly's life cycle and as they feed and breed in pits and become serious health hazards (WHO, 2000). In addition, the pit structure can also be lined and this is recommended where pit emptying is required (DWAF, 2002a), or it can be unlined where soil conditions permit, preferably in areas where the soil surrounding the pit is compact. The VIP and VIDP systems are relatively cheap to operate, not water dependent and can be constructed by the user or household. This makes them a popular alternative of sanitation provision in many developing regions, especially Africa and Asia.

The main disadvantages of the VIP and VIDP are that it has proved to contribute significantly to the contamination of surface and groundwater especially when the water table reaches the level of the pit (DWAF, 2002b). Moreover, the VIP and VIDP can not be placed inside household and do not accept domestic wastewater. As with the unimproved pit latrine, a VIP and VIDP are unhygienic, time consuming, and expensive to empty and requires intensive health awareness and education programmes which are not usually provided in developing regions. These systems also require access to the pit structure by tankers for mechanical pit-emptying and thereafter the availability of sludge treatment and disposal facility (DWAF, 2002a). Both systems require specific design criteria whereby it only functions properly if it is orientated into the wind and the vent pipe is higher than the surrounding obstacles like buildings and trees. Most of all, these systems have been linked to the prevalence of faecal oral route diseases on a global scale.

The VIP system is extensively used internationally in rural and peri-urban areas. The system is most successful in water-scarce environments, however failures are generally due to inadequate user education, poor design and construction and inappropriate location (DWAF, 2002a). The VIDP is used less extensively on an international scale and there is great resistance to the handling of decomposed waste and timely changeover of pits by householders has often been overcome through education and over time (DWAF, 2002a).

Urine diversion toilets

These latrines are designed to separate urine and faeces at the source so the nutrients from the excreta can be used in the fertilization of soil for agricultural purposes and contribute to nutrient cycling like the nitrogen and potassium cycles (Tandia, 2004, DWAF, 2002a). Waste is falls into the chamber and dry absorbent organic material, such as wood ash, straw or vegetable matter is added after each use to deodorise decomposing faeces and to control moisture and facilitate biological breakdown by composting. The urine is separated through the use of a specially adapted pedestal that collects it and it can then be applied as a fertiliser (Tandia, 2004). The faecal chamber is usually constructed above ground to provide access for the removal of decomposed waste and is completely lined with a waterproof bottom to avoid infiltration into the soil and the urine drain is normally connected to a collecting container. A vent pipe may be installed to encourage drying of the waste and the expulsion of odours (Tandia, 2004). In desiccation systems such as this one, ventilation encourages the evaporation of moisture.

The advantages of using this system are that it recovers urine and waste products that can be used to condition soil and grow food. This is advantageous in developing regions of the world that are experiencing food shortages too (Tandia, 2004). This system creates a great opportunity to use waste as a resource. The system also protects the environment and water sources from pollution from human excreta. Moreover, if used properly the system promotes hygienic practices in a community that will directly improve the health status of communities it is used in. Most of all the system does not require any water at all to function which makes it an asset in water scarce regions of the world.

The disadvantages of using this system are that it does not accept domestic wastewater because the chambers must be kept dry (DWAF, 2002a). The system requires intensive education, user acceptance and needs to be socio-culturally appropriate especially since the excreta is handled and used to condition soil for agricultural purposes. Containers for urine storage are required and continuous management of the system is imperative. Control of moisture content is fundamental for proper operation and often contents become too wet, making the vault difficult and unhygienic to empty, as well as malodorous (DWAF, 2002a).

Urine Diversion system use in developing countries is still being monitored but this technology appears to be accepted by certain communities (DWAF, 2002a).

All in all, the above section provides a comprehensive outline of the sanitation arrangements and technologies used in developing countries. As explained, all have their relative advantages and disadvantages once installed and operating. Despite the variety of these relatively simple sanitation systems, there is still a large backlog of sanitation in developing countries. It is therefore necessary to consider in more detail the limitations to sanitation provision in developing countries.

2.5 LIMITATIONS TO SANITATION PROVISION IN DEVELOPING COUNTRIES

According to Konteh (2009), many developing countries have been witness to unrestrained and ill planned urban growth resulting in the expansion of settlements without proper access to social, environmental and health services. Irrespective of this, the provision of sanitation in developing countries has been very slow as stated in previous sections. The consequences of this slow progress have been high incidences of disease and environmental pollution especially in developing countries. According to Pinto (2005), the main limitation of past and current interventions to address sanitation provision is the lack of a comprehensive focus on capacity building over the lifecycle of the infrastructure. Another fundamental limitation is that solutions tend to focus narrowly on building physical infrastructure that is at times inappropriate to the local context. This results in the symptom of the problem being addressed, rather than striking it at its source (Pinto, 2005). Deficiencies in sanitation provision, either in quality or quantity, are often symptoms of more deeply entrenched limitations endemic to service provision. This section identifies and discusses six common limitations that developing countries face in providing sustainable sanitation namely; a lack of political commitment, financial constraints, poor institutional structures, poor technical skills and knowledge and poor marketing. Each of these is discussed further below.

2.5.1 Political Commitment

According to POSTnote (2002), political commitment to sanitation provision is considered important in shaping government policy and investment priorities. Politicians and governments in developing countries need to integrate the provision of sanitation, hygiene and safe water supply to maximize their effectiveness to meet public health and environmental goals (POSTnote, 2002). Despite this, sanitation has not received the same level of investment as water supply. For example, from 1990 to 2000, sanitation provision programmes in developing countries received only 20% of the US$16 billion invested in water supply and sanitation by national governments and external support agencies. The disproportion in investment between water supply and sanitation is somewhat responsible for the gap between water and sanitation coverage (Section 2.5.2). The WHO (2004) stated that, the main sanitation challenges faced by national governments in developing countries are their commitment to sanitation and hygiene. Existing policy and institutional arrangements do not address the issue of sanitation and do not make explicit budget allocations for sanitation and hygiene programmes. Furthermore, sanitation has not been included in poverty reduction strategies and environmental action plans that are developed for these regions. Politicians in developing countries have not prioritized funding for hygiene promotion and sanitation or training and capacity building for sanitation initiatives. In general, the explicit commitment of politicians and governments is vital when implementing any programme required to meet sanitation provision targets.

2.5.2 Financial limitations

The financial constraint faced by developing countries is one of the main limitations to poor sanitation provision. A considerable share of municipal budgets in developing countries is spent on sanitation services (Gupta & van Beukering, 2000). Capital investments for sanitation provision usually come from general taxes, government-funded international loans, and overseas development assistance. These three sources are inappropriate for financing sanitation provision capital improvement and operations (Pinto, 2005). General taxes offer a variable and politically-dependent source of financing to sustainable sanitation providers that may not represent actual system costs and financing need. Additionally, general taxes are unable to send an indication to service consumers of the price of the sanitation system they receive (Pinto, 2005). Therefore, users have no price incentive to limit consumption and those with access to services develop a tendency to over consume. Inappropriate targeting of government subsidies generated from taxes have also affected government plans for increasing the rate of sanitation provision, as subsidies do not reach those who need them the most (POSTnote, 2002). Past experiences by development agencies have specified that the main problems in achieving the objectives of sustainable sanitation projects were an over-reliance on supply-driven approaches, neglect of user requirements and an emphasis on large scale projects.

Government-funded international loans from agencies such as the World Bank and regional development banks, offer comparatively low interest financing over extended repayment periods (Pinto, 2005) however, these funds place a burden on the sanitation provider to generate earnings and contribute to the Gross Domestic Product (GDP) at a rate that surpasses the rate of interest on the loan. This creates a high expectation for new systems introduced in a developing country to operate optimally with limited management and institutional resources. The probability is great that the sanitation provider will be incapable of meeting this expectation.

Overseas development assistances, in the form of direct grants or subsidies on capital imports, are erratic in timing, amount, and volatile due to currency exchange (Pinto, 2005). This form of funding may be accompanied by preconditions, such as spending for institutional change or environmental protections that are outside the jurisdiction of the sanitation provider. It is interesting to note that sanitation system's public health and environmental benefits are considered as public goods and at household level, private goods. Up until recently, most countries and donor agencies deemed sanitation only as a public good that could not be supplied by the market, and which needed to be subsidized to provide greater incentive to expand coverage (POSTnote, 2002). Additionally, since overseas assistance involves the national government, its use by sanitation providers will inevitably entail political involvement in the management of the sanitation provider (Pinto, 2005). This involvement detracts from the sanitation provider's goal of proficiently delivering safe, sustainable and reliable sanitation services. The financial aspects of sustainable sanitation provision highlight the need to consider the affordability of the type of sanitation system to be implemented (POSTnote, 2002).

2.5.3 Institutional limitations

Conventionally, the management of sanitation provision is the responsibility of government at national and other levels of political administration and is therefore usually performed by public officials (Pinto, 2005). The ministries that are normally involved are public works, health, environment and natural resources, local government, social welfare, and community development (Caincross, 1992). Commonly at the national level, there is an institute charged with the responsibility for preparing policies, planning, coordinating activities, monitoring and evaluating projects and programs (Pinto, 2005). The responsibility is placed under one chief ministry and policies are then implemented through national service boards or corporations in charge of the services. Nonetheless, in the shift from governance at the national level to implementation at the local institutional level, systematic planning for sanitation services is usually neglected (Pinto, 2005). This lack of institutional integration has frequently resulted in poor management of sanitation provision.

The absence of system planning and technical know-how is worsened by the lack of laws, regulations, and administrative structures and procedures necessary to assign responsibility and accountability for sanitation provision. Moreover, even when these laws and regulations are in place, it does not necessarily translate to progress if they are not enforced as is the case in South Africa (DWAF, 2002a). To aid the appropriate transfer of technologies, there is a critical need for information to be distributed to local decision-makers as well as the technical capacity to adapt them to local circumstances (POSTnote, 2002). This necessitates both networks for information exchange and skilled technicians to design and market locally appropriate sanitation solutions. A method of increasing local capacity for technical innovation is to support developing countries' institutions to adapt sanitation provision solutions to suit local conditions. Sanitation programmes need institutional capacity such as planners, decision-makers, and sector professionals who are trained in evaluating different approaches to providing, operating and maintaining a sustainable sanitation programme.

2.5.4 Technical Limitations

The major demand for sanitation provision in developing countries is from informal settlements and shantytowns that crowd urban areas (Pinto, 2005). Whilst centralized infrastructure and administration can meet the needs of cities in developed countries, such systems are inappropriate for these conditions. It is crucial that sanitation planning for developing countries reflects this reality. Failure to do so will result in the common case of developing countries making investments in large centralized systems that are costly, improperly operated, and unable to sustain service for the bulk of local demand (Gupta & van Beukering, 2000).

Dunmade (2002) suggested that, the main technological limitations that need to be taken into account are the accessibility of component parts, the availability of the needed infrastructure, the availability of technical know-how to accomplish such service, and the period of time between repairs. The accessibility of parts is essential as components are prone to wear and tear or breakdown during operation leading to parts failing and needing replacement. When this happens, replacement parts need to be accessible at a local level and if they are not, the service life of the equipment will end abruptly. This scenario has been seen time and time again in developing nations. Another factor is ensuring that the maintenance of imported technologies is carried out by a local service. Without this, time-lags between services could further push the technology into a state of disrepair as is the case in many developing regions. Additionally, the local availability of servicing staff is crucial to immediate maintenance and repair of introduced technologies. If one critical facility in a community suffers an unexpected failure without local expertise to rectify the problem, the environmental, social and economic costs can be excessive.

There are relatively few professionals and experts involved in the sanitation provision sector, primarily from the civil or chemical engineering professions. By and large, in the majority of developing countries, the sanitation service process is operated by a crew of unlicensed labourers under the authority of the local government (Pinto, 2005). Many governments indicate a severe shortage of engineers and field workers to provide the technical and social scientific skills to develop sanitation programmes (POSTnote, 2002). Any type of waste management as a field of study is relatively limited in developing countries due to the lack of skills, expertise and interest in the field (Gupta & van Beukering, 2000). As a profession or trade it is also viewed as an inferior occupation, the vocation filthy and unimportant. An example of this is seen in India where the lowest cast known as the "Untouchables" is responsible for waste collection and toilet cleaning.

Sanitation professionals maintain that meeting the sanitation target and sustaining its progress requires an increase in the capacity and accountability of the public sector to promote, coordinate and regulate sanitation provision.

2.5.5 Marketing Limitations

Another interesting limitation contributing to lack of sustainable sanitation provision is the marketing of sanitation (POSTnote, 2002). "Selling" sanitation on its health benefits only, has been largely ineffective. Sanitation can be marketed like any other consumer good. The marketing of sanitation could increase the demand for sanitation by advertising it as a home improvement that offers security, convenience, privacy, lack of smell and flies, and improved social status (POSTnote, 2002). However, there has been inadequate research into the effectiveness of marketing in increasing demand.

The discussion above has highlighted the limitations to sanitation provision in developing countries. The Section that follows will focus on the sanitation situation and provision in South Africa in order to gain a better understanding of the limitations and challenges it faces as a country.

2.6 PROVISION OF SUSTAINABLE SANITATION IN SOUTH AFRICA

To gain a better understanding of the limitations facing the provision of sustainable sanitation in South Africa, it is important to investigate the history and the legacy of sanitation provision from Pre-1994 to the present. The following section provides a brief account of sanitation provision in the country.

2.6.1 The South African Sanitation Story

Era: Pre-1994

During the rule of the apartheid government, sanitation provision occurred on a racially unequal basis (Mabin & Parnell, 1984; Abbot, 1994; Lewin, 1995). Limited or no sanitation services were available in the "black" urban and rural areas, especially in farm dwellings and farm schools (DWAF, 2002b). Where services were provided, these were often in poor condition. Local authorities were in charge of destroying settlements on the basis that they were unsanitary even though the very same authorities failed to provide the settlements with adequate services (Bond, 1999; Allison, 2002). Sanitation service provision pre-1994 was mainly focused on toilet building, sewer systems, and maintenance, with little thought given to community needs or health, hygiene education and environmental impacts (Robinson, 1996; DWAF, 2002b). Therefore, those with inadequate sanitation were forced to carry on using the bucket system, rudimentary pit toilets or the bush (DWAF, 2002b). According to DWAF (2002b), an estimated 21 million people in South Africa did not have access to a basic level of sanitation in the early 1990's.

Era: 1994 – 2001

Dealing with the water supply and sanitation backlog of 21 million people was one of the first priorities of the newly elected democratic government in 1994 (Bond, 1999; Goldblatt, 1999). The Department of Water Affairs and Forestry (DWAF) was established in July 1994 and consisted of new consolidated government staff from the previous structures into one new organisation (DWAF, 2001). It was then that the White Paper on Water Supply and Sanitation Policy (RSA, 1994) was produced which set out the policy for the new Department focusing specifically on sanitation provision. In addition, the Constitution of the Republic of South Africa (Act 108 of 1996) was published in 1996 and allocated the responsibility of providing access to water and sanitation services to all by local government (RSA, 1996b). A series of municipal legislation has been developed and implemented since 1994 to adjust local government as far as service provision went. The objective of local government was to, eliminate the water and sanitation backlog over a ten year period and this meant to provide each individual with at 25 litres of water per day (United Nations allocation) and to provide each household with basic sanitation, which is defined as " *an onsite sanitation facility that is in operational order*" (RSA, 1996b).

Era: 2001-Present

In 2001 the national backlog of persons without access to adequate sanitation facilities was estimated to be 18 million people or 3 million households (DWAF, 2002a; DWAF, 2002b). The bulk of persons falling in this category resided in rural areas, peri-urban areas and informal settlements. It was also estimated that up 25.2% or 756 000 urban households and 75.8% or 2.28 million rural households had inadequate sanitation (DWAF, 2002a). The backlog was further reduced during 2002 by 2.4 million persons. A National Sanitation Programme was launched in 2002 focusing on the eradication of the sanitation backlog in rural, peri-urban and informal settlement areas by 2010. Furthermore, a goal was set to eradicate the use of the bucket system, estimated at about 428 000 households by 2007 (DWAF, 2002b). The above-mentioned targets were to have been met through two primary deliverables - the promotion of sanitation, health and hygiene awareness, and the provision of basic toilet facilities. The projects implemented to meet these targets used a community-based approach, and the highest priority was given to peri-urban and informal settlement communities who faced the greatest health risks due to inadequate sanitation and who could not afford to obtain the necessary infrastructure without assistance. Very little progress has however been made since the setting of the water and sanitation targets. Sanitation has unfortunately been considered a low priority on household level by all spheres of government (DWAF, 2002a). As a result, funding allocated to sanitation is inadequate to address the backlog. This, coupled with limited human capacity in the sanitation sector, brings all wheels of progress to a grinding halt. Furthermore, local government has often been weak in the areas of highest sanitation need such as informal settlements, peri-urban and rural areas. One of the greatest hindrances is the Government's attitude that sanitation provision translates to providing infrastructure only, thereby not taking into consideration the health, social and environmental aspects.

Evidence of the sluggish progress can be verified with the recent 2005 typhoid outbreaks in Delmas, Mpumalanga Province (September 2005), and the outbreaks of cholera in the Tsishba village, Limpopo Province (September 2005). These incidences emphasise the importance of sanitation and the need for close inter-departmental co-operation and clear leadership of the sector. The National Institute for Communicable Diseases (NICD) reported that typhoid outbreaks around Delmas are common and the last major outbreak was recorded in 1993, when over 1,000 people were affected (NICD, 2005).

Water and sanitation are key issues that need to be addressed to achieve sustainable development in South Africa. Consequently, important roles of National, provincial and local government for sanitation provision are allocated in the Constitution. The use of legislation and policy is seen as a catalyst for the provision of safe sanitation in South Africa. Various pieces of legislation and policies developed post 1994 task local government with the responsibility for provision of sustainable services to communities, supported by provincial and national government.

The section that follows provides an overview of the South African legislation and policies that have been developed in order to facilitate the provision of sanitation in the country.

2.6.2 Applicable South African Legislation and Policy

Policy and legislation play a crucial role in establishing a framework for the provision of safe sanitation (Matsebe, 2006). Developing suitable categories of legislation and policies to support sanitation and hygiene services and improve their quality is necessary in the process of achieving the goals set and maintaining achievements (WHO/UNICEF, 2004). This is particularly relevant to the 2015 Millennium Development Goal set for sanitation on a global scale and nationally for South Africa's goal to provide safe adequate sanitation for all by 2010. According to the WHO/ UNICEF (2004), legislation and policies are important in creating conditions that favour innovation from both the technological and financing fields. They also define cooperation between important stakeholders and facilitate distribution of financial resources to capacity building, monitoring, implementation and maintenance. Consistent standards for sanitation and hygiene should be set across all other related sectors like, education, housing, construction and workplace safety (WHO/ UNICEF, 2004). The enforcement of enacted legislation and policies is essential and useful and effective legislation and policies will have incentives for complying and sanctions for not complying with the requirements (WHO/ UNICEF, 2004).

The South African democratic government has developed and promulgated several policies and legislative documents that focus on sanitation as one aspect of service delivery (Matsebe, 2006). These are highlighted below.

The Bill of Rights (Chapter 2 of the Constitution of the Republic of South Africa 108 of 1996) (RSA, 1996b) includes not only an environmental clause but also a number of other clauses which have made, or have the potential to make, an important contribution toward sanitation provision in South Africa (Glazewski, 2002). The environmental clause, subsection 24(a) provides that:

"*Everyone has the right to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation*"

This clause is directly relevant to sanitation as poor provision of sanitation has consequences on both the environment and community health.

The National Sanitation Policy (1996) (RSA, 1996a) is a detailed policy paper that aims to improve the health and quality of life for South Africa's' population. The paper expresses the view that sanitation for households' means much more than building toilets. It states that the fundamental requirement for safe sanitation is getting rid of human excreta; dirty water and household refuse as well as ensuring that people practise hygiene and healthy habits (RSA, 1996a). It identifies that sanitation is about health, the environment and the involvement of communities in sanitation programmes. It realises that government is not able to solely fund the building, operating and maintenance of sewerage systems for all households in South Africa, as a result it suggests that approaches be considered that use less government funds. The policy highlights that the main responsibility for providing household sanitation lies with the family or the household. Government's role is to help make this happen or to carry out those functions which can be done more efficiently at a community level.

The Water Services Act (Act 108 of 1997) (RSA, 1997) was developed to assist municipalities to undertake their role as water services authorities and to look after the interests of the consumer (DWAF, 2002b). It also defines the role of other water service institutions, especially water service providers and water boards.

The White Paper on Environmental Management for South Africa (GG 18894 of 15 May 1998) (RSA, 1998a) states that:

"To comply with the requirements of environmental justice, government must integrate environmental considerations with social, political and economic justice and development in addressing the needs and rights of all communities, sectors and individuals."

This translates directly to service provision, and more importantly, to water and sanitation provision. In addition, policy, legal and institutional frameworks must put right past and present environmental injustice and must take account of the need to protect and create employment (Glazewski, 2002).

The National Environmental Management Act 107 of 1998 (RSA, 1998b) incorporates two principles that are clearly relevant to service provision that include access to water and sanitation (Glazewski 2002). Specifically:

"Environmental justice must be pursued so that adverse environmental impacts shall not be distributed in such a manner as to unfairly discriminate against a person, particularly vulnerable and disadvantaged persons" (s2(3)(c).

And

"Equitable access to environmental resources, benefits and services to meet basic human needs and ensure human well-being must be pursued and special measures may be taken to ensure access thereto by categories of persons disadvantaged by unfair discrimination" (s2(3) (d).

The Act visualizes that these principles will be transformed into reality through environmental management and implementation plans which each organ of state will be required to prepare (Glazewski, 2002). It remains to be seen how these principles will be useful in practice.

The National Water Act 36 of 1998 (RSA, 1998c) stipulates that sanitation is a *"right to dignity and life for all South Africans."* It goes onto say that the *"failure of the apartheid government to ensure* *the provision of sanitation and water for basic human needs such as washing, cooking and drinking, for growing crops, and for economic development impacted significantly on both the right to dignity and the right to life amongst the black majority*" (RSA, 1998c). A vital improvement relevant to sanitation is the concept of the "reserve" provided for in chapter 3 of the Act, devoted to the Protection of Water Resources. The "reserve" is defined as, "*that quality and quantity of water necessary to firstly "satisfy basic human needs for all people who are, or who may be, supplied from the relevant water resource;*" and secondly "*to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant resource*" (s2(n)) (RSA, 1998c). Sanitation directly affects the reserve from a pollution and waste management perspective and as earlier sections have highlighted plays a major part in maintaining the quantity and quality of water. Bacteriological and chemical contamination and eutrophication of water resources from poorly maintained sanitation systems is also specifically highlighted as an environmental problem.

The White Paper on Integrated Pollution and Waste Management (IP & WM, 2000) (RSA, 2000a) states that the vision of the Government is:

"*To develop, implement and maintain an integrated pollution and waste management system which contributes to sustainable development and a measurable improvement in the quality of life, by harnessing the energy and commitment of all South Africans for the effective prevention, minimization and control of pollution and waste*"

The White Paper is relevant to water and sanitation provision as its objectives endeavour to prevent, minimise and monitor pollution from "sources", which we have witnessed from earlier sections originate from the lack of access to water and sanitation.

The Municipal Structures Act (Act 33 of 2000) (RSA, 2000b) provides for the organization of municipalities in agreement with the requirements concerning the category and type of municipality and to provide for a suitable division of functions and powers between categories of municipality (DWAF 2002b). The Act assigns the responsibility for water services to the District Municipality or the Local Municipality if approved by the Minister of Provincial and Local Government.

The White Paper on Basic Household Sanitation (2001) (RSA, 2001) has a strong emphasis on the environmental and health risks connected to poor household sanitation. An estimated 1.5 million cases of diarrhoea in children under the age five along with the past and recent outbreaks of cholera and typhoid has necessitated the drafting and implementation of the policy in South Africa. The policy focuses on the provision of a basic level of household sanitation to mainly rural communities and informal settlements.

The Strategic Framework for Water Services (2003) (RSA, 2003) proposes a vision for the water and sanitation sector for the next 10 years and sets out a framework that will enable the sector vision to be achieved. It emphasises that under-expenditure spent on maintenance and under-investment with respect to rehabilitation is a significant challenge to overcome in South Africa (RSA, 2003). It emphasizes that the provision of effective, efficient and sustainable water services to households, institutions, business and industry is necessary to support economic growth and development. The Strategic Framework suggests that local government should take full responsibility for ensuring appropriate water and sanitation services as provided in the Constitution.

In light of the various pieces of South African legislation and policies discussed above, it is clear that the South African government believes that sustainable development can only be achieved by focusing on poverty eradication and economic development (DWAF, 2002b). Water, sanitation and hygiene are considered important issues for the achievement of these objectives. The main contributions that the development of legislation and policies provide South Africa are the advancement of the strategies that define roles and responsibilities of different national institutions to implement the law. It also allows the involvement of stakeholders to ensure that legislation and policies will be viable and accepted to the public as well as create mechanisms for monitoring and enforcing implementation (WHO/ UNICEF, 2004). Furthermore, district or local governments can develop local sanitation and hygiene regulations in consultation with stakeholders as well as establish standards and norms and inform citizens of their rights and duties under existing sanitation legislation policies (WHO/ UNICEF, 2004).

South African communities are in a position whereby they can request specific sanitation and hygiene regulations and participate in legislation and regulation development. The communities are afforded the opportunity to explore the use of mechanisms that allow a community to report back to authorities when laws are broken. Furthermore, households have the opportunity to learn about their rights and responsibilities under existing sanitation legislation; and demand legislation and policies from local authorities and help to monitor implementation of sanitation and hygiene legislation and regulations at the local level (WHO/ UNICEF, 2004). Based on the legislation and policies that have been developed, it is clear that the South African government is committed to ensuring that its citizens have access to a basic level of sanitation. However, while the development of appropriate policies and legislation is an essential first step in the provision of adequate sanitation for all, these must be acted upon. One of the areas in South Africa most affected by the Apartheid Rule was the Eastern Cape Province, the section that follows summaries the state of sanitation in this Province.

2.6.3 State of Sanitation in the Eastern Cape

The global sanitation "crisis" described earlier identifies high rates of population growth and poverty as the main factors contributing to poor sanitation. The situation in the Eastern Cape Province of South Africa is no different. The Apartheid government pre-1994 encouraged an increasing Eastern Cape population with the exclusion and translocation policies for the majority of South Africa's black population. They also encouraged poverty by depriving the Eastern Cape population of basic services including; water supply, health, housing, education and sanitation (Woolard, 2002; Mohale, 2003).

The Eastern Cape Province has a population of 6 906 200 million with an annual population growth of 0.56% (DWAF, 2008). The population comprises 87.6% Black African, 7.4 % coloured, 0.3% Indian/Asian and 4.7% white. It is the second largest province in South Africa covering 13.9% of the total area of South Africa and is arranged into seven District Municipalities. The Eastern Cape is economically the poorest province with the highest unemployment level of 37.8% compared to the South African National average of 29.5% (DWAF, 2008). The unemployment level includes individuals that are not economically active (between the ages of 0-15 years old and 65 and above). According to Pauw (2005) the *per capita* GDP for the Eastern Cape is lower than the national average and this can be attributed to current high levels of poverty and unemployment which have been a result of past inequality. Furthermore, about 65.1% of the Eastern Cape's population lives in rural areas, 17.8% live in Metropolitan areas and 17.1% in small towns. The Eastern Cape comprises 16% of the national housing backlog and 17% of the national sanitation backlog. This is about one fifth of the national housing and sanitation backlog. The national bucket eradication programme which targeted to be completed by 2007 exhibits a 13% backlog in the Eastern Cape (DWAF, 2008).

The sanitation technologies used in the Eastern Cape are waterborne flush toilets connected either to a sewer system or containment tanks, ventilated improved pit latrines, unimproved pit latrines and bucket latrines. Pilot projects are currently being conducted in Mthatha and East London for urine diversion toilets (Matsebe, 2006). Approximately 50% and 66% of households in the Eastern Cape did not have access to treated water and sewage treatment facilities respectively. The South African Reconstruction and Development Program (RDP) which was designed to address the housing and sanitation backlog approved 1025 water and sewage treatment facilities to be constructed in the

Eastern Cape. Of this approved number, only 195 were constructed. Mohale (2003) recorded 196 sewage treatment facilities in the Eastern Cape Province and both Morrison *et al.* (2001) and Keirungi (2006) state that most facilities are running beyond their capacity. Furthermore, a study by Mohale (2003) of 98 sewage treatment facilities in the Eastern Cape found that only 12% were regularly producing effluent that met discharge requirements set out by the National Water Act 36 of 1998 of South Africa and between 41% and 46% treatment facilities disposed of final effluent by irrigation or discharged it into rivers and streams. The on-site sanitation systems like the unimproved and improved pit latrines are used in the large rural settlements found across the Eastern Cape. These on-site systems are considered as a source of environmental pollution by DWAF (2002b) which is verified in research by various authors, namely Holtzhausen (2005) and Morris *et al.* (2003) where surface and ground water sources were contaminated both biologically and chemically by latrines.

The sanitation systems in the Eastern Cape have been identified to be the major polluters of rivers such as Umtata, Keiskamma, Buffalo and Isinuka (Faniran *et al.*, 2001, Keirungi, 2006). The large rural communities in the Eastern Cape rely on the contaminated water resources for drinking, recreation, irrigation, fishing and livestock watering purposes (Faniran *et al.*, 2001, Keirungi, 2006). According to Fatoki *et al.* (2003) the lack of access to water and sanitation results in the occurrence of water bore diseases like cholera. The Eastern Cape reported a cholera outbreak in February 2001 in Qingqolo which spread to the Hlabatshane area in Mqanduli in February 2002, where it lead to the infection of 267 people and resulted in 11 deaths (Keirungi, 2006). Most recently about 114 babies died in the Eastern Cape in April and May 2008 due to the contamination of drinking water by sewage effluent (Bateman, 2008).

In conclusion, the population in the Eastern Cape is expected to increase at 0.56% per annum and failure to provide sustainable sanitation will accompany it. As discussed above, it is clear that pollution of the environment as a result of poor sanitation provision leads to unhealthy conditions and disease transmission. The question is how one chooses an alternative sanitation system that will be sustainable for a target community. This dilemma does not only face the Eastern Cape Province of South Africa but is a very common state of affairs in developing countries at present. Ideally, sanitation systems should be chosen based on an integrated and holistic approach that considers the sustainability of the system within the local social, environmental and economic context. It cannot be denied that this is a very complex and confusing exercise in itself. The section that follows describes the inclusion and use of sustainability criteria and indicators in an effort to guide decision-making for sanitation system selection.

2.7 THE SUSTAINABLE SELECTION OF SUSTAINABLE SANITATION SYSTEMS

Experts believe that adequate sanitation provision includes both the hardware (physical structures) needed to achieve the safe handling of human excreta and used water, and the necessary software (education) concerning hygienic behaviour (Dewulf & Van Langenhove, 2005). However, even if this objective were to be achieved, it may have failed to address the existing problems of not integrating the view of sustainability when identifying suitable sanitation systems (Bracken et al., 2005). By simply providing what is deemed as a technically well functioning system, municipalities run the risk of overlooking the broader issues of environmental and human health, and the important interactions between these issues (Dewulf & Van Langenhove, 2005). Important social and economic aspects of sanitation that have traditionally been seen as being outside the mandate of sanitation provision and decision-making should also be considered.

Sustainable decision-making draws upon multidisciplinary knowledge bases, integrating natural, physical, social sciences, medicine, politics and ethics (Linkov *et al.*, 2004). The success of any technology, including sanitation systems is context specific, as one system may operate well in an area whilst it may fail in another. This draws in the concept of "sustainable technologies" defined by Weaver *et al.* (2000) as, *"technologies that use less energy, require fewer limited resources, are not dependent on natural resources and do not directly or indirectly pollute the environment and can be reused or recycled at the end of their life span."*

With the Millennium Development Goals looming, decisions surrounding adequate sanitation provision have never been so pressing. The pressure also lies in the provision of sustainable adequate sanitation and this requires sustainable sanitary decision making. These decisions are frequently complex, multi-faceted and involve different stakeholders with different priorities and objectives (Linkov *et al.*, 2004). Behavioural research shows humans are classically bad at solving problems of this nature if they are unaided. The majority of people would use intuitive or heuristic approaches to simplify the complexity until the problem seems more manageable (Linkov *et al.*, 2004). This ultimately leads to loss of important information, discarding of opposing views and elements of uncertainty being ignored.

Decision making is normally a complex and confusing exercise characterized by exchanges between socio-political, environmental and economic impacts. The complexity of decision-making increases when sustainable decisions need to be made which are characterised by trade-offs between socio-political, environmental and economic impacts (Linkov *et al.*, 2004). Currently decision-makers use input from technical, modelling, monitoring, risk and cost benefit analyses. Except the present decision-making processes characteristically offer little guidance on how to integrate or critique the relative importance of information from each source (Fukuda-Parr *et al.*, 2002). Furthermore it does not take into consideration the fact that information comes in different forms. Modelling and monitoring are generally presented as quantitative estimates, whilst the cost-benefit analyses incorporate a higher degree of qualitative judgement. It is only of late that environmental modelling and formalised risk assessment has been coupled to present partially integrated analyses to the decision-makers. Information about stakeholder preferences may not be presented to the decision-maker at all and is addressed in an eccentric or prejudiced manner that exacerbates the difficulty of defending the decision process as reliable and fair (Linkov *et al.*, 2004). Additionally, where there are structured approaches used for decision-making, they run the risk of being identified as lacking the flexibility to adapt to localised concerns or faithfully represent only the "powerful minority" standpoint.

The most common type of analyses carried out to facilitate decision making are the cost-benefit analyses, which are used together with comparative risk assessment methodologies to choose between competing alternatives. The selection of appropriate on-site sanitation during sanitary decision-making should involve an integrated approach using multiple criteria including cost-benefit, risk analyses as well as environmental impact, social impact and safety assessments. It has been realized that some criteria can not be condensed into a monetary value, which complicates the integration problem inherent to making comparisons.

Prior to selection of a technology from a range of alternatives, it would be appropriate to make use of various decision making-support tools (Dunmade, 2002). As a result, technology assessments and the use of sustainability criteria are reviewed below.

2.8 TECHNOLOGY ASSESSMENTS

Negative impacts of technologies like sanitation systems were recognised long before the concept of sustainable development was formulated in growth–development discussions (Assefa *et al*, 2005). Therefore, an assortment of techniques has been developed for evaluating the impacts of technical processes and products on a number of aspects of human well-being and the environment. One approach with a very broad scope is Technology Assessment (TA) defined by UNEP (2001) as: -''A *category of policy studies, intended to provide decision-makers with information about the possible impacts and consequences of a new technology or a significant change in an old* *technology. It is concerned with both direct and indirect or secondary consequences, both benefits and disadvantages, and with mapping the uncertainties involved in any government or private use or transfer of a technology. TA provides decision-makers with an ordered set of analysed policy options, and an understanding of their implications for the economy, the environment and the social, political and legal processes and institutions of society''*

According to Ludwig (1997), solutions to global problems which threaten the concept of sustainable development can only be realised through technology, and the indispensability of TA comes due to the need to avoid ill-advised and unfounded decisions made in selecting the right technology. TA does allow for the comparison of alternative technologies however, there is debate around TA in existing literature that tends to point out the absence of a consensus on different issues related to operating TA. TA has been criticised to suffer from poor co-ordination, integration and overall balance. Furthermore it has been criticised to be "non-pragmatic" and thus by deduction not cumulative (Assefa *et al*, 2005). Both Ludwig (1997) and van Eijndhoven (1997) have portrayed the controversy around the concept as the ''TA dilemma." However, there is also a recent movement towards TA focusing primarily on environmental impacts, as is promoted by a UNEP program called Environmental Technology Assessment (EnTA). UNEP (2001) defines EnTA as, *"a process that can assist decision-makers in making informed choices that are compatible with sustainable development by examining and describing the environmental implications of new technologies"* They further state that EnTA also provides information that allows public policy makers, NGOs, and the general public to be better informed about technology choice decisions. This system however does not take into consideration the main issues faced by an area and there is limited consultation with stakeholders in developing the assessment tool (Assefa *et al*, 2005). Therefore some important factors run the risk of being lost or not prioritized.

Therefore there is a need to assess the likely success and sustainability of a system prior to its implementation. One of the approaches used by both developing and developed countries is sustainability assessments. These assessments use sustainability criteria and indicators to assess the environmental, social and economic environments of an area in an attempt to inform decision making. The section that follows discusses sustainability assessment and explains its holistic approach designed to include vital factors and prioritise important issues using sustainability criteria and indicators.

2.9 SUSTAINABILITY ASSESSMENT

Sustainability assessments are required to address the economic, social and environmental interdependencies within policies, plans, legislation and projects (Buselich, 2002). This type of assessment complements and extends other assessments and decision-making processes and enables a more inclusive and informed decision making. Numerous researchers, authors and commentators realize the absence of an integrated sustainability-based assessment and the limitations of current environmental and other assessment processes (Eggenburger & do Rosario Partiario, 2000; Smith & Sheate, 2001; Buselich, 2002; and Gibson *et al.*, 2005). For the purposes of this research, sustainability assessment is defined as, "*the assessment of proposed initiatives in terms of sustainability to determine where certain sanitation technologies should be approved and under what conditions in Buffalo City Municipality.*"

The use of sustainability assessment in sanitary decision making integrates issues and seeks to assess the cumulative and synergistic impacts of decisions and management practice, and then facilitates comprehensive decision-making in order to deliver greater certainty, transparency and accountability of decision-making (Buselich, 2002). Furthermore, the need to develop a mechanism to provide integrated social, economic and environmental information for decision makers has been recognized. The most critical issue with respect to sustainability assessment is how environmental, social and economic information is analysed, integrated and presented to decision-makers. Buselich (2002) suggests that, robust, adaptive and transparent approaches' to sustainability assessment, based on sound principles, is required.

While there is a lot of experience from around the world dealing with environmental assessment and reporting, there are very few examples of where truly integrative sustainability assessments have been undertaken (Buselich, 2002). Gibson *et al.* (2005) state that "*planning, evaluation and decision-making processes like environmental assessment are forced to apply a higher test about what kinds of undertakings should be assessed, what concerns should be given most attention, what proposals merit approval and what considerations should be imposed.*" Until recently, the main objective of these assessment processes was to predict, avoid or mitigate potentially significant negative effects of major development on the environment. Sustainability Assessment is the latest higher objective to plan and implement the best responses to publicly examined problems and opportunities, and ensure overall long-term gains (Gibson *et al.*, 2005).

The critical issue for sustainability assessment is how to integrate qualitative and quantitative information into a single assessment. The literature shows that some decision aiding techniques in use are able to combine qualitative and quantitative data in a manner accurate and effective for decision-making (Annandale & Lantzke, 2001; Devuyst, 2001; Buselich, 2002; Bracken *et al.*, 2005; Al-Sa'ed & Mubarak, 2006; Wadhwa *et al.*, 2009), but others are challenging in their attempt to merge qualitative and quantitative information through standardisation or alternatively the use of symbols that require decision-makers to take their attention away from the integrative task at hand and refer to additional information (Buselich, 2002; Lanbuschange & Brent, 2007).

According to McLaren & Simonovic (1999), there exist two metrics of sustainability, namely criteria and indicators. Of the techniques available for sustainability assessments, this thesis uses the development of criteria and indicators as a sanitary decision aid. Bracken *et al.*, (2005) used this technique and concluded that it took into consideration both qualitative and quantitative information that contributed to an integrated assessment of sanitation options. The following section will further discuss the use of criteria and indicators.

2.10 THE DEVELOPMENT OF CRITERIA AND INDICATORS FOR SANITARY DECISION-MAKING

According to The United Nations Educational, Scientific and Cultural Organisation (UNESCO) (1998), sustainability criteria and indicators offer a method for measuring relative levels of sustainability. The current approaches to the use of sustainability criteria and indicators encourage separate attention to social, economic and environmental matters. These three 'pillars' are the popular basis on which most descriptions of sustainability are constructed (Gibson *et al.*, 2005). For effectively integrated sustainability assessment, the pillar boundaries will have to be overcome and some other way found to manage the multitudes of considerations without obscuring their interconnections. An entire chapter of Agenda 21 refers to the need to incorporate the environment and development into decision making at all levels of government and business. This need to incorporate the concept of sustainable development into decision making, united with the "three pillar approach for sustainable development" resulted in the popular business term "triple bottom line decision making." That said, Moret *et al.* (2006) define sustainability criteria as "aspects that should be considered in the evaluation of initiatives in a contemporary and interdependent manner, linked to the goals and principles related to social, environmental and economic dimensions." Sustainability indicators are defined as parameters that can be used as a measure of compliance with sustainability criteria.

