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An evaluation of building sustainability considerations in South Africa: A case of  
the SAIAB building

by

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## LIST OF ABBREVIATIONS

BRE	: Building Research Establishment, United Kingdom
BREEAM™	: Building Resource Establishment Environmental Assessment Method
CFC	: ChloroFluoroCarbons
CIB	: International Council for Research and Innovation in Building and Construction
CSIR	: Council for Scientific and Industrial Research, South Africa
DEAT	: Department of Environmental Affairs, South Africa
EMP	: Environmental Management Plan
FIDIC	: International Federation of Consulting Engineers
GBCA	: Green Building Council of Australia
GDP	: Gross Domestic Product
GRI	: Global Reporting Initiative
HIV/ AIDS	: Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
HVAC	: Heating Ventilation Air Conditioning
IAQ	: Indoor Air Quality
IOD	: Institute of Directors
JSE SRI	: Johannesburg Stock Exchange Socially Responsible Investment
LCA	: Life Cycle Assessment
LEAP	: Local Environmental Action Plan, Grahamstown
LEED™	: Leadership in Energy and Environmental Design, United States of America

NBR	: National Building Regulations, South Africa
OECD	: Organisation for Economic Cooperation and Development
RSA	: Republic of South Africa
SABS	: South African Bureau of Standards
SAIAB	: South African Institute for Aquatic Biodiversity
SANS	: South African National Standards
SBAT	: Sustainable Building Assessment Tool, South Africa
SBL	: Sustainable Building Lifecycle
SDF	: Spatial Development Framework
SoER	: State of Environment Report (ing)
STATSA	: Statistics South Africa
UK	: United Kingdom
UN-DSD	: United Nations – Division for Sustainable Development
UNEP	: United Nations Environment Programme
USA	: United States of America
USGBC	: United States Green Building Council
UV-B	: Ultra Violet - B
WCED	: World Commission on Environment and Development, Brundtland Commission

## ABSTRACT

The theory of sustainable development has received worldwide acceptance, and is characterised by the protection of environmental quality, social justice and economic development to ensure a quality of life for future generations. The concepts of sustainable development have transcended to all aspects of society, including the built environment through the Habitat Agenda and building sustainability rating tools. The thesis investigates the implications of sustainable development on how it relates to the building construction industry in South Africa.

The study sought to evaluate the extent of consideration and motivation for the incorporation of sustainability criteria in building design, using the case of the South African Institute for Aquatic Biodiversity wet collection facility in Grahamstown. The goal of the thesis was achieved by evaluating sustainability considerations and barriers to adoption of sustainability criteria in the design of the SAIAB building, the rating of the building against the LEED™ criteria, and evaluation of the applicability of the LEED™ in the South African context.

The importance of the research emanates from the fact that, despite the proliferation of sustainable development and sustainability rating tools in the world, there is no widely used building sustainability rating tool in South Africa, even though the country is industrialising with a very active built environment. The study therefore contributes to the body of knowledge necessary for the implementation of a building rating tool in the country, through an understanding of barriers to implementation.

The research method used in the study was a case study with the intention of obtaining the design professional's considerations and challenges in the context of designing the SAIAB building. The case study used multiple data collection methods, with primary information obtained from interviews of professionals involved in the design of the building, whilst additional information was from analysis of technical drawings and review of literature on the subject.

The findings of the research showed that there is an understanding of sustainability and consideration in the building industry even though there is no targeted intent to meet sustainability goals. The barriers to building sustainability were identified as lack of regulation, incentives, access to land, awareness, availability of professional codes and standards, economic costs and capacity. These barriers translated into a relatively low score, a silver rating for the SAIAB building when using the LEED™ rating system.

The implications of the findings suggests a need for the development of a comprehensive building sustainability rating tool suited for the South African context, with performance standards and a technical manual to support it. This should however be done in an environment where sustainability goals are supported by regulation and incentives have been developed.

# CHAPTER 1

## INTRODUCTION

### **1.1. BACKGROUND**

The concept of sustainability has received worldwide attention since the Brundtland Commission, a commission that arose from fears about the earth's ability to perpetually support human well-being. The Brundtland Commission defines sustainable development as '... development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987:24). In its application, the framework for sustainable development has been purported to be comprised of three aspects: 'economic prosperity, environmental quality and ... social justice' (Elkington, 2001:20). These three aspects of sustainable development have been recognised as developmental tenets internationally and thus guide the understanding and interpretation of human-environment interaction.

The fundamental driver of human-environment interaction is the indispensable need for human well-being, defined as, according to Biggs, *et al.* (2004:ii), the ability to live a decent life through utilising the goods and services from ecosystems. The benefits humans derive from ecosystems pertain to the basic needs of food and shelter, in the form of water, timber, marine resources, mineral resources and others (Alcamo, *et al.*, 2003:49). It can thus be assumed that, if human well-being is to be sustained, the integrity of these ecosystems needs to be maintained and protected. In developed societies, the built environment provides shelter, making it an integral part of our interaction with the environment and should thus demonstrate sustainability, that is, the ability to meet the needs of future generations.

In response to sustainability imperatives, the built environment professions have developed frameworks to incorporate sustainability criteria into the provision of shelter through the concept of a 'green building', which, according to Paehlke (2004:12), is a building designed for human health and comfort, with minimal environmental impacts in both its creation and operation. The scope of the field of "green building" thus looks at the holistic footprint of a building, in other words, the environs, size, orientation, materials used, durability, affordability, human needs, social customs, functionality, and energy efficiency.

Some benefits have been mentioned as having arisen from green buildings, the most compelling being that it makes financial sense as a result of reduced energy costs, with Kessenides (2005:65)

citing a million dollar saving achievement from the redesign of an athletic club in America. The financial rationale for green buildings also stems from the reduction in potential litigation arising from poor indoor air quality (James and Yang, 2005:70). Similarly, Meyerson (2005:47) showed an improvement in employee productivity from employees working in a green building environment due to improved air quality and to a better working environment arising from an improved general design and the use of daylight.

The emphasis on energy efficiency and selection of materials used in buildings has situated the green building initiatives within the realm of industrial ecology, with industrial ecology, according to Ehrenfeld (2004:1), dealing with energy and materials flow, a commonality between ecosystems and industrial systems. The commonalities arise from the closed-loop functioning of ecosystems being mimicked in industrial ecology rather than a one-way consumption of resources, which has characterised industrial systems historically. Industrial ecology draws largely from Life Cycle Assessment (LCA) tools in analysing systems and their impacts. With regard to green buildings, there is evidence of LCA considerations in the United States of America's building sustainability rating standards (Kaatz *et al*, 2002).