Current literature realises that sustainability criteria can be developed for economic, social and environmental factors (UNESCO, 1998; Louks & Gladwell, 1999; Gibson *et al.*, 2005, Neba, 2006; Labuschagne & Brent, 2007). The United Nations Educational, Scientific and Cultural Organisation (UNESCO) suggests that there are a number of methods of expressing relative levels of sustainability as separate or weighted combinations of reliability, resilience and vulnerability of various criteria. UNESCO embarked on suggesting guidelines for the development of sustainability criteria and indicators which involves defining a set of criteria along with relevant ranges and values for accompanying criteria indicators (UNESCO, 1998). These decisions are however subjective and usually based on human judgement and social goals. In many cases, these may be well-defined published standards, health standards or bio-physical thresholds, separating what is considered satisfactory and what is not. The identification and evaluation of sustainable development requires consideration of multiple criteria, not all of which can be expressed in monetary terms.

In light of this, Labuschagne & Brent (2007) state that sustainable development emphasises evaluation rather than valuation and argue that traditional decision making techniques are based on reducing information solely into economic terms, as social and environmental consequences can not be reducible into economic matrices. Therefore, Multiple Criteria Decision Analysis (MCDA) has been identified as a quantitative approach to evaluating decision problems that integrate economic, social and environmental criteria. The importance of the MCDA approach to contributing to strategic triple bottom line decision making has been documented by Gibson *et al.* (2005) and Labuschagne & Brent (2007).

The MCDA approach endeavours to address the conflicts and reach compromise by following a transparent process. Brent *et al.* (2006) identifies advantages of using the MCDA methods. These are:

- Allowance of a systematic approach to evaluating policy options, and help in understanding the problem
- A mixture of qualitative and quantitative can be incorporated which allows for flexibility and inclusiveness that purely economic models tend to lack
- Various stakeholder group preferences and conflicting objectives can be taken into account

The MCDA methodology is further described by Labuschagne & Brent (2007) and is shown in Figure 2.2 below. This approach defines the set of sustainability criteria then defines the indicators that will be used to measure the criteria. The criteria are then weighted according to relative importance which normally is a subjective process. The different options are then assessed according to the indicators and criteria weights and thereafter the overall results calculated.

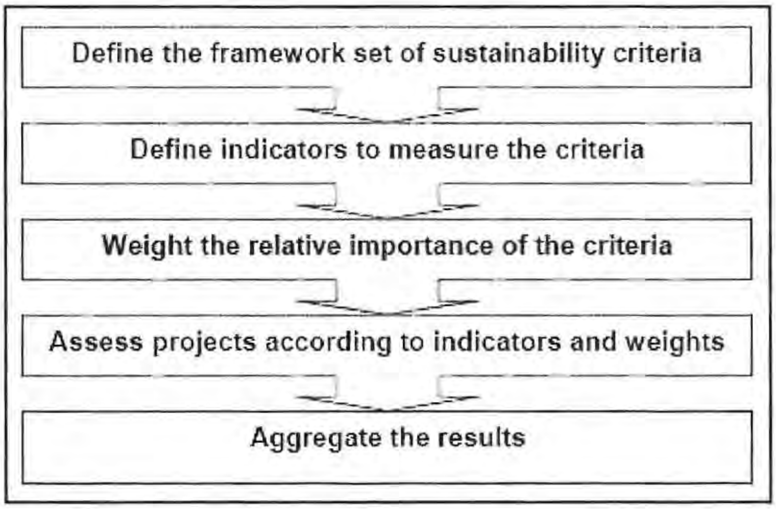

Figure 2.2: The MCDA approach (Labuschagne & Brent, 2007)

Extensive research into MCDA has made available practical methods for applying scientific decision theoretical approaches to multi-criteria problems (Loetscher & Keller, 2002; Linked *et al.*, 2004, Al-Sae's & Mubarak, 2006; Hermann *et al.*, 2007; Labuschagne & Brent, 2007). Attempts have been made by some researchers, especially Loetscher and Keller (2002) and Al-Sae's & Mubarak (2006), to formalise MCDA into a structure applicable to sustainable sanitary decision-making which has the environment in mind in concert with risk assessment and stakeholder participations which are of crucial concern. Furthermore, organised methodology that assimilates the information and ranks different options to make a decision have been developed by Al-Sae's & Mubarak (2006) for onsite sanitation in Palestine and by Gomontean *et al.* (2008) for community forest conservation in Thailand. This approach facilitates decision-makers to use all the necessary information to support the decision made concerning a particular option. In response to the current decision-making challenges, this thesis documents the development of sustainability criteria and indicators to assess sanitation technology options in BCM as well as the pilot application of the tool.

Initially, it was considered important to obtain updated data regarding sanitation provision in BCM, therefore the Chapter that follows reports on the Status Quo of sanitation in BCM.

CHAPTER 3: SANITATION IN BUFFALO CITY MUNICIPALITY - THE STATUS QUO

3.1 INTRODUCTION

The poor provision of sanitation in developing countries, including South Africa, has been attributed largely to the increase in population, rapid urbanisation and increasing levels of poverty (Black & Sutila, 1994; Paterson *et al.*, 2005). This scenario is experienced in Buffalo City Municipality (BCM) in the Eastern Cape Province. Many rural residents throughout the Province have the impression that BCM can provide employment and better access to social and health support than surrounding municipalities. The inevitable consequence of this is increased urbanization with a parallel increase in requirements for services such as water, electricity and sanitation (BCM, 2006). Within BCM the latter in particular is proving to be a significant challenge. Despite the urgency for sanitation services, this must be provided in a manner that is sustainable environmentally, socially, economically and technically. As such, sustainability criteria need to be developed and incorporated into decision-making. It is important to note that these criteria must be context specific to ensure functionality and acceptability to all stakeholders.

In order to develop sustainability criteria to facilitate the selection of sanitation technologies within the BCM, it was necessary to first establish the current state of sanitation in the Municipality, specifically within the low-cost housing developments and informal settlements. It is important to note that a full assessment of the BCM State of Sanitation Report (BCM, 2006) was completed and presented to the BCM Council in April 2006 in which a status quo of sanitation in BCM using data from 2001 to 2004 was presented. BCM Council indicated in June 2006 that an update of the status quo with recent data was required with a view of the development of a Sanitation Policy and Implementation Strategy for BCM. The primary questions to be answered in this chapter are:

1. What is the current state of sanitation in BCM?
2. Is there evidence that a lack of adequate sanitation is having adverse impact on the natural environment, specifically water resources?

3.2 METHODOLOGY

Before assessing the status quo, it was important to define the limits of the study area (see Section 3.2.1 below).

3.2.1 Study Area

This research focused on the Buffalo City Municipality (BCM) which is situated in the Eastern Cape Province of South Africa (Figure 3.1). Buffalo City Municipality is one of eight constituent Local Municipalities (LM) within the Amatole District Municipality (ADM). Buffalo City is the second largest urban complex in the Eastern Cape Province of South Africa and incorporates East London, King William's Town, Bishop, MacLean town, Mdantsane and other smaller townships and surrounding rural villages and farms.

3.2.2 Information gathering

To better understand the status quo of sanitation in BCM, it was important to identify the sanitation technical sanitation options available and associated processes used in the municipality. To ensure that all the sanitation options were identified and investigated, the five different components of a sanitation system identified by the International Water Association (IWA) (2006), was used. These five components of a sanitation system consist of a combination of a toilet, a collection mechanism, a transport mechanism, a treatment process and a disposal or re-use mechanism.

Three focus group meetings were held with the BCM Council, BCM upper management and BCM departments to contribute to the update of the status quo of sanitation in BCM. The ward councillors and ward committee members are the link between the local government and BCM residents. Therefore the BCM community was represented by their respective ward structures and not directly engaged. Table 3.1 details the date, venue, number of attendees and a summary of their responsibility and function in BCM. Table 3.2 provides the structure of the meetings discussions which were divided into the five sanitation system components, the method of investigation carried out to ascertain the status quo and the questions discussed in the meetings.

To provide a better understanding of the current main sanitation issues identified by the BCM upper management, BCM officials and departments, site visits to the affected communities were conducted. Sites in BCM were recommended by the ward councillors and were conducted in conjunction with the BCM Integrated Environmental Management Unit (IEMU). The site visits were conducted after the initial meetings during the months of October 2006 to December 2006. Where further data was required e.g. water quality data or records of technology failures, the relevant municipal departments were approached. Details of the sources of additional data are provided in Section 3.3.

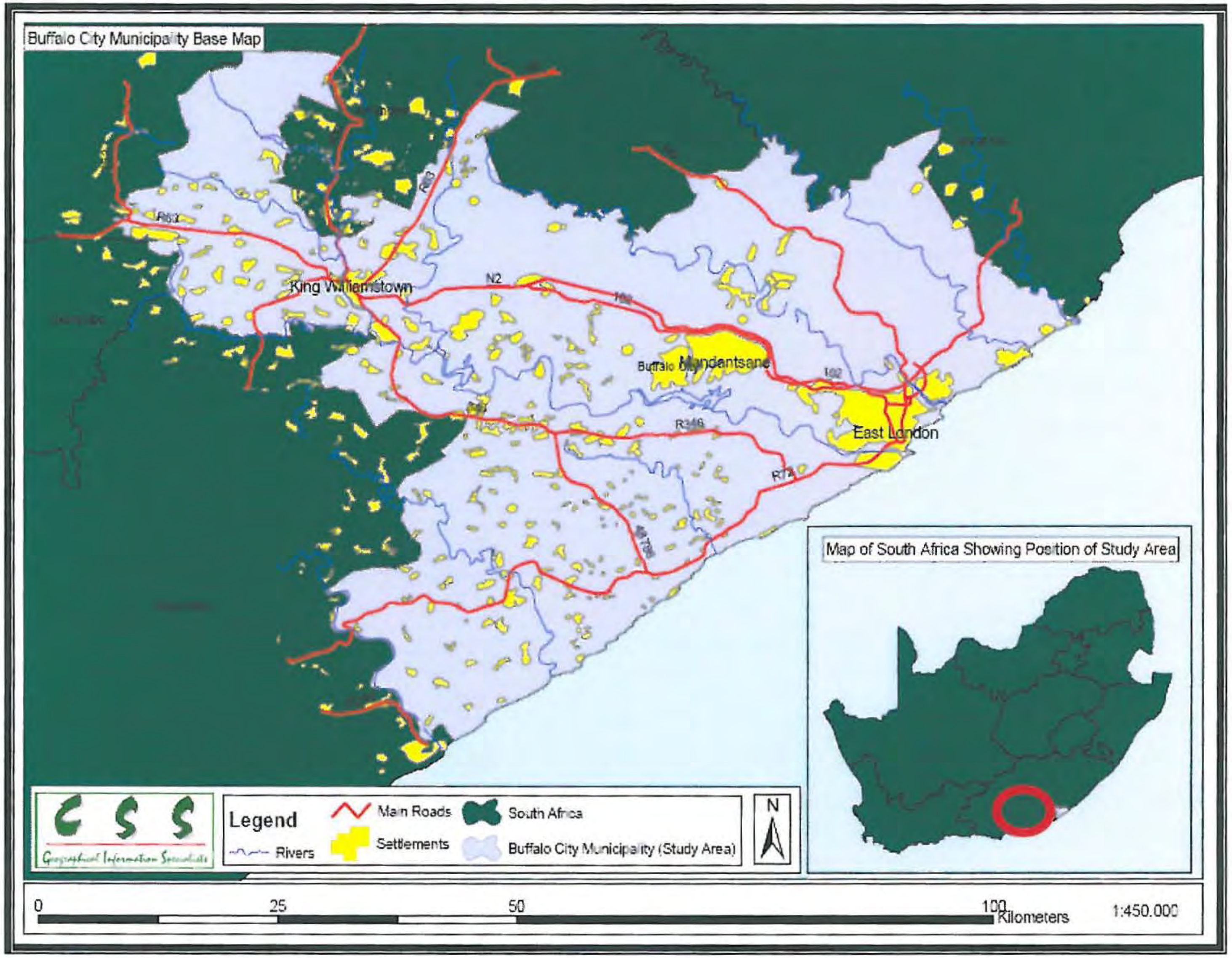

Figure 3.1: Location of Buffalo City Municipality

Table 3.1: Sanitation focus group meeting details and attendees

Sanitation Focus Group Meeting	Date	Venue	Attendees
BCM Upper Management/Council - Is the highest political level of decision making for BCM. It is made up of the Mayor, Mayoral Committee, City Manager, Portfolio Councillors and Ward Councillors. The ward councillors are considered the major link between the municipal government and the residents of BCM.	4/09/06	East London City Hall	1 BCM Mayoral Representative 2 BCM Mayoral Committee members 1 City Manger Representative 4 Portfolio Ward Councillors 29 Ward Councillors **TOTAL No = 37**
BCM Officials - The City Manager heads the BCM administration and provides a link between the political and administrative arms of the Municipality. It is made up of five directorates, financial services, engineering services, corporate services, planning and economic development and social services headed by managers. They provide vital information to the BCM Council for decision-making.	14/09/06	Gonubie Municipal Council Chambers	1 City Manger official 3 Financial Services Department officials 2 Engineering Services Department officials 1 Corporate Services official 2 Planning and Economic Development officials 2 Social Services officials **TOTAL No = 11**
BCM Departments – The BCM departments are actively involved in baseline projects. They report directly to the BCM officials on progress, alternatives and possible ways forward. Information gathered by different departments directly influences decisions made at the BCM Council level.	21/09/06	BCM IEMU Board Room	2 Scientific Services Department representatives 3 Engineering Department representatives 4 Amenities Department representatives 2 Environmental Health Department representatives 3 Development Planning Department representatives 2 Cleansing Department representatives 4 Environmental Services representatives 1 Integrated Development Planning Department representative 3 Integrated Environmental Management Unit representatives **TOTAL No = 24**

Table 3.2: Structure of methods of investigation and sanitation focus group meeting discussions

Sanitation System Component	Methods of Investigation	Questions Discussed During Focus Group Meetings
Toilet	- Meetings with BCM upper management, officials and departments - Site Visits/Observations to suggested sites - Data collected from Rural Master Plan Database (2007)	- What type of sanitation technologies are available to BCM residents? - How many toilets for each technology are present in BCM? - What are main challenges faced by toilets in BCM? - Which areas in BCM can be visited to observe the main issues?
Collection mechanism	- Meetings with BCM upper management, officials and departments	- What type of sanitation collection mechanisms are available in BCM? - How many collection mechanisms for each technology are present in BCM? - What are the main issues faced with using the collection mechanism from each technology?
Transport Mechanism	- Meetings with BCM upper management, officials and departments - Sewer spill data for 2005 -2007* collected from BCM Engineering Department records	- What type of sanitation transport mechanisms are available in BCM? - How many transport mechanisms for a specific technology are present in BCM? - What are the main issues faced by the transport mechanism?
Treatment Process	- Meetings with BCM upper management, officials and departments - Site Visits/Observations to suggested sites - Data collected from BCM Engineering Department of capacity and current flow amounts	- What type of sanitation treatment processes are available to BCM residents? - How many treatment facilities for a specific technology are present in BCM? - What are the main issues faced by treatment processes from each technology? - Which areas in BCM can be visited to observe the main issues?
Disposal / re-use Mechanism	- Meetings with BCM upper management, officials and departments - Site Visits/Observations to suggested sites - Water quality data collected from rivers and streams from 2005-2007*	- What type of sanitation disposal/re-use mechanisms are available in BCM? - How many disposal/re-use mechanisms for a specific technology are present in BCM? - What are the main issues faced by the disposal/re-use mechanisms for each technology? - Which areas in BCM can be visited to observe the main issues?

***NB** Data for 2008 was not available due to BCM Engineering changing the database capturing from paper to electronic format.

3.3 RESULTS AND DISCUSSION

The results of the focus group meetings show that the sanitation technologies used in BCM fall into two main categories. These categories are "centralised" which are technologies that are connected to a sewer network and "decentralised" systems which are technologies not connected to a sewer network. Each of the categories contain different technology options as detailed in Table 3.3 below and the status of each of the components of the sanitation system will be discussed.

Table 3.3: BCM sanitation technology categories and suggested site visits

Sanitation Component	Centralised	Decentralised	Suggested Site Visited
Toilet	- Privately owned waterborne - Communal waterborne - Public waterborne - Communal Pour flush latrines	- Bucket latrine Privately owned pit latrines -Communal pit latrines - Privately owned ventilated improved pits (VIPs) - Communal ventilated improved pits (VIPs) - Privately owned composting toilets (Enviro-loos) - Communal chemical toilets - Privately owned ventilated improved double pits (VIDPs) - Privately owned urine diversion	- Duncan Village Section C Communal toilets - Newlands VIPs - Ducats – Composting Toilets
Collection	- Secondary Sewers - Conservancy Tanks	- Vaults - Chambers	-None
Transportation	- Sewerage System	- Municipal vacuum tankers (Honey Suckers) - Buckets	- None
Treatment/re-uses	- Conventional Sewage Treatment Works - Oxidation Ponds	- Composting	- Amalinda Treatment Works - King Williams Town Treatment Works - Kidds Beach Oxidation Ponds -Ducats Township
Disposal/ re-use	- Effluent released into water systems - On-site sludge storage - Marine Outfalls	- Landfill - Subsistence Agriculture	- Roundhill Landfill Site - Hood Point Marine Outfall - Scenery Park Urine diversion Pilot Project

3.3.1 Toilets

The results gathered from the meetings showed that there are currently nine different sanitation technologies used in BCM. These technologies are waterborne, pour flush latrines, bucket latrines, pit latrines, ventilated improved pits (VIPs), ventilated improved double pits (VIDPs), chemical toilets, composting toilets and urine diversion toilets. The "decentralised" category contains seven more technologies in use than the "centralised" category. All public toilet facilities fall under the "centralised" category and were all waterborne.

The number and percentage of toilets from each technology is summarised in Figure 3.2 and presents data gathered in 2007 from municipal surveys and mapping (BCM, 2007). From the pie chart it can be seen that the waterborne technology makes up 78% of the total number of toilets available in BCM. The VIP toilets amount to 12% of the total number of toilets in BCM, followed by pit toilets which constitute 3%. Both the bucket system and chemical toilets contribute 1% each to the total number of toilets available in BCM. The urine diversion and composting toilets amount to less than 1% of the total number of toilets in BCM with urine diversion toilets contributing the least number of toilets available.

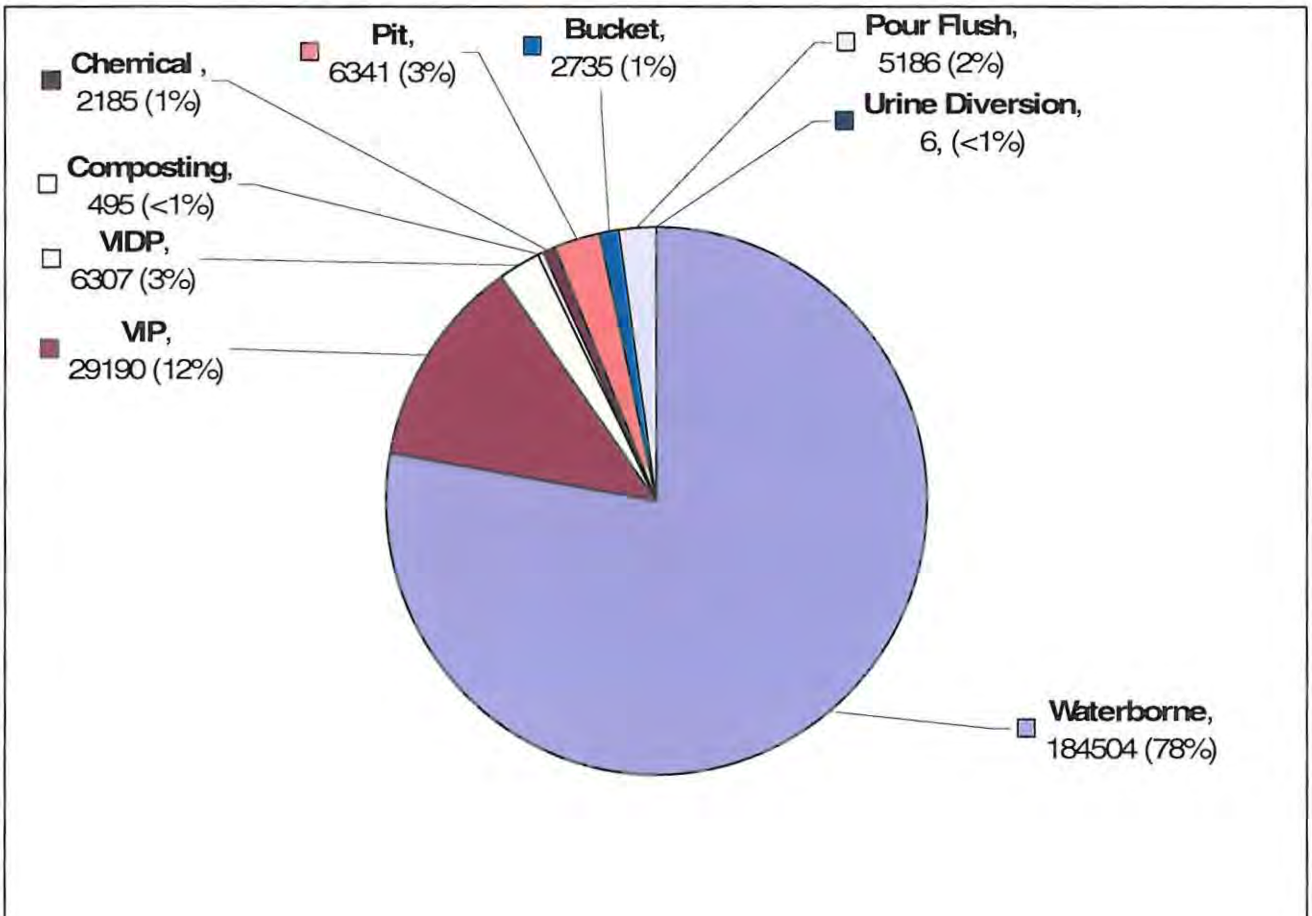

Figure 3.2: Pie chart depicting the number of each type of sanitation technology in BCM (BCM, 2007)

The BCM State of Sanitation Report (BCM, 2006) documented the number of toilets per technology. Table 3.4 depicts the changes in numbers and percentages of each technology from 2001 to 2007. This table provides the current arrangement of technologies within BCM and shows that the waterborne technology use has increased by 12% and was the most dominant technology within BCM. It shows that pour flush, composting and urine diversion toilets which were not reported in 2001 are now being used in 2007. The use of VIPs has increased about 4 times to a percentage of 12%, whilst the use of VIDP has decreased from 12% to 3%. The use of bucket latrines and chemical toilets has not changed considerably from 2001 and 2007 and the numbers remain relatively static. The pit latrine use has decreased five times from 15% to 3% of the total number of toilets used in BCM.

Table 3.4: Number of toilets per sanitation technology in BCM in 2001 and 2007

Sanitation Technology	Nº of toilets 2001	Percentage	Nº of toilets 2007	Percentage
Waterborne Flush Toilet	126824	66%	184504	78%
Pour Flush toilet	0	0%	5186	2%
Chemical toilet	2180	1%	2185	1%
VIP latrine	6668	3%	29190	12%
VIDP latrine	23624	12%	6307	3%
Composting toilet	0	0%	495	<1%
Pit latrine	29027	15%	6341	3%
Bucket latrine	2723	1%	2735	1%
Urine Diversion	0	0%	6	<1%
TOTAL	**191046**	**100%**	**236949**	**100%**

In light of the fact that the waterborne technology constitutes more than three quarters of the entire number of toilets in BCM, it is important to know where these toilets are located within BCM. The BCM Water Services Development Plan (2003) stated that formal settlements mainly in urban and larger peri-urban areas have more access to sanitation facilities than the informal settlements and rural areas. During the discussions with BCM officials, it was confirmed that this situation was largely unchanged. This was attributed to the intensive supply of waterborne technologies with the urban areas and slow provision of "decentralised" systems in the more rural areas (BCM, 2006). The decrease in pit and VIDP technologies can be attributed to the intensive installation of VIPs by DWAF from 2001 to 2007 (Ingels, 2008).

This scenario of more intensive supply of sanitation technologies within the urban areas as opposed to the rural areas can further be explained by the sanitation coverage density shaded map produced by Statistics South Africa in 2003 based on 2001 data (Figure 3.3). This map was presented in the BCM State of Sanitation Report (BCM, 2006) and is relevant here as it shows the trend towards developing sanitation infrastructure in the urban areas. It shows the percentage of BCM households without toilet facilities and shows that the south and south western regions of BCM have the highest percentage of households without sanitation. These areas are considered to be located in the more rural areas outside of the urban edge and thus are not supplied with a waterborne sanitation technology. The south eastern areas (towards the coast) show a relatively low percentage of households without sanitation services which are regions that fall within or around the urban areas of BCM. The meetings with BCM officials confirmed that the map presented the current scenario in BCM. This situation is a direct consequence of rapid urbanisation which is a trend that Kontech (2008) and the UNFPA (2007) recognise as a growing concern in countries like South and East Asia, Latin America and sub-Saharan Africa.

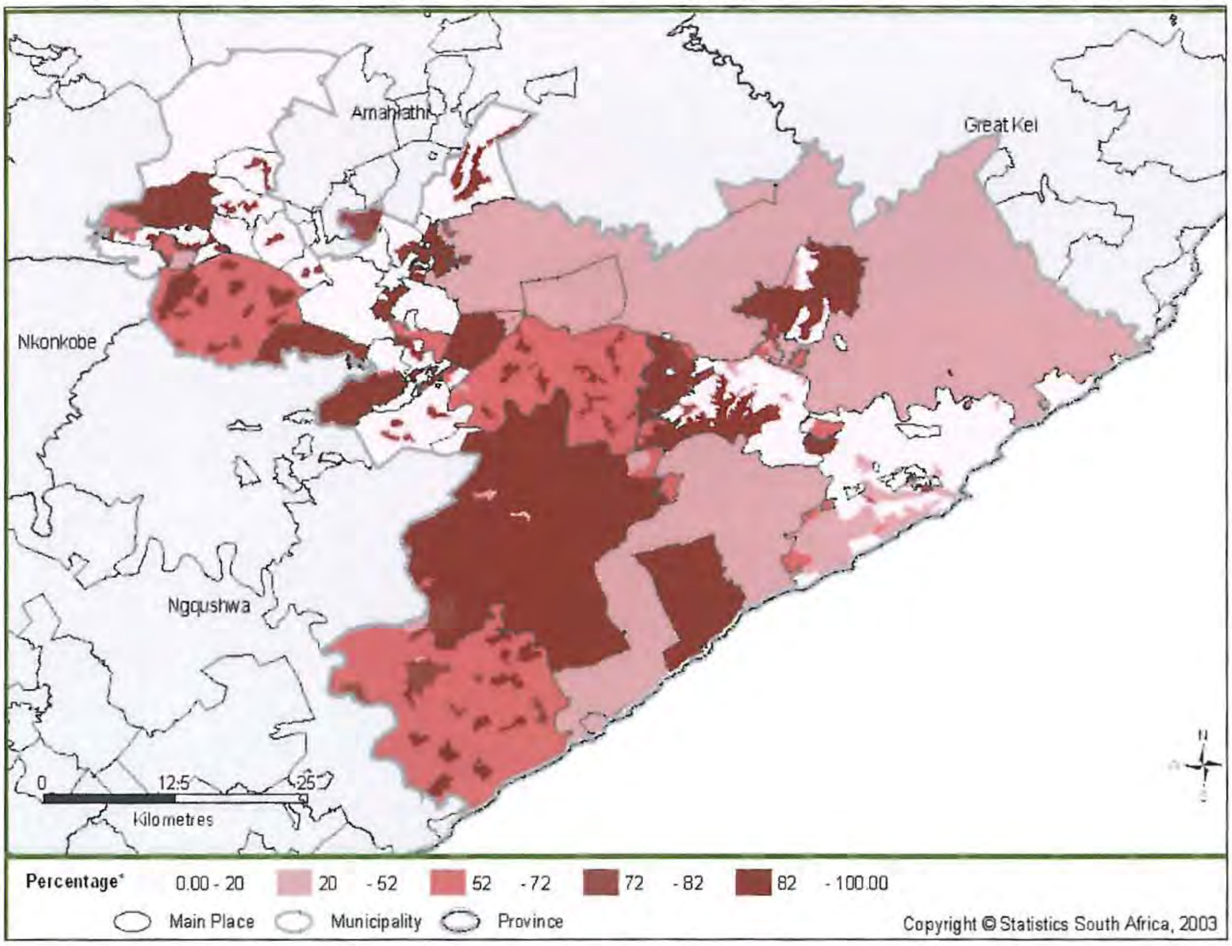

Figure 3.3: Percentage (%) coverage of BCM households with no toilet facilities

Main Challenges

BCM officials identified the main issues surrounding the use and provision of toilets in BCM. The two main issues that were identified related to the poor state of communal waterborne toilets and the filling up of the VIPs toilets. Each issue was discussed at length during the meetings and the main causes are presented in Table 3.5. Site visits were conducted to areas that presented suitable evidence of the main issues identified.

Table 3.5: Main challenges facing the use of communal waterborne toilets and VIPs in BCM

TECHNOLOGY	ISSUE	CAUSE	SITE VISITED
Communal Waterborne			
	Vandalism	The toilets are not owned by individuals and the toilet pedestals, cisterns and piping are broken beyond repair or are removed	Section C Duncan Village
	Blockages	The use of hard abrasive material like cardboard, newspaper and bond paper block the piping. Tissue paper is not commonly used due to costs.	
	Health & Hygiene Risks	Continual use of the toilets despite them being blocked.	
	Privacy and Security	The theft of doors and gates has resulted in limited privacy and has posed a security risk especially for women and children at night.	

The BCM Cleansing Department is responsible for the cleaning and repair of the public and communal toilets. A site visit to a block of communal toilets in Section C of Duncan Village was conducted as suggested by BCM officials. The block consisted of 30 sections with a total of 150 toilets, which are cleaned daily by 18 personal from the Cleansing Department. The same block of communal toilets was assessed in the State of Sanitation Report (BCM, 2006), however the data for that report was gathered in 2005. It reported 23 personnel employed to clean and repair the toilets which shows a decrease of 5 personnel in over a year. The state of the communal toilets inspected during the site visit to Duncan Village was very similar to that presented in the BCM State of Sanitation Report (BCM, 2006) one year earlier. They were for the most part blocked, inoperative and in a state of disrepair.

Of the 150 toilets it was recorded that currently only 27 toilets were operational. The BCM State of Sanitation Report (BCM, 2006) found that in one block consisting of 40 toilets, not a single toilet was operational due to blockages. The site visit recorded accounts of faecal matter, urine and other waste spilling onto the floors of the ablution facilities and out into the street was recorded (Plate 3.1 and Plate 3.2). The fact that these facilities were not owned by the users, is likely to have lead to vandalism and damage of the toilets. The site visit established that 18% of the toilets in Section C of Duncan Village were blocked and the main reason for this was the use of thick abrasive material for body cleansing after use. Even though blockages occur, the toilets are still used by the residents. This increases health and hygiene risks for the users.

The literature shows that this situation is not unique to BCM or South Africa. Whittington *et al.*, (2009) reported that in Kolkata, India, communal waterborne technologies serviced about 90% of the overcrowded low income slum. The shared facilities have been linked to the spread of disease like cholera and typhoid in this slum since in some parts sewage flows into open drains outside the houses. The discussions with BCM officials confirmed that the main social impact was the lack of privacy and security risks caused by the theft of doors from the entrance to the facility and inside the individual toilets as well as theft of the lighting equipment in these facilities. None of the facilities had doors and inside the facility there was no form of electrical lighting equipment making them an inconvenient facility to use in terms of privacy and comfort.

Plate 3.1: Communal toilet sewage currently being flushed into the street in Duncan Village

Plate 3.2: Blocked communal toilet in Duncan Village still being used by residents

As mentioned in Chapter 1, the current BCM population of 722 603 is increasing annually by 0.53%. With high rural to urban drift rates, the urban population which makes up 79.6% of the BCM population is expected to increase. Based on the number of toilet facilities in BCM, each toilet is BCM has an average of 4.3 users which is set to increase with the rate of population growth and rural to urban drift. Konteh (2008) noted that urbanisation in low to middle income countries, especially in Asia and Africa, has been comparatively high. In the developing world today poor sanitation and health impacts affect the urban poor in much the same way as it did the working class households in the industrialised countries in Europe and America (Konteh, 2008). Diseases like cholera, typhoid, dysentery, and tuberculosis, were common then as they are today in low income cities of the developing world today (Sclar *et al.*, 2005). High levels of morbidity and mortality were linked to poor sanitation, inadequate waste disposal system and water supply provision, poverty and deprivation during the 19th century just as they are today in the developing world.

3.3.2 Collection

The different types of technologies have different collection systems based on whether they belong to the centralised or decentralised category. The information gathered from the meetings identified four different types of collection mechanisms in BCM which are divided into categories of "centralised" and "decentralised." The collection systems within the centralised systems are secondary sewers and conservancy tanks. The decentralised collection systems are vaults or chambers and municipal vacuum tankers.

The secondary sewers service the waterborne and pour flush technologies and are predominantly found within the urban edge. These collection mechanisms are connected to the toilet facility and are the link between the major transport mechanism and the toilet. Excreta are held in these secondary sewers before it is transported to the main sewage system. The exact number of toilets connected to the secondary sewer in BCM is not known because during the BCM surveys and mapping data gathering, no distinction was made between a waterborne toilet connected to a secondary sewer or a waterborne toilet connected to a septic tank. However during discussions with the BCM Engineering Department it was estimated that about 70% (129153) of the waterborne toilets were connected to a secondary sewer. The other centralised collection mechanism is a conservancy tank. Data provided by the BCM Engineering Department shows that there are approximately 83 conservancy tanks registered within BCM and these are mainly found within the rural areas.

The decentralised collection systems are in the form of vaults or chambers or collection containers. The vaults and chambers are collection mechanisms for the pit latrines, VIPs, VIDP and composting toilets. The collection containers are associated with chemical toilets, buckets and the urine diversion toilets. Each of these technologies are designed to have their own vault or collection container therefore the number of collection mechanisms will be equivalent to the number of toilets per technology (Table 3.4). From Table 3.4, it can be deduced that VIPs constitute the highest number of collection mechanisms with 29190 vaults for collection. The table also shows that the bucket latrines have the most number of collection containers with 2735 containers, but the urine diversion toilets have the least amount of collection containers with only six being currently used in Scenery Park. The main challenges with collection mechanisms are discussed below.

Main Challenges

From discussions in the respective meetings with BCM officials, two main challenges were highlighted with regards to collection mechanisms. The first was the filling up of VIP vaults and the second was the improper use of urine diversion vaults. Table 3.6 below provides a summary of the main issues and causes and the different sites visited to ground truth the main challenges identified during the initial meetings.

Table 3.6: Main issues with collection mechanisms

TECHNOLOGY	ISSUE	CAUSE	SITE VISITED
VIPs			
	Full vaults	Pits have not been emptied since installation and users now use the bush for ablution	**Newlands**
	Child Safety	Children have fallen down the toilets into the pit	**Newlands**
Urine Diversion			
	Collection containers are not being used	Users of toilets preferred to use the vault as a refuse bin rather than a toilet and toilets were not being used	**Scenery Park**

After the waterborne technology, VIPs are most widely used throughout BCM (12%), and the municipality does not have the resources to manage them (BCM, 2006). During the meetings with the BCM officials it was revealed that most VIP collection pits in BCM have filled up and 90% of them have never been emptied since their installation. The ward councillor of Newlands reported on the site visit that the filling up of VIP pits was one of the biggest problems facing BCM. The reason why the VIPs collection pits are not being emptied was that some are located in areas that are not accessible for the municipal vacuum tankers. Some of these areas are located on steep slopes and do not have vehicular road access to the toilet (Plate 3.3). In addition the VIP pits that are accessible have solid material in them and require large amounts of water to make the pit material liquid enough to pump into the tankers. This results in the pits not being emptied and the VIP toilets filling up. This situation is also seen in other parts of South Africa. The VIP was considered the minimum level of sanitation for most municipalities in South Africa responsible for improving access to services in rural and peri-urban communities (WRC, 2008). Over one million VIPs have been constructed around South Africa since 1994. The South African Government has since identified that they offer a good basic service of sanitation however, their long-term sustainability poses a number of challenges to policy makers when the VIPs fill up. Not much thought was given on what should happen if the pits filled up. The WRC (2008) have started that once the pit is full, it no longer can fulfil its function of providing safe, hygienic and dignified sanitation. This situation is very much the case in BCM.

Another issue discussed in the meetings was the safety of young children, who have reported by fallen into VIP pits. The VIPs tend to only be used by adults due to this issue and results in young children using the bushes. This potentially leads to social impacts like poor health and hygiene and safety risks as well as contributes to environmental impacts like surface water pollution especially after runoff from the area enters nearby water resources.

Plate 3.3: Two VIPs in Newlands (circled in red) located far from an access road

Six households in the area of Scenery Park use the UD toilet system. The ward councillor reported that the UD toilets were not being used by the households because the toilets produced smells and flies. During the site visit to the households, urine tanks were inspected and they were all full, and the vaults seemed to be used as a household waste bin (Plate 3.4). The bushes were used for defecation and UD toilet and urinal used for urination. The households avoided using the toilets for defecation so they would not have to handle the collecting container containing human faeces. Dunker *et al.* (2006) also made this finding whilst researching various communities in Northern Cape, Eastern Cape, KwaZulu-Natal and North West Provinces of South Africa where urine diversion toilets had been built. They found that communities considered the handling and use of excreta as bad practise and they would not eat any produce grown from excreta. It is interesting to note that this trend has been identified across the country and highlights a cultural and social boundary to the acceptance of UD sanitation systems.

Interestingly the BCM household owners did not seem to mind handling the collecting container containing urine (Plate 3.5). The ward councillor reported that the households were satisfied with the fact that they at least had a house, but would have preferred to have a flush toilet, as the operation and maintenance of a UD toilet collecting mechanisms was perceived to be difficult and crossed cultural barriers.

Plate 3.4: Urine diversion toilet showing faecal vault being used as a household waste bin

Plate 3.5: Household user emptying a full urine collection container into a soakaway

3.3.3 Transportation

There are three transport mechanisms serving the different sanitation technologies within BCM. These mechanisms are sewerage systems, municipal vacuum tankers and buckets. The sewerage systems serve the centralised technologies and collection systems by transporting sewage to treatment plants. The municipal vacuum tankers transport sewage from collection mechanisms not connected to the sewerage systems to treatment plants. Buckets are used to transport sewage from bucket latrines to disposal sites or treatment facilities.

The sewerage systems are found only within the urban edges of BCM and their function is to transport sewage to treatment facilities. Only the waterborne system is serviced by this transport mechanism and therefore about 78% of the toilets in BCM are connected to the sewerage system. According to mapping data gathered from the BCM Engineering Department only 42% of the total BCM urban edge area has sewerage coverage. The oldest sewerage network was established in 1920 in the East London urban edge and new sewers have been linked to this system for over 80 years. The sewerage systems in King Williams Town, Mdantsane Berlin and Dimbasa were formally established during the 1960's (Ingles, 2007). The breakdown of percentage coverage of sewers in BCM urban edges is documented in Table 3.7. From the table it can be deduced that East London shows the highest sewerage coverage of 71% followed by Mdanstsane with 62% and King Williams Town with 40%. The urban edges of Berlin and Dimbasa have the lowest percentage sewerage coverage's of 23% and 18% respectively.

Table 3.7: Percentage sewerage coverage within the BCM urban edge

Urban Edge	Percentage Sewerage Coverage
East London	71%
Mdantsane	62%
King Williams Town	40%
Berlin	23%
Dimbasa	18%

The other collection systems are the municipal vacuum tankers and buckets. The municipal vacuum tankers are operated and maintained by the BCM Engineering Department. There are currently 43 tankers operating in the BCM area. These tankers service conservancy tanks, septic tanks, VIPs and pit latrines in BCM. Using the toilet mapping data was calculated that the each tanker must service an average of 978 toilets in BCM per year. The bucket system involves the transportation of sewage manually carried in a bucket from the household to a transportation tanker and onto the treatment facility. The number of toilets operating this collection mechanism in BCM is estimated to be 2735.

Therefore it can be seen that there is a large number of toilet facilities in BCM that require a transport mechanism and the main issues faced by the transport mechanisms are discussed below.

Main Issues

From the meetings held with BCM the main issue with the transportation systems was the poor state of sewers within BCM. The BCM officials reported that the poor state of sewers caused frequent sewage spills and environmental pollution that posed a health risk to BCM communities. This issue was highlighted in both the BCM State of Environment Report (BCM, 2005) and State of Sanitation Report (BCM, 2006) and an investigation was carried out as part of this research to substantiate the claims in these reports.

Data was gathered from records kept by the BCM Engineering Department for the whole of BCM for the period of Jan 2005 to Dec 2006. The data was collected from daily log sheets filled out by maintenance staff for every call out to unblock or repair sewerage pipes due to the presence of a spill. Data for 2007 to 2008 was not available due to the BCM Engineering Department changing the data collection process from a paper based system to an electronic database system. Since the objective of this chapter was to update the State of Sanitation Report (BCM, 2006), which only used data from 2001 to 2004, the use of data from 2005 to 2006 was considered sufficient to update the State of Sanitation Report (BCM, 2006) and to make current conclusions about the state of sewers.

Records included the number of sewage spills caused by cracks and blockages during the course of 2005 to 2006. The definition of a sewage spill for the benefit of this research was "the discharge of effluent from a pipe, manhole or drain that inevitably results in the exposure of the environment to raw sewage." Figure 3.4 illustrates the number of sewage spills recorded on a monthly basis in the BCM over a period of two years (2005-2006). February 2005 recorded the highest number of recorded spills at 696, whilst the lowest number of spills recorded at 197 occurred during June 2005. These results translate to an average of 520 reported sewage spills in BCM a month and an average of approximately 17 reported sewage spills a day. It is interesting to note that the trend line shows a slight decline in the amount of sewerage spills for the period of 2005 to 2006, however the trend line still remains above 500 spills per month. An analysis was done to determine the main cause of the spills and this is presented in Figure 3.5. The analysis found that 76% of the spills were caused by cracked or damaged sewerage pipes, whilst only 24% of the spills were caused by blockages. The very high incidences of spills due to cracked sewerage pipes are indicative of infrastructure that requires replacement. Furthermore, the municipal officials reported that the vandalism of manholes was one of the main contributing factors to a high number of recorded blockages. Residents in informal settlements block the manholes deliberately to irrigate their crops which are planted adjacent to the sewer lines and manholes.

These results validate the BCM State of Sanitation (BCM, 2006) and BCM State of Environment (BCM, 2006) reports' claim that the sanitation infrastructure throughout BCM is in a poor state of repair, resulting in frequent discharges of raw sewage into rivers and streams. According to Bond (1999), negative ecological impacts related to poorly maintained infrastructure is a major environmental consequence of poor municipal infrastructure management in South Africa.

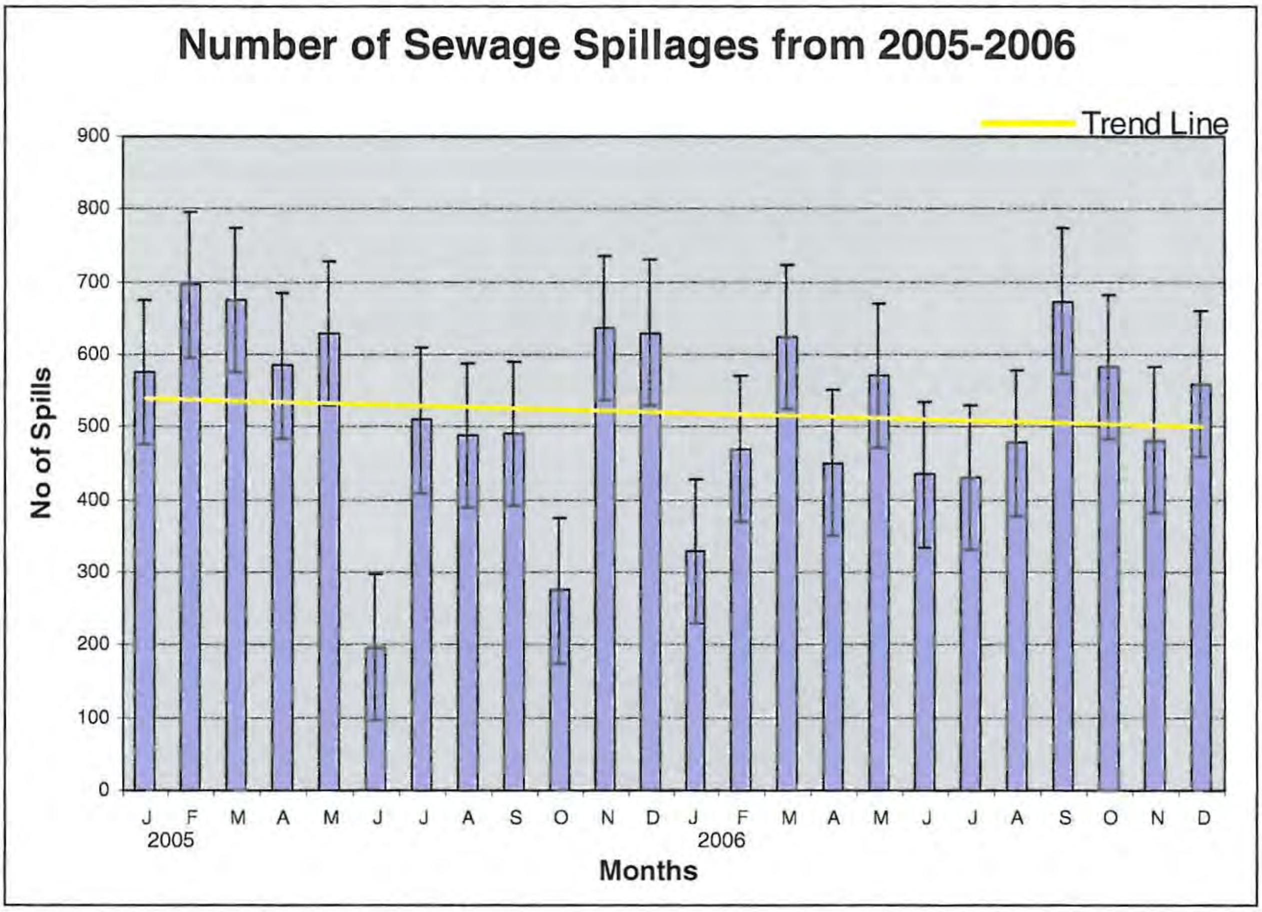

Figure 3.4: No of sewerage spills recorded in BCM from 2005 – 2006 (Scientific Services data)

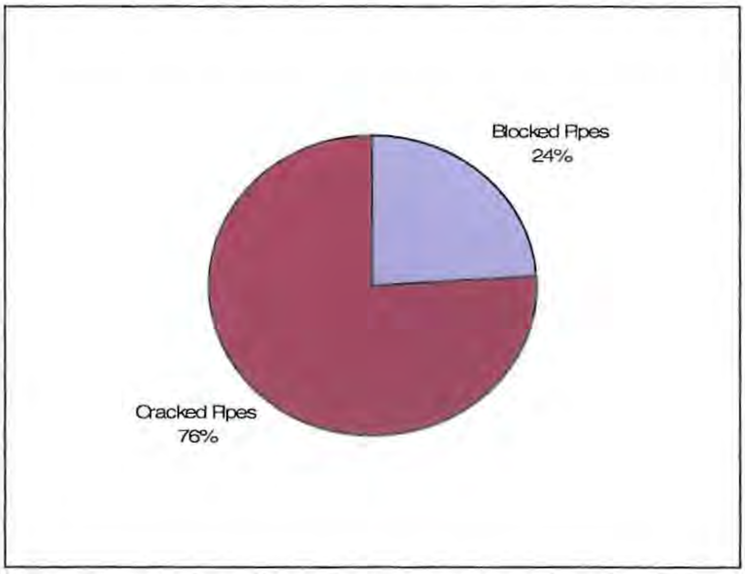

Figure 3.5: Causes of sewerage pipe spillages (%)

Numerous international research studies have concluded that spillages from poorly maintained sewers have contributed to pollution of the environment, especially aquatic systems (Himlin, 1997; Bishop *et al.*, 1998; Bond; 1999; Reynolds & Barrett, 2003; Souvent *et al.*, 2006). Notably, contamination of surface and groundwater resources by effluent spilling from sewers has been recorded in the town of Ljubljana in Slovenia. Here sewer lines were built in 1965 and are currently leaking and polluting water resources used for municipal water supply (Souvent *et al.*, 2006). Bishop *et al.* (1998) used an incidence recording technique, like the one used in this research, to conclusively connect sewer spillages with groundwater contamination. They concluded that poor groundwater quality found in England and Wales was directly linked to sewer spillages (Bishop *et al.*, 1998).

Based on the available information from BCM it can be deduced that the sewers that carry the effluent to the respective WWTWs need to be replaced or upgraded and measures put into place to address vandalism, if the number of sewage spills into rivers, streams and the environment is to be reduced.

3.3.4 Treatment

Currently sewage treatment mechanisms in BCM are dealt with by conventional sewage treatment works, oxidation ponds and by composting the sewage. The conventional sewage treatment and oxidation ponds treat sewage by passing it through primary, secondary and tertiary treatment processes. The conventional sewage treatment works also known as Waste Water Treatment Works (WWTW) and oxidation ponds fall into the centralised category and mainly serve the waterborne technology, however any sewage collected by BCM municipal tankers from pour flush toilets is also treated at WWTW. Within Treatment of sewage by composting serves technologies falling into the decentralised category namely the composting toilets, VIPs, VIDPs, pits and urine diversion.

Discussions with municipal officials revealed that there are currently 11 WWTWs and four oxidation pond treatment facilities in BCM. Table 3.8 below details the name, date of establishment and design capacity of all WWTW and oxidation ponds in BCM. Figure 3.6 illustrates the position of the different treatment systems in BCM.

Table 3.8: Waste Water Treatment Works and Oxidation Ponds found in BCM

No	Treatment Facility (Year established)	Area Serviced	Design Capacity (ML/Day)
1	Berlin WWTW (1972)	Berlin Urban Edge	2
2	Bisho Ponds (1993)	Bisho Urban Edge	0.8
3	Breidbach Ponds (Date Unknown)	Breidbach Urban Edge	1
4	Central WWTW (Amalinda) (1972 and 1997)	East London Urban Edge	5
5	East Bank WWTW (1985)	East London Urban Edge	40
6	Gonubie WWTW (1975)	East London Urban Edge	6
7	Reeston WWTW (1999)	East London Urban Edge	2
8	Screening Station (Headworks) (2002)	East London Urban Edge	40
9	Dimbaza WWTW (1986)	Dimbasa Urban Edge	7
10	Kaysers Beach (Ponds) (2003)	Kaysers Beach Urban Edge	0.2
11	King William's Town WWTW (1971)	King Williams Town Urban Edge	4.8
12	Mdantsane East WWTW (1972 and 1976)	Mdantsane Urban Edge	18
13	Mdantsane West WWTW (Postdam) (1984)	Mdantsane Urban Edge	9
14	Zwelitsha WWTW (1975 and 1982)	Zwelitsha Urban Edge	9
15	Kidds Beach Ponds	Kidds Beach Urban Edge	0.6

ML/Day = Mega litres per day

From Table 3.8 it is clear that East London has the highest number of treatment facilities serving it due to its high percentage of sanitation coverage of between 80 -100% (Figure 3.2) and the highest concentration of sewerage infrastructure (71%) in BCM. East London urban edge is serviced by five WWTWs (Figure 3.6). However discussions during the meetings with BCM officials revealed that only four of the WWTWs namely Central, East Bank, Gonubie and Reeston process sewage through primary, secondary and tertiary treatment before disposal. The Screening Station processes sewage only to a stage of primary treatment before disposal. The Mdantsane urban edge is served by two WWTWs and one more is proposed, due to the growing urban population currently experienced in all urban centres in BCM. The other nine WWTWs and oxidation pond facilities service their respective urban edges and there is only one facility per urban edge.

The treatment of sewage by composting is practised mainly in the peri-urban and rural areas of BCM. Since the pit, VIP, VIDP, composting toilet and urine diversion toilet technologies practise the drop and store mechanism of collection, they also rely on the breakdown of the sewage. Composting toilets rely on the breakdown and the technology makes provision for ventilation through vents and heat retention by ensuring the collection container is black in colour to absorb heat for the composting process. The BCM officials reported that the composting of the sewage is used as a "default" treatment mechanism and because the pit, VIP and VIDP technologies do not specifically make provision for ventilation and heat retention the breakdown is not as rapid. This results in the filling up of the pits and subsequent negative social and health impacts. The main issues faced by BCM with regards to the treatment of sewage is disused below.

Main Issues

During discussions with the BCM officials the main issue with the treatment of sewage was that many of the treatment facilities were running at or over capacity. Table 3.9 shows that six out of 14 treatment facilitates in BCM had reached their respective capacities and were overloaded with respect to the volume of effluent received daily. Three WWTWS were operating between 75%-99% capacity and all three will soon reach their capacity based on the estimated population and household growth rates of 0.53% and 0.54% respectively. Only three WWTW's in BCM were operating below 75% capacity and Reeston WWTW is not operational due to the lack of funding and Kaysers Beach and Kidds Beach Oxidation Ponds are not monitored and therefore there was no data available on the volumetric loading of these systems. Closer analysis showed that of the six overloaded treatment facilities, four fall within the most populated regions of BCM. These were the Central WWTW in East London, Gonubie WWTW, King Williams Town WWTW and Mdantsane East WWTW. With this in mind, the BCM seeks to not only build the 26 306 accommodation units it needs to satisfy the current household sanitation backlog, but BCM officials confirmed that it explicitly favours waterborne sanitation system installation into these units. This is despite the fact that 75% of the currently operating treatment facilities in BCM are running near to capacity or over capacity.

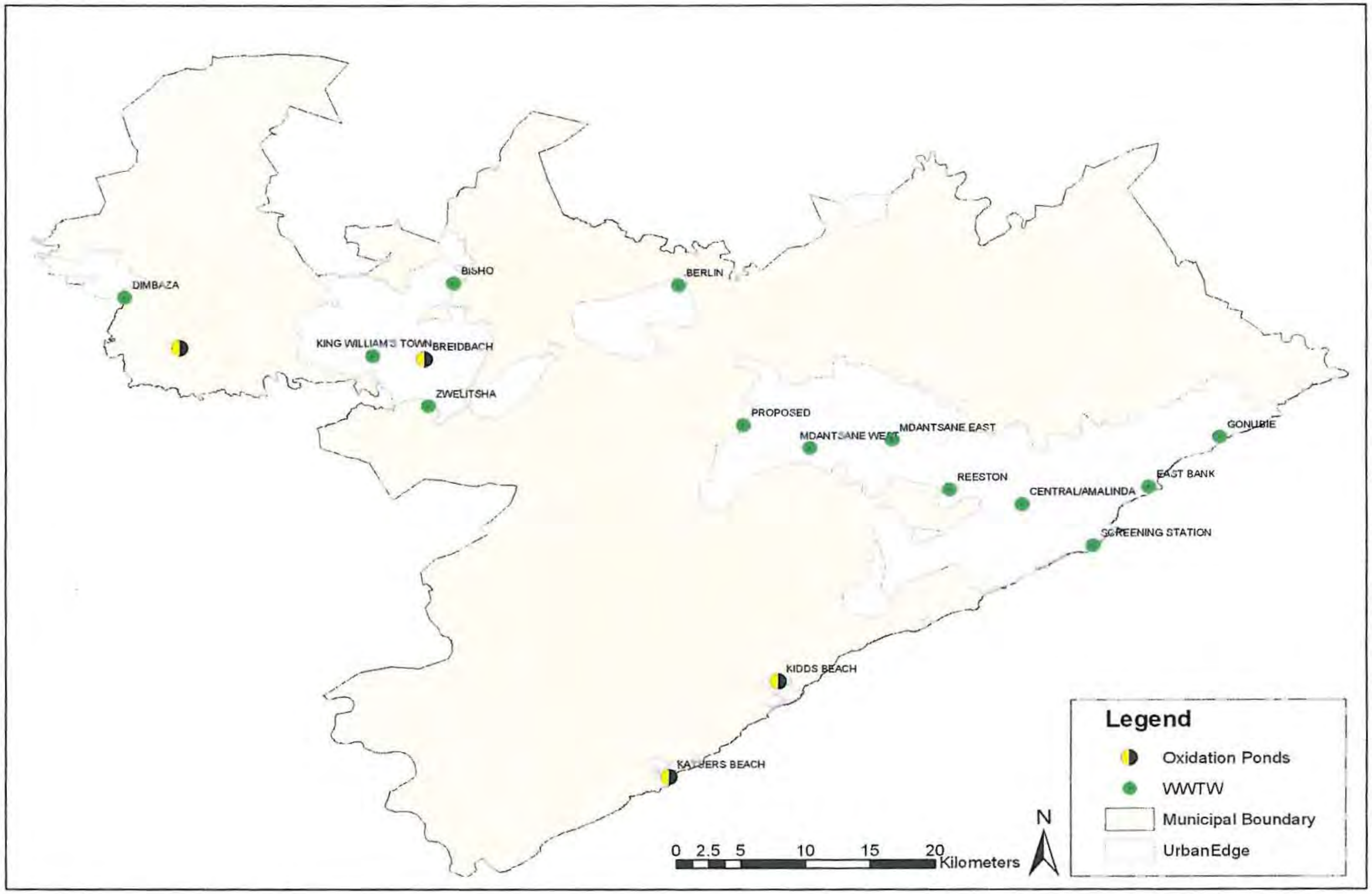

Figure 3.6: Location of waste water treatment works and oxidation ponds in BCM

Table 3.9: Design and current effluent flows at wastewater treatment works

Treatment Works (Year established)	Design Capacity (ML/Day)	Current Flow (ML/Day)	Percentage Capacity (%)
Berlin (1972)	2	0.4	20
Bisho Ponds (1993)	0.8	2	250
Breidbach Ponds (Date Unknown)	1	2	200
Central (Amalinda) (1972 and 1997)	5	5	100
Dimbaza (1986)	7	6	86
East Bank (1985)	40	35	88
Gonubie (1975)	6	8	133
Kaysers Beach (Ponds) (2003)	0.2	Unknown	Unknown
Kidds Beach (Ponds) (1999)	0.6	Unknown	Unknown
King William's Town (1971)	4.8	5.2	108
Mdantsane East (1972 and 1976)	18	20	111
Mdantsane West (Postdam) (1984)	9	7	77
Reeston (1999)	2	0 (Not in Operation)	0 (Not in Operation)
Screening Station (Headworks) (2002)	40	8	20
Zwelitsha (1975 and 1982)	9	6	66

<75% Capacity | 75%-99% Capacity | 100% - >100% Capacity

In addition to the over capacity issues faced by BCM treatment facilities, another issue is the production of non-compliant effluent. Since 75% of treatment facilities in BCM were running at or over capacity, the quality of the effluent being discharged from all the treatment facilities was analysed and compared to DWAF general limits standards. This allowed the percentage compliance of each treatment facility to be ascertained (Figure 3.7). There are different discharge limits applied to freshwater and marine water (Table 3.10). Two of the WWTW disposed of their effluent to the marine environment (Hood Point Marine Outfall and the Bats Cave outfall) and therefore had to comply with the relevant discharge standards. The remaining WWTW discarded to river systems and therefore had to comply with the discharge standards for freshwater. The relevant standards are presented in Table 3.10. Data for 2007 and 2008 was not available for analysis due to the fact that data capturing system changed to an electronic format that was not currently available. There was also no data available for Kaysers and Kidds Beach Oxidation Ponds and Reeston WWTW was not operational. Therefore, the current analysis was run for ten treatment facilities.

Table 3.10: DWAF effluent discharge limits for disposal to the freshwater and coastal waters (RSA, 1998)

Parameter	Fresh Water Limits	Coastal Water Limits
pH	5.5-9.5	5.5-9.5
Suspended solids at 105°C	25	1500
Ammonia Nitrogen as N (mg/L)	10.0	190
Permanganate Value (4-h) as O_2	10.0	-
Chemical Oxygen Demand as O_2	75	4500
Dissolved Oxygen (% sat.)	>75	-
Cadmium as Cd (mg/L)	0.05	1.2
Copper as Cu (mg/L)	1.00	1.6
Chromium (total) as Cr (mg/L)	0.50	2.5
Lead as Pb (mg/L)	0.10	3.7
Manganese as Mn (mg/L)	0.40	-
Zinc as Zn (mg/L)	5.00	7.8
Iron (mg/L)	-	20
Nickel (mg/L)	-	7.8
Arsenic (mg/L)	-	3.6
Faecal coliforms (MPN/100ml)	100	1000 (in 80% of Samples)
E coli (MPN/100ml)	100	1000 (in 80% of Samples)

From Figure 3.7 it is clear that all ten treatment facilities produced treated effluent that at some point was non-compliant to DWAF general limits over the period of 2005 to 2006. This may be due to the poor management and the fact that they are running at or over capacity. The Gonubie WWTW was the most compliant treatment facility for the two years investigated with a compliance of 87% and 88% for the 2005 and 2006 years respectively. The other nine treatment facilities recorded a compliance of below 80% for 2005 and 2006. The effluent quality for each of the WWTW was routinely sampled once per month. A compliance of 100% therefore means that all parameters were where within the discharge limits of each occasion over the 2005 – 2006 period. Similarly a compliance of 50% meant that all discharge limits were met on only half the sample events. For the purpose of this study, non-compliance could be as a result of only a single water quality parameter or more than one parameter.

It is interesting to note that the effluent quality record did not appear to be correlated to volumetric loading relative to design capacity. For instance, Zwelitsha and Berlin treatment facilities are running under 75% capacity, however the effluent they produced was below a percentage compliance of 80%. In addition, there does not seem to be a real difference between systems that are overloaded and those that were not, for example Gonubie WWTW is running at 133% capacity, but produces the most compliant effluent of all the treatment facilities in BCM. Nonetheless, the data confirmed the concerns of the BCM official's, i.e. that none of the treatment facilities produced effluent that was able to consistently meet the DWAF general limits.

For purposes of this research, the actual reason (s) for non-compliance were less important than the confirmation that centralised treatment facilities within BCM were not able to perform adequately with respect to minimizing negative impacts of sewage. A closer look at the various water quality criteria (Section 3.3.5) provided some insights into the possible nature of the negative impacts.

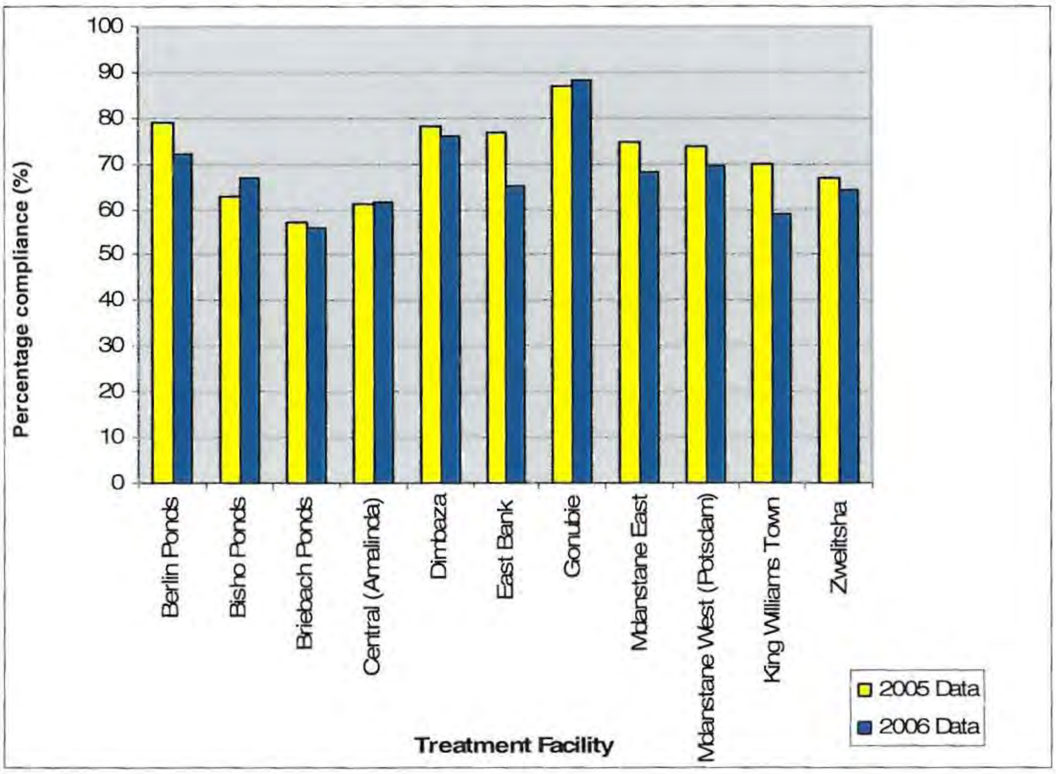

Figure 3.7: Percentage compliance of effluent from treatment facilities releasing into freshwater in BCM for 2005 and 2006

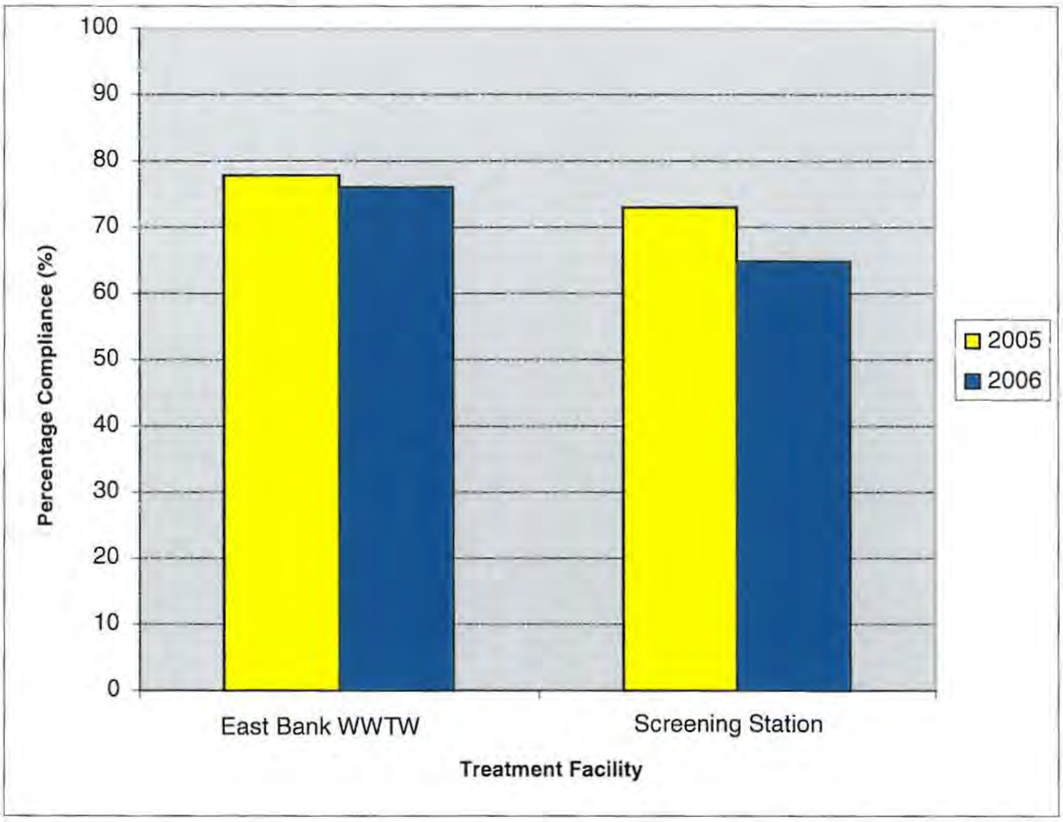

Figure 3.8: Percentage compliance of effluent from treatment facilities releasing into coastal water in BCM for 2005 and 2006

Neither of the treatment facilities releasing effluent into coastal water were able to consistently meet the required DWAF limits (Figure 3.8) and both had percentage compliance values below 80%. However, the East Bank WWTW shows the most compliant effluent for 2005 and 2006. This may be due to the fact that the sewage at this facility undergoes primary, secondary and tertiary treatment before the effluent leaves the facility, whereas the Screening Station only undertakes primary treatment before releasing effluent to the marine environment.

The potential impact of poorly treated effluent has been seen recently in Zimbabwe where the United Nations issued a health warning of a possible outbreak of cholera in November 2008 (WRC, 2008). It was reported that the outbreak occurred due to the management of the water and sanitation services being handed to the Zimbabwe National Water Authority (ZINWA). The United Nations (UN) reports that since February 2008, 120 people died of cholera and the onset of the rainy season could make the disease and epidemic. Approaches to address the impacts of the release of none compliant effluent have been developed in the Mediterranean countries (Bdour *et al.*, 2009). They identified that is was common practise to discharge effluent, of which less than 10% has been treated, directly into surface water bodies which caused significant health and economic risks.

Realising how unsustainable this was especially in water stressed areas, they suggested that treatment be decentralised to avoid overloading and to facilitate the reuse of treated effluent for agricultural purposes (Bdour *et al.*, 2009). Similar thinking may be applied to the management of sewage in BCM.

The disposal of the products of treatment is the next sanitation component and this is discussed below.

3.3.5 Disposal and re-use

The last of the sanitation components is the disposal method for different products. Through discussions with BCM officials it was ascertained that there were five disposal methods currently practiced in BCM. For the centralised systems, disposal methods include discharge to freshwater, onsite sludge storage (solid), and discharge to the marine environment via marine outfalls. The decentralised systems have two possible types of disposal which are landfill disposal and re-use in subsistence agriculture.

Table 3.11 shows the type of disposal management of effluent and sludge used for each treatment facility within BCM. From the table it can be seen that ten treatment facilities store their sludge onsite whilst two namely the East Bank WWTW disposes of its sludge with the effluent and sludge from the Screening Station (West Bank) at the Hood Point Marine Outfall (Figure 3.9). During discussions with the BCM officials it was clear that there was no sludge management plan for BCM and the continued onsite sludge storage and disposal out to sea is the only method envisaged for the future.

Table 3.11: Disposal mechanisms for waste water treatment works in BCM

Treatment Works (Year established)	Effluent Discharge Point	Sludge Management
Berlin (1972)	Nahoon River	Sludge has never been emptied from digesters
Bisho Ponds (1993)	Buffalo River	Sludge has never been removed since establishment
Breidbach Ponds (Date Unknown)	Buffalo River	Sludge has never been removed since establishment
Central (Amalinda) (1972 and 1997)	Buffalo River	Undigested and digested sludge placed in drying beds and emptied onsite
Dimbaza (1986)	Buffalo River	Sludge disposed of on-site
East Bank (1985)	Bats Cave Marine Outfall	Sludge sent to West Bank Sea outfall for disposal
Gonubie (1975)	Gonubie River	Sludge placed onsite into sludge lagoons"
Kaysers Beach (Ponds) (2003)	Not in operation	Not in operation
King William's Town (Date Unknown)	Buffalo River	Sludge is removed and stockpiled onsite
Mdantsane East (1972 and 1976)	Inyana Stream to Buffalo River	Sludge is removed and stockpiled onsite
Mdantsane West (Postdam) (1984)	Buffalo River	Sludge is removed and stockpiled onsite in trenches
Reeston (1999)	Not in operation	Not in operation
Screening Station (Headworks) (2002)	Hood Point Marine Outfall	Screened Sludge disposed into sea
Zwelitsha (1975 and 1982)	Buffalo River	Sludge scraped and stockpiled in trenches onsite

The Screening Station on the West Bank of East London collects the effluents from the West Bank area and discharges these to sea as no treatment facility has yet been built to service the area (BCM, 2005). Existing discharges include 60% from the municipality's raw domestic sewage which includes waste activated sludge from the East Bank treatment works and 40% effluent from the West Bank residential and industrial areas and saline industrial effluent (BCM, 2005). The effluent is currently discharged at a rate of about six to seven mega litres per day into the surf zone. In addition, the treated effluent at the East Bank WWTWs is currently disposed of into the sea at Bats Cave (Figure 3.9).

The disposal mechanisms used by the decentralised systems are either disposal at a landfill site or via incorporation into subsistence agriculture. The sludge collected from VIPs, VIDPs and pits mainly in from Newlands and Ncera areas is disposed of at a landfill site. However, due to the fact that collection is difficult and inconsistent, BCM officials reported during the meetings that this form of disposal was not practised on a regular basis and there was no reliable data or records detailing the amount of sludge usually collected or how often it was collected. The urine diversion pilot project in Scenery Park of BCM is currently practising the application of composted faeces into soil to grow subsistence crops. The faeces from six households is currently collected in onsite composting boxes where it is stored for a period of six to eight months. Thereafter it is applied onto the soil as a soil conditioner. The mechanisms of disposal described above do have their challenges and these are discussed below.

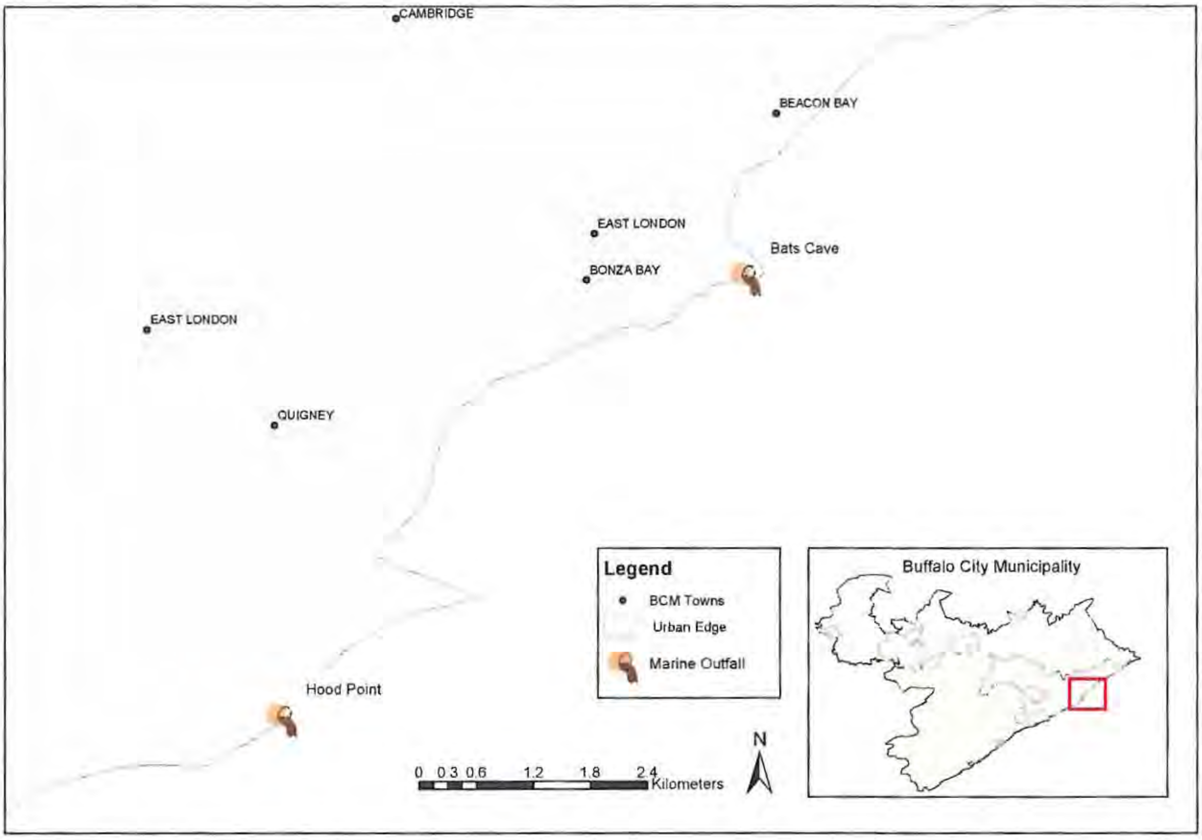

Figure 3.9: Location of Hood Point and Bats Cave Marine Outfall

Main Issues

Based on the meetings with BCM officials, site inspections and performance data (Section 3.3.4) related to the other four components of a sanitation system, it appears that sanitation systems within BCM have the potential to pose a significant threat to environmental and human health. It was therefore decided to review available water quality data to see whether there was any evidence of potential degradation of the environment, specifically water quality, which could be attributed to the poor performance of sanitation systems.

The water quality data for faecal coliforms for the period of 2005- 2006 was collected for those streams, rivers and coastal areas/waters that would be receiving effluent from treatment facilities. In all cases, the sampling points were located below the WWTWs. BCM Scientific Services monitors water quality and reports to DWAF on compliance against the DWAF Freshwater (DWAF, 1996a) and Coastal water guidelines (DWAF, 1996b). Since the freshwater quality limits are different to those for coastal waters, these have been analysed separately. The DWAF guidelines for recreational use were compared to the data and Table 3.12 provides details on the compliance of the main freshwater bodies that receive effluent from treatment facilities within BCM. The standard parameter for monitoring the presence of sewage contamination of freshwater is the faecal coliform count. The DWAF limits for faecal coliforms in fresh water is:

1. Low risk – 0-130 cfu/100ml
2. Medium risk – 200-400 cfu/100ml
3. High risk - >400 cfu/100ml

The DWAF limits for faecal coliforms in coastal water is:

4. Low risk – 0-80 cfu/100ml
5. Medium risk – 81-99 cfu/100ml
6. High risk - >100 cfu/100ml

The table shows that the Nahoon River, the Ihlanza Stream and Inyana Stream were the most non-compliant with respect to faecal coliform levels during the course of 2005 and 2006. The BCM State of Sanitation Report (BCM, 2006) noted that in previous years (2002 to 2004), it was the Buffalo River that had the highest non-compliant faecal coliform record. It is interesting to note that only the Berlin Ponds release effluent into the Nahoon River system whilst the Buffalo River has seven treatment facilities releasing predominantly non-compliant effluent into the river (Table 3.11). The effluent from Berlin WWTW for the period of 2005-2006 was below 80% compliant (Figure 3.7) and this may have been a contributing factor, however it does not fully explain the very high levels of faecal coliforms in the Nahoon River. Section 3.3.2 identified a number of VIP systems in the Newlands area which are located adjacent to the Nahoon River. It is possible that the Nahoon River is also polluted by the VIP toilet systems that are currently not emptied on a regular basis. The Gonubie River is more compliant than all the other river systems, showing compliance for 15 out of the 24 months. This may be due to the fact that the effluent released into the river was the most compliant during the course of 2005 to 2006 (Figure 3.7). However in general, the table shows that the prevalence of faecal coliforms had increased from 2005 to 2006, resulting in a decrease in freshwater quality.