The United States of America uses a building rating standard called Leadership in Energy and Environmental Design or the LEED™ (USGBC, 2001), which evaluates the environmental and economic performance of commercial and residential buildings. The standard was established based on industry principles, practices, materials and standards, and it evaluates buildings under six criteria: sustainable sites; water efficiency; energy and atmosphere; materials and resources; indoor environmental quality; and innovation and design process. However, several standards exist worldwide in countries like Canada, Australia, the United Kingdom and Japan.

Even though standards are available worldwide, and the environmental, economic and social benefits of green buildings have been recognised internationally, South Africa seems to be lagging behind, despite being a signatory of a number of international agreements on sustainable development. The lack of green building standards occurs in a context of an active built environment, with Statistics South Africa indicating that the number of completed residential buildings has almost doubled since 1990, with completed buildings in 2005 being approximately 75,000 units, excluding commercial and low cost housing properties (ABSA, 2006:3). That the target for low cost housing delivery by the government was 350,000 units per annum (Department of Housing, 1997:22), suggests a significant environmental, economic and social

footprint. However, the targets have not been met by government as only 138,000 units were delivered in 2005/2006 (Statsa, 2006:ii).

Taking into cognisance rapid development in the South African built environment, and the availability of rating systems worldwide for building sustainability, this study seeks to understand the potential constraints to the adoption of green building principles in South Africa and to contribute to the development of a framework for assessing building sustainability for South Africa using the South African Institute for Aquatic Biodiversity wet collection facility as a case study. The South African Institute for Aquatic Biodiversity (SAIAB) is a government institute operating within Rhodes University, one of the institutes under the National Research Foundation. The objective of the institute is the protection of the aquatic natural history of our country. The collections under the curatorship of SAIAB include dry collections and wet collections, which are made available for scientific research. Currently both the wet and dry collections are stored in an existing facility that is also used as offices, adjacent to the new wet collection facility.

The choice of the SAIAB building as a case study was primarily driven by the fact that, the building was in the design stage during the initiation of the study, facilitating effective extraction of design considerations from the design team. Access to the design team and technical drawings also played an important role in the selection of the case study, as the researcher was working for an organisation that was part of the design team, albeit not directly involved.

## **1.2. RESEARCH OBJECTIVES**

The goal of the research is to provide insights into the state of building sustainability rating in South Africa evaluating potential challenges and barriers, using experiences in the design of the SAIAB building. The goal is achieved to through addressing the following objectives,

- i. Evaluation of sustainability considerations in the design of the SAIAB building, and barriers encountered
- ii. Demonstrating how the building rate against the LEED<sup>TM</sup> building sustainability rating system
- iii. Evaluation of the applicability of the LEED<sup>TM</sup> rating system in the context of South Africa

### 1.3. THESIS OUTLINE

The thesis begins with a literature review in which the theory of sustainable development and the resultant sustainability indicator frameworks are discussed, as is how the latter informs building sustainability rating systems. Building sustainability rating systems used in various countries are reviewed and key differences between them identified. With the theoretical framework grounding the thesis, the methodology section presents the goals of the research, research approach and paradigm. Additionally, the data collection techniques employed are discussed. The section on the results of the study presents the outcomes of the assessment of the first goal of the research, that is, the considerations taken in the design of the South African Institute for Aquatic Biodiversity wet collection facility in Grahamstown, as well as challenges experienced. The second section of the results presents the rating of the SAIAB building against the LEED™ criteria. The third section in the presentation of the results evaluates the relevance of the LEED™ criteria in the context of South Africa. The general discussion section presents the recommendations and gaps towards a South African Rating System cognisant of locally prevalent economic, social and environmental conditions.

## CHAPTER 2

### LITERATURE REVIEW

The context of the study is on the built environment and the application of sustainable development and sustainability theory, thus the historical development of sustainable development as the underlying theory is reviewed. Sustainable development theory is translated into application through the use of indicator frameworks, which are, in turn, the building blocks of building sustainability rating systems. The various sustainability rating systems readily available worldwide are then reviewed on the basis of the theoretical links outlined above, with differences between the various systems being explored.

#### **2.1 THE THEORY AND APPLICATION OF SUSTAINABLE DEVELOPMENT**

The historical development of sustainable development from early environmental writings, and how those progressed and entered the global agenda are discussed, as are their implications for South Africa. The theoretical basis of sustainable development is explored through the review of competing paradigms, with a discussion of the current worldview of sustainable development. This provides perspective as the departure paradigm influences selection, measurement, and interpretation of sustainability indicators, whereas indicators merely report on the extent to which a defined state that constitute sustainable development has been achieved.

##### *2.1.1 HISTORICAL ACCOUNT OF SUSTAINABLE DEVELOPMENT*

###### **Silent Spring**

Mainstream environmental awareness of the human impacts on the environment and the ability of earth to sustain human existence can be traced back to the book *Silent Spring* by Rachel Carson in 1962. The publication focused on the long-term impacts of chemical pesticides on the environment through their interference with the food chain, the subsequent accumulation of residues, and their impacts on human health (Nerlich and Wright, 2006). The book brought to the public and international community the challenges faced by our civilisation in maintaining a continued relationship between humans and the environment.

###### **Stockholm Conference**

The first international community meeting in which development needs and the environment were discussed was the United Nations Conference on the Human Environment held from 5 - 16

June 1972 in Stockholm. The meeting culminated in a declaration paving way for a common outlook of development challenges, recognising the interdependence of man, future economic development and the environment. Habitat destruction and pollution, the role of population pressure and development disparities amongst nations were identified as drivers of environmental degradation (UNEP, 2006).

Of major future significance was clause 6 of the declaration, identifying an agenda for the world: ‘...to defend and improve the human environment for present and future generations has become an imperative goal for mankind – a goal to be pursued with, and in harmony with, the established and fundamental goals of peace and worldwide economic and social development’ (UNEP, 2006). The significance of this clause bears evidence of future thought in sustainable development, as it underlies the intergenerational principle and the triad of sustainable development that dominate current worldview. The conference paved the way for the establishment of the United Nations Environment Programme, which was launched later in 1972 (Meakin, 1992).

### **Brundtland Commission**

The next milestone in the progress of sustainable development was the appointment of the World Commission on Environment Development in December 1983 on matters within the United Nations Environment Programme, known as the Brundtland Commission. The commission was charged with developing long-term strategies for sustainable development for the year 2000 and beyond; common goals for development for developing and developed economies; ways in which the international community can deal with these issues; and shared perceptions of issues and efforts for protection and enhancement of the environment (WCED, 1987). The importance of shared perceptions of environmental issues and their mitigation was central to the commission as it would outline the key concepts and practice of sustainability.