Table 3.12: Faecal coliform compliance of main freshwater bodies receiving effluent from WWTWs in BCM

	Fresh Water				
Months	Gonubie River	Nahoon River	Ihlaza Stream	Inyana Stream	Buffalo River
2006					
JAN	3,753	8,202	11,000	11,000	11,000
FEB	37	84	750	11,000	11,000
MAR	356	463	487	975	2,853
APR	53	11,000	7,293	5,392	8,932
MAY	2,853	837	843	6,382	73
JUN	246	848	9,854	9,483	10,733
JUL	18	493	568	11,000	300
AUG	1 500	493	289	5,274	75
SEPT	27	402	3,593	750	750
OCT	4,600	843	11,000	11,000	0
NOV	643	382	81	6,893	750
DEC	321	83	375	183	1 500
2005					
JAN	7,932	8,353	3,829	11,000	1 500
FEB	64	203	750	11,000	11,000
MAR	21	91	73	769	2 300
APR	95	2,943	5,832	3,925	4,693
MAY	210	734	823	29	73
JUN	423	4,202	6,493	3,942	5,732
JUL	32	4,372	732	853	422
AUG	1 500	2,100	364	4,846	83
SEPT	82	1,031	967	750	63
OCT	963	636	11,000	11,000	0
NOV	73	4,929	83	6,835	474
DEC	52	4,042	534	71	74

LEGEND	Compliant 0-130 (cfu/100ml)	Compliant but nearing threshold 131 -400 (cfu/100ml)	Non-Compliant >400 (cfu/100ml)

The coastal waters close to marine outfalls exhibited a high level of non-compliance with DWAF marine water quality standards during the course of 2005 and 2006. This is also documented in the BCM State of Sanitation Report (BCM, 2006) for 2002 to 2004. From Table 3.13 it can be deduced that the effluent from at the Hood Point Marine Outfall is polluting the marine environment the most with 22 months out of 24 having faecal coliform counts above required standards. This may be due to the fact that the there is only primary treatment of the effluent and sludge before it is released into the environment and the quality of effluent was less than 80% compliant during the course of 2005 and 2006 (Figure 3.8). The BCM State of Sanitation Report (BCM, 2006) identified that this discharge is illegal in terms of Section 22(2)(e) of the National Water Act, 1998 (5).

Table 3.13: Faecal coliform compliance of main coastal areas receiving effluent from Treatment Facilities

	Gonubie Beach	Bonza Bay Beach	Nahoon Beach	Nahoon Point	Bats Cave Outfall	Eastern Beach	Orient Beach	Hood Point Marine Outfall
2006								
JAN	942	954	11,000	163	11,000	11,000	4,726	2,300
FEB	82	30	1,769	0	11,000	503	11,000	11,000
MAR	0	4	276	943	39	485	632	11,000
APR	235	210	560	3,264	11,000	23	63	10,385
MAY	4	850	1,289	623	6,305	11,000	4,929	8,543
JUN	0	0	96	0	7,423	72	3	8,639
JUL	0	0	0	0	3 800	11,000	829	395
AUG	0	0	0	0	75	0	399	4,953
SEPT	0	8	9	0	971	0	920	3 800
OCT	9	0	72	84	11,000	984	392	5,824
NOV	4	0	281	0	931	4	937	7,780
DEC	4	7	93	0	7 500	175	299	11,000
2005								
JAN	476	750	847	74	5,832	973	274	4,850
FEB	96	37	2,958	0	11,000	58	876	11,000
MAR	0	91	53	3	423	85	929	11,000
APR	74	88	395	532	11,000	42	484	896
MAY	0	257	912	38	730	200	882	418
JUN	0	0	82	0	3,482	63	489	11,000
JUL	0	0	0	0	912	562	322	244
AUG	0	0	0	0	74	0	458	796
SEPT	0	4	4	0	780	0	858	69
OCT	9	0	51	46	11,000	385	892	3,782
NOV	4	0	0	0	274	0	626	23
DEC	3	0	9	0	5,860	28	2,982	11,000

LEGEND	Compliant 0-80 (cfu/100ml)	Compliant but nearing threshold 81 -99 (cfu/100ml)	Non-Compliant >100 (cfu/100ml)

Efforts have been ongoing since 1980 to identify an alternative means of disposing of the sewage effluent on the West Bank (BCM, 2006). An application to construct a 1.4 km pipeline out to sea at Hood Point where the existing screening station is located was permitted by both DWAF and Department Economic Affairs Environment and Tourism (DEAET) following the completion of an Environmental Impact Assessment (EIA) in 1996 (BCM, 2006). However, the DWAF authorization has since lapsed and a new permit has not as yet been issued. The future of the Hood Point Marine Outfall remains uncertain even though the non-compliant discharge continues to be pumped out to sea on a daily basis.

This pollution of the environment by the disposal of sewage effluent is not unique to BCM. Zhoa *et al.* (2009) noted that in China outflow from sewage treatment plants pollutes the water bodies discharge into due to high volume and heavy pollution load. They identify that it is the location of the discharge point such as an outfall that is considered to be the most important element affecting surrounding water quality. This may explain the data in Table 3.13 where the direct discharge for the marine outfalls and the Orient Beach have the most non-compliant water quality results.

3.4 CONCLUSION

This chapter examined the different components of a sanitation system to better understand the Status Quo of sanitation in BCM. This provided a useful update of the 2006 BCM State of Sanitation Report (BCM, 2006). It was found that the waterborne toilets were the most widely used sanitation technology in BCM and there was a preference to supply this technology to communities. In addition, it was determined that, each toilet in BCM has an average of 4.3 users based on current population and toilet numbers. The main issues faced by BCM were the poor management of communal toilets and on-site rural facilities. Collection of sewage was negatively affected by inaccessibility of toilet facilities in rural areas and densely populated informal settlements. The transportation of sewage was also inadequate as over 75% of sewers were considered cracked or broken and in need of maintenance or replacement. BCM only has a limited number of municipal tankers that are required to service the entire municipality and this proves very problematic as sewage is ultimately not collected and pollutes the environment. In addition WWTWs within BCM frequently release non-compliant effluent to major freshwater and coastal water resources. If this situation continues, BCM will have a polluted coastline and water resources. This may result in negative impacts on human health of BCM residents. In addition it may result in great potential loss of recreational use of fresh water and coastal water resources with associated negative socio-economic implications. Perhaps the most significant finding of this chapter was the lack of legal compliance with regards to DWAF water standards, most likely caused by inadequate sanitation throughout the municipality. There is a need for BCM to consider sanitation as one of its greatest environmental, health and economic threats to the future of the municipality and a great need to address the sustainability of sanitation systems in BCM. The findings of this chapter confirmed the urgent need to develop a series of context-specific criteria to assist with the provision of additional sanitation requirements of the BCM.

CHAPTER 4: DEVELOPMENT OF SUSTAINABILITY CRITERIA FOR DECISION MAKING IN BCM

4.1 INTRODUCTION

The BCM State of Sanitation (BCM, 2006) and BCM State of Environment (BCM, 2005) Reports identify and discuss the threats of environmental pollution, economic loss and negative social consequences caused by the lack of and poor sanitation within BCM. Taking this forward BCM devised a plan to create a Sanitation Policy and Implementation Strategy. During the development of the Sanitation Policy, it was noted that context specific criteria for BCM needed to be created to assist with decision making.

Developing and using a context-specific list of criteria to predict the overall sustainability of sanitation systems can assist the decision-making process by incorporating the issues relevant to different stakeholders, and shifts the emphasis from basic economic and techno-centric discussions (Bond, 1999; Bracken *et al.*, 2005; Gibson *et al.*, 2005; Al-Sa'ed & Mubarak, 2006). Refsgaard *et al.* (2005) states that sustainability criteria can be used as the focal point of multiple criteria decision-making processes. The criteria assist decision-makers in learning about a problem and the alternative courses of possible action, by allowing individuals to reflect upon their values and preferences from numerous points of view. According to Bracken *et al.* (2005) a sustainability oriented criteria based approach should be used across the whole range of planning and implementation levels. This approach could be used from a macro level, by including them in the terms of reference for sanitation projects, to the micro level where they can be used by communities to, "*select sanitary systems aligned to their needs and vision of sustainability*" (Bracken *et al.*, 2005).

Sustainability criteria in the context of sanitation systems are used to evaluate different options. However it is imperative that the criteria are considerate of the definition of a sanitation system. Bracken *et al.* (2005) stated that, "*a sanitation system should be considered as comprising the users of all parts of the system, along with the collection, transport and treatment of human waste, and the management of the resulting end products.*" This sets the boundary conditions for the system wide enough to ensure that all effects of the system are contained within its limits.

The development of appropriate sustainability criteria reduces bias towards more conventional sanitation solutions thereby facilitating the selection of "alternative" or innovative sanitation technologies under certain conditions. Gibson *et al.* (2005) emphasised that, "*development of sustainability criteria requires participation, coherence, accountability and learning, guaranteeing that specified decision criteria are publicly discussed, widely published and complemented by legally enforceable requirements.*"

Advocates of sustainability have been designing decision-making criteria lists from as early as 1972 at the United Nations Conference on the Human Environment held in Stockholm. The literature clearly highlights the main components, principles and core objectives of these lists including, the protection of natural resources (Riddell, 1981; McCormick, 1989; Nelson *et al.*, 2004), improvement of the quality of human life (IUCN, UNEP & WWF, 1980), balancing human numbers with resources (Riddell, 1981), justice to the socially disadvantaged, future generations and nature (Pearce, 1988), inter-relationships between ecological, economic and social systems (Robinson & Tinker, 1997; Bradley *et al.*, 2002) and the evaluation of legislation and policy (Matais *et al.*, 2002). These principles are an effective means of ensuring reasonable adherence to the sustainability agenda as they encourage decisions which serve the interests of accountability, complexity, uncertainty and easier learning from mistakes.

The use of sustainability orientated criteria to assess different sanitation systems is not new, and has been carried out by many researchers (Holmberg, 1995; Larsen and Gujer, 1997; Lundin *et al.*, 1999; Loetscher and Keller, 2002; van der Vleuten-Balkema, 2003; Bracken *et al.*, 2005; Gibson *et al.*, 2005; Al-Sa'ed & Mubarak, 2006). Although research so far has divided sustainability criteria into the economic, socio-cultural, environmental and functional categories (Loetscher & Keller, 2002; van der Vleuten-Balkema, 2003), Bracken *et al.* (2005), strongly suggest that it is impossible to identify a complete list of categories and associated sustainability criteria without knowing the specific context in which the criteria will be used. Additionally, criteria lists do not provide easy answers for decision makers they only help by narrowing down lengthy discussions. The main drawback with the existing criteria lists is that they are inappropriate for use in the highly specific context of a municipal area such as BCM. For this very reason Bracken *et al.* (2005) suggested that, "*existing sustainability criteria lists must be reduced or expanded on a case by case basis.*" As discussed earlier, the development of criteria involves the use of legislation, policy and the interrelationships between ecological, economic and social systems which are highly context specific. For example, legislation and policy as well as environmental relationships can vary significantly from one municipality to the next.

Bracken *et al.*, (2005), developed a list of general sustainability criteria aimed at advancing the discussion surrounding the use of criteria in sanitation decision-making. The list which was discussed and developed during the course of two international workshops (Eschborn, Germany, December 2003 and Stockholm, Sweden, April 2004) and is based on sustainability criteria and indicators and already being used by researchers working in this field. The criteria in the list were fashioned deliberately to be general in recognition of the fact that criteria need to be developed in specific contexts for them to be relevant in decision-making. Bracken *et al.* (2005) divided their sustainability criteria list into five different categories namely; health, environment, economy, socio-culture and technological function, with each category being accompanied by criteria indicators. The categories are supported by the universally acknowledged sustainability pillars also known as the "triple bottom line" of economy, society and environment (Bracken *et al.*, 2005). The health category was separated from the society pillar in an effort to emphasise the fact that the protection and promotion of human health is the main aim of sanitation. The technical function was considered an important criterion for sustainable functioning of sanitation systems that could not be adequately addressed under the other categories.

The objective of this part of the study was therefore to adapt the criteria list developed by Bracken *et al.* (2005) to suit the needs of BCM's current situation through participation of all stakeholders, inclusion of local legislation and policy, local knowledge and understanding of the municipality. It is intended that the criteria list would encourage sanitation planners, decision-makers and other stakeholders in BCM to integrate the concept of sustainability in sanitation decision-making. To meet the objective of this chapter, the following research questions had to be answered:

1. What criteria and indicators should be considered when selecting sanitation technologies for BCM?
2. What was the relative importance of each of the criteria?

4.2 METHODOLOGY

A review of the existing research identified the fundamental characteristics of sustainability criteria to be the interaction between social, economic, and ecological systems (Adams, 2002; Hughes *et al.*, 2004; Bracken *et al.*, 2005; Gibson *et al.*, 2005; Al-Sa'ed & Mubarak, 2006; Gomotean *et al.*, 2008). This research applied the main approaches and techniques identified in past research to develop sustainability criteria. These approaches involve the adoption, expansion and elimination of criteria and indicators from a generic list, intensive stakeholder engagement, local participation, legal review and scientifically based local ecological knowledge. In light of the above, the methodology used to develop sustainability criteria and indicators for the selection of sanitation technologies in BCM was termed the Sustainability Criteria and Indicator Development Approach (Figure 4.1). This approach involved five main steps to reach a final decision on the selection of a sanitation technology. These steps were initiation, criteria and indicator expansion, criteria and indicator consolidation and criteria, indicator weighting and coarse screening. Each of these steps is described in detail below.

Step 1: Initiation

Step 1 involved the review of an existing sustainability criteria list developed by Bracken *et al.* (2005). This list was used as the baseline criteria for this research because it was generic and broad and provided a good starting point for development of context specific criteria. The expected outcome of this step was a revised list of sustainability criteria for BCM which included criteria identified by officials for adoption and further expansion, but excluded criteria considered irrelevant and impractical. This approach was suggested by Bracken *et al.* (2005) as a starting point for researchers to develop context specific sustainability criteria.

A focus group meeting with 16 BCM officials was held on the 7th May 2005 to discuss the generic sustainability criteria list developed by Bracken *et al.* (2005). These individuals represented all key departments within BCM, including:

- Scientific Services
- Engineering
- Amenities
- Environmental Health
- Development Planning
- Cleansing
- Environmental Services
- Integrated Development Planning
- Integrated Environmental Management Unit (IEMU)

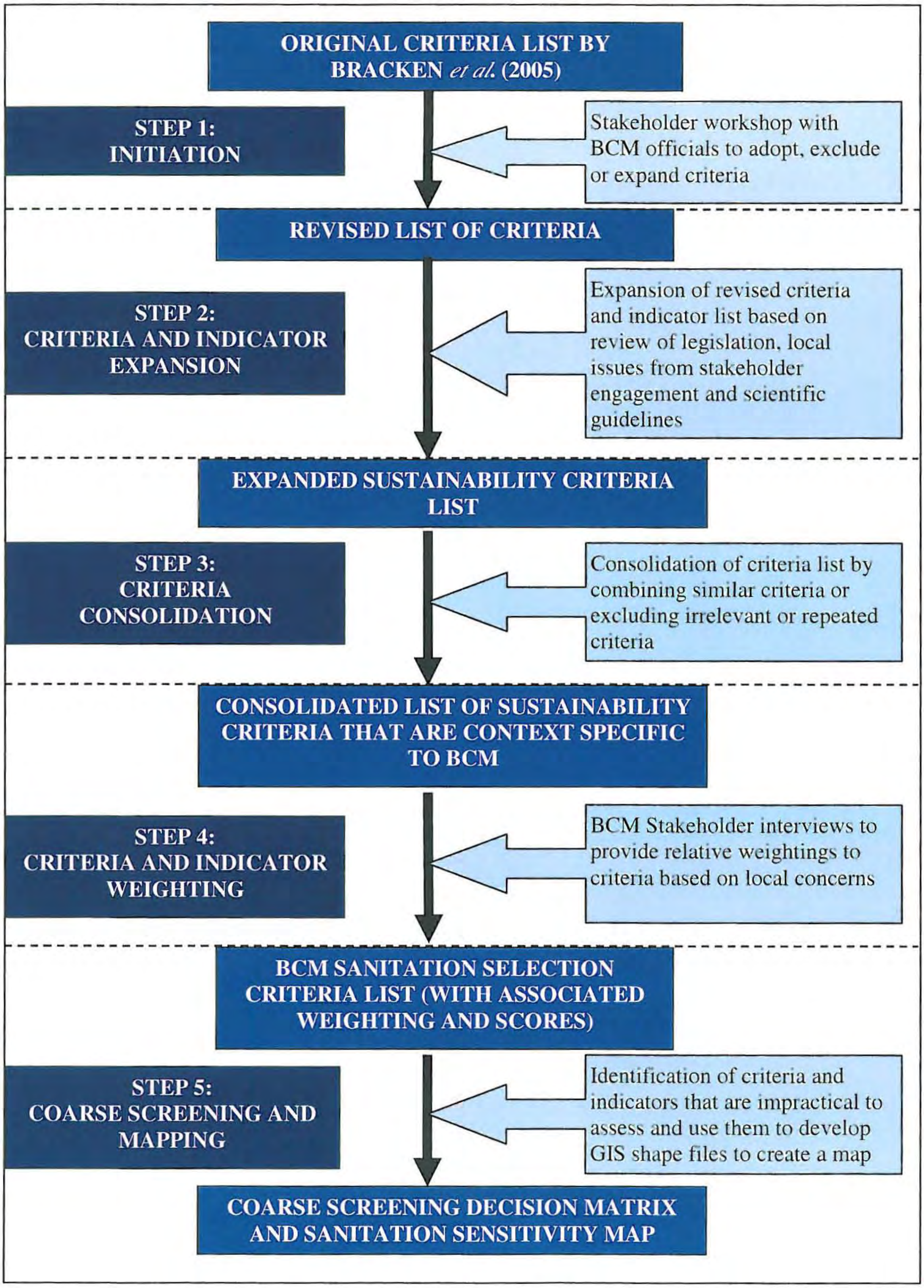

Figure 4.1: The Sustainability Criteria and Indicator Development Approach

The general criteria list developed by Bracken *et al.* (2005) was presented and discussed systematically by considering the different categories, criteria and indicators and their relevance to BCM. Based on discussions with officials, those considered not relevant were removed from the list, those considered relevant were adopted and those needing expansion were further developed using the Step 2.

The structure of the final BCM sanitation criteria list was discussed and debated at length and an executive decision was made at this initiation meeting to structure the developed criteria into the categories found in the National Sanitation Policy (RSA, 1996a). The categories are as follows:

- Health and hygiene education and promotion
- Community issues and human resources development
- Environmental impact
- Financial and economic approach
- Technical considerations
- Institutional and organizational frameworks.

The following section describes the expansion of sustainability criteria using legislation and policy, stakeholder engagement and scientific knowledge.

Step 2: Criteria Expansion

Step 2 involved the expansion of criteria and indicators identified in Step 1. This was achieved through consideration of National and municipal legislation and policy, identification of issues through of review of BCM Reports and intensive stakeholder engagement (Figure 4.2). Thereafter the indicators for the expanded and developed criteria were developed. The outcome of this step was an expanded sustainability criteria and indicator list that was context specific to BCM.

This Step firstly involved a review of existing National legislation that directly pertained to the identified criteria and indicators from Step 1. This ensured that the identified criteria would be relevant to the current National legislation governing South Africa. Thereafter, the same approach was used to apply municipal by-law requirements specific to BCM so as to ensure that the newly developed criteria were relevant to the specific laws governing BCM.

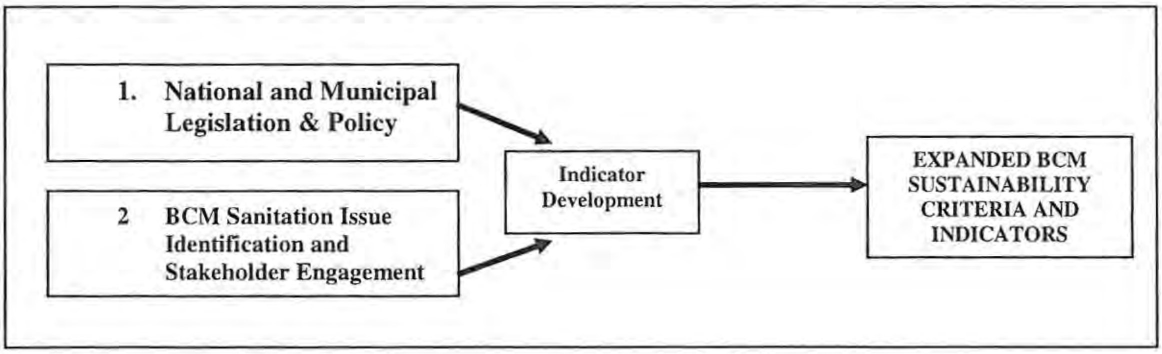

Figure 4.2: The Expansion of Revised Criteria and Indicator Approach

Consideration of local legislation is vital when developing context-specific decision-support criteria as to ensure that the selected systems would be considered legal and aligned with Policy. Moreover, legislation is included in criteria development because legislation regarding basic sanitation has changed over recent times. Furthermore, South Africa's environmental legislation is structured around the concept of sustainable development and so provides a useful "first check." Table 4.1 details the relevant legislation reviewed to develop the expanded criteria and indicator list.

Table 4.1: National Legislation used to expand criteria and indicators

Date	Legislation
1996	The Constitution and the Bill of Rights (Chapter 2 of the Constitution of the Republic of South Africa 108 of 1996)
1996	The National Sanitation Policy
1997	The Water Services Act (Act 108 of 1997)
1998	The White Paper on Environmental Management for South Africa (GG 18894 of 15 May 1998
1998	The National Environmental Management Act (Act 107 of 1998)
1998	The National Water Act (Act 36 of 1998)
2000	The White Paper on Integrated Pollution and Waste Management (IP & WM)
2000	The Municipal Structures Act (Act 33 of 2000)
2001	The White Paper on Basic Household Sanitation (2001)
2003	The Strategic Framework for Water Services (2003)

In addition, the legislation and policy review included BCM municipal by-laws. The BCM Municipal by-laws were created by the BCM with the authorization from the South African National Government. These by-laws are specifically created for a municipality to maintain the health, safety and wellness of the BCM residents. The by-laws listed in Table 4.2 were reviewed and specific by-laws pertaining to sanitation were incorporated in the development of an expanded criteria and indicator list.

Table 4.2: Buffalo City Municipal by-laws used to expand criteria and indicators

By Law No	By Law Subject
No 104a	Sanitary Standard By-Law (PN527/1952 – 25/7/1952) – as Amended
No 107a	Sewage Tariff By-Law (PN 82/1970 -23/01/1970) – As Amended
No 107a	Sewage (PN 322/1982 – 23/04/1982)
No 127	Water Supply (PN 323/1982 -23/04/1982)
No 62	Public Health Regulations (PN 371/1974 – 08/03/1974)

Secondly, this step involved the identification of sanitation issues by reviewing the BCM State of Environment (BCM, 2005) and BCM State of Sanitation (BCM, 2006) Reports. These issues were then discussed and presented to BCM Stakeholders who further identified additional issues and condensed broad issues into categories for new criteria development. The Revised Criteria and Indicator List from Step 1 was used as a guide to developing new context specific criteria using the categorised issues identified by the review of the BCM Reports and the BCM Stakeholders. Table 4.3 summarises the stakeholder engagement schedule related to the expansion of sanitation selection criteria over the period of nine months.

A complete list of issues was then divided into the categories detailed in the Policy (RSA, 1996a). The list documented the following:

1. Issue - Main issue faced by BCM
2. BCM Issue Statement – Important strategies to address issue

Once issues had been identified, BCM criteria statements were developed to expand the sustainability criteria identified in the Revised Criteria and Indicator List. These statements were declarations made by BCM ward councillors and officials that addressed the key issues. BCM Sanitation Selection Criteria were then expanded based on statements.

After the legal and policy review, identification of issues by stakeholders and development of criteria, indicators were developed for each criterion. The following questions were considered when developing the indicators:

1. What considerations need to be taken into account to satisfy or describe the criteria?
2. Which 'measurements' can be applied to the criteria as indicators from the review of scientific knowledge?
3. What measurements/factors describing the indicator contribute to the separation of technologies during a selection process?

Table 4.3: Stakeholder engagement table

EVENT	DATE	LOCATION	NOTIFICATION METHOD	AUDIENCE AND ATTENDANCE	ENGAGEMENT METHOD
BCM UPPER MANAGEMENT WORKSHOP	*13 May 2005*	Osner Hotel	Municipal Memo sent to all departments 25/04/05	BCM Directors and Officials Attended: 34	Identification of broad sanitation provision challenges in BCM
BCM COUNCILLOR SEMINAR	*23 June 2005*	Kennaway Hotel	Municipal Memo to Councillors 13/06/05	BCM Councillors Attended: 29	Discussion and information gathering on legal, social, economic, ecological impacts caused by sanitation.
PUBLIC ROADSHOWS	*7 – 9 September 2005*	7September 2005: East London City Hall Gonubie Hall 8 September 2005: King Williams Town Mdantsane Hall Berlin Hall 9 September 2005: Kaysers Beach Golf Club Tyolomna Hall Kidds Beach Bowls Club	Newspaper Adverts	BCM Public Attended: -East London City Hall: 62 -Gonubie Hall: 24 -King Williams Town: 16 -Mdantsane Hall:22 -Berlin Hall:12 -Kaysers Beach Golf Club:29 -Tyolomna Hall: 11 -Kidds Beach Bowls Club: 13	Identification of social and environmental impacts caused by sanitation
SANITATION WORKSHOP	*27-28 January 2006*	East London City Hall	Municipal Memo sent to all councillors	BCM Ward Councillors Attended: 42	Sanitation impacts in BCM identified in each ward during a focus group workshop
SANITATION WORKSHOP	*1-2 February 2006*	Mpongo Park	Municipal Memo sent to all BCM departments	BCM Departments Attended: 14	Main causes of sanitation impacts in BCM identified during a focus group discussion

After the legal and policy review, identification of issues by stakeholders and development of criteria, indicators were developed for each criterion. The following questions were considered when developing the indicators:

1. What considerations need to be taken into account to satisfy or describe the criteria?
2. Which 'measurements' can be applied to the criteria as indicators from the review of scientific knowledge?
3. What measurements/factors describing the indicator contribute to the 'separation' of technologies during a selection process?

The application of scientific knowledge to assign relevant indicators to the Revised Criteria and Indicator List from Step 1 was undertaken by using specific scientific indicators. The objective of assigning quantifiable indicators based on scientific knowledge was to ensure that sanitation systems in BCM are not developed in areas with inherent environmental fatal flaws that will lead to the pollution of the environment.

The South African Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998) detail specific land aspects that represent fatal flaws that could potentially result in pollution from landfill sites. The criteria and indicators suggested by these Minimum Requirements were considered appropriate for incorporation into the development of indicators for sanitation systems. Section 4 of the Minimum Requirements suggests aspects that should influence site selection for landfills. The relevant aspects suggested by the requirements and which were incorporated into the sanitation selection criteria are detailed in Table 4.4.

In addition, since BCM is located in along the coastline of South Africa, indicators were expanded by taking into consideration the Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone (WRC, 1999). These guidelines suggest requirements that minimise exposure of the environment to pollutants like nutrients and biological contaminants that are associated with sewage. The guidelines provide criteria for the assessment of the suitability of land to support onsite effluent disposal. These criteria, summarised in Table 4.5, were also incorporated into the sanitation selection criteria.

The main outcome of Step 2 was the Expanded Sustainability Criteria and Indicator List which was consolidated in Step 3 as discussed below.

Table 4.4: South African Minimum Requirements for Waste Disposal by Landfill Fatal Flaw Aspects (DWAF, 1998)

Landfill Fatal Flaw Aspect	Description	Optimum Location Conditions for Pollution Prevention
Distance to ground or surface water resources	The greater this distance, the more suitable the site is in terms of lower potential for water pollution.	- >1.5m from Groundwater - >100 m from Surface Water
Areas below the 1 in 50 year flood line: Unstable areas	This eliminates wetlands, vleis, pans and flood plains, where water pollution would result from waste disposal.	- Outside the 1 in 50 year flood line
Unstable areas	These could include fault zones, seismic zones and dolomitic or karst areas where sinkholes and subsidence is likely	- 100m from fault lines - 100m from seismic zones - 100m from Dolomite outcrops
Areas characterised by flat gradients, shallow or emergent groundwater	Area like vleis, pans and springs, where a sufficient unsaturated zone separating the waste body and the ground water would not be possible.	- >100 m from Shallow or emergent groundwater Water
Areas characterised by steep gradients	The stability of slopes and steep slopes where hydrostatic pressure would be significantly high	- Slopes should not be steeper than 30 degrees
Important aquifers	Areas lying or adjacent to important or potentially important. The greater the resource value of the water, the more sensitive the establishment of a landfill on account of the potential for water pollution.	- 100m from underground aquifers of great resource value
Shallow bedrock	Areas characterised by shallow bedrock with little soil cover	- Soil depth should be at least 1.5m

Table 4.5: Guidelines for the use of septic tank systems in the South African coastal zone (WRC, 1999)

Land Characteristic	Feature	Optimum Feature Conditions for Sewage Treatment
Absorption Ability	Site drainage / depth to seasonal water table	>1.5m
	Soil Permeability	Loam soils
	Depth to impermeable layer	>1.5m
	Stone Content	50-90%
Purification Ability	Soil Permeability	Loam soils
	Nature of soil: texture and coherence	Loam soils
	Depth to impermeable layer	>1.5m
	Site drainage	Loam soils
	Slope	< 30°
Ease of excavation	Depth to rock	>1.5m
	Slope	< 30°
	Stone content	50-90%
	Rock outcrop	Few
	Site drainage	Loam soils
Water pollution risk (Over land flow)	Absorption ability	-Loam soils
	Runoff	-Loam soils -Slope < 30°
Water pollution risk (Sub-surface leaching)	Nature of soil: texture and coherence	-Loam soils
Flood Hazard	Slope	-Slope < 30° -Loam soils

Step 3: Consolidation

Step 3 involved the consolidation of criteria and indicators that were repeated or very similar in nature. This consolidation was performed by listing the repeated and similar criteria, their origin and their focus. Thereafter only the fundamental aspects of the criteria or indicators were used to develop new consolidated criteria and indicators. This resulted in the creation of a Consolidated List of Sustainability Criteria and Indicators that was context specific to BCM. Each of the criteria in this list was then weighted as discussed in Step 4 below.

Step 4: Criteria weighting and indicator scores

To ensure that the Consolidated List of Sustainability Criteria and Indicators was useful to BCM the criteria were weighted. This step served to enhance the context-specificity of the sanitation criteria selection criteria. The weighting of each criterion was developed through extensive consultation with key stakeholders. The meeting to weight the criteria was held with 14 BCM officials on the 12th August 2006. The following Departments were represented at the meeting.

- Scientific Services
- Engineering
- Amenities
- Environmental Health
- Development Planning
- Cleansing
- Environmental Services
- Integrated Development Planning
- Integrated Environmental Management Unit (IEMU)

Each Department was asked to rank the criteria as high (values 6-5), medium (values 4-3) or low (values 2-1). These results were recorded and an Actual Importance Index (AII) weighting system developed by Neba (2006) was then used to assign a maximum score to each criterion. From the weighting values it was expected that the mean or standard deviations would not effectively represent the BCM Department's judgements in terms of the weighting of the criteria or, more specifically, that a mean weighting value was not the most accurate way to represent potentially divergent weightings. Therefore an AII for each criterion was calculated by dividing the mean weighting allocated to the criteria by its standard deviation. This AII value was then used as the final weight assigned to each criterion.

The indicators were also scored according to a range of scores that best described the indicator and ensured that the highest score would be allocated to the most sustainable technology. However this process was conducted independently and without the BCM Stakeholders. For the purposes of this research, the scoring range for most of the indicators was three, however for some indicators a scoring range of two was considered more practical. Those indicators with a scoring range of three assigned the highest score of three to the indicator option which was considered to contribute most to sustainability, a score of two to the indicator option that was considered to contribute moderately to sustainability and a score of one was allocated to the indicator option that was considered to contribute least to sustainability. In the case of indicators that only had a scoring range of two, the indicator option contributing most to sustainability was assigned the score of three and the option contributing the least to sustainability was assigned the score of one. The indicator score for a particular criterion could then be multiplied by the AII value to give the sustainability score for the criterion. The scores for all criteria were then summed up and the sanitation technology option with the highest total sustainability score would then be considered the most sustainable option to use in the given context.

The final BCM Sanitation Selection Criteria List with Associated Weighting and Scores was created by using criteria and indicators developed during all four steps described above. The compilation of the final BCM Sanitation Selection Criteria List documented each criterion, its associated indicators, the indicator options and associated weights, the criterion's AII and the available sanitation technologies available in BCM. This list allowed for sustainability criteria and indicators to be applied to available sanitation technologies in BCM and allows for their potential sustainability in a BCM context to be assessed. The higher the Total Sustainability Score the more suitable and sustainable the system, and the lower the Total Sustainability Score, the less suitable and unsustainable the system. It should be noted that the overall score for any technological option only indicates its sustainability relative to other technologies rather than some "absolute score for sustainability" (Al-Sa'ed & Mubarak, 2006)

Step 5: Coarse screening and mapping

During the development process (steps 1-4), certain criteria were identified that would immediately exclude sanitation technologies from further consideration in a given context. It was therefore decided that these criteria would be incorporated into a preliminary selection process termed "coarse screening." To facilitate the "coarse screening process" it was further decided that a comprehensive list of the coarse screening criteria in a single matrix would be formulated. As many of the "coarse screening" criteria were linked to physical land features, it was considered appropriate to generated a "sensitivity map" for BCM to further aid the "coarse screening" step.

The mapping process firstly involved the identification of quantifiable indicators from the coarse screening decision matrix that could be directly represented spatially in a GIS shape file. The GIS shapefile data were obtained from a local consultancy UWP (BCM, 2007) and the BCM Planning

Department. Thereafter, GIS queries were run using the computer programme ArcView GIS 9.2 to manipulate and accommodate the indicator requirements. The different shape files were overlaid onto a base map of the entire BCM area using the same GIS software as the interface to create the map. A list of existing shape files considered during the process is provided in Table 4.6 below. In order to address the objective of the pilot application, it was also necessary to incorporate the location of existing sanitation technologies within BCM on the sensitivity map.

Table 4.6: List of Existing BCM Shape files

Shape File Name	Data Description	Data Origin
BCM Municipal Boundary	Outline of the area within the bounds of BCM	BCM Planning Department
BCM Towns	Location of all Major Settlements in BCM	BCM Planning Department
BCM Major Rivers	Major rivers within the BCM area	BCM Planning Department
BCM Minor River	Minor rivers within the BCM area	BCM Planning Department
BCM Major Dams	Major Dams within the BCM area	BCM Planning Department
BCM Slopes of 15^o	Slopes that are steeper than 15^o	BCM Planning Department
BCM Soil Type	Description soil types within BCM	BCM Planning Department
BCM Soil Depth	Description soil depth within BCM	BCM Planning Department
BCM Geology	Description of underlying geology within BCM	BCM Planning Department
100m Set back from Rivers and Dams	Areas that fall within 100m from a major river or a Dam	UWP Consulting
100m Set back from areas Susceptible to Flooding	Areas that fall within 100m from areas that are prone to flooding	UWP Consulting
BCM Wastewater Treatment Works (WWTW)	Location of WWTWs in BCM	UWP Consulting
BCM ventilated improved pits (VIPs)	Location of areas with VIPs in BCM	UWP Consulting
BCM ventilated improved double pits (VIPs)	Location of areas with VIDPs in BCM	UWP Consulting
Septic Tanks	Location of areas with Septic Tanks	UWP Consulting
Pour Flush Toilets	Location of areas with pour flush toilets	UWP Consulting
Pits	Location of areas with Septic Tanks	UWP Consulting
Oxidation Ponds	Location of all Oxidation Ponds in BCM	UWP Consulting
Enviro-loo	Location of areas with Enviro-loos	UWP Consulting
Conservancy Tanks	Location of areas with Conservancy Tanks	UWP Consulting
Buckets	Location of areas using Buckets	UWP Consulting

Each relevant shape file was then buffered using the buffer function in ArcView GIS 9.2 and finally merged into one shape file. This allowed for the creation of a single BCM sensitivity shape file and consequently the BCM Sanitation Sensitivity Map.

4.3 RESULTS AND DISCUSSION

4.3.1 Step 1: Initiation

The BCM departments systematically examined the criteria list developed by Bracken *et al.* (2005) and provided comment with respect to what action needs to be taken for each criterion (Table 4.7).

Table 4.7: Revised list of criteria and indicators based on those by Bracken *et al.* (2005)

Number	Criteria	Indicator	BCM Comment
	Health		
1	Risk of infection of complete use of system	Risk assessment or qualitative	Expanded using Step 2
2	Risk of exposure to harmful substances: heavy metals, medical residues, organic compounds	Risk assessment or qualitative	Expanded using Step 2
	Environment		
	Use of natural resources, construction:		
3	Land (investment)	m^2/pe	Adopted by BCM from an availability perspective
4	Energy	MJ/pe	Considered Impractical and immeasurable by BCM Stakeholders
5	Construction materials	Type and volume	Expanded using Step 2
6	Chemicals	Type and volume	Adopted by BCM from a cleaning perspective
	Use of natural resources, O&M:		
7	Land (investment)	m^2/pe/yr	Considered repeated by BCM Stakeholders
8	Energy	MJ/pe/yr	Considered Impractical and immeasurable by BCM Stakeholders
9	Fresh water	m^3/pe/yr	Adopted by BCM from a water availability perspective
10	Construction materials	Type and volume/pe/yr	Expanded using Step 2
11	Precipitation agents or other chemicals	Type and volume/pe/yr	Considered not applicable by BCM Stakeholders
	Discharge to water bodies:		
12	BOD / COD	g/pe/yr	Expanded using Step 2
13	Impact on eutrophication	g/pe/yr of NP	Expanded using Step 2
14	Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	mg/pe/yr	Expanded using Step 2
	Air emissions		
15	Contribution to global warming	kg of CO_2 equivalent/yr	Adopted by BCM
16	Odour	Qualitative	Expanded using Step 2
	Resources recovered (potential for approaches)		
17	Nutrients	% of incoming to system of NPKS	Expanded using Step 2
18	Energy	% of the consumption of the system	Considered impractical and immeasurable by BCM Stakeholders
19	Organic material	% of incoming to the system	Expanded using Step 2
20	Water	% of incoming to the system	Expanded using Step 2
	Quality of recycled products (released to soil)		
21	Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	mg/unit	Adopted by BCM taking into consideration the quality of re-cycled product
	Economy		
22	Annual costs, including capital and maintenance costs	Cost/pe/yr	Expanded using Step 2
23	Capacity to pay – user (% of available income), municipality	Disposable income/pe	Expanded using Step 2
24	Local development	Qualitative	Expanded using Step 2
	Socio-culture (institutional and user related)		
25	Willingness to pay (% of available income)	Reasonable % of income	Expanded using Step 2
26	Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups)	Qualitative	Expanded using Step 2
27	Institutional requirements		Expanded using Step 2
28	Responsibility distribution	Definition of level of organization	Expanded using Step 2
29	Current legal acceptability	Qualitative	Expanded using Step 2
30	Appropriateness to current local cultural context (acceptable to use and maintain)	Qualitative	Expanded using Step 2
31	System perception (complexity, compatibility, observability – including aspects of reuse)	Qualitative	Expanded using Step 2

Number	Criteria	Indicator	BCM Comment
32	Ability to address awareness and information needs	Qualitative	Expanded using Step 2
	Technical function		
33	System robustness: risk of failure, effect of failure, structural stability	Qualitative	Expanded using Step 2
34	Robustness of use of system: shock loads, effects of abuse of system	Qualitative	Expanded using Step 2
35	Robustness against extreme conditions (e.g. drought, flooding, earthquake etc.)	Qualitative	Expanded using Step 2
36	Possibility to use local competence for construction	Qualitative	Expanded using Step 2
37	Possibility to use local competence for O&M	Qualitative	Expanded using Step 2
38	Ease of system monitoring	Qualitative	Expanded using Step 2
39	Durability / lifetime	Yrs	Expanded using Step 2
40	Complexity of construction and O&M	Qualitative	Expanded using Step 2
41	Compatibility with existing system	Qualitative	Expanded using Step 2
42	Flexibility / adoptability (to user needs and existing environmental conditions – high groundwater level, geology etc.)	Qualitative	Expanded using Step 2

Criteria were assigned a number for identification purposes throughout the criteria development process. From the 42 generic criteria proposed by Bracken *et al.* (2005), five were directly adopted, five were excluded and 32 were considered for expansion during Step 2 of the Sustainability Criteria and Indicator Development Approach. Those criteria that were applicable and adopted were noted (Table 4.8) although certain indicators were changed by the BCM Stakeholders into a format they considered to be more useable.