The commission presented its findings in three parts, the first being common concerns covering future threats, the concept of sustainable development and the interrelationship between the international economy, environment and development. The second part of the report covered common challenges of population, environment and development, whilst the last section dealt with the management of commons as well as peace, security development and the environment (WCED, 1987).

Significant contributions from the commission emanated from the first section in defining sustainable development, as being achieved when ‘... present needs can be met without compromising the ability of future generations to meet their own needs (WCED, 1987:24). The report further asserted that the biosphere’s assimilative capacity is the limiting factor to development even though technological social developments can mitigate the limits set by the environment. The importance of access to resources and the distribution of wealth as means of eliminating poverty were identified as crucial aspects of sustainable development. The report also recognised the relationship between population and affluence as a driver of environmental pressure and should be within the ecosystem productive potential (WCED, 1987:24, 25). These observations are critical in the understanding of the theory and critique of sustainable development.

### **Rio Earth Summit**

Following the Brundtland Commission, the next major global event was the first Earth Summit in Rio de Janeiro held from 3-14 June 2002, which built on the Stockholm Declaration and incorporated new insights from the Brundtland Commission. The outcomes of this summit were the adoption of the Rio Declaration, and a global plan of action for global, national and local implementation of sustainable development, called Agenda 21. The Stockholm Declaration and the Brundtland Commission Report paved the way for global principles and an understanding of sustainable development, with the value added by the Rio Summit being the implementation framework, as well as consensus obtained from the more than 178 attending countries, albeit the extent of buy-in differed from country to country (Meakin, 1992).

Another important outcome of the conference was the signing of the Convention on Climate Change, regarding the reduction of greenhouse gas emissions, by 130 countries. However, criticism was levelled against the convention primarily due to non-commitment by the United States of America, and the moderation of reference to alternative energy sources by countries such as Saudi Arabia (Meakin, 1992). Another outcome of the summit was the signing of the Convention on Biodiversity, with the aim of protecting endangered species and their habitats, and recognising the role of genetic resources in human wellbeing. It was also criticised on the basis of the United States of America’s refusal to sign the convention, even though all other attending countries signed, as well as its definition of biodiversity, and how its value is defined (Meakin, 1992).

The Rio Summit sought to address resource degradation, the plight of the developing world and poverty, and the use of the commons, like the oceans and atmosphere, and bring about an implementation regime for sustainable development. Even though no agreement was reached on issues like forest protection, desertification, population growth, and the financing and implementation oversight, statements outlining principles on deforestation and protection of marine resources were adopted (Meakin, 1992). According du Plessis (2002:iii), relevant to the built environment was the recognition of the role of human settlements in sustainable development in Chapter seven of Agenda 21, which led to the Habitat Agenda.

### **Habitat Agenda**

The recognition of the importance of human settlements in sustainable development led to the Habitat II Conference in Istanbul, which came up with the Habitat Agenda, emphasising the importance of using locally available, appropriate, affordable, safe, efficient, environmentally sound building materials and systems using locally available human resources as the cornerstone of sustainable construction (UN Habitat, 2003). The outcomes of the conference paved way for the development of Agenda 21 for sustainable construction by the International Council for Research and Innovation in Building and Construction (CIB) in 1999, defining parameters for sustainable human settlements as being safety and health; physical, psychological social and economic wellbeing of people; meeting societal goals by the construction industry (du Plessis, 2002: iii; Watermeyer and Milford, 2003:1). In attempt to interpret the relevance of sustainable construction in the developing world, the Council for Scientific and Industrial Research, South Africa (CSIR) proposed Agenda 21 for Sustainable Construction in developing countries, which would have better applicability for countries like South Africa (du Plessis, 2002).

From just awareness in *Silent Spring*, global political will was demonstrated in the Stockholm Conference on the unsustainable nature of economic development, the development of a definition of sustainable development by the Brundtland Commission, the development an implementation plan in Rio de Janeiro and sector specific responses such as the Habitat Agenda, demonstrates the mainstream progression of the concept over the last 40 years. The impact of that worldview on South Africa is evident in a number of legislations, and that the country is a signatory of most existing global conventions on the environment. That South Africa is a constitutional democracy makes the Constitution the supreme law of the country, and provision of environmental rights to the country's citizens in section 24 (a) and (b) of the Constitution (RSA, 1996); a clear demonstration of the Rio Declaration it affirmed the rights of citizens to live in a clean environment and the rights of developing countries to pursue sustainable

developments. These rights are brought to effect by legislations such as the National Environmental Management Act (No 107 of 1998) which provides framework environmental management legislation advocating environmental management principles that encompass sustainable development, and implementation strategies such as the Integrated Pollution and Waste Management Strategy citing that it is aimed at meeting goals of Agenda 21 (DEAT, 2000).

### *2.1.2 THE THEORY AND CRITIQUE OF SUSTAINABLE DEVELOPMENT*

Sustainable development has been shown to be comprised of elements sustaining humans as well as sustaining nature, and it is thus conceivable that the relationship between humans and their environment is the basis of understanding sustainability. Several paradigms of the human-environment interaction have been postulated, and the theory behind environmental economics, deep ecology, poststructuralist, and dialectical materialism are reviewed and critiqued. The critique is followed by a review of the mainstream and emergent approaches to sustainable development.

#### **Classic liberalism theory**

The environmental economist's paradigm is nested on classical liberalism, which is based on beliefs of individualism, utilitarianism, and free market principles. The utilitarian paradigm according to Milner (in Castro, 2004:208) suggests a possessive individual who seeks to maximise utility from resources. Culture is considered a constant in this theory, which assumes that all nations in the world attempt to achieve individual utility, which is challenged by poststructuralist authors such as Escobar rejecting that the destination culture should be that of suggesting sustainability can be achieved through reduction in the affluence levels in the developed world (Castro, 2004:211). This paradigm thus asserts that protection of property rights will lead to a better management of natural resources as they have the potential to generate utility for their owner, therefore a vested interest to protect the natural environment. According to Escobar (in Castro, 2004:210), this is ecocracy, that is, the incorporation of nature into capitalism, with the prime objective being only extraction of utility by the most efficient means. On the other hand, dialectical materialists suggest private property in the developing world can lead to the mining of resources to meet short-term gains and acquire green technology (Castro, 2004:219).

The second cornerstone of this paradigm relates to free market principles, suggesting that goods and services bought and sold in the market are produced efficiently, as the driver of firms is

improving the input output ratio to achieve profitability (Castro, 2004:205). Because markets are considered efficient, they are assumed to efficiently arrive at the real exchange value, and thus sustainability will be achieved only when nature is valued accurately (Clark and York, 2005:319), using tools like cost: benefit analyses to decide whether a development is sustainable or not (Castro, 2004:205). Arguments in favour of the paradigm state that, the rationality of markets suggests that ecological awareness will lead to a new rationality that is not only based on economic rationality thus can mitigate environmental degradation. It has however been suggested that the mystery and interconnectedness of nature makes it difficult to incorporate it into markets, thus cannot efficiently value nature (Clark and York, 2005:322).

The third important aspect of the classical liberalism school of thought is that it challenges the limits to growth philosophy, as it suggests technological innovations have the ability to substitute natural resource usage (Clark and York, 2005; Castro, 2004:205). According to Clark and York (2005:321), arguments put forward by Grossman and Krueger (1995) suggest that at the early stages of capitalist development environmental impacts are high, gradually reducing as countries develop as they can afford cleaner technologies. This is the environmental Kuznets curve, where an inverted U-plot results from the plotting of environmental impacts on the y-axis and income on the x-axis. Sustainability is purported to be possible if developing nations tunnel through the curve using the developed world's clean technology. Natural or green capitalism proposed by Lovins, Lovins and Hawken (2004:71) subscribes to this school of thought suggesting that technology can improve sustainability through progression towards closed-loop systems.

In summary, the suggestion from this school of thought is that capitalist development has the potential of driving sustainability. However, other schools of thought challenge the interpretation of the relationship of humans and nature through classic liberalism.

### **Deep ecology theory**

The second paradigm discussed is that of deep ecology or idealist perception of sustainable development. The fundamentals of this approach are based on the premise of rejecting human superiority over the natural environment as proposed by natural theology. An eco-centric approach is postulated, suggesting that humans are part of the ecosystem (Clark and York, 2005: 325). This theory's understanding of nature and humans encompasses the Gaia Hypothesis, which assumes earth is an organism in its own right of which humans are an integral part, and that earth is not necessarily for the service of the human race (Lovelock, in Clark and York, 2005: 325). Deep ecology suggests an ideal harmony of all elements of the 'earth organism' that

is controlled by spiritual supernatural forces, and that industrialisation is the driver of environmental degradation.

This paradigm resonates well with the Malthusian school of thought that asserts that human population is controlled by the carrying capacity of the earth, and famine and disease are necessary controls of human population, thus humans are not superior to nature. 'In contemplating the plagues and sickly seasons in these tables which occur after a period of rapid [population] increase, it is impossible not to be impressed by the idea that the number of inhabitants had, in these instances exceeded the food and accommodation necessary to preserve them in health' (Malthus, 1809:48). Deep ecology also suggests that traditional indigenous societies are sustainable, and that sustainability can be achieved by a return to indigenous practices (Clark and York, 2005:325).

This theory draws from Buddhism, Christianity, Darwin, Rachel Carson and other theorists and is thus a medley of science and spirituality. The criticism of this paradigm, firstly, is cited as the '...limited characterisation of the idealised harmonious state', whereas natural history is characterised by drastic biophysical changes and discontinuities. Secondly, because the causative element is inexplicable and supernatural, it challenges the value system of modernity and science thus cannot be interrogated even though its basis includes science. Lastly, deep ecology does not offer an explanation of human-nature interaction with regard to how to attain sustainability, but focuses on changing the value system (Clark and York, 2005:325).

### **Poststructuralist theory**

The third paradigm from which sustainability can be explained is through the poststructuralist school of thought. The driving philosophy of this theory of development is incorporation of the concept of culture as an important aspect of defining development (Castro, 2004:213). According to Escobar (in Castro, 2004:213), the poststructuralist school of thought suggests multi-cultural models of development indicating them as an imperative in attaining sustainable development. The author further mentions that non-western cultures have demonstrated more resilience, thus indigenous knowledge is tightly intertwined with sustainability.

The second assertion of poststructuralists is the co-evolutionary nature of sustainable development, with Richard Norgaard (1994) suggesting that social organisation, values, knowledge, and technology are essential aspects of the human-environment interaction with a change in one leading to a response in the other, something that Marxism and liberalism fail to

appreciate (Castro, 2004:213). This is a further assertion that indigenous knowledge is an integral part of sustainable development as indigenous community knowledge is still in contact with the ecosystems of which they are an integral part. Further arguing the co-evolutionary nature of humans and the environment, Castro (2004) suggests it is naïve to assume that industrialisation will not destroy culture as it is influenced by the economy and vice versa. Contribution to sustainable development lies in a localised understanding of human-environment interaction.

Castro (2004:213) submits a critique of the poststructuralist model particularly Escobar, suggesting that as much it rejects the cultural superiority model typical of classic liberalism that defines development as being modernity it fails to provide a definition of poverty. Finally, the model focuses on state power whereas power does not only lie in the state, and fails to explain the role of capital in development. Another criticism is that the model is not based on an ideology or social system that can explain acceptable and unacceptable change (Castro, 2004:213). The contribution of poststructuralist theory is that it proposes co-evolution and interdependence of humans and nature.

### **Dialectical materialism theory**

The last paradigm reviewed is that of dialectical materialism which has its leanings on Marxism, whose core tenet rejects the reduction of social process to just the allocation of goods and services, in other words, the capital nature of defining resources whose objective is to derive surplus value from a productive process (Castro, 2004:216). According to Clark and York (2005) dialectical materialism is characterised by two elements in the understanding of the interaction of nature and man, the first being that nature includes processes that operate on their own with no inherent purpose. Secondly, it recognises that human society constantly interacts with nature resulting in a continuous transformation of both nature and society; there is thus a dialectical relationship. Citing Vernandsky (1998), there is no suggestion of human superiority over nature in dialectical materialism theory.

This school of thought challenges the economist's point of view as even though it is based on materialist principles on the basis of the liberalist view that it reduces nature to a factor of production, and does not appreciate its complexity. It challenges deep ecology on the grounds that it rejects material causality (Clark and York, 2005:326). Challenging the deep ecology theory, Levins and Lewonthin (in Clark and York, 2005:330) challenge the notion of a pre-determined genetic blueprint idea based on Darwinism, but put forward phenotypic expression

suggesting active life. Lewonthin (2000) further supports this idea, citing the limitation of Darwinism as the separation of internal and external effects, assuming the external environment is independent of the organism. On the other hand, dialectical materialism proposes that evolution is not adaptation but construction, due to the two-way influence between the organism and its environment.