It is interesting that all the criteria excluded and adopted originated from the Environment Category in the Bracken *et al.* (2005) list. It is also important to note that *energy* used as a resource during *construction* and a *recovered resource* were both excluded from the list as impractical and immeasurable criteria. The BCM Stakeholders acknowledged the importance of energy to run sanitation technologies, however, the discussions revealed that it would be very difficult to measure the amount of energy required or used. This exclusion of the energy criteria by BCM Stakeholders is indicative that current BCM energy requirements are not known or measured.

Table 4.8: Criteria adopted unchanged by Stakeholders from Bracken *et al.* (2005) Sustainability Criteria list

No	Criteria	Indicator
3	Land availability	-m^2
6	Chemicals used for cleaning the system	-Biodegradable
9	Piped Freshwater Availability	-Litres
15	System contributes to global warming	-Carbon dioxide emissions
21	Recycled Product: Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	-Correct Storage

The five adopted criteria range from the availability of resources like land to the release of recycled products into the environment. It is important to note that the BCM Stakeholders considered the *Hazardous Substances* (Criteria No 14 and 21) as important criteria as these directly polluted the environment. However the BCM Stakeholders preferred that the criteria dealing directly with water quality (Criteria No 14) be expanded in Step 2 of the Sustainability Criteria and Indicator Development Approach but the criteria dealing with soil (Criteria 21) be adopted together with the indicator.

The adoption exercise of the criteria developed by Bracken *et al.* (2005) was a constructive as it took the most relevant criteria identified in the list and provided the fundamental similarities between the BCM list and the list suggested by Bracken *et al.* (2005). This adoption of sustainability criteria has also been performed by Moret *et al.* (2006). Their research adopted sustainability criteria for bio-energy in Brazil using input from a criteria list developed by the Forestry Stewardship Council (FSC). This proved to be a useful method of aligning sustainability principles for the bio-energy plant and as found in the BCM list was a constructive method of identifying fundamental similarities between a generic list and a context specific list.

4.3.2 Step 2: Criteria and Indicator Expansion

The expanded or new criteria developed though the review of legislation are shown in Table 4.9 and 4.10. One of the main findings made during the criteria expansion process was that some of the criteria that were developed could not be used to specifically contribute to the separation of technologies later on after Step 4. These were however still considered important aspects that should be taken into consideration during the selection process and were therefore termed Sustainability Recommendations that accompanied the final BCM Sanitation Selection Criteria List. These recommendations did not have indicators describing them and were to be used as guidelines during the selection process. The incorporation of these recommendations in the actual technology selection process is considered further in Chapter 5.

National legislation and Policy

Of the five South African Acts and five policies reviewed only two Acts and two policies were considered relevant for the expansion of sustainability criteria and indicators for BCM. The Acts were the Water Services Act (108 of 1997) (RSA, 1997) and the National Water Act (36 of 1998) (RSA, 1998c) and the policies were the White Paper on Basic Household Sanitation (2001) (RSA, 2001) and the DWAF Strategic Framework for Water Services (2003) (RSA, 2003). During the review of the legislation for criteria expansion, the specific Section Reference and new criteria were documented and are shown in Table 4.10. The specific criterion number from the Bracken *et al.* (2005) list and the criterion were documented along with the expanded criterion and its accompanying indicators.

The National legislation was found to be relevant to all the criteria categories suggested by Bracken *et al.* (2005). However the categories most expanded were the "Health" and "Environment" which are the prominent focus of most South African Legislation dealing with sanitation. Based on The White Paper on basic Household Sanitation (2001) (RSA, 2001), it was necessary to expand "Health" and "Environment" criteria to include *Health awareness*, *Health risks* and *Safe collection* and *Removal of human excreta*. The indicators of these criteria focused on the ease of operation and maintenance of the technology to ensure its proper use which will reduce health risks by human contact with unsterile sewage. The White Paper also influenced the *Convenience* criterion suggested by Bracken *et al.* (2005) as it relates to criteria for *Accessibility, Odour* and *Safety*, and provides one sustainability recommendation specifically focusing on *Ownership* of the sanitation technology. Based on the Water Services Act (108 of 1997) (RSA, 1997) it was necessary to develop the *Water conservation* criterion which was not expanded from the list suggested by Bracken *et al.* (2005). Choosing technologies that promote water conservation was considered important as South Africa is a water scarce country. This criterion is particularly relevant to BCM as it falls into one of the driest parts of South Africa. BCM officials recommended that a technology that uses up to six litres of water will promote water conservation and therefore six litres was used as the indicator for the water conservation criterion.

The National Water Act (36 of 1998) (RSA, 1998c) required expansion of the "Environment" criteria and resulted in the development of criteria that specifically dealt with the potential *Pollution of surface* and *groundwater* resources. The indicators developed from the South African Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998) aimed to prevent the pollution of these water sources in BCM. The DWAF Strategic Framework for Water Services (2003) (RSA, 2003) necessitated the development of the criterion termed *Gender Sensitive* as it recognises the gender requirements of both the male and female sex.

Municipal By-laws

Of the five Municipal by-laws reviewed, only one, the Sanitary Standard By-Law, was considered relevant to the expansion of criteria suggested by Bracken *et al.* (2005). The expansion process resulted in the development of three additional criteria (Table 4.10). These criteria were the need for *Municipal approval* before the technology is installed, *Suitable soil porosity* onsite and the *Water pollution risk.* The latter two fell into the "Environmental Impact" category whilst the *Municipal approval* was considered as part of the "Institutional and Organisational Framework" category. This approval is necessary to ensure that BCM can monitor and manage the sanitation technologies being installed within the municipality.

Table 4.9: Criteria expanded and developed by using National legislation from Bracken *et al.* (2005) Sustainability Criteria list

*** Sustainability Recommendations**

Bracken *et al.* (2005) Criteria	BCM EXPANDED AND NEW CRITERIA	BCM INDICATORS
Water Services Act (108 of 1997) Section 12		
23- Capacity to pay – user (% of available income), municipality	**Technology Affordability** – The sanitation technology must be affordable from installation, operation and maintenance perspectives from BCM and household levels	**- Affordability to Municipality - Affordability to Household**
Not Addressed	**Water Conservation** – The sanitation technology must promote water saving and minimise the depletion of the surface and ground water resources	**- Amount of water used during operation and maintenance (< 6 litres)**
National Water Act (36 of 1998) Sections 19 and 144		
12- BOD / COD *13-* Impact on eutrophication	**Ground Water Quality** – The sanitation technology must not decrease the quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with the effluent and sludge during storage ,transportation, treatment or and disposal	**- Distance to water table (>1.5m) - Possible contact during storage transportation, treatment and disposal - Slope (<30°)**
13- Impact on eutrophication *14* - Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	**Surface Water Quality** – The sanitation technology must ensure the quality of fresh and marine water (ecological and human reserve) by ensuring that surface water will not come into contact with untreated effluent and sludge during transportation, storage and disposal	**- Location relative to flood line (>100m) - Slope (<30°) - Quality of discharged effluent during disposal into freshwater or marine water**
White Paper on Basic Household Sanitation (2001) Requirements for safe sanitation		
1- Risk of infection of complete use of technology *2-* Risk of exposure to harmful substances: heavy metals, medical residues, organic compounds	**Hygiene Awareness** – The sanitation technology must promote awareness of hygienic practices	**-Difficulty of operation and maintenance to intended user -Novelty of Technology operation and maintenance**
1- Risk of infection of complete use of technology *2-* Risk of exposure to harmful substances: heavy metals, medical residues, organic compounds	**Health Risks-** The sanitation technology must have measures and structures in place that promote health and hygienic practises to protect the community and the environment from health risks, disease and pollution by instituting the use of barriers and hygienic practises between human excreta and the community and surrounding environment	**-Hand washing facilities - Structures for pest control**
26 - Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups)	**Accessible** – The sanitation technology should be accessible to all household members including young children, the elderly and the disabled	**-Access to the facility -Provision for a child seat**
26 - Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups) *16* - Odour	**Odour** – The sanitation technology should not emit unpleasant odours, particularly inside the household	**Prone to Odour**
28 - Responsibility distribution	****Ownership*** – *Ownership of the toilet should be promoted to ensure sustainable operation and maintenance*	**NONE IDENTIFIED**
26 - Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups)	**Safety** – The sanitation technology must be secure and located within or in very close proximity of the household	**-Location of Technology**
30 - Appropriateness to current local cultural context (acceptable to use and maintain) *31* - Technology perception (complexity, compatibility, observability – including aspects of reuse)	**Acceptability**– The sanitation technology must be considered as an acceptable form of sanitation technology in terms of the policy's definition and by BCM (as the Local government) and the target community as users	**-Accepted by community -Culturally appropriate -BCM approved - DWAF approved**
1- Risk of infection of complete use of technology *2-* Risk of exposure to harmful substances: heavy metals, medical residues, organic compounds	**Safe Collection** – The sanitation technology must have measures in place that ensures the safe handling of human excreta during collection	**-Human contact with un-sterile material during collection**
1- Risk of infection of complete use of technology *2-* Risk of exposure to harmful substances: heavy metals, medical	**Safe Removal** – The sanitation technology must have measures in place that facilitates the safe removal of human excreta so that it does not impact on the community or the environment	**-Human contact to excreta during removal**

Bracken *et al.* (2005) Criteria	**BCM EXPANDED AND NEW CRITERIA**	**BCM INDICATORS**
residues, organic compounds *14* - Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones		
12- BOD / COD *13*- Impact on eutrophication *14* - Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	**Safe Disposal** – The sanitation technology must have measures in place that ensures the safe treatment of human excreta that does not negatively impact on the environment	**-Human contact with un-sterile material during disposal**
DWAF Strategic Framework for Water Services (2003) Goals and targets for water and sanitation services		
26 - Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups)	**Gender Sensitive** – The sanitation technology must take into consideration the different needs required by the male and female sexes	**-Gender needs**

Soil porosity affects the treatment of human excreta from sanitation technologies based on soil type and depth and in turn affects possible pollution of water sources which BCM has determined to be a major issue. The indicators applied to the criteria originated from the scientific knowledge suggested by the South African Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998) and the Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone (WRC, 1999). The criteria suggested by Bracken *et al.* (2005) regarding the discharge into water bodies was expanded into a criterion that specifically considered a sanitation technology's contribution to *Water pollution risk*. The indicators applied to this criterion are also sourced from the scientific knowledge provided by the South African Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998) and the Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone (WRC, 1999). These indicators require that the positioning of the sanitation technology take into consideration the location of a flood line, slope angle, distance from the water table to the surface, distance from fault lines and dolomite outcrops. All these indicators have specific measurements to ensure that a sanitation technology is located in a position that will minimise the likelihood that sewage would contribute to water pollution. This will be very important for BCM as water pollution is one of the major issues it faces from the disposal of untreated effluent from sanitation technologies (See Chapter 3).

Stakeholder Engagement

In an effort to develop criteria from the issues identified, the stakeholders strategized a desired outcome by developing "Stakeholder Issue Statements." Relevant issues and statements for the expansion and creation of sustainability criteria were identified and documented (Table 4.11). Thereafter relevant criteria for expansion from the existing list by Bracken *et al.* (2005) were listed and expanded upon. The indicators were developed by addressing the questions stated in the methodology and were informed by scientific knowledge provided by the South African Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998) and the Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone (WRC, 1999).

Table 4.10: Criteria expanded and developed by using Municipal legislation

Bracken et al. (2005) Criteria	BCM BY-LAW REQUIREMENT	BCM EXPANDED AND NEW	BCM INDICATORS
Sanitary Standard By-Law (PN527/1952 – 25/7/1952) – as Amended (No 104a)			
27. Institutional Requirements	Part II 1, 2, (1), – Application for Approval B-27	**Municipal approval** – Construction plans of sanitation systems should be approved by the municipality	**-Currently approved technology by BCM**
3. Land (investment)	Part II 3 – Site Suitability Requirements B-42	**Suitable soil porosity** – Soil supporting system shall be of sufficient porosity and depth for the disposal of effluent	**-Soil type (Loam)** **-Soil depth (>1.5m)**
12. BOD/COD 13. Impact on eutrophication	B -12, 13,	**Water Pollution Risk** – Technology should not be installed where a water source is likely to become polluted	**- Slope Angle (<30°)** **- Distance to water table (>1.5m)** **- Distance from fault lines (>100m)** **- Distance from Dolomite outcrops (>100m)**

The Stakeholders divided the issues identified into the same categories as used by the National Sanitation Policy (RSA, 1996a). There were eight main issues identified that were used to create BCM issue statements (Table 4.11). From these BCM issue statements, criteria suggested by Bracken *et al.* (2005) were aligned with the main focus of the issue statement. Thereafter, new criteria and indicators context specific to BCM were created and developed (Table 4.11).

It was interesting to note that the issue of water quality and pollution monitoring created the most issue statements. This issue fell within the "Environmental Impact" and "Health" categories of the BCM criteria. Compared to the other issues like capital and operational costs and beneficiation of by-products, water quality and pollution monitoring had ten more BCM issue statements created. This was indicative of the fact that this is one of the main problems faced by BCM. Since the water quality and pollution monitoring issues resulted in the creation of the most BCM issue statements, it was therefore expected that the most BCM criteria would also be developed from this issue. Eight BCM criteria were developed focussing on the appropriate treatment, management, waste beneficiation and reduced pollution risk for human excreta.

Once the expansion process was complete, the criteria and indicators were taken through Step 3 which was the consolidation of the expanded criteria. Whilst indicators developed as part of the Legislation and Policy review relied heavily on scientific knowledge, the indicator development from the stakeholder engagement process did not. These indicators were developed more from a perspective of describing the criteria and ensuring that the indicators would be able to differentiate between technologies when it came to selection. This highlighted the importance of the participatory approach to developing BCM criteria. This participatory approach combined with the

Table 4.11: Expansion of criteria and indicators using stakeholder engagement and scientific knowledge

* *Sustainability Recommendations*

BCM STAKEHOLDER ISSUE	BCM STAKEHOLDER ISSUE STATEMENTS	Bracken *et al.* (2005) CRITERIA	BCM CRITERIA	INDICATORS
1. HEALTH AND HYGIENE EDUCATION AND PROMOTION				
<u>Issue 1:</u> Need to raise awareness of incidents of diseases	Raise awareness of the diseases caused by unhealthy sanitation behaviour and practices;	1.Risk of infection of complete use of technology 32. Ability to address awareness and information needs	**Ease of education**: Education of hygienic use of the sanitation technology	**-Ease of education**
	Support and provide health and hygiene education that will enable people to improve their health through correct hygienic practices;	2. Risk of exposure to harmful substances: heavy metals, medical residues, organic compounds	**User willingness**: User willingness to address and understand the risks of using the sanitation technology	**-User acceptance of health education**
2. COMMUNITY ISSUES AND HUMAN RESOURCES DEVELOPMENT				
<u>Issue 3:</u> BCM needs to consider the full range of communities sanitation needs	Communities **<u>must</u>** be involved in decision-making regarding the levels of service, but must incorporate the willingness-to-pay for both capital and recurrent costs. Such decisions **<u>must</u>** be made in an informed and democratic manner while taking the needs of others, including future generations and the environment into consideration.	25. Willingness to pay (% of available income)	**User Willingness to pay**– User by-in to contributing to the safe use of the sanitation technology	**-User Buy-in**
	Women **<u>must</u>** be involved in the decision-making processes at all levels.	26. Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups)	***Inclusion of women–*** *Involve women in the decision making process to provide perspective into women's needs for different technologies*	**NONE IDENTIFIED**
		26. Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups)	**Gender specifications -** The sanitation technology must acknowledge gender specific requirements	**- Gender specific facilities**
	Social and cultural factors that affect sanitation practices in certain communities **<u>must</u>** be taken into account.	30. Appropriateness to current local cultural context (acceptable to use and maintain)	**Cultural norms** – The sanitation technology must take into consideration the societal norms and practices	**-Cultural boundaries crossed**
	Improved sanitation **<u>should</u>** be marketed and promoted on the basis of social factors such as increased privacy, status, security, health and convenience.	26. Convenience (comfort, personal security, smell, noise, attractiveness, adopted to needs of different age, gender and income groups)	**User privacy** – Capacity of sanitation technology to encourage privacy needs of users	**- Doors attached** **-Location of technology entrance**
			User Safety – Capacity of sanitation technology to provide user safety	**-Located within the household property**
			User Convenience – The sanitation technology must be located within or in close	**-Location of technology**

BCM STAKEHOLDER ISSUE	BCM STAKEHOLDER ISSUE STATEMENTS	Bracken *et al.* (2005) CRITERIA	BCM CRITERIA	INDICATORS
			proximity of the household	
	Sanitation improvements **should** maximise the benefits to the local economy by making optimal use of local builders and businesses.	36. Possibility to use local competence for construction	**Local Resources**– Local materials and labour should be used to build the technology infrastructure	**-Availability of local resources for building** **-Availability of local building skill (community)**
3. ENVIRONMENTAL IMPACT				
Issue 4: Water quality & pollution monitoring	Any activity that would result in the deterioration of the quality of a water resource **must** be carefully assessed prior to implementation.	13. Impact on eutrophication	**Treatment of Excreta –** Methods of excreta handling from source to disposal must not negatively affect the environment	**-Treatment separates excreta from the environment before safe disposal**
	Existing and future contamination of aquifers by various sanitation solutions **must** be assessed and remedied where practical.	12. BOD / COD 13. Impact on eutrophication	**Pollution risk of aquifers** – The sanitation technology must ensure safe disposal of effluent and sludge	**- Distance to water table (>1.5m)** **- Likelihood of safe transportation and storage** **- Slope Angle (<30°)**
	Promotion of recycling and waste minimisation **must** form an integral part of sanitation management strategies. Waste beneficiation opportunities **should** be encouraged (e.g. sludge, nutrients, urine use, etc.)	Resources Recovered: 17. Nutrients 19. Organic Material 20. Water	**Waste Beneficiation** – Recycling and re-use opportunities must be instituted into the treatment of excreta	**-Possible Use of any by-product produced from treatment**
	Sewage treatment **must** strive toward legal and permit compliance (as a minimum) and wherever possible and feasible, improve sewage treatment beyond compliance. The direct discharge of untreated sewage to the environment without an appropriate permit **must** be prohibited.	33. Technology robustness: risk of failure, effect of failure, structural stability 12. BOD / COD 13. Impact on eutrophication	**Pollution Risk:** Likelihood of sewage entering the environment from the sanitation technology	**- Location to flood line (>100m)** **- Slope Angle (<30°)** **-BCM Sanitation Department's authorisation** **- DWAF authorisation**
		N/A	**Treatment Management-** The sewage treatment technology must be have adequate capacity to accommodate sewage from the target community population	**- Likely quality of discharged effluent during disposal** **-Technology must be able to accommodate the intended volumetric load**
	Water quality and pollution monitoring BCM **must** establish an appropriate response to planned and un-planned sewage spillages. BCM **must** establish and maintain a monitoring programme for: Ambient environment Point sources of waste effluent (e.g. industry, storm water, etc.) Facilities where compliance reporting is required. Water quality monitoring of streams and other water courses in informal settlements **must** be	12. BOD / COD 13. Impact on eutrophication 38. Ease of technology monitoring	**Ease of monitoring environmental pollution:** Monitoring technology that ensures that provision is made for early exposure of pollution from the technology	**-Technology allows for leaks and spills to be identified quickly** **-Technology malfunctions can be identified quickly and at source**
			Ease of Detection: Ability for the early identification of problems with the technology	**-Technology malfunctions can be identified quickly and at source** **-Technology allows for mechanisms to be**

BCM STAKEHOLDER ISSUE	BCM STAKEHOLDER ISSUE STATEMENTS	Bracken *et al.* (2005) CRITERIA	BCM CRITERIA	INDICATORS
	enhanced as they are particularly vulnerable to water contamination and could pose significant health risks.			**continuously monitored**
	Disasters A sewage pollution disaster or contingency plan **should** be developed or updated and key roles and responsibilities identified. Potential high-pollution-risk activities **should** be required to adopt appropriate emergency plans and codes of conduct.	34. Robustness of use of technology: shock loads, effects of abuse of technology 35. Robustness against extreme conditions (e.g. drought, flooding, earthquake etc.)	**Emergency Containment**: Ability to contain sewage from the environment in disaster situations	**- Sufficiently large backup holding storage facility available**
4. FINANCIAL AND ECONOMIC APPROACH				
Issue 5: Capital & operational costs	***General financial policy*** Households and/or communities **must** have the responsibility to choose and implement the mix of service levels that they desire, taking into account municipal policies and socio-economic realities.	22. Annual costs, including capital and maintenance costs	****Flexibility of Choice*** – *Households must be responsible to choose the sanitation service level they desire and based on what they can afford*	**NONE IDENTIFIED**
Issue 6: Beneficiation of by-products	Opportunities for the beneficiation of by-products of sanitation **should** be given due consideration with a view to promoting local economic development and using income generated to subsidise sanitation services.	24. Local development Resources Recovered: 17. Nutrients 19. Organic Material 20. Water	**Economic beneficiation opportunities** – The sanitation technology must provide economic opportunities from by-products produced	**-Viable income from the safe treatment of by-products**
5. TECHNICAL CONSIDERATIONS				
Issue 7: Maintenance	Sanitation technologies **must** be designed to minimise the environmental impact of unmanaged human waste disposal. The specific technological risks of technology failure **must** be considered at the time of technology selection.	36. Possibility to use local competence for construction 39. Durability / lifetime	**Technological problems** – The availability of spare parts for maintenance of the sanitation technology	**-Availability of spare parts for operation and maintenance of the technology**
		37. Possibility to use local competence for Operation and Maintenance 40. Complexity of construction and O&M 41. Compatibility with existing technology	**Local Technological Skill**- Capability of local skill development for construction, repairing and maintaining the sanitation technology	**-Community/ Household by-in to develop skills for construction and maintenance of the technology**
6. INSTITUTIONAL AND ORGANIZATIONAL FRAMEWORKS				
Issue 8: Inter-sectoral linkages must be promoted & encouraged	BCM **must** achieve broad stakeholder and political commitment and agreement on the long-term vision with clear time frames for the provision of sanitation services.	27. Institutional requirements	**Political and Stakeholder Commitment** – Support from political parties and stakeholders for sustainable sanitation technologies must be encouraged	**-Local ward committee approval** **-BCM Council approval**

Legal and policy review contributes to developing indicators which are both specific to BCM and part of regulatory framework.

Two Sustainability Recommendations developed in this process originated from the "Community and Human Resources Development" category and one from the "Financial and Economic Approach" category. The Sustainability Recommendations developed were the *Inclusion of women* in the decision making process and the *Flexibility of choice*. These recommendations developed from the issues in these categories were difficult to measure and would not specifically contribute to differentiating between technologies. They were, however, very pertinent and it was proposed that they be considered during the fine screening process.

This process of expansion of the criteria and indicators is reflective of work conducted by Singh *et al.* (2009). They attempted to provide an overview of various methodologies that developed indices or measures of sustainability. They found that as described in the Sustainability Criteria and Indicator Development Approach, it was important to compile the information used to create the measures using three steps, specifically normalisation, weighting and aggregation. The normalisation step was very similar to Step 2 of the Sustainability Criteria and Indicator Development Approach as it involved the identification of the issues from which sustainability measures could be developed. This method has been used by Herman *et al.* (2007) who developed an analytical tool called COMPLIMENT that provided detailed information on the overall environmental impact of business. The methodology to create the tool drew from life cycle assessments, multi-criteria analysis and environmental performance indicators. The output data from the methodology used by Herman *et al.* (2007) was similar to the criteria developed by Step 2. Normalisation was also used by Wakernagel & Rees (1997) to formulate an Ecological Footprint which used qualitative land and water requirements which were interpreted as a measure of ecological sustainability. This compares with the use of the South African Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998) and the Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone (WRC, 1999) to develop indicators for the criteria as described in Step 2.

Sahely *et al.* (2005) describe a method of developing Sustainability Criteria and Indicators for urban infrastructure systems. They found that the development process involved the use of a framework that firstly defined the problem, developed an inventory analysis and conducted and impact assessment that informed decision analysis. The defining of the problem used in the framework is very similar to the process of Stakeholder Engagement during the expansion of the criteria where the main issues and concerns could be harnessed. This allowed for different categories of sustainability criteria and indicators to be developed like environmental, social, engineering and economic (Sahely *et al.*, 2005) which was a similar outcome of the expansion of the criteria described in Table 4.11.

The outcome of Step 2 was the creation of expanded criteria for use in Step 3 which consolidated similar or repeated criteria and indicators. The following section describes and documents the process of Step 3.

4.3.3 Step 3: Consolidation of criteria and indicators

The criteria and indicators created in Steps 1 and 2 for BCM was reviewed and any criteria and indicators that were similar, overlapped or repeated were consolidated (Table 4.12). The consolidated criteria table lists the origin of the criteria, the indicators and associated consolidated criteria and indicators. This consolidation approach ensured minimal repetition of criteria and indicators in the final BCM Sustainability Criteria List.

During the consolidation process, 11 criteria and their associated indicators were consolidated into five new criteria. Five of the 11 criteria focussed on the prevention of pollution, with three criteria specifically focussed on ground water and two on surface water. Even though all five criteria focused on similar aspects of the prevention of water pollution it is interesting to note that they originated from different sources of information. This is indicative of the fact that the all sources of information used to develop the criteria were aware of the threat sanitation technologies have on water sources. For example, the criterion termed *Pollution of Ground Water* was a result of consolidation of criteria developed from National legislation, BCM By-laws and Stakeholder engagement. These all noted that pollution was a major aspect that should be incorporated into the Sustainability Criteria for the selection of sanitation technologies. The indicators of this criterion were a combination of the indicators from the original three criteria. Similarly, the criteria termed *Pollution of Surface Water* was a result of the consolidation of two criteria developed from National legislation and stakeholder engagement.

Two criteria dealing with gender issues were consolidated into one criterion. This was the consolidation of two *Gender sensitive* and *Gender specifications* criteria that originate from National legislation and stakeholder engagement respectively. Again, the origin of the information developing the criteria was different and these criteria were consolidated since both sources of

Table 4.12: Consolidation of BCM Criteria and Sustainability Recommendations

BCM CRITERIA CATEGORY	FOCUS	ORIGIN	BCM CRITERIA DEVELOPED	BCM INDICATORS DEVELOPED	BCM CONSOLIDATED CRITERIA	BCM CONSOLIDATED INDICATORS
1. Health and hygiene education and promotion						
			NONE IDENTIFIED			
2. Community issues and human resources development						
	Gender	Stakeholder Engagement	**Gender specifications** – The sanitation technology must acknowledge gender specific requirements	**- Gender specific facilities**	**Specific Gender Requirements** - The technology must have facilities installed for both sexes	**- Gender specific facilities - Gender needs**
	Gender	National Legislation	**Gender sensitive** – The sanitation technology must take into consideration the different needs required by the male and female sexes	**-Gender needs**		
	Safety	Stakeholder Engagement	**User Safety** – Capacity of sanitation technology to provide user safety	**-Located within the household property**	**User Safety** - The technology should preferably be located within or in close proximity of the household to provide user safety	**-Located within the household property -Location of Technology**
	Safety	National Legislation	**Safety** – The sanitation technology must be secure and located within or in very close proximity of the household	**-Location of Technology**		
3. Environmental impact						
	Ground water pollution	National Legislation	**Ground Water Quality** – The sanitation technology must not decrease the quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with the effluent and sludge during storage ,transportation, treatment or and disposal	**- Distance to water table (>1.5m) - Possible contact during storage transportation, treatment and disposal - Slope (<30°)**	**Pollution of Ground Water**- The sanitation technology must not be installed in a area that would contribute to the pollution or decrease in quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with untreated effluent and sludge during storage, transportation, treatment and or disposal	**- Distance to water table (>1.5m) - Possible contact during storage transportation, treatment and disposal - Slope (<30°) - Likelihood of safe transportation and storage**
	Ground water pollution	Stakeholder Engagement	**Pollution risk of aquifers** – The sanitation technology must ensure safe disposal of effluent and sludge	**- Distance to water table (>1.5m) - Likelihood of safe transportation and storage - Slope Angle (<30°)**		
	Surface water pollution	National Legislation	**Surface Water Quality** – The sanitation technology must ensure the quality of surface water (ecological and human reserve) by ensuring that surface water will not come into contact with effluent and sludge during transportation, storage and disposal	**- Location relative to flood line (>100m) - Slope (<30°) - Quality of discharged effluent during disposal**	**Pollution of Surface Water** - The sanitation technology must not be installed in areas prone to pollute and decrease the quality of fresh and marine water (ecological and human reserve) by ensuring that surface water will not come into contact with untreated effluent and sludge during transportation, storage and disposal	**- Location relative to flood line (>100m) - Slope (<30°) - Quality of discharged effluent during disposal - Distance to water table (>1.5m) - Distance from fault lines (>100m) - Distance from Dolomite outcrops (>100m) -BCM Sanitation Department's authorisation - DWAF authorisation**
	Surface water pollution	Municipal Legislation	**Water Pollution Risk** – Technology should not be installed where a water source is likely to become polluted	**- Location to flood line (>100m) - Slope Angle (<30°) - Distance to water table (>1.5m) - Distance from fault lines (>100m) - Distance from Dolomite outcrops (>100m)**		
	Surface water pollution	Stakeholder Engagement	**Pollution Risk:** Likelihood of sewage entering the environment from the sanitation technology	**- Location to flood line (>100m) - Slope Angle (<30°) -BCM Sanitation Department's authorisation - DWAF authorisation**		
	Identification of possible pollution	Stakeholder Engagement	**Ease of monitoring environmental pollution:** Monitoring technology that ensures that provision is made for early exposure of pollution from the technology	**-Technology allows for leaks and spills to be identified quickly -Technology malfunctions can be identified quickly and at source**	**Ease of monitoring and detection** - The technology should have systems in place that allows for the monitoring and early detection of problems	**-Technology allows for leaks and spills to be identified quickly -Technology malfunctions can be identified quickly and at source -Technology allows for mechanisms to be continuously monitored**
	Identification of possible pollution	Stakeholder Engagement	**Ease of Detection**: Ability for the early identification of problems with the technology	**-Technology malfunctions can be identified quickly and at source -Technology allows for mechanisms to be continuously monitored**		
4. Financial and economic approach						
			NONE IDENTIFIED			
5. Technical considerations						
			NONE IDENTIFIED			
6. Institutional and organizational frameworks						
			NONE IDENTIFIED			

Information required that gender specific issues be taken into consideration when selecting a sanitation technology.

Whilst the literature describes the systematic development of the criteria and indicators in a similar fashion as the Sustainability Criteria and Indicator Development Approach used in this study (Gibson *et al.*, 2005; Krajnc & Glavic, 2005; Sahely *et al.*, 2005; Moret *et al.*, 2006; Al-Sa'ed & Mubarak, 2006; Herman *et al.*, 2007) a consolidation step is not described or documented. However, Thabrew *et al.* (2009) reviewed different environmental assessment tools and used the criterion of "Deal with cross sectional linkages and highlight inter-linkages" as an important criterion.

The development of criteria and indicators to measure the sustainability of sanitation technologies compares well with the methods used by other researchers. Singh *et al.* (2009) state that, after normalisation, which compares with Step 2, weighting and aggregation are required. The outcome of Step 3 in this study was the creation of a Consolidated Criteria List which includes the consolidated criteria developed in this Step (Appendix 1). This list was then taken through Step 4 which involved the weighting of each criterion and indicator to assist in providing scores for different technology options during the selection process.

4.3.4 Step 4: Weighting

The weighting of the criteria was conducted with BCM Stakeholders and, as described in Section 4.2, involved the use of Actual Importance Indices (AII). Singh *et al.* (2009) state that the choice of the method used to develop the weighting system is dependent on the nature and scope of the study, the data and the analyst. The results of the ranking and the calculation of the AII scores are presented in Appendix 2. The AII scores were rounded to the nearest whole number. Figure 4.3 shows graphically the results of the weighting process. It is clearly evident from the graph that there were three criteria that were weighted the highest, each with a total AII score of 18. These were *Pollution of surface water*, *Health risks*, *Treatment management* and *Municipal approval*. These criteria reflect the conclusions made by the BCM State of Sanitation Report (BCM, 2006) and Chapter 3 of this thesis which revealed that poor treatment of effluent at WWTWs pollute surface water sources with organisms indicative of contamination by sewage, which poses threat to the health of BCM residents. This was indicative of the fact that BCM Departments acknowledge that the treatment facilities require management and sanitation technologies require approval to contribute to the sustainability of the Municipality.

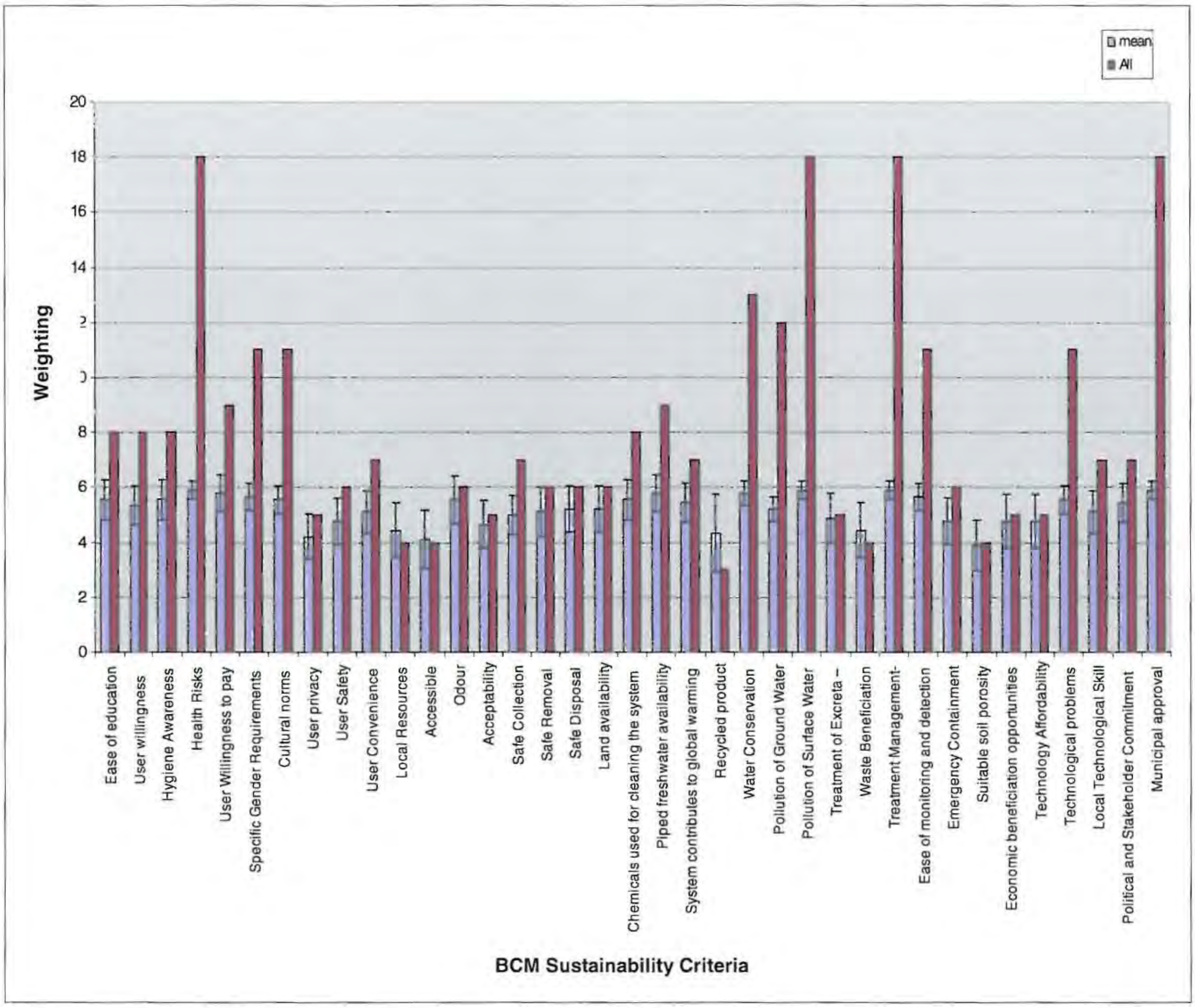

Figure 4.3: Mean, standard deviation (bars) and AII scores for the BCM sustainability criteria

However, it was interesting to note that the AII weight for the *Pollution of Ground Water* criterion was 12 which is 6 AII values less than, the criterion for the *Pollution of Surface Water*. These two criteria aim to ensure that the integrity of water resource's quality is not decreased due to pollution from a sanitation technology. However, the fairly large difference in the AII weights is suggestive of the fact that because the surface water pollution monitoring and data analysis is reviewed by the Departments there may be an unintended bias towards ranking the criterion of the *Pollution of Surface Water* higher than the criterion for the *Pollution of Ground Water*.

It was expected that the criteria of *Political and Stakeholder Commitment* and *Technology Affordability* would have high AII scores since these had been identified as major limiting factors for the implementation of sanitation technologies. However, this was not the case and these criteria showed unexpected low AII scores. The criterion of *Political and Stakeholder Commitment* is integral as it is the BCM Council that authorises the installation of a sanitation technology in an area. The AII score of 7 was much lower than expected since the functions of BCM Departments remain dependent on political and stakeholder influence, especially when it comes to decisions around planning. The fact that this was ranked lower than expected may be due to reluctance by the BCM Departments to instigate political debate of the strong influence BCM politics has over decision making.

The criterion of the *Technology Affordability* also shows an unexpected low AII score of 5. The affordability of the technology is one of the main determining factors of the success for the implementation of sanitation technology (BCM, 2006). This low AII score might be explained by examining the ranking assigned by each department. Only three out of the nine Departments ranked this criterion as 'high' with a value of 6. The Departments that that ranked this criterion as high were those that mainly dealt directly with the funding of sanitation technologies, like Engineering, IEMU and IDP. Departments that were not directly involved in dealing with funding around sanitation technologies, such as Scientific Services, Environmental Services and Development Planning, ranked the issue of funding as medium which inevitably resulted in a lower AII score than expected.

The results show that the calculation of the AII achieved the objective of widening the range of the assigned weights more effectively than the mean values from the ranking. For instance the criteria of *Health Risks* and *User Willingness to Pay* had a mean rank of 5.8 and 5.9 respectively (Appendix 2). Therefore both criteria were ranked as high but their standard deviations differed by 0.34 and the calculation of the AII weight separated the variation of importance of the two criteria by nine AII weight values. Eventually, the criterion of *Health Risks* had an AII value of 18 and the criterion of *User Willingness to Pay* was 9, which was corroborated by the raw data captured that showed that the *Health Risks* criterion was ranked consistently higher than the *User Willingness to Pay* criterion.

This substantiates the expectation that mean and standard deviation values would not alone have effectively separated the weighting appropriately and validates the use of the AII process to appropriately weight the criteria. This also ensured that the final Total Sustainability Scores (Appendix 4) were distinctly different to make an informed judgment on which technology was most sustainable.

Gomontean *et al.* (2008) used a similar method of weighting ecological criteria and indicators for community forest conservation in Thailand. The approach to weighting the criteria and indicators drew from the Analytic Hierarchy Process ranking system developed by Saaty (1980) which is widely used by many decision makers. The process is very similar to the participatory ranking system used in this study because it takes into consideration the weight assigned to both the criteria and indicators and calculates the scores for a decision to be made. It also contributes to ensuring the significance of each indicator is taken into consideration relative to its criterion. Although the method used by Gomontean *et al.* (2008) is similar in nature it ultimately compares the consistency of the weights to ascertain the reliability of the judgements made. This is not the case with the development of the AII scores in this research and the judgements made were considered to be reliable since they were made by the decision makers themselves.