Lewonthin uses the Marxist concept of stasis in challenging the economist's view of nature, that change is not smooth but results from temporal periods of indeterminate length, counterbalancing opposing forces, leading to an abrupt radical change, and cites that ecosystem resilience operates in that manner. An example of this is that in global climate change incremental emissions result in changes that are not catastrophic over a period of time, but cause a dramatic catastrophic change when a breakpoint is reached. Stasis suggests there is no linear change between environmental pressure and change in the environment, thus an economic value of nature cannot be measured due to its unpredictability because, as the change in state is abrupt, it cannot be factored into market knowledge (Clark and York, 2005:330).

Dialectical materialists also challenge the free trade requirement of sustainable development as it creates a metabolic rift due to the difference in nature's productive sites and human consumption due to concentration of consumption in cities far away from production sites. The impact is increased pressure on energy resources due to food transportation (Castro, 2004:216). It is also conceivable that depletion will increase in peripheral economies, whilst pollution will increase in developed nations due to this metabolic rift, such as is the case in Japan and Ireland where waste is a big problem.

The criticism of dialectical materialism, according to Castro (2004:219), is that it does not propose how the dialectical relationship between humans and the environment can create a sustainable society, nor does it explain how people can exert real influence on their leaders in shaping their development needs. The contribution of dialectical materialism is in its explanation of the relationship with nature and the paradigm of capital accumulation as the driving force behind environmental degradation.

### **Current worldview of sustainable development**

Mainstream sustainable development as it was conceptualised at the Stockholm Conference, defined by the Brundtland Commission and implemented after the Rio Summit is embedded in the paradigm of classical liberalism. Criticism of classical liberalism as the appropriate vehicle

for attaining sustainable development has been challenged particularly from its growth orientation, and its weakness in addressing the needs of the developing world. However, no alternative models have been put forward in line with the various schools of thought; as a result the application of sustainable development demonstrates the economic and social development imperatives, as well as the need to maintain environmental integrity to sustain continued growth.

This is evident in the taxonomy of sustainable development by Parris and Kates (2003), in defining what has to be sustained and what is to be developed. The authors argue that nature, in the form of the earth, biodiversity and ecosystems; life support in the form of ecosystem services, resources and the environment; and the community, encompassing cultures, groups and places, need to be sustained. To be developed the authors cite people, such as in the facets of child survival, life expectancy, education, equity and equal opportunities; economy, referring to wealth, productive sectors and consumption; and society, which is composed of institutions, social capital, states and regions. On the basis of this taxonomy, indicators would serve the purpose of demonstrating the reduction in the utilisation of what has to be sustained and the enhancement of what has to be developed. The next section reviews some of the principles and indicator frameworks that have been used in the decision making process and practise of sustainable development.

### *2.1.3 THE APPLICATION OF SUSTAINABLE DEVELOPMENT*

The usefulness of paradigms and theories are in defining what the goals of sustainability should be, but they are not pragmatic with regards to achieving those goals. Indicator frameworks present the practical opportunities for decision makers, whether to a business or government institution. This section reviews some principles used in sustainable development, The Natural Step and the Business Charter for Sustainable Development, as well as indicator frameworks, the Global Reporting Initiative (GRI), the Johannesburg Stock Exchange's Socially Responsible Investment (JSE SRI), and the State of Environment Reporting (SoER) as these are considered directly relevant to the current research.

#### **The use of principles in application of sustainable development**

The abstract nature of sustainable development has in most cases been clarified using sets of principles to guide decision making. This is evident in all sustainable development declarations, twenty-six principles in the 1972 Stockholm Declaration and twenty-seven principles in the 1992 Rio Declaration, with the Habitat Agenda and Brundtland Commission also using a set of goals

and principles (UNEP, 2006; Meakin, 1992; UN Habitat, 2003; WCED, 1987). The use of principles has also been adopted in general and business application of sustainable development.

### *The Natural Step*

Some general principles of sustainability are encompassed in 'The Natural Step'. 'The Natural Step is a strategic planning tool which helps an organisation to identify risks and opportunities associated with the sustainability challenge' (Burns, 2000). The Natural Step Framework is anchored on scientific principles and the properties of matter, and the ability of the earth to assimilate waste and regenerate its productive processes. The framework suggests four system conditions for the achievement of sustainable development:

- Substances from the earth's crust must not systematically increase in the biosphere, this system condition focuses on extractive activities of minerals and fossil fuels whose activity provides a massive flux of certain elements from one system, the lithosphere, to the biosphere, creating an imbalance that compromises the functioning of both systems (Rosenblum, 2000a).
- Substances produced by society must not systematically increase in the biosphere. This system condition evaluates, firstly, whether man-made materials can be assimilated back into the environment and, secondly, whether their rate of production is not beyond the assimilative capacity (Rosenblum, 2000b).
- For society to be sustainable, nature's functions and diversity should not be impoverished by physical displacement, over-harvesting or any other form of ecosystem manipulation. This system conditions refer to the direct impact we have on ecosystems and their ability to deliver on ecosystem services, through protection and utilising the services on their carrying capacity of the environment (Rosenblum, 2000c).
- In order for society to be sustainable, resources must be used fairly and efficiently in order to meet basic human needs globally. This system condition is people and behavioural centred in terms of political, economic and social patterns that compromise environmental integrity (Rosenblum, 2000d).

The proposed system conditions are fundamental in nature, with applicability to any institution that has an environmental impact. The strength of these principles is the ability to assist any firm to interpret what constitutes an impact and what has to be enhanced to contribute to sustainable development.

### *Business Charter for Sustainable Development*

Another set of reporting principles comes from the Business Charter for Sustainable Development, and was developed by the International Chamber of Commerce, and adopted in 1991 at the Second World Industry Conference on Environmental Management. The objective of the Charter is assisting business to improve environmental performance using a set of sixteen principles (ICC, 1991). The Business Charter principles go beyond corporate governance and focus on actual business process. The principles identify sustainable development as being a corporate priority that needs to be incorporated in integrated management; business process improvement; employee education; prior or baseline assessment; the development of products with no undue impact on the environment; customer advice; appropriate design of facilities and operations; research; precautionary approach; the promotion of the adoption of these principles by contractors and suppliers; emergency preparedness in cases of hazards; transfer of good technologies; the contribution to common causes of environmental protection; openness to concerns over impacts of the business; and, most importantly, compliance with corporate governance standards and audits.