Finalisation of the BCM Sanitation Selection Criteria List

The final BCM Sanitation Selection Criteria List with associated weighting and scores is also presented in Appendix 3. The table is organised into the six issue categories suggested by the National Sanitation Policy (RSA, 1996a) and each category contains the BCM Sustainability Criteria and Indicators developed from Steps 1 to 4 of the Sustainability Criteria Indicator Development Approach (Figure 4.1). The table combines the BCM Sustainability Criteria and Indicators, their weights and the nine different sanitation technology options available to the BCM residents. The development of these sustainability criteria and indicators will inform the decision makers on the most sustainable decision to make. Since the criteria are context specific to BCM they address and highlight the major issues and concerns that should be taken into consideration before making a decision on a specific sanitation technology. These concerns were environmental, social, technical and economic in nature and the criteria and indicators developed address these adequately. Furthermore, since the criteria and indicators were developed from a combination of an existing generic list, national and municipal legislation, stakeholder engagement and scientific research, they were comprehensive.

The participatory approach of developing the criteria and indicators with major stakeholders from the BCM Council to the residents themselves rendered the decision making tool developed relevant to the context in which it is applied. The generic list suggested by Bracken *et al.* (2005) proved to be a useful baseline source of information for the development of the decision making tool.

The literature shows that similar sustainability criteria and indicator lists also make use of the main issues to develop context specific criteria in the environmental, social, economic and technical categories (Guijt *et al*,. 2001; MMSD, 2002; Bradley *et al.*, 2002; Nelson *et al.*, 2004; Gomontean *et al.*, 2008) However, sustainability lists in the literature are mainly used for sustainability-centred appraisals for the process of planning in anticipation of implementing plans made. As with the BCM Sustainable Sanitation Selection Criteria List, the lists found in the literature all aim to inform decisions on choosing between defined alternatives and ensuring that they are sustainable.

The Sustainability Recommendations were used as a "final check" after the evaluation and assessment process to ensure that the important aspects identified by BCM Stakeholders were taken into consideration during the final selection process. The following Sustainability Recommendations developed from Steps 1 and 2 were considered after the evaluation process:

- Ownership: Ownership of the toilet should be promoted to ensure sustainable operation and maintenance
- Inclusion of women in decision making: Involve women in the decision-making process to provide perspective to women's needs for different technologies
- Flexibility of Choice: Households should be responsible to choose the sanitation service level they desire and based on what they can afford

4.3.5 Coarse Screening and Mapping

The coarse screening decision matrix included six criteria and ten indicators that were used in a coarse screening process (Table 4.13). These criteria were, *Pollution of Ground water*, *Pollution of Surface water*, *Municipal Approval*, *Land availability*, *Piped water availability* and *Suitable soil porosity*.

The physical land characteristic indicators of the table originate from criteria developed in the Environmental Impact category which was aimed at reducing pollution of ground and surface water and the Institutional and Organisational Frameworks category which was aimed at identifying which existing technologies were approved by BCM.

Mapping

Based on the review of the criteria, three of the six coarse screening criteria, all from the Environmental Impact Category, were identified for inclusion into a Sanitation Sensitivity Map. The criteria were *Pollution of Ground water*, *Pollution of Surface water* and *Suitable soil porosity, Municipal Approval, Land availability and Piped water availability.* These criteria have measurable indicators that were already available as a GIS shape file (Table 4.14). The criteria identified were considered to be the fatal flaw criteria that expressed the sensitivity of the area to, or the likelihood of pollution from sanitation systems. It should be noted that the map only indicated areas prone to pollution and not areas where sanitation technologies should not be installed. Figure 4.4 illustrates those sensitive areas within BCM i.e. where the number of appropriate sanitation options was likely to be low.

Table 4.13: Coarse screening decision matrix

Criteria	Indicators	Technology Options Available								
		PIT	VIP	VIDP	COMP	W/B	P/F	S/T	UD	CONS
Pollution of Ground water	-Acceptable distance to water table									
	-Slope									
	Acceptable distance from fault lines									
	-Acceptable distance from Dolomite outcrops									
Pollution of Surface Water	-Acceptable location relative to flood line									
	-Slope									
Municipal Approval	- Currently approved technology by BCM									
Land Availability	-Plot area									
Piped water availability	-Availability									
Suitable soil porosity	-Soil type									
	-Soil depth									
KEY										
√	Acceptable technology									
X	Unacceptable technology									

The existing shape files did not have data on seismic zones or faults so these could not be included on the map. However, the position of dolomite outcrops was included. These areas are unstable and could result in pollution of underlying water bodies if sanitation systems were installed on them. The shape file data for soil type identified areas within BCM with either sandy soil with high permeability rates or areas with clay soil with very low permeability rates. These areas were considered sensitive because in sandy soil effluent from pits or vaults could rapidly infiltrate into and pollute groundwater sources, whereas in clay soil the effluent would very slowly infiltrate into the soil and may flow into surface water resources.

The indirect translation of the criteria and indicators had to be applied to some shape files. This was due to the fact that some of the existing shape file data could not be directly translated into the requirements set out by the indicators. These were mainly the soil depth and the slope shape files. The coarse screening criteria dealing with the land characteristics required that areas in which the sanitation systems are to be installed have a soil depth of more than 1.5m and the soil type - clay to loam. The existing shape files however only had data extending to a depth of 0.75m therefore these areas were buffered and were still considered relevant to the criteria and indicator since they described areas with shallow soil. The existing shape files for the slopes only had data for areas steeper than 15^{o} and none for slopes steeper than 30^{o}. This measurement was therefore used because the BCM SDF already considered areas steeper than 15 ^{o} inappropriate for development and this was relevant to the installation of sanitation technologies. These are examples of the modification of the original coarse screening criteria and it is important to note that the revised criterion was more conservative than the original.

The Sanitation Sensitivity Map (Figure 4.4) illustrates the sensitive areas within BCM based on the risk of water and land pollution from sanitation systems. A significant area of BCM was considered sensitive to pollution as almost half of the map was covered by the bright orange colour. The north and north eastern part of municipality were considered to have the most sensitive areas while the western and southern regions were considered less sensitive. This was probably due to the fact that areas lying to the north of BCM are characterised by major catchment areas that have large rivers and dams of significant importance to BCM's water supply. In addition, areas with slopes steeper than 15^{o} are found in the northern area of BCM as are areas with dolomite outcrops and shallow soil depth. All these factors contribute to the high sensitivity shown in the northern portions of BCM. In contrast, deeper soils and slopes less than 15^{o} are found in the southern region. These factors contribute to the non-sensitive areas that are found mainly in the southern portions of BCM.

Figure 4.4 highlights two important points about BCM. Firstly with respect to the position of the existing sanitation systems within BCM - a high concentration of VIPs, buckets toilets and composting toilets (Enviro-loos) are currently located in the north within the sensitive areas. The VIPs are especially densely concentrated above the town of Mdantsane which falls within the Newlands area. This area was considered sensitive according to the sanitation sensitivity map but contains VIPs which have been proven to pollute the environment, especially water resources (DWAF, 2002a, Mara, 2005, WRC, 2008). This supports the claim that river catchments in this area are polluted as a result of the placement of inappropriate sanitation technologies (BCM, 2006).

Table 4.14: List of criteria and indicators to be translated into GIS shape files

BCM Criteria	BCM Indicators Used	Corresponding Existing Shape file	GIS Query Run
Pollution of Ground Water- The sanitation technology must not be installed in a area that would contribute to the pollution or decrease in quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with untreated effluent and sludge during storage, transportation, treatment and or disposal	**- Distance to water table** (i) Water table >1.5m deep (ii) Water table 1.4m – 1m deep (iii) Water table< 1m deep **- Possible contact during storage transportation, treatment and disposal** (i) Definite (ii) Possible (iii) Unlikely **- Slope** (i) < 30° (ii) > 30° **-Distance from fault lines** i) >150m (ii) 150m – 100m (iii) <100m **-Distance from Dolomite outcrops** i) >150m (ii) 150m – 100m (iii) <100m	-100m Set back from areas Susceptible to Flooding - BCM Soil Depth -100m Set back from areas Susceptible to Flooding -BCM Slopes >15° -BCM Geology -BCM Geology	- Buffered 100m around all areas susceptible to flooding -Buffered areas with soil depth below 750mm -Buffered Slopes > 15° -Buffered 100m around Dolomite outcrops
Pollution of Surface Water - The sanitation technology must not be installed in areas prone to pollute and decrease the quality of fresh and marine water (ecological and human reserve) by ensuring that surface water will not come into contact with untreated effluent and sludge during transportation, storage and disposal	**- Location relative to flood line** (i) >150m (ii) 150m – 100m (iii) <100m **- Slope Angle** (i) <30° (ii) > 30°	-100m Set back from areas Susceptible to Flooding -BCM Slopes >15°	- Buffered 100m around all areas susceptible to flooding -Buffered Slopes > 15°
Suitable soil porosity – Soil supporting system shall be of sufficient porosity and depth for the disposal of effluent	**-Soils type** (i) Loam (ii) Clay or Sandy **-Soil depth** (i) > 1.5 m (ii) 1.4m -0.75m (iii) <750m	-BCM Soil Type BCM Soil Depth	-Buffered areas with soil sandy soils and clay soils -Buffered areas with soil depth below 750mm

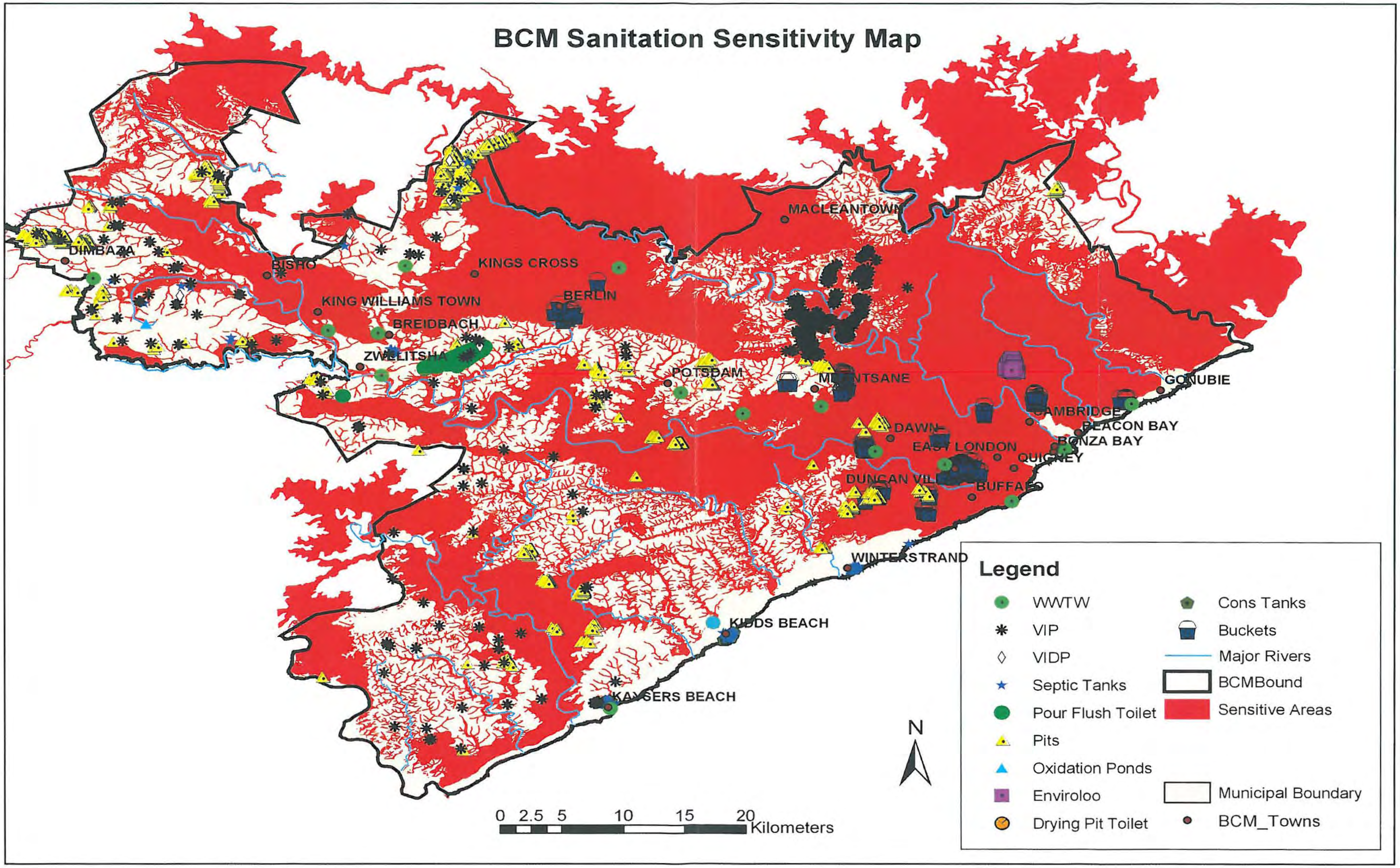

Figure 4.4: BCM Sanitation Sensitivity Map

Secondly, the map highlights the location of towns and settlements within the sensitive area. These towns include densely populated urban nodes including East London, Gonubie, King Williams Town and Bisho. These areas are mainly urban areas surrounded by peri-urban settlements. It is ironic that the built up areas fall within the sensitive areas in terms of potential for sanitation systems to pollute water resources. However, this may be due to the initial planning of the towns which required them to be located in close proximity of water supplies from rivers and dams. The relatively less sensitive areas located in areas outside of main towns and settlements and outside of areas characterised by the major rivers and dams within BCM. In addition, the coastal regions in the southern part of BCM are not considered to be sensitive, whereas the coastal regions north of the town of Winterstand are considered to be sensitive. Again, this may be due to the high concentration of major water sources like rivers and dams found in the north, but may also be influenced by the deeper soils and flatter slopes experienced in the southern area.

This type of sensitivity analysis using GIS based information has been used by other researchers to manage pollution and the impacts it has on the environment (Foster & McDonald, 2000; Rae *et al.*, 2007; Zamorano *et al.*, 2008). The method of assimilating GIS data in pollution risk assessment was considered as an ideal tool for land planning (Foster & McDonald, 2000) as it integrated relevant land characteristic data and allowed for different scenarios to be presented to decision-makers (Rae *et al.*, 2007). Research conducted by Foster & McDonald (2000) on the quality of drinking water supplies and treatment efficiencies confirmed the finding that the use of GIS can assist in environmental decision making. Zamorano *et al.* (2008) conducted a similar study on the suitable location of landfill sites using GIS based information and they also found that it assisted in providing information to decision makers who could then make informed decisions based on the physical characteristics of the land. Their research however developed indices to measure the suitability of the specific sites. This aspect was not included in the current study since the objective was to only identify areas that were prone to pollution.

4.4 CONCLUSION

The objective of developing a decision support tool for the selection of sanitation technologies in BCM was achieved through the application of the Sustainability Criteria and Indicator Approach (Figure 4.1). This approach also resulted in the development of a weighting system, a coarse screening decision matrix and a Sanitation Sensitivity Map to assist with selection of sanitation technologies in BCM to ensure that the most sustainable technologies are chosen for a given context. The use of the generic Bracken *et al.* (2005) sustainability list proved useful and relevant to development of sustainability criteria. Criteria and indicators were effectively adopted and expanded. The consolidation and weighting of the criteria and indicators was a useful method of quantifying the sustainability of each technology during the selection process and the use of the coarse screening decision matrix ensured that sanitation technologies could be screened for their suitability to a given context before they were evaluated by the BCM Sanitation Selection Criteria List. The data used for the Sanitation Sensitivity Map used modified data that resulted in the data being more conservative than the original. The pilot implementation of the final sanitation selection criteria and associated indicators and sustainability recommendations is presented in Chapter 5.

CHAPTER 5: PILOT APPLICATION OF SANITATION SELECTION CRITERIA IN BCM

5.1 INTRODUCTION

The main application of sustainability assessment is a decision-making process that is informed by sustainability-based criteria that aim to deliver "*multiple, lasting, mutually reinforcing gains rather than the mitigation of environmental damage*" (Gibson *et al.*, 2005). This approach underpinned the development of sanitation selection criteria for BCM as documented in the preceding chapters. Although the approach involved extensive stakeholder engagement and review of guideline documents, it was considered necessary to undertake an initial pilot testing of the criteria and indicators in order to identify any potential weaknesses.

The sustainability criteria developed for BCM were designed to cross the typical social, ecological and economic boundaries and to facilitate integrated consideration. Past literature indicates that the development of sustainability criteria used this cross boundary approach and found it to be a challenge because it demanded unfamiliar thinking (Lawrence, 1997; Louks & Gladwell, 1999; Maltais *et al.*, 2002; Bracken *et al.*, 2004; Gibson *et al.*, 2005). Whilst unfamiliar thinking about sanitation systems may be what is needed for BCM, it may be a challenge to apply and adopt by those involved in the sanitation selection process within BCM.

Louks & Gladwell (1999) found that the basic challenge with criteria application was determining what rules and specific decision criteria could be identified for application, and what generic processes could be designed for reasonably effective, efficient and fair elaboration of detailed criteria. This challenge is addressed in this chapter by using coarse screening and fine screening to assist BCM decision-makers in making a sustainable decision regarding which sanitation technologies to select for installation.

The objective of this chapter was therefore to evaluate the application of the sanitation selection criteria that were developed in Chapter 4. More specifically, it was decided that it would be useful to use the pilot study to assess the degree to which the types of sanitation technologies already installed in certain areas of BCM conformed to the preferred sanitation options as identified through use of the BCM specific sanitation selection criteria.

The specific research questions addressed in this chapter were:

1. To what extent is the sanitation selection criteria system practical with respect to aiding sanitation selection within BCM?
2. To what extent did existing sanitation systems within the low-income and informal settlements of BCM meet the criteria of sustainable sanitation with respect to the newly-developed sustainability criteria?
3. With regards to future provision of sanitation within target pilot communities in BCM, which technologies are likely to be the most sustainable?

5.2 METHODOLOGY

In order to overcome the potential challenges associated with the application of the sanitation selection criteria, it was necessary to develop what was referred to as the Criteria Implementation Approach (Figure 5.1). The approach involved three distinct steps namely; Coarse Screening, Fine Screening and Decision Makers' Review. Each Step involved a process component that created an output which was then used by the subsequent Step until a final decision on a selected sanitation technology was made. During the development of this approach, it was deemed necessary to consider not only the immediate application within BCM, but also future application of the approach in other municipalities within South Africa.

Step 1 of the approach was Coarse Screening whereby, based on the BCM Sanitation Sensitivity Map, areas of sensitivity to pollution in a specific study area could be identified. This Step also involved the identification of the limiting factors and physical characteristics of that area indicating which sanitation technologies would be feasible for implementation. Step 2 was the process of Fine Screening of the feasible technology options identified in Step 1 above. In this step, total Sustainability Scores were calculated from the application of the BCM Sanitation Selection Criteria List. Step 3 involved the review of the Sustainability Scores from Step 2 by BCM decision-makers and a final decision as to which sanitation technology to implement.

Sections 5.2.1 – 5.2.3 below provide detailed descriptions of each of the Steps involved in the implementation approach described above.

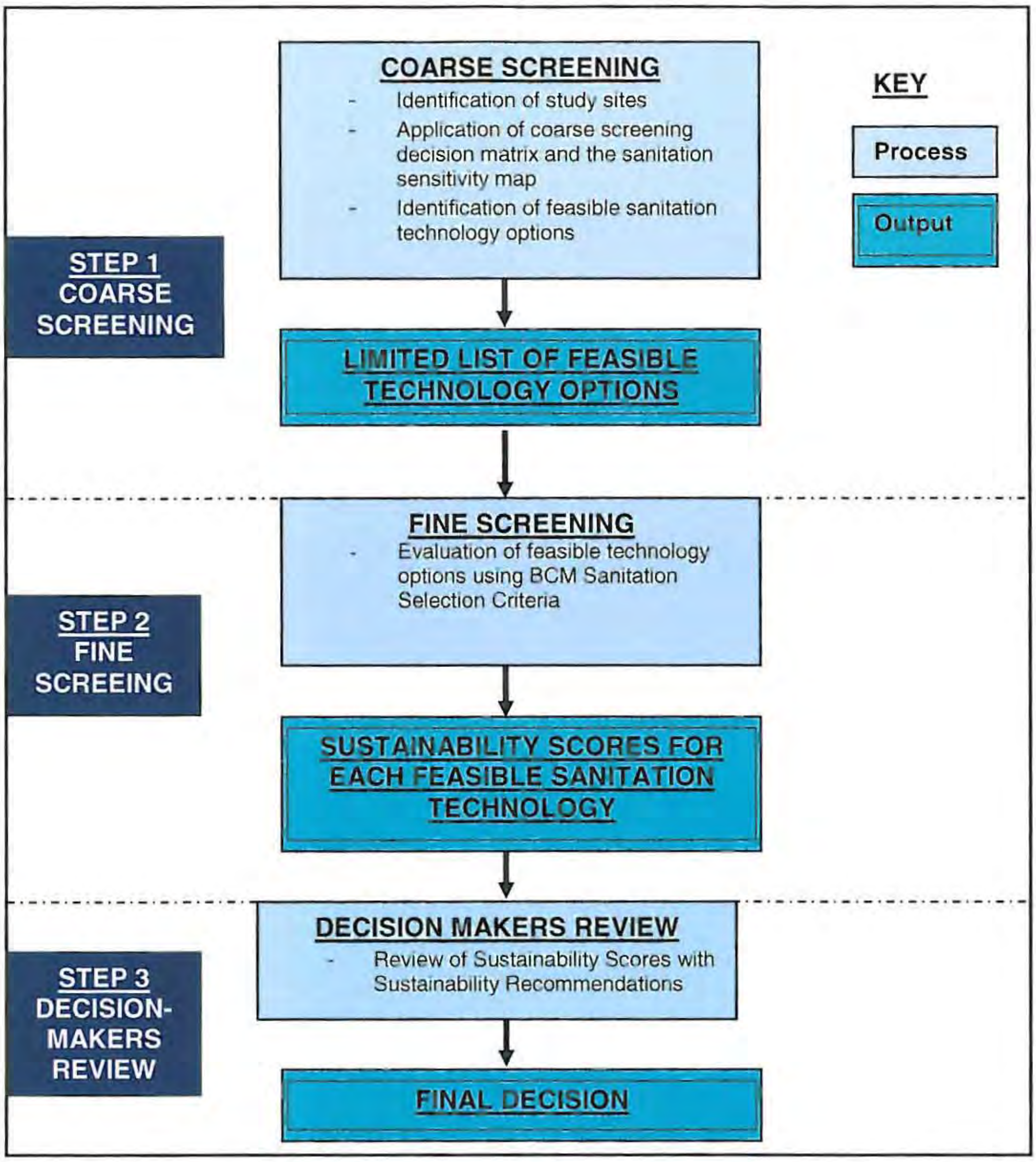

Figure 5.1: Criteria implementation approach

5.2.1 Step 1: Coarse Screening

Step 1 involved the identification of the study areas, the application of the Sanitation Sensitivity Map and the coarse screening decision matrix, and the identification of the feasible sanitation technology options.

A meeting was held on 8th September 2008 with the BCM Manager of the IEMP Unit at the BCM IEMP Unit offices and it was at this meeting that the Unit decided to use three study sites to test the sanitation selection criteria. These study sites were specifically chosen as a result of their rapid expansion and demand for sanitation provision. Selection of these areas was also influenced by the contexts in which they occurred i.e. rural, peri-urban and urban. The study sites chosen by the BCM IEMP Unit were:

1. Newlands Township – Rural (Ward 13)
2. Nompumelelo Township – Peri-urban (Ward 29)
3. Mdantsane Central (Unit 13) – Urban (Ward 16)

Newlands rural settlement study site

The Newlands rural settlement is located 45 km north east of East London on the eastern side of the N2 highway. The settlement falls within Ward 13 of BCM (Figure 5.2) which has a total area of 67,336 km^2 (MDB, 2006). This settlement has a population of 15 808 people of which only 22.2 % of the economically active are employed. Approximately 47.8% of the households in the Newlands area do not have access to sanitation and the majority of the households that do (52.2%) are mainly reliant on unimproved pit latrines (Table 5.1).

Nompumelelo Study Site

The Nompumelelo peri-urban township is located 7 km north of East London on the western side of the N2 highway. The township falls within Ward 29 of BCM (Figure 5.3) which has a total area of 66,708 km^2 (MDB, 2006). The township has a population of 11 075 people of which about 52.2 % of the economically active are employed. In this area, households with access to sanitation facilities mainly use flush toilets connected to a sewer or a septic tank (Table 5.2). In addition, approximately 38% of the households in the Nompumelelo area use the bucket system or do not have access to a sanitation facility. However, according to DWAF (2008) a programme was put in operation to eradicate the use of buckets in South Africa by the year 2007. This programme has obviously not met its target since the bucket system is still being used at this study site.

Mdantsane Unit 3

The Mdantsane Unit 3 urban area is located 23 km north east of East London on the western side of the N2 highway. The urban are falls within Ward 16 of BCM (Figure 5.4) which has a total area of 4,186 km^2 (MDB, 2006). This urban settlement has a population of 19 362 people of which about 19% of the economically active are employed. Approximately 23% of the households in the area do not have access to a sanitation facility. Of those households with access to sanitation facilities, flush toilets, are the most widely used sanitation technology (Table 5.3).

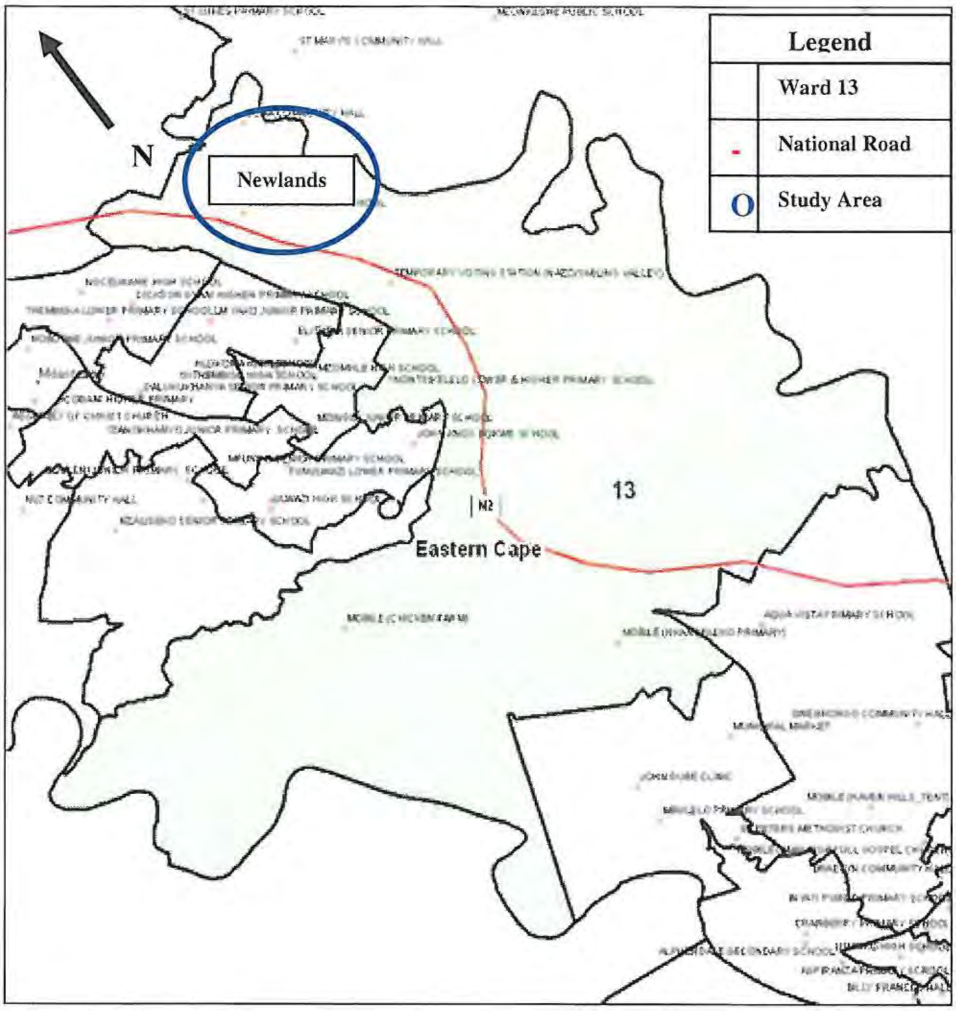

Figure 5.2: Location Map of Newlands Township

Table 5.1: Household Sanitation systems in Newlands

Sanitation System	No of Households
Flush Toilets	720
Septic Tanks	87
Chemical Toilet	138
VIP	330
Pit Latrine	1801
Bucket	12
None	1478

Source: Municipal Demarcation Board (www.demarcation.org.za)

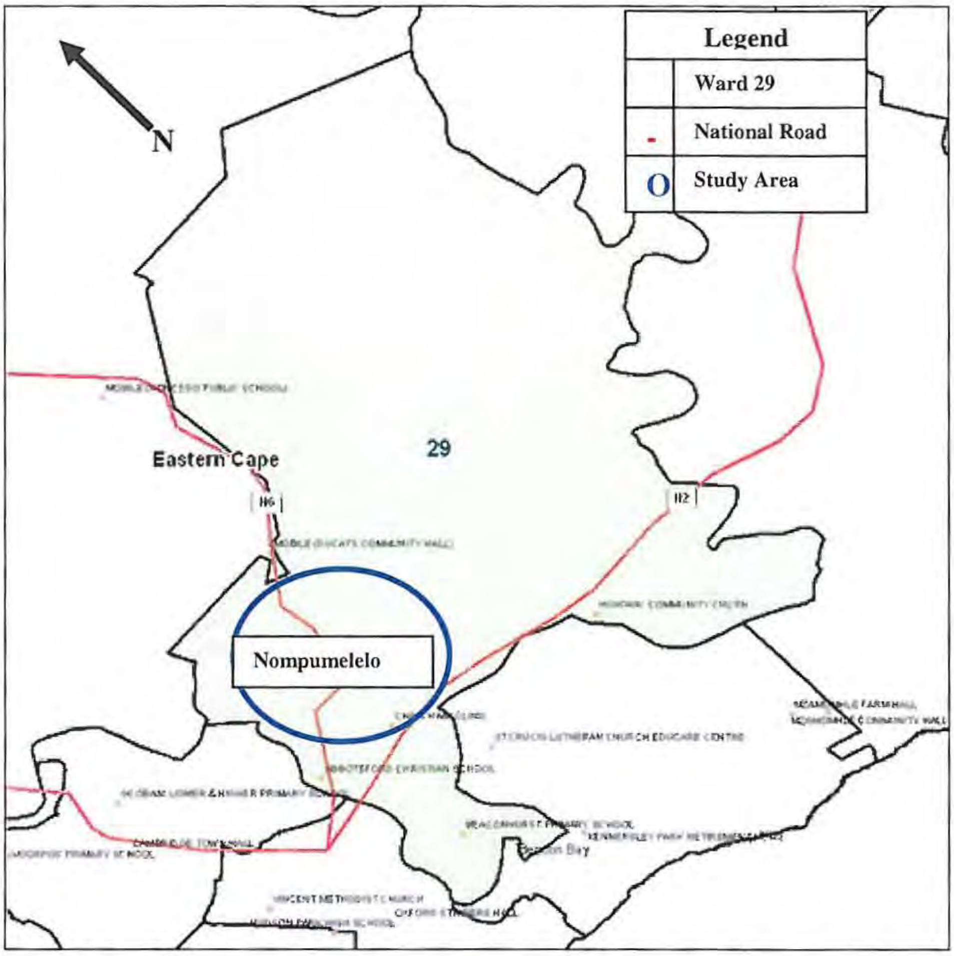

Figure 5.3: Location of Nompumelelo peri-urban township (MDB, 2006)

Table 5.2: Household Sanitation systems in Nompumelelo

Sanitation System	No of Households
Flush Toilets	1962
Septic Tanks	243
Chemical Toilet	3
VIP	41
Pit Latrine	70
Bucket	1203
None	224

Source: Municipal Demarcation Board (www.demarcation.org.za)

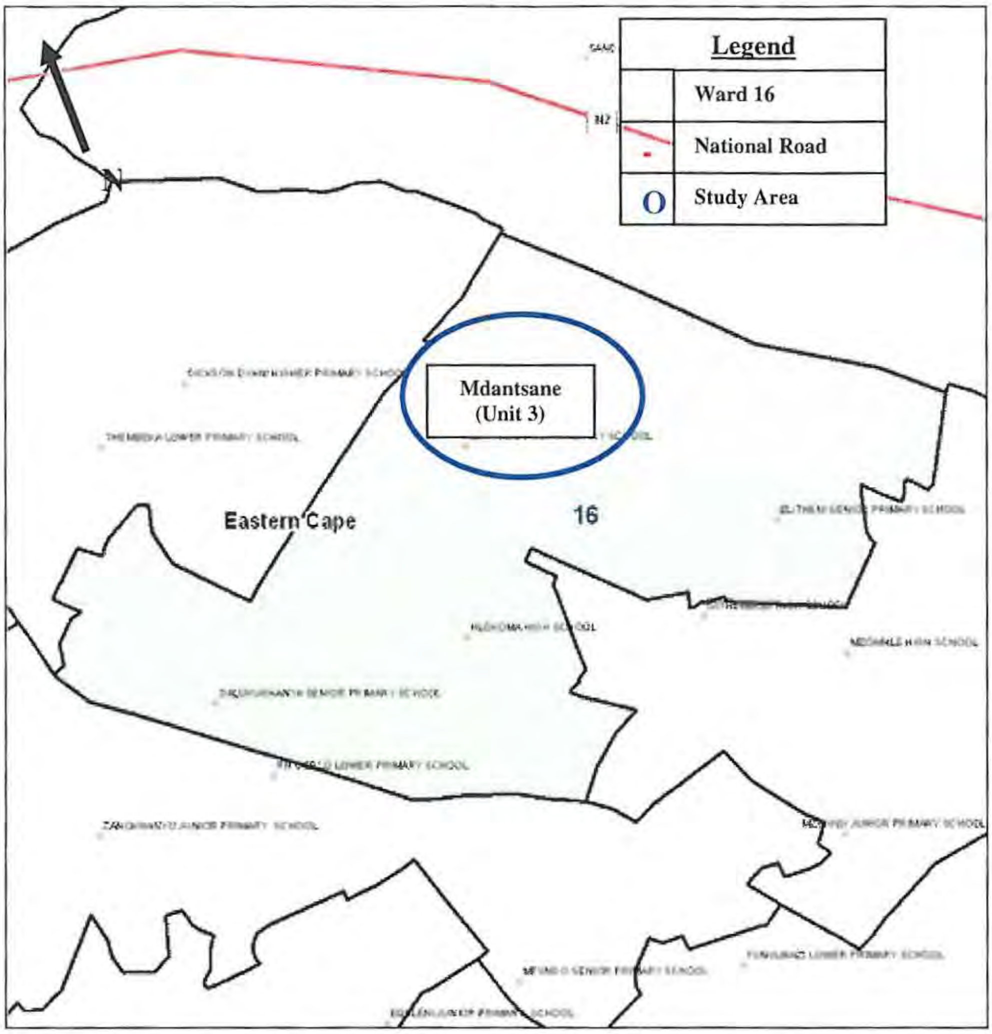

Figure 5.4: Location of Mdanstane (Unit 3)

Table 5.3: Household Sanitation systems in Mdantsane (Unit 13)

Sanitation System	No of Households
Flush Toilets	3413
Septic Tanks	199
Chemical Toilet	33
VIP	37
Pit Latrine	59
Bucket	85
None	1149

Source: Municipal Demarcation Board (www.demarcation.org.za)

A focus group meeting was held with the BCM IEMP Unit Manager and the Ward Councillors of the target study sites on September 12th 2008. This focus group meeting aimed to accomplish the following Coarse Screening objectives in order to determine which sanitation technologies could potentially be installed in the three different areas discussed above. The method for the Coarse Screening of the criteria was as follows:

1. Using the Sanitation Sensitivity Map, the main aspects of sensitivity in the three study areas were identified. The sensitivity of each study area was shown by overlaying the BCM Ward GIS shapefile of the three wards onto the Sanitation Sensitivity using GIS ArcView 9.2 as the interface. Thereafter, a detailed analysis of the three study area maps and one site visit with the BCM IEMP Unit was conducted to confirm the initial description and sensitivity of the individual study sites.
2. Using the coarse screening decision matrix which was used in conjunction with the Sanitation Sensitivity Map, the technologies that could be considered for further evaluation and assessment and the ones that could not were identified.

The sanitation technologies available in BCM for each study area were evaluated against the criteria in the decision matrix. Of the criteria used in the coarse screening decision matrix, the *Pollution of Ground water* and *Pollution of Surface water* criteria were used in both the screening processes due to some indicators belonging to those criteria being applicable in the coarse screening and others in the fine screening. The other four criteria, specifically, *Municipal approval, Land availability, Piped water availability and Suitable soil porosity* were exclusively used in the coarse screening process and not considered during the fine screening process.

The coarse screening decision matrix in this study did not use the criterion pertaining to the *Distance from fault lines* as this data was unavailable and not used in the Sanitation Sensitivity Map. The feasible sanitation technologies were selected in this process by assessing how many criteria a particular technology met. If more than three criteria were not met, the technology was not considered a feasible option in that study site. This process resulted in the production of a list of feasible sanitation technologies for detailed evaluation using the BCM Sanitation Selection Criteria List, for each study site. These identified sanitation technologies were then evaluated in Step 2 as described in Section 5.2.2 below.

5.2.2 Step 2: Fine Screening

This process evaluated and assessed only the feasible technology options identified in Step 1. This process was conducted during a final meeting held on 5 November 2008 with the BCM IEMP Unit and the Ward Councillors of the study sites. The evaluation involved systematically running through the BCM Sanitation Selection Criteria List and assigning sustainability scores to each criterion, for each feasible technology identified for that specific study site.

Following the above, final sustainability scores for each criterion were calculated by multiplying the raw score for each criterion by the respective weighting. The total Sustainability Score for each technology was then calculated as the sum of the Sustainability Scores for all criteria. The higher the score, the more suitable and sustainable the technology for the study site and the lower the score, the less suitable the technology would be in the study site. These scores were then reviewed and considered in Step 3 in order to make a final decision on the most sustainable sanitation technology to be installed in each study site.

5.2.3 Step 3: Review by decision-makers

This was the final step in the process and was undertaken in order to make a decision as to which sanitation technology should be installed in the study sites. This step involved the review and comparison of the total Sustainability Scores for each feasible sanitation technology option. This review and comparison was conducted on 5th November 2008 with the BCM IEMP Unit and study site Ward Councillors. The technology with the highest Sustainability Score was considered to be the most sustainable option. Whilst the final decision was made, Sustainability Recommendations were taken into consideration to ensure that the technology met those recommendations. The recommendations included the following:

- Ownership – Ownership of the toilet should be promoted to ensure sustainable operation and maintenance
- Inclusion of women in decision making – Involve women in the decision-making process to provide perspective to women's needs for different technologies
- Flexibility of Choice – Households should be responsible to choose the sanitation service level they desire and based on what they can afford

Thereafter a final decision was made on which technology to use in a specific study site.

5.3 RESULTS AND DISCUSSION

5.3.1 Coarse Screening

As discussed above, the Sanitation Sensitivity Map provided a crude guide as to the physical characteristics of various parts of the Municipality, more specifically, those characteristics that could influence the risk of pollution to water resources. During coarse screening, this map was used in conjunction with the coarse screening matrix to rule out certain sanitation options for specific target areas. The end product would then be a list of those sanitation technologies that would potentially be suitable, although potentially with varying degrees of relative sustainability.

According to the sanitation sensitivity map analysis, the Newlands area fell within a predominantly sensitive area (Figure 5.5) mainly due to the steep slopes and presence of the Nahoon River and associated tributaries that feed the Nahoon Dam lower down the catchment. A site visit confirmed that the area was characterised by valleys and further analysis of the soil type shape file showed that the area had shallow alluvial erodible sandy soils. These factors contributed to the sensitivity of the Newlands area to pollution from sanitation systems. The existing sanitation technologies on site were VIPs that were densely concentrated in and along the floodplains and steep valley slopes of the Nahoon River.