Principles specific to business do not only attempt to provide theoretical concepts of sustainability, but provide guidance to business on compliance reporting, for example, the Global Reporting Initiative (GRI). The GRI principles do not prescribe the kind of policies that an organisation needs to adopt, but provides an outline of how to report on those sustainability policies, thus these principles can be seen as those of corporate governance, an important component of sustainable development. According to the GRI reporting principles (2002), a sustainability report should demonstrate transparency, inclusiveness, auditability, completeness, relevance, sustainability context, accuracy, neutrality, consistency, clarity, and timeliness. The GRI principles are applicable to any organisation that has an environmental footprint; however, its main contributions are to indicators that can be used to assess sustainability of organisations and the format of preparing sustainability reports. Several other principles for sustainable development have been developed for both public and private application including the Bellagio and Milan Straskraba Ecological Principles.

### **Measuring progress towards sustainability and sustainable development**

As sustainable development itself cannot be measured, it is necessary to gauge progress towards this ideal state through a variety of indicators. According to Warhurst (2002:10), several definitions of indicators have been proposed, citing that the OECD (1993) defines an indicator as 'a parameter or derived value from parameters, which provides information about a

phenomenon. The indicator has significance that extends beyond the properties directly associated with the parameter values. Indicators provide a synthetic meaning and are developed for a specific purpose'. The key elements of this definition are that indicators are inferential in nature and provide a metric towards or away from a specified system condition.

In South Africa the principles of sustainability are embedded in the King II Report Code of Corporate Practise and Conduct, a review of the 1994 King Report. This report emphasised the move from a single profit bottom-line to a triple bottom-line that covers environmental and social aspects of a company's performance as a guide to sustainability for business and government institutions (IOD, 2001:12). The report strongly draws from mainstream sustainable development theory, however does not specify how it should be done with the GRI and JSE SRI bridging that gap.

#### *The Global Reporting Initiative (GRI)*

The GRI identifies three thematic areas - economic, environmental and social sustainability – with the thematic areas covering six categories and thirty-six aspects, with the indicators divided into core and additional indicators (GRI, 2002:36). The indicators are briefly discussed. In understanding economic performance, the customer perspective in terms of market share and dominance by the company needs to be indicated, and magnitude of purchases and source country are also reported on. Employee payroll and company training investment are monitored, as are sources of capital in terms of debt: equity as well as corporate social investment in infrastructure and donations. An important additional indicator is the externality costs of the organisation's product or services (GRI, 2002:48).

Environmental performance is measured in terms of materials usage by the organisation as well as waste generated in the process, with the use of water dealt with as a separate material monitored through water usage total and recycling. The energy use of the organisation, both its direct and indirect consumption, is also measured, including initiatives to use renewable energy and product life cycle energy usage. Biodiversity is also considered from a perspective of land owned in threatened areas, as well as impact of company operations on the environment and transformation due to land use, for example, building footprints resulting in impermeable areas. Emissions, effluents and waste are also used by companies, particularly greenhouse gases, ozone-depleting materials, persistent organic pollutants and waste. The mitigation measures employed are also included. The life cycles of products and services, as well as impacts of products, have to be reported on in this framework and compliance with environmental soft and

hard law by the company, and environmental performance of suppliers also form part of the metrics. The life cycle of building materials and their embedded energy, as well as resource extraction and waste generated during their manufacturing make these indicators particularly relevant to the building construction industry.

The social performance indicators in the GRI are fairly robust, covering the employment creation benefits and labour relation practices of the organisation. Occupational health and safety practices in the organisation, including policies and practices on HIV/AIDS indicators, also form part of the metric. Diversity in the workplace at various management levels of the organisation is also measured, as is training spent in relation to company turnover. Human rights policies of the organisation are also scrutinised, in which use of child labour, freedom of association, forced labour and indigenous rights are considered. Societal issues of bribery and corruption, political contributions, antitrust regulation and management of impacts are interrogated. Finally, product stewardship in terms of customer safety and health, product labelling, consumer privacy and ethical advertising are also considered. As can be seen from the above, the list of criteria covered by the GRI is comprehensive and many would apply to the evaluation of the construction sector and, potentially, buildings themselves.

#### *Johannesburg Stock Exchange Socially Responsible Investment (JSE SRI)*

The JSE SRI is not fundamentally quantitative as is the case with GRI. Rather, it focuses on thematic areas that the company should demonstrate to have addressed. These thematic areas are based on the three pillars of sustainability (economic, environmental, and social), but also include elements of corporate governance. Each of the four thematic areas is assessed for policy considerations, management and performance as well as reporting transparency and consultation. Several criteria indicators are used under each of the four thematic areas, with measurement based on level of adoption or implementation, with a scoring scale of 0, 1, 2, and 3, for none, partial/efforts, full/complete, and exceeding compliance respectively. The index categorises companies into high, medium and low impact businesses. High impact companies are chemical companies, food manufacturing, aerospace and defence, automotive and others, whilst the medium impact category is for retailers, household goods and textiles, real estate, information technology, and others. Services in the low impact category include banks, insurance companies, and investment entities (JSE, undated). Even though real estate is considered medium impact it should be noted that the related activities such as, brick, steel and cement manufacturing fall under the high impact categories. A major limitation of the index is that the metrics are fairly

subjective and not quantifiable, and it does not provide hard and fast rules for trends that can be monitored over time.

On economic questions of the JSE SRI, several considerations are made regarding risk management, procurement and investor relations. On corporate governance the questionnaire solicits answers on the responsibility of the board on strategy; auditing and accounting risk management; appointment and remuneration of the board and top management; as well as corporate citizenship. Knowledge management, investment in and retention of human resources, supplier management procedures, insurance and contingency plans, customer and product satisfaction, and general legal compliance are monitored for each company (JSE, 2003). These criteria of the JSE SRI can be equated to the client-design team, particularly around the process of setting goals, be it for functionality or sustainability, thus providing best practise for commissioning of buildings.

On environmental performance, the presence of a policy and its continuous review are amongst the measures used, with its implementation being measured by the structures available for implementation. The business's impact assessment requirements are evaluated, so as the adoption and robustness of an Environmental Management Plan (EMP) to mitigate both direct and indirect impacts. Biodiversity, natural resources are measured using biodiversity protection and alien invasive species control initiatives by the company in its own property, as well as the consumption of biological resources in the productive processes. The environmental considerations also include emissions and discharges by the company as well as involvement in greenhouse gas trading emission schemes and mitigation measures employed to reduce greenhouse gasses. Energy and water usage form part of the indicator set, with consideration for alternative renewable energy sources being considered for energy and consumption reduction, and recycling initiatives being considered for water. Waste generation and recycling initiatives are also considered. Environmental incidents, provisions for environmental liability, and investment in environmental education awareness also form part of the evaluation criteria (JSE, 2003). Several environmental indicators are common between the GRI the JSE SRI, similarly having a potential applicability to buildings.

On social indicators, the thematic area evaluates the presence of a policy that covers: corporate governance; ethics; corruption; bribery and money laundering; stakeholder engagement; black economic empowerment; skills development; health and safety; HIV/AIDS; employment equity; diversity and transformation; human rights; community development; and consumer protection

and awareness. These are also evaluated on the basis of adequacy of the implementation and performance framework (JSE, 2003). The limitation of this index is that it does not set benchmarks, but assesses general performance.

### *State of Environment Reporting*

On public reporting, the State of Environment Reporting is the accepted practice in South Africa, based on the Agenda 21 requirements of the incorporation of environmental information in decision-making. The South African system makes provision for national, provincial, and municipal reporting, not excluding resource driven reporting (Balance and King, 1999). The methodology used in the State of Environment Reporting in South Africa is the Driver-Pressure-State-Impact-Response, or simply the DPSIR. The drivers of environmental change are defined by Department of Environmental Affairs and Tourism, (in Balance and King, 1999:7) as the underlying social and economic human activities that lead to environmental change. These include concepts such as population, industrial activity and poverty. Pressures are the resultant changes from drivers with regard to the quality and quantity of resources; the state evaluates the pressure trends over time and impacts refer to consequences of the pressures on humans and the environment, for example, on human health, loss of biodiversity, economic growth. The last component of the reporting system is responses, evaluating mitigation measures employed through policies and practical interventions by organs of state.

The national indicator set adopted for South Africa for the 2002 reporting mainly covers the monitoring of impacts, pressures and drivers even though there are indicators for states and responses. The indicators cover nineteen thematic areas using a total of one hundred and two indicators. The thematic areas are: climate change; stratospheric ozone; air quality; species diversity; habitat change; resource value; environmental management; human settlements; vulnerability; water quantity and quality; freshwater system integrity; land use; land condition; resource management resource quality; natural heritage resources; waste generation and waste reduction (Gibberd, 2003). The thematic areas are consistent in a lot of respects with the United Nations Indicators for Sustainable Development (UN-DSD, undated). There is an observable bias towards biophysical environment indicators with sixteen out of the nineteen thematic areas and eighty-nine indicators covering biophysical states. Within the biophysical elements there is also a strong focus on water and climate change related measures. The indicators used in the thematic areas are presented below, after Gibberd (2003).

The climate change indicators include, drivers of change such as greenhouse gases, energy use and intensity whilst differentiating between renewable and non-renewable sources. The dominance of coal-derived energy in South Africa makes greenhouse gas emissions an important environmental pressure for South Africa especially that South Africa has an energy intensity that is 50% higher per economic output unit, and contributes half the consumption on energy in Africa, for only 5% of the continent's population (Spalding-Fecher, 2002:5). Stratospheric ozone change is monitored using as the driver the consumption of ozone depleting materials, whilst the pressure is measured using ozone levels and the state monitored using UV-B trends.

The species diversity theme is monitored through threatened, extinct and endemic species per taxonomic group, as well as the extent of invasive alien species and the monitoring of selected indicators species. Habitat change is monitored using the extent of natural areas and those conserved, and disturbance regimes such as fire, drought and flood occurrence. South Africa prides itself in its biodiversity, with the country considered a biological hotspot, but vulnerable due to shallow soils, variable rainfall and climate; this makes biodiversity an important aspect of sustainability in the country (Balance and King, 1999:24).

The resource value theme primarily measures extracted value rather existing value, and measures the economic contribution of a variety of resources, e.g. freshwater, marine and terrestrial species, as well as the contribution to job creation of conserved areas and eradication of alien species. Water quality and quantity are measured using indicators of intensity and sectoral use of ground and surface water resources as well as access to water in terms of available water per capita and affordability. Quality issues are measured using chemical and biological characteristics; with freshwater integrity monitored using riparian vegetation and aquatic habitat. According to Mukheibir and Sparks (2003:2), the most limiting factor to development in South Africa is water, with projects like the Lesotho Highlands Water Project, being a prime example of acceptable cost to bringing water in the country. The authors further mentioned that the total water demand for year 2000 was  $13\,280 \times 10^6 \text{ m}^3$  with the limit of available water being  $13\,911 \times 10^6 \text{ m}^3$ , reinforcing that water is the most limiting resource to development in the country, thus an important resource.

Land use is measured using land cover and land productivity compared to potential, whilst land condition measures the decline in quality due to salinisation, desertification, and the accumulation of persistent organic pollutants. The resource management and quality themes focus on the marine environment by measuring fisheries exploitation and monitoring threats to

quality, like pollution incidence, population increases in the coastal zone, pollutants, estuarine ill-health and achievements in terms of beaches with blue-flag status.

Vulnerability is measured using an array of indicators that include Gross Domestic Product (GDP) per capita, employment rate, and the population growth rate, HIV/AIDS incidence as well as access to basic services like water and sanitation. Human settlements are monitored using proportion of urban areas compared to total land area as well as rural population against urban population. Housing density, contaminated land and green space per settlement are also used as indicators of the quality of human settlements. The country has identified as national priority the improvement of the quality of life, economic growth, employment and the provision of basic need, with the government recognising the resultant environmental pressure increase, however considered as an acceptable trade-off (Balance and King, 1999:11).

Environmental management is also reported on as a theme, measuring improvement in policy direction based on international agreements entered into, as well as practice by various tiers of government in terms of budgetary allocation on environmental programmes and the use of available tools in mitigating environmental damage. Waste generation and reduction thematic areas measure the per capita generation of waste per income group, including hazardous waste, with volumes of and value of waste recycled being measured. The same is true of the available landfill space and investment in waste management. Waste is also recognised as an important consideration in South Africa, not only due to landfill space availability, but recognised as a direct impact of achieving national priorities due to increased economic activity and affluence of citizens.

The interpretation of sustainability for the built environment was demonstrated in reviewing the historical development of the sustainable development, with indicator frameworks reviewed showing relevant indicators to building construction. The indicators were grounded on identifying the important sustainability considerations based on issues highlighted in the State of Environment Reporting for South Africa. The report prioritises human development, resource extraction from the development requirements, with a specific mention of water, biodiversity, pollution and energy. The next section reviews some sustainability rating systems for buildings, with a comparison of the systems also presented.