The Sanitation Sensitivity Map analysis (Figure 5.6) identified the Nompumelelo Township as an area that is sensitive and highly susceptible to environmental pollution from sanitation technologies. The site visit confirmed that the area lies between two major rivers, the Quinera and the Nahoon. The township is characterised by drainage lines that eventually lead to these two rivers. The area is also characterised by steep slopes and shallow soils. The lower reaches of the township are susceptible to flooding which poses a great risk of pollution from the sanitation systems found onsite. Currently the main sanitation technology used in Nompumelelo is the bucket system and there was evidence of the lower reaches of the township towards the drainage lines being used as open toilets (Plate 5.1).

In Mdantsane (Unit 3) a relatively small proportion of the study site was considered sensitive based on the Sanitation Sensitivity Map analysis (Figure 5.7). The map shows that some of the northern areas of the study site are sensitive to environmental pollution while the central region is less sensitive. The study site is located within an urban node and the site visit confirmed that the area is not characterised by major rivers or dams and contains few minor drainage lines. An investigation into the soil depth shape file concluded that the soil was deep enough in the area to satisfy the 0.75m requirement. There was no evidence of dolomite outcrops which would have rendered the site unstable. These factors contributed to the relatively low sensitivity of the study area. However, the slopes in northern part of the study site are steep and this is the main reason for the sensitivity.

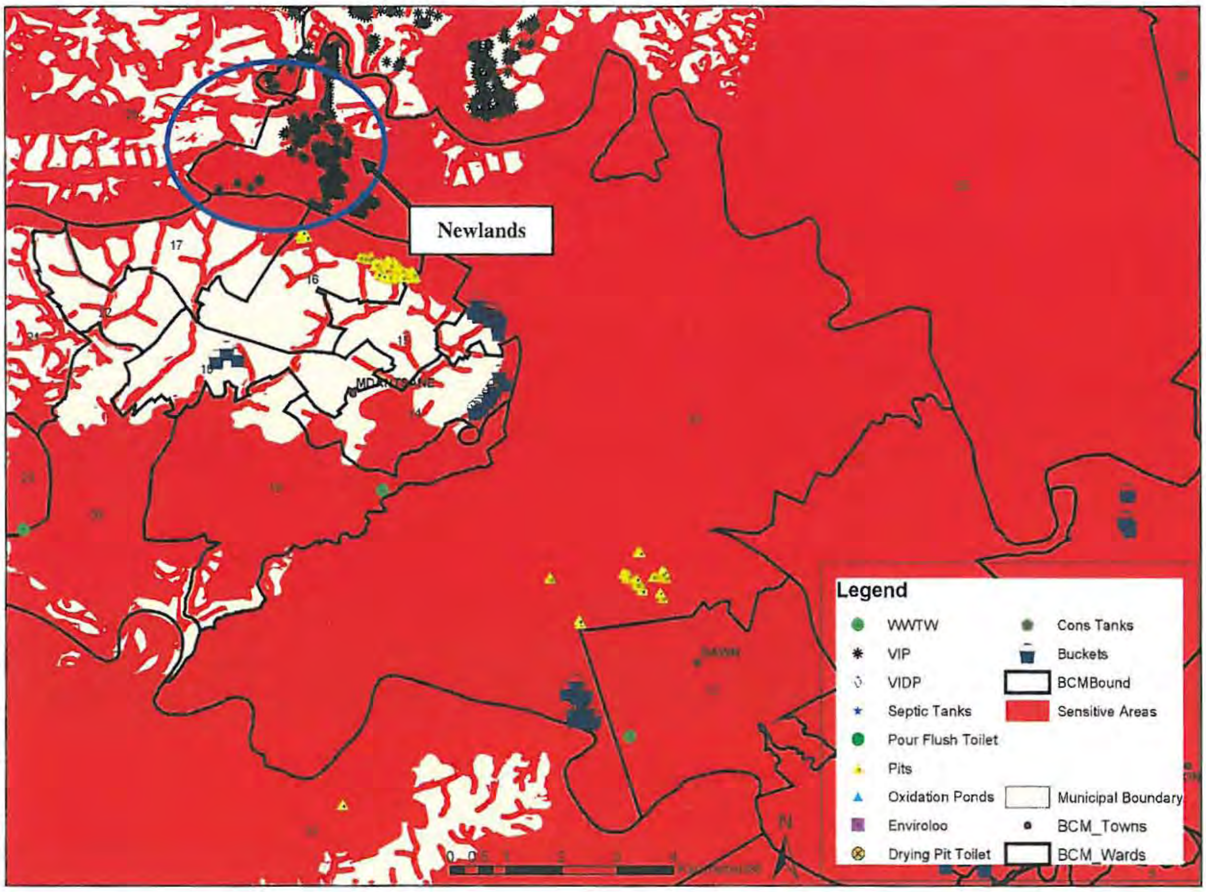

Figure 5.5: Sanitation Sensitivity Analysis of Newlands

Table 5.9 provides the results of which sanitation systems are feasible in all three study areas based on the sanitation coarse screening matrix and the application of the Sanitation Sensitivity Map. The technologies that were considered by the coarse screening decision matrix as feasible in Newlands were composting toilets, septic tanks, waterborne, pour-flush, urine diversion and conservancy tanks. These feasible options identified for each study site were then assessed in the Step 3. It is interesting to note that VIPs and VIDPs were not considered feasible technologies for Newlands, but they are the predominant technologies currently existing and being used in the area (BCM, 2006). Although currently in addition to pit latrines, VIPs and VIDPs are the predominant sanitation technologies in the Newlands site, these technologies were not considered by the coarse screening decision matrix as feasible options for this area due to their contribution to ground and surface water pollution as evidenced in the BCM State of Sanitation Report (BCM, 2006). This indicates that the technologies currently employed in this area are unsustainable.

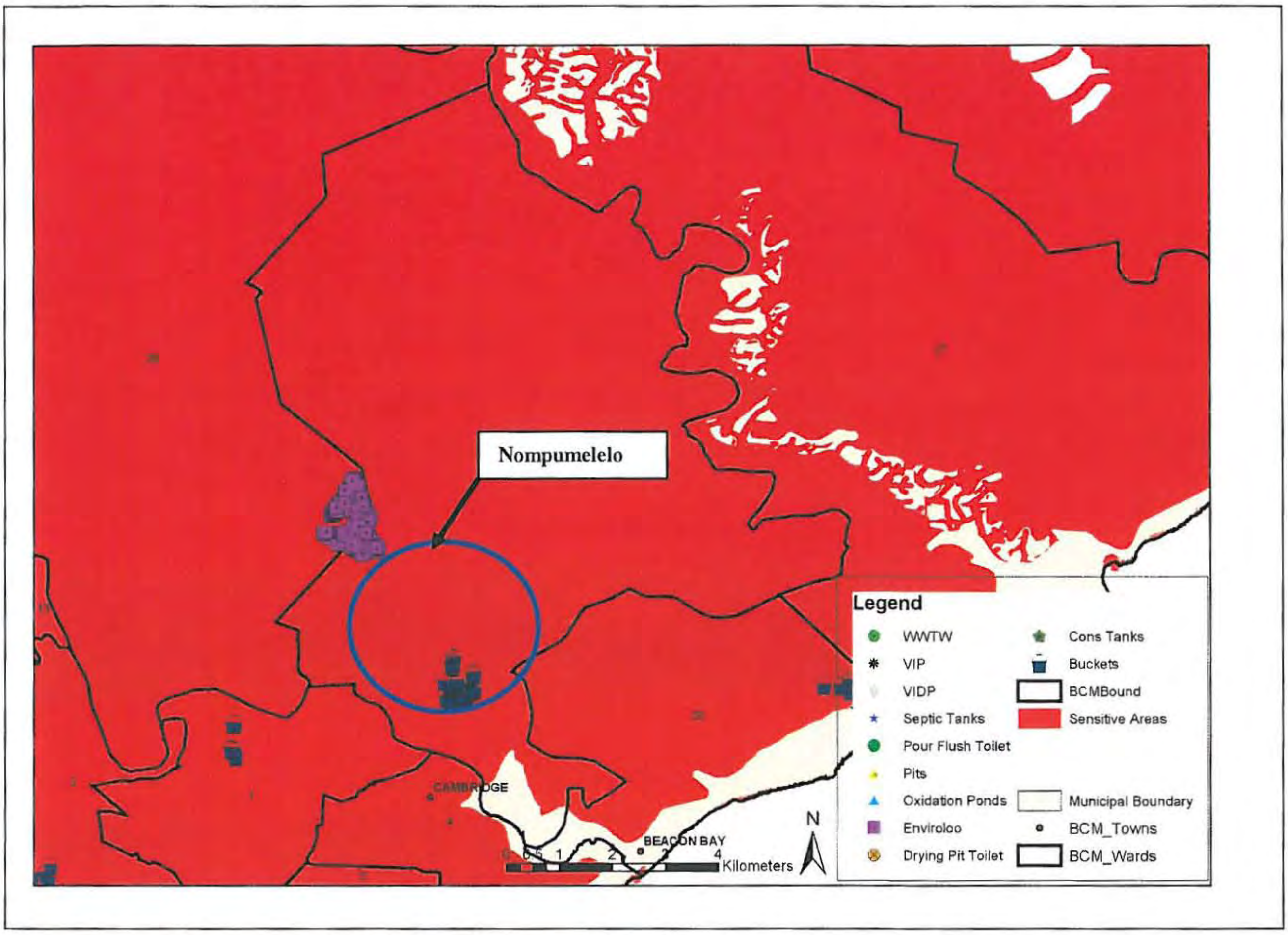

Figure 5.6: Sanitation Sensitivity Analysis of Nompumelelo Township

Plate 5.1: Human stool and anal cleansing material located along a path towards a drainage line (Nompumelelo Township)

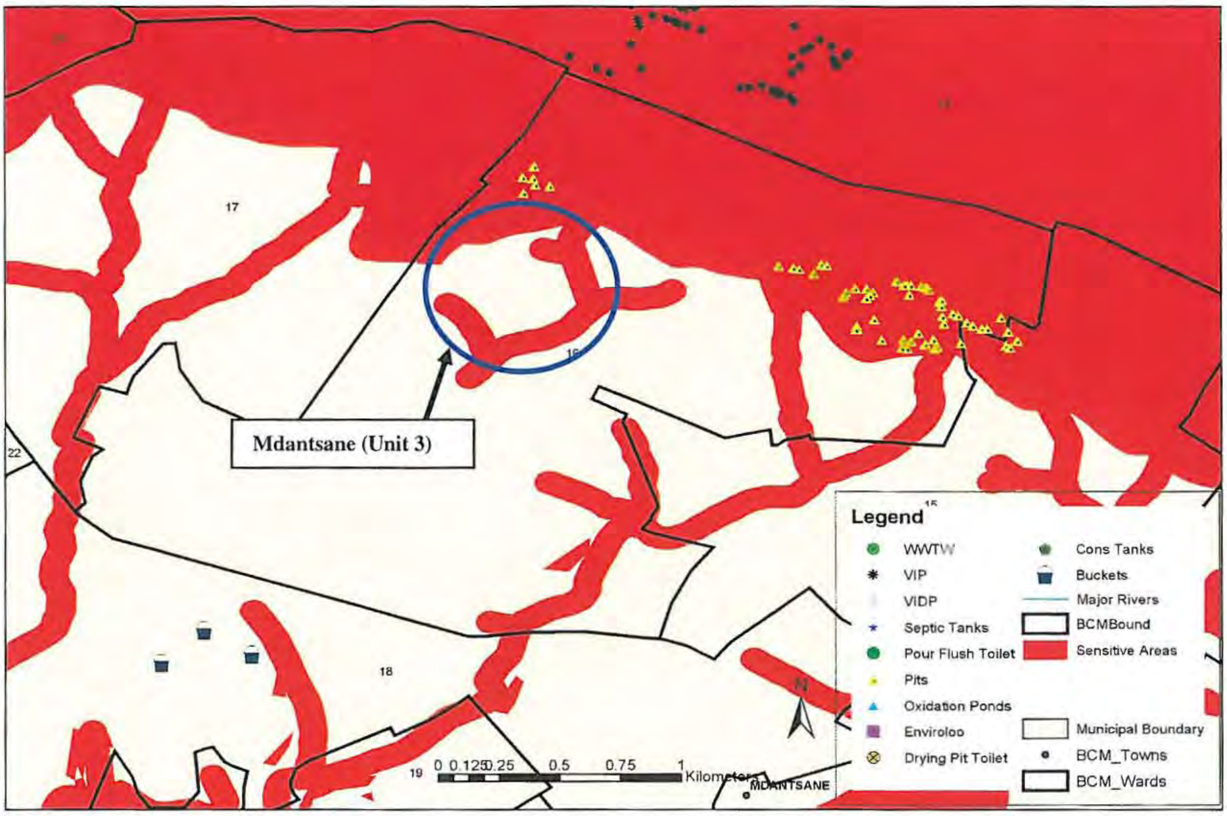

Figure 5.7: Sanitation Sensitivity analysis of Mdantsane (Unit 3)

The feasible sanitation options in Nompumelelo were waterborne, pour-flush, urine diversion and conservancy tanks. This site is considered to be sensitive by the Sanitation Sensitivity Map and therefore the VIP, VIDP, composting and septic tank technologies were not considered as feasible options. The main reason for their exclusion was that, they were considered to cause ground and surface water pollution. In addition the small amount of land available in the Nompumelelo Township as well as the shallow soil excluded these as feasible options. The sustainability of these options was assessed and evaluated in Step 3.

From Table 5.9, it can be deduced that that all eight sanitation technologies were considered feasible in the Mdantsane study site mainly due to the fact it was considered be less sensitive than the other two study sites (Figure 5.7). The decision matrix found that due to pollution of ground and surface water, VIP and VIDP technologies were only considered feasible in Mdanstane. However it is interesting to note that this study site falls in an urban area where these dry technologies are traditionally not installed due to lack of space (WRC, 2008). Nonetheless, they were considered as options and the sustainability of all the feasible options at this study site was assessed and evaluated in Step 3.

Table 5.4: Feasible technology options for each study site

Newlands	Ne
Nompumelelo	No
Mdantsane	Md

Criteria	Indicator	VIP			VIDP			Composting			Waterborne			Pour flush			Septic tank			Urine diversion			Conservancy tank		
		Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md
Pollution of Ground water	-Acceptable distance to water table																								
	-Slope																								
	-Acceptable distance from Dolomite outcrops																								
Pollution of Surface Water	-Acceptable location relative to flood line																								
	-Slope																								
Municipal Approval	- Currently approved technology by BCM																								
Land Availability	-Plot area																								
Piped water availability	Availability																								
Suitable soil porosity	-Soil type																								
	Soil depth																								
Preferred Options		X	X	√	X	X	√	√	X	√	√	√	√	√	√	√	√	X	√	√	√	√	√	√	√
Study Sites for further Assessment		- Mdantsane			-Mdantsane			-Newlands -Mdantsane			-Newlands -Nompumelelo -Mdantsane			-Newlands -Nompumelelo -Mdantsane			-Newlands Mdantsane			-Newlands -Nompumelelo -Mdantsane			-Newlands -Nompumelelo -Mdantsane		

5.3.2 Fine Screening

Table 5.5 below provides a summary of the Sustainability Scores for various sanitation technologies at each study site based on the calculations in Appendix 4.

Table 5.5: BCM Sustainability Scores technology options for all study sites

STUDY SITE	TECHNOLOGY OPTION SUSTAINABILITY SCORES							
	VIP	VIDP	COMP	W/B	P/F	S/T	UD	CONS
Newlands			763	896	820	848	1049	800
Nompumelelo				919	884		1027	898
Mdantsane	757	786	790	939	900	870	1014	836

It is clear from Table 5.5 above that based on the fine screening criteria; the urine diversion technology had the highest Sustainability Score in all three study sites. The scores presented in this table were then reviewed and considered in Step 3 (decision-maker's review) in order to make a final decision on the most sustainable sanitation technology to be installed in each study site.

5.3.3 Decision Makers Review

This involved the review and comparison of the total Sustainability Scores for each feasible sanitation technology option as obtained from the fine screening, the results of which were presented in Table 5.5 above. As discussed in Section 5.2.3, Sustainability Recommendations were also taken into account by ensuring that; no communal facilities would be feasible options, two women were part of the decision-making process and, the identification of feasible options would provide a baseline on which communities would choose the sanitation level they desired and based on what they can afford.

Urine diversion technology had the highest Sustainability Score in all three study sites. During the review and comparison of the total Sustainability Scores for each feasible sanitation technology option, it was ascertained that this high score was attributed largely to the technology meeting the criteria of *Pollution of Surface water, Water conservation, Specific Gender Requirements, Treatment management Ease of monitoring and detection, System Contribution to global warming, Emergency containment and Technology Affordability.* However, even though the urine diversion was considered the most suitable technology in general and finally selected by the decision makers for all three study sites, the specific conditions within which it is to be implemented have to be considered. Provided below is a discussion on how the specificity of the study area would potentially influence the 'sustainability' of the technology.

Newlands Study Site

Even though the urine diversion system was selected for the Newlands study site, the criteria that scored low were *Hygiene awareness*, *Local Resources*, *Cultural norms*, and *Technological problems*. The low scores of the *Hygiene awareness* criterion can be attributed to the fact that the technology was considered difficult to operate and maintain in addition to it not being a well known technology. The low score for the *Cultural norms* criterion arose from the fact that communities in this area and BCM as a whole consider human excreta to be dirty and a substance that must be avoided and not handled. Dunker *et al.* (2006) also noted the reluctance to handle human excreta in the Kwazulu-Natal and North West Provinces of South Africa and found that it was contributing to the mismanagement and misuse of this technology type. Because the urine diversion system is not well known in the area and South Africa as a whole compared to the other feasible options, the criteria of *Technological Problems* and *Local Resources* were not met in this study site. According to Dunmade (2002), for a technology to be sustainable, local servicing resources including technical experts, maintenance facilities and materials specific to the technology must be available.

The other feasible technology options in this study site were composting toilets, septic tanks, waterborne toilets, pour-flush toilets and conservancy tanks. The composting toilet is the only technology out of these remaining feasible options that would not require the availability of water. The criteria that differentiated the scores between the composting toilet technology and the urine diversion technology and scored much lower were mainly, *Ease of education*, *Pollution of Ground water*, *Pollution of Surface water*, *Odour*, *Safe disposal* and *Treatment management*. The *Treatment management* criterion is a very important criterion especially in the BCM context because the State of Sanitation Report (BCM, 2006) states that there is no sludge management for the technology. This is one of the main criteria limiting the establishment of this technology in Newlands. Technologies that required water availability in the area would face the challenge identified in the coarse screening process. The BCM IEMP Unit officials confirmed that no plans for piped water were expected in the Newlands area in the next five years and existing waterborne and septic tank technologies use private water supplies not provided by the municipality. The fact that the municipality does not envisage supplying piped water, is considered a fatal flaw for the establishment of water dependent technology options, even though they underwent the fine screening process. From this information, it is suggested that the criterion of *Piped water availability* should have been a fatal flaw criterion in the coarse screening process that excluded technologies requiring water at an earlier stage of technology selection.

In essence the only technologies that should gone to the decision review stage are urine diversion and composting toilets because they do not require piped water for operation. The BCM stakeholders made the final decision that due to the environmental protection, economic beneficiation and affordability advantages the urine diversion technology has over the other technologies, it should be considered as the technology for implementation in the Newlands study site. However, during the implementation process strategies that address the criteria that scored low during the fine screening process should be instituted, especially education needs and cultural aspects.

Nompumelelo Study Site

Although the urine diversion system was considered to be the most sustainable technology at this study site, some of the criteria including; *Hygiene awareness*, *Ease of education*, *Health risks*, *Political Stakeholder Commitment*, *Technological problems*, *Acceptability*, *Willingness to pay*, *Local Resources* and *Cultural norms* scored low and were not met.

The *Hygiene awareness* criterion for the urine diversion system scored low compared to that for the other feasible options mainly due to the fact that it is a technology that is considered to be difficult to operate and maintain, and an unfamiliar technology to the users in the Nompumelelo study site. The criterion for *Political Stakeholder Commitment* scored low because the Ward Councillor would not approve of its use in Nompumelelo. This may also have contributed to the low scores for the criteria of *Acceptability* and *Cultural norms*. Milburn *et al.* (2002) also found that the implementation of urine diversion technologies in densely populated areas is affected by cultural and organisational restrictions and political will.

The other feasible options were waterborne, pour-flush and composting toilets. All these technologies require piped water availability for operation. The Nompumelelo area does have piped water, but this is only available from stand pipes and is not provided to individual households. During discussions with BCM IEMP Unit, it was not clear as to when the Nompumelelo area would be provided with individual water supply. This is an interesting scenario, in which piped water is made available, but only for drinking and domestic use which does not include sanitation. The BCM IEMP Unit confirmed that the existing waterborne and septic tank technology facilities are currently supplied by an old borehole that serviced the former farm that the township is now situated on. The capacity of this water source to supply the Nompumelelo area was determined by the BCM Engineering department as low and therefore unsustainable. Therefore, the township was included into a municipal water supply plan that would only be implemented in 2014 (Ingles, 2008). This reflects the findings by the WHO (2000) that in most developing countries water dependent sanitation technologies have proven to be impractical as it is difficult enough to provide potable water to a tap at a stand pipe for drinking purposes, let alone for flushing toilets with a reliable and uninterrupted water connection. Consequently, the unsustainable supply of the current borehole and the provision of piped water to the site for sanitation purposes earmarked to occur only in 2014, renders the *Piped water supply* criterion as a fatal flaw that should have excluded the water dependent technologies during the coarse screening process, before inclusion into the fine screening process.

The decision made during the decision makers review was to implement the urine diversion system due to the fact that the site was highly sensitive to pollution as discussed in the coarse screening process and the major environmental and technological and advantages the technology offered. However, the criteria that scored low should be taken into consideration during implementation, especially the *Hygiene awareness, Political Stakeholder Commitment, Cultural norms, Willingness to pay, Local resources and Acceptability criteria.* It was discussed in the meeting that these criteria should be formulated into strategies to address the perceptions, desires and community buy-in before the implementation of the technology in Nompumelelo. If these criteria are not taken into consideration during the implementation phase, there is a very high chance that the technology will be unsustainable and BCM will be in the same position it is in currently.

Mdantsane Study Site

Irrespective of the fact that the urine diversion technology was considered the most sustainable option for the Mdantsane study site, it scored low and did not meet the criteria for *Hygiene awareness, Health risks, User buy-in, Acceptability, Ease of education, Political Stakeholder Commitment* and *Cultural norms.* The main reason why these criteria scored low was due to the fact that the technology was relatively unknown and its practical implementation in the study site was uncertain. The criteria that scored low for this technology were mainly health and social in nature and the fact that the technology was unknown and crossed cultural barriers may explain the low scores scored for the *User by-in, Acceptability, Ease of Education* and *Political Stakeholder Commitment* criteria. Insert explanation on why each of the above criteria scored low in this study area.

The other seven technologies presented in Table 5.5 were considered feasible sanitation options for this study site. These technologies ranged from dry technologies to wet technologies and posed different challenges to implementation. Although the VIPs, VIDPs and composting toilets were considered as feasible option in the study site, the fact that they have larger land requirements that the other technologies (e.g. waterborne, pour-flush) and would therefore be less feasible in the urban context was not made effectively enough by the coarse screening process. The BCM IEMP Unit and Ward Councillor of the study site affirmed that Mdantsane (Unit 3) can only accommodate households with plot sizes below $100m^2$ and therefore there would be very little space to include VIPs, VIDPs or composting toilets onsite. This suggests that the *Land availability* criterion should be considered a fatal flaw during the coarse screening process so as to exclude the technologies that require large plots before the fine screening process. In addition the BCM IEMP Unit confirmed that wet technologies like the septic tank and conservancy tank require at least $2000m^2$ to be installed. This land requirement far surpasses the land available on each plot and therefore these technologies should also not be considered feasible and excluded during the coarse screening process.

The waterborne and pour-flush systems were mainly limited by the criterion of *Treatment management*. This is mainly due to the fact that the nearest treatment facility which is Mdantsane East is already operating at 111% and any further connections to the WWTWs would only exacerbate the poor management of the WWTWs and cause further non-compliant effluent to be disposed of into the environment. Consequently, the BCM IEMP Unit and the Ward Councillor decided that the final decision should be that the urine diversion technology be installed at the study site due to the environmental and technical advantages it has over the other technologies. However, as with the other study sites, the conditions of the implementation of the technology should take into account the criteria that scored low and incorporate them into implementation strategies to ensure the sustainability of the technology.

In general, based on the discussion above, it is clear that although the urine diversion system was selected at all three study sites, largely as a result of the high scores obtained in the environmental impact category as well as the financial and economic approach, there were other important criteria particularly in the categories of; health and hygiene education and promotion; community issues and resources development; technical considerations; and institutional and organisational frameworks which scored low and were not met. It was therefore imperative that the latter categories be considered before the technology can be implemented in any of these study sites. In the event that these challenges cannot be met, other feasible technology options would have to be considered.

The decision-makers took the criteria not met into consideration and proposed that implementation strategies for the urine diversion technology be instituted prior to implementation. It was suggested that a Sanitation task team made up of the BCM officials and the Ward Councillors drive the implementation of the strategies and monitor its progress and report back to the task team. The following implementation strategies were suggested for all study sites:

- Sanitation Awareness Campaign
- Sanitation Health and Hygiene Programme
- Urine Diversion Training
- Troubleshooting Training

Some of the issues raised during the review process by the BCM Selection Criteria List would not have been considered in the normal BCM decision-making process. The BCM IEMP Unit officials and the Ward Councillors therefore noted that the process of applying the criteria was useful in informing them as to which issues they needed to take into consideration when making decisions. In addition, they decided to continue using the BCM Sanitation Selection Criteria List in future in order to assist the municipality in ensuring that sustainability remains the core focus in sanitation provision.

Based on the results presented in this chapter, some of the strengths of the Criteria Implementation Approach become apparent. These included:

- The integration of different tools;
- The integration of multiple perspectives, and;
- The incorporation of creative design.

Each of these is discussed in more detail below.

The integration of different tools

The approach brought together the strengths of different tools such as the use of GIS data, sensitivity analysis and criteria, and indicator analysis to inform decision-making. This integration of tools was also identified by the development of COMPLIMENT developed by Hermann *et al.* (2007), where strengths in the methodologies of Life Cycle Assessment, Multiple-Criteria Analysis and Environmental Performance Indicators were combined. The tool was both useful and applicable to different situations (Hermann *et al.*, 2007). The approach developed in this research is also adaptable and would only require that context specific criteria be incorporated and GIS information included before a final decision can be made. Rousis *et al.* (2008) used a decision-making method called PROMETHEE that selected between different management schemes/systems for waste management. Their research also produced a sensitivity analysis like the Sanitation Sensitivity Map and assisted in a final decision on the most suitable alternative management style to use.

The integration of multiple perspectives

The second strength of this approach was the development of criteria and indicators organised into multiple categories that the National Sanitation Policy (RSA, 1996a) identified as components that contribute to sustainable sanitation. These categories were health and hygiene education promotion, community issues and human resources development, environmental impact, financial and economic approach, technical considerations, institutional and organisational frameworks. The importance and value of using criteria and indicators focused on multiple perspectives has been identified in the literature (Hall *et al.*, 2005; Al-Sa'ed & Mubarak, 2006; Hall & Davis, 2007; Labuschagne & Brent, 2007; Wadhwa *et al.*, 2009). For example Labuschagne & Brent (2007) concluded that the incorporation of criteria that consider the environmental, social and economic, as presented in this research, addressed the objectives and aims of sustainable development and ensured that decisions could be made using a transparent process. This approach was also used by Al-Sa'ed & Mubarak (2006) who selected sustainable onsite sanitation systems in Palestine based on social, economic and environmental considerations. In addition, Hall & Davis (2007) confirmed that decisions made based on multiple perspectives as presented by the approach taken in this research, enhanced decision makers' abilities to make better-informed decisions.

The incorporation of creative design

The third strength of this approach was its creative design which provided the decision makers with options and information which they may not have otherwise considered. The impact of creativity on the decision making process was researched by Guissppi & Newman (2007) by applying a creativity enhancing decision making support system. They stated that during their research it was apparent that the creative approach to decision making improved the process of and outcome of decision making by generating ideas and providing information. The BCM decision makers who used the Criteria Implementation Approach commented that it provided them with a different perspective whilst making a decision (Appendix 5). This confirmed that the creativity of the approach informed the decision makers thus improving the decision-making process and informing the outcome of the decision.

5.4 CONCLUSION

The application of the BCM Sanitation Selection Criteria List was undertaken through application of the Criteria Implementation Approach which involved three steps of, Coarse Screening, Fine Screening and the final decision-makers review. The results included the identification of feasible sanitation options for the implementation of the BCM Sanitation Selection Criteria List. It was identified that the process provided new insights and provided different perspectives into decision making for the BCM officials. It also integrated different tools to ensure all aspects of sanitation were considered. In addition, the approach informed the decision-makers of important issues that needed to be taken into consideration by incorporating Sustainability Recommendations. Furthermore, it was realised that in certain instances, those criteria that did not score highly in the decision making process needed to be addressed prior to the final selection and implementation of a technology. This found that the criteria of *Land availability* and *Piped water availability* should have been documented as fatal flaws during the coarse screening process due to the fundamental limitations they pose on certain technology options. In addition, the decision making review process developed proposed implementation strategies for the study sites to address the criteria that scored low and ensure the long-term sustainability of the urine diversion system in the respective study sites. The BCM Stakeholders involved in this implementation process found the approach to be of value and have stated that they will consider the Sustainability Criteria and Indicator List in future sanitation decision making.

CHAPTER 6: GENERAL DISCUSSION AND CONCLUSION

The South African State of the Nation 2007 Report (Buhlungu *et al.*, 2007) states that South Africa is obliged by its commitment to paragraph 162 (b) of the Johannesburg Plan of Implementation (JPOI) which states that, "*States should take immediate steps to make progress in the formulation and elaboration of national strategies for sustainable development and begin their implementation by 2005...Such strategies could be formulated as poverty reduction strategies that integrate economic, social and environmental aspects of sustainable development...in accordance with national priorities.*" This required South Africa to formulate a National Strategy for Sustainable Development (NSSD) and municipalities to take part in this process. This obligation included the development of explicit goal-orientated policy frameworks and strategies to meet the Millennium Development Goals (MDGs) including "*halving the number of people without access to sanitation by 2015*." Although this strategy was supposed to be lodged with the UN in 2005, it was still being developed at that time. To date, the only explicit statement of sustainability criteria integration into National Policy made by the NSSD is the call to government to, "*decouple growth from natural resource consumption and continued degradation of ecosystems*" (Buhlungu *et al.*, 2007).

Buffalo City Municipality (BCM) in the Eastern Cape Province of South Africa is aware of the MDGs and National obligations as well as their targets and has already identified aspects that threaten sustainable development within the municipality including environmental pollution as a result of poorly functioning and managed sanitation infrastructure (BCM, 2005; BCM, 2006), and inadequate sanitation provision. Sanitation systems in BCM are already under stress with pressures stemming from reduced rainfall, increased population, increased urbanisation, water scarcity and the need to address the sanitation backlog of 92 055 people and 26 306 households (DWAF, 2008). Whilst it may be tempting to simply provide waterborne sanitation technology to all in an attempt to meet the backlog targets, this would be short sighted and may contribute to further overloading of existing infrastructure including Waste Water Treatment Works (WWTWs). As discussed in Chapter 3 of this thesis, many of these WWTWs in BCM are currently producing 'treated' effluent that does not meet National Department of Water Affairs and Forestry (DWAF) discharge standards consequently posing a threat to ecosystems and human health. As a result, improved methodology for selecting the most sustainable sanitation option(s) in BCM was required. This research would also provide a useful update of the 2006 BCM State of Sanitation Report (BCM, 2006).

The main sanitation issues faced by BCM were found to be the poor management of on-site rural sanitation facilities, and the frequent release of poor effluent from urban sanitation facilities into major freshwater and coastal water resources. Although it was not the objective of this thesis to prove the linkage between discharge of poorly treated effluent and the quality of marine and freshwater resources, in BCM, a preliminary examination of water quality data did point in this direction. Importantly, the findings presented in Chapter 3 provided a sound rationale for the urgent development of a decision support tool that could facilitate the selection of appropriate sanitation technologies for BCM. Based on discussions with key stakeholders and review of relevant literature, it became apparent that any such system would need to involve the extensive involvement of local communities and municipal officials and that the selection process would need to balance the needs and desires of these communities with economic, technical and environmental considerations.

The objective of developing a decision support tool for the selection of sanitation technologies in BCM was achieved through the development and application of the Sustainability Criteria and Indicator Approach. This approach also resulted in the development of a weighting system, a coarse screening decision matrix and a Sanitation Sensitivity Map to assist with selection of sanitation technologies in BCM in order to ensure that the most sustainable technologies are selected for a given context. The approach made use of the sustainability list proposed by Bracken *et al.* (2005), which proved useful and relevant to the development of sustainability criteria in BCM. Criteria and indicators were effectively adapted and expanded. The consolidation and weighting of the criteria and indicators provided a useful method of quantifying the sustainability of each technology during the selection process. Use of the coarse screening decision matrix ensured that sanitation technologies could be screened for their suitability within a given context, thereby reducing the number of technologies requiring detailed fine screening based on the BCM Sanitation Selection Criteria List.

Based on the results of the literature review presented in Chapter 2, it was clear that the challenges facing BCM with respect to the improvement of sanitation systems were common to many other municipalities within South Africa and indeed many other developing countries. Although software based decision support systems appropriate to the sanitation field do exist, it is believed that the approach developed during the current study is potentially more easily adapted to a variety of different spatial scales. The degree of context-specificity can be adjusted to suit a small rural community, a larger town or city, or even a province or country. At the larger scale, the approach may be used at a strategic level to inform the development of sanitation policy, while application at a small spatial scale is likely to be aimed at the actual provision of sanitation systems. In general, one of the main advantages of the approach was its adaptability. The approach need not be limited to sanitation provision, but could be equally well applied to the provision of potable water and other basic municipal services.

The pilot implementation of the final sanitation selection criteria in three study sites selected as examples of a rural, peri-urban and urban area resulted in the development of the Criteria Implementation Approach. This approach involved three steps; Coarse Screening, Fine Screening and the final Decision-makers review. The pilot application of the tool confirmed the importance of a wide variety of stakeholders in the initial development of the tool. This continuity meant that all involved in the pilot testing were not only aware of the need for such a tool, but were also interested and able to contribute in a meaningful way to the pilot testing. Interestingly, the tool was even accepted by the engineering professionals in BCM who have traditionally been more concerned with the technical practicalities and costing of sanitation options rather than environmental and social considerations.

The results of the pilot implementation found the urine diversion sanitation system to be the most sustainable technology in all three pilot communities in BCM. One concern however, was that the existing approach may have resulted in some sanitation technologies obtaining higher relative sustainability scores despite having lower scores for some key indicators. For instance, high scores for environmental indicators may balance particularly low scores for certain social indicators such as "community acceptance" and this would need to be addressed prior to final approval of a technology where the score of this indicator was initially low. It is suspected that the urine diversion technology would, in particular, face this type of challenge, yet it is regarded as highly sustainable from an environmental perspective under the right conditions. The BCM Stakeholders involved in this implementation process found the approach to be of value to BCM (Appendix 5) and stated that, this research, "*provided a useful tool to assist municipal decision making for sanitation technologies within BCM...* and *...provided BCM with a set of tools and information to help it practically operationalise sustainability within the functioning of the organisation, specifically with regards to sanitation.*" They further stated that this research has, "*been useful as far as updating the State of Sanitation Report...*"

Even though this research produced many useful outcomes, the development and application of sustainability criteria and sanitation requires further study, particular aspects include:

1. Further refinement of both AII weightings, coarse screening criteria and fine screening criteria based on stakeholder engagement;

2. Comparison of the long-term (10-20 years) sustainability of the sanitation technologies in a specific area that had been selected using criteria versus technologies that were not selected using criteria;
3. Extension of similar selection criteria to either components of the waterborne sanitation system (WWTW technology) or other municipal infrastructure (collection, transport, disposal);
4. Application of the Sanitation Selection Criteria List in other municipalities where perceptions, constraints and desires regarding sanitation may be different.

CHAPTER 7: REFERENCES

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APPENDIX 1: CONSOLIDATED BCM CRITERIA AND INDICATOR LIST

CONSOLIDATED BCM CRITERIA AND INDICATOR LIST

Sustainability Recommendations

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS
1. Health and hygiene education and promotion		
	Ease of education: Education of hygienic use of the sanitation technology	**-Ease of education**
	User willingness: User willingness to address and understand the risks of using the sanitation technology	**-User acceptance of health education**
	Hygiene Awareness – The sanitation technology must promote awareness of hygienic practices	**-Difficulty of operation and maintenance to intended user** **-Novelty of technology operation and maintenance**
	Health Risks- The sanitation technology must have measures and structures in place that promote health and hygienic practises to protect the community and the environment from risks disease and pollution by instituting the use of barriers and hygienic practises between human excreta and the community and surrounding environment	**-Hand washing facilities** **- Structures for pest control**
2. Community issues and human resources development		
	User Willingness to pay– User by-in to contributing to the safe use of the sanitation technology	**-User Buy-in**
	***Inclusion of women–** **Involve women in the decision making process to provide perspective into women's needs for different technologies**	**NONE IDENTIFIED**
	Specific Gender Requirements - The technology must have facilities installed for both sexes	**Gender specific requirements** **Gender needs**
	Cultural norms – The sanitation technology must take into consideration the societal norms and practices	**-Cultural boundaries crossed**
	User privacy – Capacity of sanitation technology to encourage privacy needs of users	**- Doors attached** **-Location of technology entrance**
	User Safety - The technology should preferably be located within or in close proximity of the household to provide user safety	**-Located within the household property**
	User Convenience – The sanitation technology must be located within or in close proximity of the household	**-Location of technology**
	Local Resources– Local materials and labour should be used to build the technology infrastructure	**-Availability of local resources for building** **-Availability of local building skill (community)**
	Accessible – The sanitation technology should be accessible to all household members including young children, the elderly and the disabled	**-Access to the facility** **-Provision for a child seat**
	Odour – The sanitation technology should not emit unpleasant odours, particularly inside the	**-Prone to Odour**

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS
	household	
	***Ownership** – Ownership of the toilet should be promoted to ensure sustainable operation and maintenance*	**NONE IDENTIFIED**
	Acceptability– The sanitation technology must be considered as an acceptable form of sanitation technology in terms of the policy's definition and by BCM (as the Local government) and the target community as users	**-Accepted by community -Culturally appropriate -BCM approved - DWAF approved**
	Safe Collection – The sanitation technology must have measures in place that ensures the safe handling of human excreta during collection	**-Human contact with un-sterile material during collection**
	Safe Removal – The sanitation technology must have measures in place that facilitates the safe removal of human excreta so that it does not impact on the community or the environment	**-Human contact to excreta during removal**
	Safe Disposal – The sanitation technology must have measures in place that ensures the safe treatment of human excreta that does not negatively impact on the environment	**-Human contact with un-sterile material during disposal**
3. Environmental impact		
	Land availability	**-Plot Area**
	Chemicals used for cleaning the system	**-Cleaning Chemicals**
	Piped freshwater availability	**-Availability**
	System contributes to global warming	**-Carbon dioxide emissions**
	Recycled product: Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	**-Correct Storage**
	Water Conservation – The sanitation technology must promote water saving and minimise the depletion of the surface and ground water resources	**-Amount of water used during operation and maintenance**
	Pollution of Ground Water- The sanitation technology must not be installed in a area that would contribute to the pollution or decrease in quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with untreated effluent and sludge during storage, transportation, treatment and or disposal	**- Distance to water table (>1.5m) - Possible contact during storage transportation, treatment and disposal - Likelihood of safe transportation and storage - Slope (<30°)**
	Pollution of Surface Water - The sanitation technology must not be installed in areas prone to pollute and decrease the quality of fresh and marine water (ecological and human reserve) by ensuring that surface water will not come into contact with untreated effluent and sludge during transportation, storage and disposal	**- Location relative to flood line (>100m) - Slope (<30°) - Quality of discharged effluent during disposal - Distance from fault lines (>100m) - Distance from Dolomite outcrops (>100m) -BCM Sanitation Department's authorisation - DWAF authorisation - Distance to water table (>1.5m)**
	Treatment of Excreta – Methods of excreta handling from source to disposal must not negatively affect the environment	**-Treatment separates excreta from the environment before safe disposal**
	Waste Beneficiation – Recycling and re-use opportunities must be instituted into the treatment of excreta	**-Possible Use of any by-product produced from treatment**
	Treatment Management-	**- Likely quality of discharged effluent during disposal**

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS
	The sewage treatment technology must be have adequate capacity to accommodate sewage from the target community population	**-Technology must be able to accommodate the intended volumetric load**
	Ease of monitoring and detection - The technology should have systems in place that allows for the monitoring and early detection of problems	**-Technology allows for leaks and spills to be identified quickly** **-Technology malfunctions can be identified quickly and at source** **-Technology allows for mechanisms to be continuously monitored**
	Emergency Containment: Ability to contain sewage from the environment in disaster situations	**- Sufficiently large backup holding facility available**
	Suitable soil porosity – Soil supporting system shall be of sufficient porosity and depth for the disposal of effluent	**-Soil type (Loam)** **-Soil depth (>1.5m)**
4. Financial and economic approach		
	***Flexibility of Choice* – Households must be responsible to choose the sanitation service level they desire and based on what they can afford**	**NONE IDENTIFIED**
	Economic beneficiation opportunities – The sanitation technology must provide economic opportunities from by-products produced	**-Viable income from the safe treatment of by-products**
	Technology Affordability – The sanitation technology must be affordable from installation, operation and maintenance perspectives from BCM and household levels	**- Affordability to Municipality** **- Affordability to Household**
5. Technical considerations		
	Technological problems – The availability of spare parts for maintenance of the sanitation technology	**-Availability of spare parts for operation and maintenance of the technology**
	Local Technological Skill- Capability of local skill development for construction, repairing and maintaining the sanitation technology	**-Community/ Household by-in to develop skills for construction and maintenance of the technology**
6. Institutional and organizational frameworks		
	Political and Stakeholder Commitment – Support from political parties and stakeholders for sustainable sanitation technologies must be encouraged	**-Local ward committee approval** **-BCM Council approval**
	Municipal approval – Construction plans of sanitation systems should be approved by the municipality	**-Currently approved technology by BCM**

APPENDIX 2: CALCULATION OF AII SCORES

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS	Scientific	Engineering	Amenities	Env Health	Dev Plan	Cleansing	Env Serv	IDP	IEMU	mean	SD	AII
1. Health and hygiene education and promotion														
	Ease of education: Education of hygienic use of the sanitation technology	**-Ease of education**	4	5	6	6	6	6	6	5	6	5.6	0.73	8
	User willingness: User willingness to address and understand the risks of using the sanitation technology	**-User acceptance of health education**	5	6	6	5	6	5	5	4	6	5.3	0.71	8
	Hygiene Awareness – The sanitation technology must promote awareness of hygienic practices	**-Difficulty of operation and maintenance to intended user**	6	5	6	6	4	5	6	6	6	5.6	0.73	8
		-Novelty of technology operation and maintenance												
	Health Risks- The sanitation technology must have measures and structures in place that promote health and hygienic practises to protect the community and the environment from risks disease and pollution by instituting the use of barriers and hygienic practises between human excreta and the community and surrounding environment	**-Hand washing facilities** **- Structures for pest control**	6	6	6	6	5	6	6	6	6	5.9	0.33	18
2. Community issues and human resources development														
	User Willingness to pay– User by-in to contributing to the safe use of the sanitation technology	**-User Buy-in**	6	4	6	6	6	6	6	6	6	5.8	0.67	9
	Specific Gender Requirements - The technology must have facilities installed for both sexes	**-Gender specific requirements**	6	6	6	6	5	5	5	6	6	5.7	0.50	11
	Cultural norms – The sanitation technology must take into consideration the societal norms and practices	**-Gender needs** **-Cultural boundaries crossed**	6	6	5	5	5	5	6	6	6	5.6	0.53	11

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS	Scientific	Engineering	Amenities	Env Health	Dev Plan	Cleansing	Env Serv	IDP	IEMU	mean	SD	All
	User privacy – Capacity of sanitation technology to encourage privacy needs of users	**- Doors attached** **-Location of technology entrance**	4	5	4	5	3	4	5	3	5	4.2	0.83	**5**
	User Safety - The technology should preferably be located within or in close proximity of the household to provide user safety	**-Located within the household property**	4	5	3	5	5	5	5	6	5	4.8	0.83	**6**
	User Convenience – The sanitation technology must be located within or in close proximity of the household	**-Location of technology**	6	5	5	4	4	5	5	6	6	5.1	0.78	**7**
	Local Resources– Local materials and labour should be used to build the technology infrastructure	**-Availability of local resources for building** **-Availability of local building skill (community)**	5	4	5	3	3	5	4	5	6	4.4	1.01	**4**
	Accessible – The sanitation technology should be accessible to all household members including young children, the elderly and the disabled	**-Access to the facility** **-Provision for a child seat**	4	5	3	4	3	5	4	3	6	4.1	1.05	**4**
	Odour – The sanitation technology should not emit unpleasant odours, particularly inside the household	**-Prone to Odour**	6	6	6	4	6	4	6	6	6	5.6	0.88	**6**
	Acceptability– The sanitation technology must be considered as an acceptable form of sanitation technology in terms of the policy's definition and by BCM (as the Local government) and the target community as users	**-Accepted by community** **-Culturally appropriate** **-BCM approved** **- DWAF approved**	4	6	5	5	4	5	3	5	5	4.7	0.87	**5**
	Safe Collection – The sanitation technology must have measures in place that ensures the safe handling of human excreta during collection	**-Human contact with un-sterile material during collection**	5	4	5	6	5	4	5	5	6	5.0	0.71	**7**
	Safe Removal – The sanitation technology must have measures in place that facilitates the safe removal of human excreta so that it does not impact on the community or the environment	**-Human contact to excreta during removal**	5	4	5	6	4	6	4	6	6	5.1	0.93	**6**

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS	Scientific	Engineering	Amenities	Env Health	Dev Plan	Cleansing	Env Serv	IDP	IEMU	mean	SD	All
	Safe Disposal – The sanitation technology must have measures in place that ensures the safe treatment of human excreta that does not negatively impact on the environment	**-Human contact with un-sterile material during disposal**	5	4	6	6	4	6	5	5	6	5.2	0.83	**6**
3. Environmental impact														
	Land availability	**-Plot Area**	5	6	6	4	5	6	4	5	6	5.2	0.83	**6**
	Chemicals used for cleaning the system	**-Cleaning Chemicals**	6	5	6	4	6	5	6	6	6	5.6	0.73	**8**
	Piped freshwater availability	**-Availability**	6	6	4	6	6	6	6	6	6	5.8	0.67	**9**
	System contributes to global warming	**-Carbon dioxide emissions**	6	5	5	6	6	5	4	6	6	5.4	0.73	**7**
	Recycled product: Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	**-Correct Storage**	6	4	5	3	5	2	5	6	3	4.3	1.41	**3**
	Water Conservation – The sanitation technology must promote water saving and minimise the depletion of the surface and ground water resources	**-Amount of water used during operation and maintenance**	6	5	6	6	6	6	5	6	6	5.8	0.44	**13**
	Pollution of Ground Water- The sanitation technology must not be installed in a area that would contribute to the pollution or decrease in quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with untreated effluent and sludge during storage, transportation, treatment and or disposal	**- Distance to water table (>1.5m)**	5	6	5	5	5	5	6	5	5	5.2	0.44	**12**
		- Possible contact during storage transportation, treatment and disposal												
		- Likelihood of safe transportation and storage												
		- Slope (<30°)												
	Pollution of Surface Water - The sanitation technology must not be installed in areas prone to pollute and decrease the quality of fresh and marine water (ecological and human reserve) by ensuring that surface water will not come	**- Location relative to flood line (>100m)**	6	6	6	6	6	6	6	5	6	5.9	0.33	**18**
		- Slope (<30°)												
		- Quality of discharged effluent during disposal												
		- Distance from fault lines (>100m)												

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS	Scientific	Engineering	Amenities	Env Health	Dev Plan	Cleansing	Env Serv	IDP	IEMU	mean	SD	All
	into contact with untreated effluent and sludge during transportation, storage and disposal	**- Distance from Dolomite outcrops (>100m)**												
		-BCM Sanitation Department's authorisation												
		- DWAF authorisation												
		- Distance to water table (>1.5m)												
	Treatment of Excreta – Methods of excreta handling from source to disposal must not negatively affect the environment	**-Treatment separates excreta from the environment before safe disposal**	4	6	5	4	6	5	4	6	4	4.9	0.93	**5**
	Waste Beneficiation – Recycling and re-use opportunities must be instituted into the treatment of excreta	**-Possible Use of any by-product produced from treatment**	4	4	5	6	3	4	4	4	6	4.4	1.01	**4**
	Treatment Management- The sewage treatment technology must be have adequate capacity to accommodate sewage from the target community population	**- Likely quality of discharged effluent during disposal**	6	5	6	6	6	6	6	6	6	5.9	0.33	**18**
		-Technology must be able to accommodate the intended volumetric load												
	Ease of monitoring and detection - The technology should have systems in place that allows for the monitoring and early detection of problems	**-Technology allows for leaks and spills to be identified quickly**	6	6	6	6	5	5	5	6	6	5.7	0.50	**11**
		-Technology malfunctions can be identified quickly and at source												
		-Technology allows for mechanisms to be continuously monitored												
	Emergency Containment: Ability to contain sewage from the environment in disaster situations	**- Sufficiently large backup holding facility available**	6	4	5	4	4	4	5	5	6	4.8	0.83	**6**
	Suitable soil porosity – Soil supporting system shall be of sufficient porosity and depth for the disposal of effluent	**-Soil type (Loam)**	5	5	4	4	3	4	2	4	4	3.9	0.93	**4**
		-Soil depth (>1.5m)												

BCM CRITERIA CATEGORY	BCM CRITERIA	BCM INDICATORS	Scientific	Engineering	Amenities	Env Health	Dev Plan	Cleansing	Env Serv	IDP	IEMU	mean	SD	All
4. Financial and economic approach														
	Economic beneficiation opportunities – The sanitation technology must provide economic opportunities from by-products produced	**-Viable income from the safe treatment of by-products**	4	5	6	5	5	6	4	3	5	4.8	0.97	**5**
	Technology Affordability – The sanitation technology must be affordable from installation, operation and maintenance perspectives from BCM and household levels	**- Affordability to Municipality** **- Affordability to Household**	3	5	4	6	5	5	4	5	6	4.8	0.97	**5**
5. Technical considerations														
	Technological problems – The availability of spare parts for maintenance of the sanitation technology	**-Availability of spare parts for operation and maintenance of the technology**	6	5	6	5	5	6	5	6	6	5.6	0.53	**11**
	Local Technological Skill- Capability of local skill development for construction, repairing and maintaining the sanitation technology	**-Community/ Household by-in to develop skills for construction and maintenance of the technology**	5	6	4	5	5	4	5	6	6	5.1	0.78	**7**
6. Institutional and organizational frameworks														
	Political and Stakeholder Commitment – Support from political parties and stakeholders for sustainable sanitation technologies must be encouraged	**-Local ward committee approval** **-BCM Council approval**	6	5	6	6	5	6	5	4	6	5.4	0.73	**7**
	Municipal approval – Construction plans of sanitation systems should be approved by the municipality	**-Currently approved technology by BCM**	6	5	6	6	6	6	6	6	6	5.9	0.33	**18**

APPENDIX 3: BCM SANITATION SELECTION CRITERIA LIST

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
1. Health and hygiene education and promotion					
	Ease of education: Education of hygienic use of the sanitation technology	8	**-Ease of education**		
			(i) Easily understood	3	24
			(ii) May need demonstration and pilot study to ensure understanding	2	16
			(iii) Difficult to understand	1	8
	User willingness: User willingness to address and understand the risks of using the sanitation technology	8	**-User acceptance of health education**		
			(i) Household and community acceptance	3	24
			(ii) Only Household acceptance	2	16
			(iii) No acceptance	1	8
	Hygiene Awareness – The sanitation technology must promote awareness of hygienic practices	8	**-Difficulty of operation and maintenance to intended user**		
			(i) Low	3	24
			(ii) Medium	2	16
			(iii) High	1	8
			-Novelty of Technology operation and maintenance		
			(i) Well known	3	24
			(ii) Known but awareness raising required	2	16
			(iii) Not known	1	8
	Health Risks- The sanitation technology must have measures and structures in place that promote health and hygienic practises to protect the community and the environment from risks disease and pollution by instituting the use of barriers and hygienic practises between human excreta and the community and surrounding environment	18	**-Hand washing facilities**		
			(i) Permanent facilities available	3	54
			(ii) Temporary facilities available	2	36
			(iii) No hand washing facilities available	1	18
			-Structures for pest control		
			(i) Sealed storage containment structures	3	54
			(ii) Partially sealed containment structures	2	36
			(iii) Open containment structures	1	18
2. Community issues and human resources development					
	User Willingness to pay– User by-in to contributing to the safe use of the	9	**-User Buy-in**		
			(i) YES	3	27

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
	sanitation technology		(ii) NO	1	9
	Specific Gender Requirements - The technology must have facilities installed for both sexes	5	**-Gender specific requirements**		
			(i) Urinal and Pedestal	3	15
			(ii) Pedestal	1	5
			-Gender needs		
			(i) Allows for disposal of sanitary pads	3	15
			(ii) Separate disposal of sanitary pads	1	5
	Cultural norms – The sanitation technology must take into consideration the societal norms and practices	11	**-Cultural boundaries crossed**		
			(i) YES	3	33
			(ii) NO	1	11
	User privacy – Capacity of sanitation technology to encourage privacy needs of users	5	**-Doors attached**		
			(i) Yes	3	15
			(ii) No	1	5
			-Location of technology entrance		
			(i) Inside household	3	15
			(ii) Outside household	1	5
	User Safety - The technology should preferably be located within or in close proximity of the household to provide user safety	6	**--Located within the household property**		
			(i) Inside household	3	18
			(ii) On household property	2	12
			(iii) Off household property	1	6
	User Convenience – The sanitation technology must be located within or in close proximity of the household	7	**-Location of technology**		
			(i) Inside household	3	21
			(ii) On household property	2	14
			(iii) Off household property	1	7
	Local Resources– Local materials and labour should be used to build the technology infrastructure	4	**-Availability of local resources for building**		
			(i) YES	3	12
			(ii) NO	1	4
			-Availability of local building skill (community)		
			(i) YES	3	12
			(ii) NO	1	4
	Accessible – The sanitation technology should be accessible to all household	4	**-Access to the facility**		
			(i) No slope or stairs	3	12

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
	members including young children, the elderly and the disabled		(ii) Sloped entrance	2	8
			(iii) Stairs to entrance	1	4
			-Provision for a child seat		
			(i) YES	3	12
			(ii) NO	1	4
	Odour – The sanitation technology should not emit unpleasant odours, particularly inside the household	6	**-Prone to Odour**		
			(i)YES	3	18
			(ii)NO	1	6
	Safety – The sanitation technology must be secure and located within or in very close proximity of the household	6	**-Location of Technology**		
			(i) Inside household	3	18
			(ii) On household property	2	12
			(iii) Off household property	1	6
	Acceptability– The sanitation technology must be considered as an acceptable form of sanitation technology in terms of the policy's definition and by BCM (as the Local government) and the target community as users	5	**-Accepted by community**		
			(i) YES	3	15
			(ii) Maybe – After awareness raising	2	10
			(ii) NO	1	5
			-Culturally appropriate		
			(i) YES	3	15
			(ii) NO	1	5
			-BCM approved		
			(i) YES	3	15
			(ii) NO	1	5
			-DWAF approved		
			(i) YES	3	15
			(ii) NO	1	5
	Safe Collection – The sanitation technology must have measures in place that ensures the safe handling of human excreta during collection	7	**-Human contact with un-sterile material during collection**		
			(i) Low	3	21
			(ii) Medium	2	14
			(iii) High	1	7
	Safe Removal – The sanitation technology must have measures in place that facilitates the safe removal of human excreta so that it does not impact on the community or the environment	6	**-Human contact to excreta during removal**		
			(i) No exposure	3	18
			(ii) Possible Exposure to sterilized excreta only	2	12

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
			(iii) Possible Exposure to un-sterilised excreta	1	8
	Safe Disposal – The sanitation technology must have measures in place that ensures the safe treatment of human excreta that does not negatively impact on the environment	6	**-Human contact with un-sterile material during disposal**		
			(i) Low	3	18
			(ii) Medium	2	12
			(iii) High	1	6
3. Environmental impact					
	Land availability	6	**-Plot Area**		
			(i) >100 m^2	3	18
			(ii) <100 m^2	1	6
	Chemicals used for cleaning the system	8	**-Cleaning Chemicals**		
			(i) Biodegradable	3	24
			(ii) Non-Biodegradable		8
	Piped freshwater availability	9	**-Availability**		
			(i) YES	3	27
			(ii) NO	1	9
	System contributes to global warming	7	**-Carbon dioxide emissions**		
			(i) Low	3	21
			(ii) Medium	2	14
			(iii) High	1	7
	Recycled product: Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones	3	**-Correct Storage**		
			(i) YES	3	9
			(ii) NO	1	1
	Water Conservation – The sanitation technology must promote water saving and minimise the depletion of the surface and ground water resources	13	**-Amount of water used during - operation and maintenance**		
			(i) No Water used	3	39
			(ii) < 6 litres per use	2	26
			(iii) > 6 litres per use	1	13
	Pollution of Ground Water- The sanitation technology must not be installed in a area that would contribute to the pollution or decrease in quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with untreated effluent and sludge during storage, transportation, treatment and or disposal	12	**-Distance to water table (>1.5m)**		
			Coarse Screening		
			Possible contact during storage transportation, treatment and disposal		
			(i) Definite	3	36
			(ii) Possible	2	24
			(iii) Unlikely	1	12

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
			-Likelihood of safe transportation and storage		
			(i) Definite	3	36
			(ii) Possible	2	24
			(iii) Unlikely	1	12
			-Slope (<30°)		
			Coarse Screening		
	Pollution of Surface Water - The sanitation technology must not be installed in areas prone to pollute and decrease the quality of fresh and marine water (ecological and human reserve) by ensuring that surface water will not come into contact with untreated effluent and sludge during transportation, storage and disposal	18	**- Location relative to flood line (>100m)**		
			Coarse Screening		
			-Slope (<30°)		
			Coarse Screening		
			-Likely Quality of discharged effluent during disposal		
			-100% compliant with DWAF Standards	3	54
			- 75-99% compliant with DWAF Standards	2	36
			-<75% compliant with DWAF standards	1	18
			-Distance from fault lines (>100m)		
			Coarse Screening		
			- Distance from Dolomite outcrops (>100m)		
			Coarse Screening		
			-BCM Sanitation Department's authorisation		
			(i) YES	3	36
			(ii) NO	1	18
			-DWAF authorisation		
			(i) YES	3	36
			(ii) NO	1	18
			-Distance to water table (>1.5m)		
			Coarse Screening		
	Treatment of Excreta - Methods of excreta handling from source to disposal must not negatively affect the environment	5	**-Treatment separates excreta from the environment before safe disposal**		
			(i) YES	3	15

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
			(ii) PARTIALLY	2	10
			(iii) NO	1	5
	Waste Beneficiation – Recycling and re-use opportunities must be instituted into the treatment of excreta	4	**-Possible -Use of any by-product produced from treatment**		
			(i) YES	3	12
			(ii) NO	1	4
	Treatment Management- The sewage treatment technology must be have adequate capacity to accommodate sewage from the target community population	18	**-Likely quality of discharged effluent during disposal**		
			-100% compliant with DWAF Standards	3	54
			- 75-99% compliant with DWAF Standards	2	36
			-<75% compliant with DWAF standards	1	18
			-Technology must be able to accommodate the intended volumetric load		
			(i) YES	3	54
			(ii) NO	1	18
	Ease of monitoring and detection - The technology should have systems in place that allows for the monitoring and early detection of problems	11	**-Technology allows for leaks and spills to be identified quickly**		
			(i) YES	3	33
			(ii) NO	1	11
			-Technology malfunctions can be identified quickly and at source		
			(i) YES	3	33
			(ii) NO	1	11
			-Technology allows for mechanisms to be continuously monitored		
			(i) YES	3	33
			(ii) NO	1	11
	Emergency Containment: Ability to contain sewage from the environment in disaster situations	6	**-Sufficiently large backup holding facility available**		
			(i) YES	3	18
			(ii) NO	1	6

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
	Suitable soil porosity - Soil supporting system shall be of sufficient porosity and depth for the disposal of effluent	4	**-Soil type (Loam)**		
			Coarse Screening		
			-Soil depth (>1.5m)		
			Coarse Screening		
4. Financial and economic approach					
	Economic beneficiation opportunities – The sanitation technology must provide economic opportunities from by-products produced	5	**-Viable income from the safe treatment of by-products**		
			(i) Contributes to household/community income and resource recovery	3	15
			(ii) Does not contribute to income and resource recovery	2	10
			(iii) Uses household income and resources	1	5
	Technology Affordability – The sanitation technology must be affordable from installation, operation and maintenance perspectives from BCM and household levels	5	**-Affordability to Municipality**		
			(i) YES	3	15
			(ii) NO	1	5
			-Affordability to Household		
			(i) YES	3	15
			(ii) NO	1	5
5. Technical considerations					
	Technological problems – The availability of spare parts for maintenance of the sanitation technology	11	**-Availability of spare parts for operation and maintenance of the technology**		
			(i) Local	3	33
			(ii) National	2	22
			(iii) International	1	11
	Local Technological Skill- Capability of local skill development for construction, repairing and maintaining the sanitation technology	7	**-Community/ Household by-in to develop skills for construction and maintenance of the technology**		
			(i) YES	3	21
			(ii) Possibly with assistance from BCM	2	14
			(ii) NO	1	7
6. Institutional and organizational frameworks					
	Political and Stakeholder Commitment – Support from political parties and stakeholders for sustainable sanitation	7	**-Local ward committee approval**		
			(i) YES	3	21
			(ii) NO	1	7

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR WEIGHT	MAXIMUM SCORE
	technologies must be encouraged				
			-BCM Council approval		
			(i) YES	**3**	**21**
			(ii) NO	**1**	**7**
	Municipal approval – Construction plans of sanitation systems should be approved by the municipality	**18**	**-Currently approved technology by BCM**		
			(i) YES	**3**	**54**
			(ii) NO	**1**	**18**

APPENDIX 4: CALCULATION OF SUSTAINABILITY SCORES

Newlands	Ne
Nompumelelo	No
Mdantsane	Md

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR SCORE	MAXIMUM SCORE	VIP			VIDP			COMP			W/B			P/F			S/T			UD			CT		
						Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md
1. Health and hygiene education and promotion																													
	Ease of education: Education of hygienic use of the sanitation technology	8	**-Ease of education**																										
			(i) Easily understood	3	24			24			24				24	24	24			24			24	24				24	24
			(ii) May need demonstration and pilot study to ensure understanding	2	16													16	16		16				16		16		
			(iii) Difficult to understand	1	8							8		8												8			
	User willingness: User willingness to address and understand the risks of using the sanitation technology	8	**-User acceptance of health education**																										
			(i) Household and community acceptance	3	24			24			24				24	24	24		24	24			24	24			24	24	
			(ii) Only Household acceptance	2	16							16		16				16			16				16	16			16
			(iii) No acceptance	1	8																								
	Hygiene Awareness – The sanitation technology must promote awareness of hygienic practices	8	**-Difficulty of operation and maintenance to intended user**																										
			(i) Low	3	24										24	24	24												
			(ii) Medium	2	16															16	16		16					16	16
			(iii) High	1	8			8			8	8		8				8	8					8	8	8	8		
			-Novelty of Technology operation and maintenance																										
			(i) Well known	3	24										24	24	24		24										
			(ii) Known but awareness raising required	2	16			16			16							16		16			16						
			(iii) Not known	1	8							8		8							8			8	8	8	8	8	8
	Health Risks- The sanitation technology must have measures and structures in place that promote health and hygienic practises to protect the community and the environment from risks disease and pollution by instituting the use of barriers and hygienic practises between human excreta and the community and surrounding environment	18	**-Hand washing facilities**																										
			(i) Permanent facilities available	3	54										54	54	54		54	54	54		54				54	54	54
			(ii) Temporary facilities available	2	36			36			36	36		36				36						36	36	36			
			(iii) No hand washing facilities available	1	18																								
			- Structures for pest control																										
			(i) Sealed storage containment structures	3	54										54	54	54							54	54	54	54	54	54
			(ii) Partially sealed containment structures	2	36			36			36	36		36				36	36	36	36		36						
			(iii) Open containment structures	1	18																								
2. Community issues and human resources development																													
	User Willingness to pay– User by-in to contributing to the safe use of the sanitation technology	9	User Buy-in																										
			(i) YES	3	27										27	27	27	27	27									27	27
			(ii) NO	1	9			9			9	9		9						9	9		9	9	9	9	9		

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR SCORE	MAXIMUM SCORE	VIP			VIDP			COMP			W/B			P/F			S/T			UD			CT		
						Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md
	Specific Gender Requirements - The technology must have facilities installed for both sexes	5	**Gender specific requirements**																										
			(i) Urinal and Pedestal	3	15										15	15	15	15	15	15	15		15	15	15	15	15	15	15
			(ii) Pedestal	1	5			5			5	5		5															
			Gender needs																										
			(i) Allows for disposal of sanitary pads	3	15			15			15																		
			(ii) Separate disposal of sanitary pads	1	5							5		5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
	Cultural norms – The sanitation technology must take into consideration the societal norms and practices	11	**Cultural boundaries crossed**																										
			(i) NO	3	33			33			33				33	33	33	33	33	33	33		33				33	33	33
			(ii) YES	1	11							11		11										11	11	11			
	User privacy – Capacity of sanitation technology to encourage privacy needs of users	5	**- Doors attached**																										
			(i) Yes	3	15			15			15	15		15	15	15	15	15	15	15	15		15	15	15	15	15	15	15
			(ii) No	1	5																								
			-Location of technology entrance																										
			(i) Inside household	3	15										15	15	15		15	15	15		15	15	15	15	15	15	15
			(ii) Outside household	1	5			5			5	5		5				5											
	User Safety - The technology should preferably be located within or in close proximity of the household to provide user safety	6	**-Located within the household property**																										
			(i) Inside household	3	18										18	18	18	18	18	18	18		18	18	18	18	18	18	18
			(ii) On household property	2	12			12			12	12		12															
			(iii) Off household property	1	6																								
	User Convenience – The sanitation technology must be located within or in close proximity of the household	7	**-Location of technology**																										
			(i) Inside household	3	21										21	21	21		21	21	21		21	21	21	21	21	21	21
			(ii) On household property	2	14			14			14	14		14				14											
			(iii) Off household property	1	7																								
	Local Resources– Local materials and labour should be used to build the technology infrastructure	4	**-Availability of local resources for building**																										
			(i) YES	3	12																								
			(ii) NO	1	4			4			4	4		4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
			-Availability of local building skill (community)																										
			(i) YES	3	12											12			12										
			(ii) NO	1	4			4			4	4		4	4		4	4		4	4		4	4	4	4	4	4	4
	Accessible – The sanitation technology should be accessible to all household members including young children, the elderly and the disabled	4	**-Access to the facility**																										
			(i) No slope or stairs	3	12										12	12	12	12	12	12	12		12		12	12	12	12	12
			(ii) Sloped entrance	2	8																								
			(iii) Stairs to entrance	1	4			4			4	4		4										4					
			-Provision for a child seat																										
			(i) YES	3	12																			12	12	12			
			(ii) NO	1	4			4			4	4		4	4	4	4	4	4	4	4		4				4	4	4
	Odour – The sanitation technology should not emit unpleasant odours, particularly inside the	6	**-Prone to Odour**																										
			(i) NO	3	18										18	18	18	18	18	18	18		18	18	18	18	18	18	18
			(ii) YES	1	6			6			6	6		6															

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR SCORE	MAXIMUM SCORE	VIP			VIDP			COMP			W/B			P/F			S/T			UD			CT		
						Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md
	household																												
	Safety – The sanitation technology must be secure and located within or in very close proximity of the household	6	**-Location of Technology**																										
			(i) Inside household	3	18										18	18	18	18	18	18	18		18	18	18	18	18	18	18
			(ii) On household property	2	12			12			12	12		12															
			(iii) Off household property	1	6																								
	Acceptability– The sanitation technology must be considered as an acceptable form of sanitation technology in terms of the policy's definition and by BCM (as the Local government) and the target community as users	5	**-Accepted by community**																										
			(i) YES	3	15										15	15	15	15	15	15	15		15				15	15	15
			(ii) Maybe – After awareness raising	2	10							10		10										10	10				
			(ii) NO	1	5			5			5															5			
			-Culturally appropriate																										
			(i) YES	3	15			15			15				15	15	15	15	15	15	15		15				15	15	15
			(ii) NO	1	5							5		5										5	5	5			
			-BCM approved																										
			(i) YES	3	15			15			15	15		15	15	15	15	15	15	15	15		15	15	15	15	15	15	15
			(ii) NO	1	5																								
			- DWAF approved																										
			(i) YES	3	15			15			15	15		15	15	15	15	15	15	15	15		15	15	15	15	15	15	15
			(ii) NO	1	5																								
	Safe Collection – The sanitation technology must have measures in place that ensures the safe handling of human excreta during collection	7	**-Human contact with un-sterile material during collection**																										
			(i) Low	3	21										21	21	21	21	21	21	21								
			(ii) Medium	2	14																		14	14	14	14	14	14	14
			(iii) High	1	7			7			7	7		7															
	Safe Removal – The sanitation technology must have measures in place that facilitates the safe removal of human excreta so that it does not impact on the community or the environment	6	**-Human contact to excreta during removal**																										
			(i) No exposure	3	18																			18	18	18			
			(ii) Possible Exposure to sterilised excreta only	2	12																								
			(iii) Possible Exposure to un-sterilised excreta	1	8			8			8	8		8	8	8	8	8	8	8	8		8				8	8	8
	Safe Disposal – The sanitation technology must have measures in place that ensures the safe treatment of human excreta that does not negatively impact on the environment	6	**-Human contact with un-sterile material during disposal**																										
			(i) Low	3	18						18				18	18	18			18			18	18	18	18			
			(ii) Medium	2	12			12										12	12										
			(iii) High	1	6							6		6							6						6	6	6
3. Environmental impact																													
	Chemicals used for cleaning the system	8	**-Cleaning Chemicals**																										
			(i) Biodegradable	3	24			24			24										24		24	24	24	24			
			(ii) Non-Biodegradable	1	8							8		8	8	8	8	8	8	8							8	8	8
	System contributes to global warming	7	**-Carbon dioxide emissions**																										
			(i) Low	3	21																			21	21	21			
			(ii) Medium	2	14			14			14	14		14	14	14	14	14	14	14			14						
			(iii) High	1	7																7						7	7	7
	Recycled product:	3	**Correct Storage**																										

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR SCORE	MAXIMUM SCORE	VIP			VIDP			COMP			W/B			P/F			S/T			UD			CT		
						Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md
	Hazardous substances: heavy metals, persistent organic compounds, antibiotics/medical residues, hormones		(i) YES	3	9						9										9		9	9	9	9	9	9	9
			(ii) NO	1	3			3				3		3	3	3	3	3	3	3									
	Water Conservation – The sanitation technology must promote water saving and minimise the depletion of the surface and ground water resources	13	**Amount of water used during operation and maintenance**																										
			(i) No Water used	3	39			39			39	39		39										39	39	39			
			(ii) < 6 litres per use	2	26													26	26	26									
			(iii) > 6 litres per use	1	13										13	13	13				13		13				13	13	13
	Pollution of Ground Water- The sanitation technology must not be installed in a area that would contribute to the pollution or decrease in quality of groundwater (ecological and human reserve) by ensuring that ground water will not come into contact with untreated effluent and sludge during storage, transportation, treatment and or disposal	12	**- Possible contact during storage transportation, treatment and disposal**																										
			(i) Unlikely	3	36																								
			(ii) Possible	2	24			24			24			24	24	24	24	24	24	24	24		24	24	24	24	24	24	24
			(iii) Definite	1	12							12																	
			- Likelihood of safe transportation and storage																										
			(i) Definite	3	36																								
			(ii) Possible	2	24						24													24	24	24	24	24	24
			(iii) Unlikely	1	12			12				12		12	12	12	12	12	12	12	12		12						
	Pollution of Surface Water - The sanitation technology must not be installed in areas prone to pollute and decrease the quality of fresh and marine water (ecological and human reserve) by ensuring that surface water will not come into contact with untreated effluent and sludge during transportation, storage and disposal	18	**Likely Quality of discharged effluent during disposal**																										
			-100% compliant with DWAF Standards	3	54																			54	54	54			
			- 75-99% compliant with DWAF Standards	2	36																								
			-<75% compliant with DWAF standards	1	18			18			18	18		18	18	18	18	18	18	18	18		18				18	18	18
			-BCM Sanitation Department's authorisation																										
			(i) YES	3	36			36			36	36		36		36	36	36	36	36	36		36	36	36	36	36	36	36
			(ii) NO	1	18										18														
			- DWAF authorisation																										
			(i) YES	3	36			36			36	36		36	36	36	36	36	36	36	36		36	36	36	36	36	36	36
			(ii) NO	1	18																								
	Treatment of Excreta - Methods of excreta handling from source to disposal must not negatively affect the environment	5	**-Treatment separates excreta from the environment before safe disposal**																										
			(i) YES	3	15							15		15		15	15		15	15	15			15	15	15			
			(ii) PARTIALLY	2	10						10				10			10					15				10	10	10
			(iii) NO	1	5			5																					
	Waste Beneficiation – Recycling and re-use opportunities must be instituted into the treatment of excreta	4	**-Possible Use of any by-product produced from treatment**																										
			(i) YES	3	12							12			12	12	12	12	12	12	12		12	12	12	12			
			(ii) NO	1	4			4			4			4													4	4	4

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR SCORE	MAXIMUM SCORE	VIP			VIDP			COMP			W/B			P/F			S/T			UD			CT		
						Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md
	Treatment Management- The sewage treatment technology must be have adequate capacity to accommodate sewage from the target community population	18	**- Likely quality of discharged effluent during disposal**																										
			-100% compliant with DWAF Standards	3	54																			54	54	54			
			- 75-99% compliant with DWAF Standards	2	36									36	36		36			36			36					36	
			-<75% compliant with DWAF standards	1	18			18			18	18				18		18	18		18						18		18
			-Technology must be able to accommodate the intended volumetric load																										
			(i) YES	3	54							54		54										54	54	54		54	
			(ii) NO	1	18			18			18				18	18	18	18	18	18	18		18				18		18
	Ease of monitoring and detection - The technology should have systems in place that allows for the monitoring and early detection of problems	11	**-Technology allows for leaks and spills to be identified quickly**																										
			(i) YES	3	33							33		33										33	33	33			
			(ii) NO	1	11			11			11				11	11	11	11	11	11	11		11				11	11	11
			-Technology malfunctions can be identified quickly and at source																										
			(i) YES	3	33							33		33										33	33	33			
			(ii) NO	1	11			11			11				11	11	11	11	11	11	11		11				11	11	11
			-Technology allows for mechanisms to be continuously monitored																										
			(i) YES	3	33							33		33	33	33	33	33	33	33	33			33	33	33			
			(ii) NO	1	11			11			11												11				11	11	11
	Emergency Containment: Ability to contain sewage from the environment in disaster situations	6	**- Sufficiently large backup holding facility available**																										
			(i) YES	3	18																			18	18	18			
			(ii) NO	1	6			6			6	6		6	6	6	6	6	6	6	6		6				6	6	6
4. Financial and economic approach																													
	Economic beneficiation opportunities – The sanitation technology must provide economic opportunities from by-products produced	5	**-Viable income from the safe treatment of by-products**																										
			(i) Contributes to household/community income and resource recovery	3	15									15										15	15	15			
			(ii) Does not contribute to income and resource recovery	2	10			10			10	10																	
			(iii) Uses household income and resources	1	5										5	5	5	5	5	5	5		5				5	5	5
	Technology Affordability – The sanitation technology must be affordable from installation, operation and maintenance	5	**- Affordability to Municipality**																										
			(i) YES	3	15			15			15	15		15		15	15	15	15	15	15			15	15	15			
			(ii) NO	1	5										5								5				5	5	5

BCM CRITERIA CATEGORY	BCM CRITERIA	All WEIGHTING	BCM INDICATOR OPTIONS	INDICATOR SCORE	MAXIMUM SCORE	VIP			VIDP			COMP			W/B			P/F			S/T			UD			CT		
						Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md	Ne	No	Md
	perspectives from BCM and household levels		**- Affordability to Household**																										
			(i) YES	3	15			15			15	15		15			15			15	15		15	15	15	15		15	15
			(ii) NO	1	5										5	5		5	5								5		
5. Technical considerations																													
	Technological problems – The availability of spare parts for maintenance of the sanitation technology	11	**Availability of spare parts for operation and maintenance of the technology**																										
			(i) Local	3	33																								
			(ii) National	2	22			22			22				22	22	22	22	22	22	22		22				22	22	22
			(iii) International	1	11							11		11										11	11	11			
	Local Technological Skill- Capability of local skill development for construction, repairing and maintaining the sanitation technology	7	**-Community/ Household by-in to develop skills for construction and maintenance of the technology**																										
			(i) YES	3	21																								
			(ii) Possibly with assistance from BCM	2	14			14			14	14		14	14	14	14	14	14	14	14		14	14	14	14	14	14	14
			(ii) NO	1	7																								
6. Institutional and organizational frameworks																													
	Political and Stakeholder Commitment – Support from political parties and stakeholders for sustainable sanitation technologies must be encouraged	7	**-Local ward committee approval**																										
			(i) YES	3	21										21	21	21	21	21	21	21		21	21			21	21	21
			(ii) NO	1	7			7			7	7		7											7	7			
			-BCM Council approval																										
			(i) YES	3	21			21			21	21		21	21	21	21	21	21	21	21		21	21	21	21	21	21	21
			(ii) NO	1	7																								
	Total Sustainability Score				**2124**			**757**			**786**	**763**		**790**	**896**	**919**	**939**	**820**	**884**	**900**	**848**		**870**	**1049**	**1027**	**1014**	**800**	**898**	**836**

APPENDIX 5: LETTER FROM BCM – IEMP UNIT

BUFFALO CITY MUNICIPALITY

☎ (043)7052000
✉ 134 EAST LONDON/ E-MONTI 5200)

FAX/IFAKSI

(043) 7438568

Trust Centre: Cnr of North and Oxford Streets/Kwikona ye-North- ne Oxford Street/EAST LONDON/ E-MONTI 5201

Directorate of Community Services

IEMP Department

Our ref.: Ifayile yethu: **I.E.M.P. /**	Enq.: Imibuzo: **Fergus** 707 5803	Your ref.: Ifayile yakho:

23-12-2008

To: Mr. S. Hoossein

MASTERS RESEARCH INTO SUSTAINABILITY CRITERIA FOR SANITATION TECHNOLOGIES IN BCM

The unit would like to commend you for undertaking your research into developing sustainability criteria for sanitation technologies in BCM. It is gratefully acknowledged that you have extensively engaged and involved the BCM departments during the course of developing your research and that you have used the proper channels within BCM to gather data and information for which we are thankful. Your feedback provided to BCM with regards to the outcome of my research is also kindly acknowledged.

From our point of view your research has:

1. Been useful as far as updating the State of Sanitation Report and providing a current state of sanitation that can be included in the BCM Sanitation Policy and Implementation Plan;
2. Involved the correct stakeholders (e.g. Ward councillors, Ward committees, and BCM officials) to ensure a useful output;
3. Produced a useful output in the form of a sanitation sensitivity map;
4. Provided a useful tool to assist municipal decision making for sanitation technologies within BCM;

5. Provided BCM with a set of tools and information to help it practically operationalize sustainability within the functioning of the organization, specifically with regards to sanitation.

Once again we thank you for utilizing BCM for your research and for contributing to our municipality's ability to provide sustainable sanitation which will ensure a better environment for all.

Thanks

S. G. FERGUS

MANAGER: INTEGRATED ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENT UNIT