## 2.2 GREEN BUILDING RATING SYSTEMS

In recognition of the fundamental nature of shelter provision, the footprint of buildings forms an important component of drivers of environmental change. The economic impacts of the construction industry are evident in that, more than half of the wealth in the USA is in buildings, contributing \$800 billion, or 13% of the GDP (Gottfried, 1996). This is supported by du Plessis (2002:16) indicating that construction accounts for more than half of a country's gross capital formation, and 10% of Gross National Product. In South Africa, the value of completed buildings by the private sector in 2005 was over R 33 billion Statsa (2006).

According to du Plessis (2002:13) the impacts of the construction industry is pronounced in developing countries due to industrialisation, making construction an active industry. Construction environmental impacts include resource extraction such as timber and the mining of other construction materials impacting on biodiversity. Greenhouse gas emissions, primarily in the production of concrete and steel have also been identified as major impacts of the construction industry. The author indicates that cement production is second only to burning of fossil fuels in contribution to greenhouse gas emissions, with further embodied energy being in its transportation. The waste generated during construction materials manufacturing process and construction, as well as toxic effluents in the manufacturing and disposal of materials such as paints, sealants, chlorinated materials were also cited as of major environmental significance (du Plessis, 2002:15). According to Gottfried (1996), the impact of the built environment accounts for one-sixth of the extraction of water resources, one-quarter of wood harvest, two-fifths of materials and energy flow, and also impacts watersheds, air quality and transportation patterns in communities

Social impacts of the construction industry are predominantly positive, for example, that the construction industry is the largest industrial employer; particularly in developing countries thus play an important role in improving the quality of life. However the industry has a reputation of corruption, unfair labour practises, discrimination and poor safety records (du Plessis, 2002:15). Responding to the built environment footprint, several countries have progressed to develop industry specific indicators of sustainability, or, green building rating systems. The Australia, Canada, UK and US rating systems are reviewed. Even though countries like Japan have their own systems, the rationale of country choice for systems under review is the leadership of the US system worldwide, the potential comparability of the Australian climate and geography with South Africa's, and the structural difference of the UK system.

### 2.2.1 UNITED STATES GREEN BUILDING RATING SYSTEM

The US green building rating system is called the Leadership in Energy and Environmental Design or the LEED™, with the United States Green Building Council, an industry driven coalition for development of built environment sustainability, being the custodian of its implementation. The provisions on the LEED™ NC Version 2.2 released in 2005 (See **Appendix 1**) are used in reviewing the USA rating system. The system provides rating systems for, (i) new construction (ii) existing buildings (iii) core and shell (iv) homes, and (v) neighbourhood development, with the last three standards being under development as of 2005 (USGBC, 2005: 3). The USGBC accredits LEED™ rating professionals who in turn contribute to both the design and rating of buildings.

The rating is undertaken using a three level hierarchy of thematic areas covering a broad group of criteria. It also covers necessary prerequisites, considered minimum performance requirements, thus no points are awarded, whereas credits are considerations for which points are scored. The thematic areas are:

- *Sustainable Sites*: This includes measuring spatial aspects of the building footprint on biodiversity, micro-climate, water resources and aesthetics. The maximum score possible from this theme is 14 points, translating to a 20% weighting of this theme towards the final score.
- *Water Efficiency*: This involves measuring water use efficiency from both the landscape and the building, and also addresses wastewater treatment options exercised. This theme contributes the least in the rating system, with 5 points or a 7% weighting going to the total score.
- *Energy and Atmosphere*: This category measures the energy performance of the building, adoption of renewable energy sources, and minimisation of ozone depleting chemicals. The theme contributes the most, at 15 points, contributing almost 22% to the total score.
- *Materials and Resources*: This category measures the re-use and minimisation of the use of virgin materials. Where virgin materials are used, consideration is given to the life cycle costs of selected materials. This theme contributes 13 points, just under 19% to the total weighting.
- *Indoor Air Quality*: In this category, building health with regard to the operational aspects of daylight, thermal, ventilation comfort of the building are measured. The theme contributes significantly to the overall score, with 15 points that make up just under 22% of the total weighting.

- *Innovation and Design Process*: This measures the extent to which the design incorporated sustainability beyond the prescripts of the LEED™, and the involvement of a LEED™ professional in the design process. This aspect has the same point contribution as water, with a 5 points 7% contribution to the total.

The rating classifies building into, certified for 26-32; silver with 33-38; gold with 39-51, and platinum with 52-69 points; with however, status cannot be awarded if prerequisites are not met. For the sustainable sites theme, the prerequisite is the prevention of pollution by construction activity, with the intent of preventing soil erosion, waterborne sedimentation, and dust. For the energy and atmosphere theme, commissioning of energy performance is a must, the goal of commissioning being the verification of installations and calibration of energy related systems according to specifications. The second prerequisite for energy and atmosphere is the establishment and adoption of minimum energy performance of system, with the third being a reduction in the use of ozone depleting materials. Under the materials and resources theme, the provision of waste storage and recycling systems on site is necessary, so as minimising landfill disposal is also considered a prerequisite. Concerning indoor air quality, the establishment of minimum performance to enhance occupant health is one prerequisite, the second being control of environmental tobacco smoke. No prerequisites are set neither for water efficiency nor for the innovation and design process.

Various criteria are applied to each of the themes and they typically propose a minimum performance that a building should achieve and/ or suggest a technology, and the methodology for assessment that should be used to minimise the environmental impact. A significant number of the benchmarks are based on regulations and standards applicable to the state in which the building is located. The sustainable sites, energy and atmosphere and indoor air quality are mainly benchmarked using regulations and standards, with the benchmarks for other criteria and within the aforementioned being set by the USGBC through the LEED™.

### *2.2.2 UNITED KINGDOM GREEN RATING SYSTEM*

The United Kingdom System is called the Building Research Establishment's Environmental Assessment Method (BREEAM™) and its custodian is the independent Building Research Establishment, an organisation held in trust on behalf of the construction industry. The UK system also has different rating systems for different building types: (i) industrial (ii) offices (iii) prisons (iv) retail, and (v) schools. The EcoHomes XB: The Environmental Rating for Existing Housing, Issue 2.5 is used to demonstrate the criteria of the BREEAM™ rating tool (BRE,

2006). The rating system uses seven thematic areas with a total possible 56 points being allocated. The themes are as follows:

- *Management*: This theme measures the existence of policy, awareness, and environmental practice in the operation of the building, and it scores 8 points, just over 14% of the overall weighting.
- *Energy*: The energy performance of the building is measured through specific considerations in the design. This theme contributes the most points at 20, in other words, 36% of the overall weighting.
- *Transport*: Transport measures the access to transport and the subsequent reduction in energy costs. 2 points are scored from this theme, which means it contributes just over 4%.
- *Pollution*: This theme scores 3 points and is measured on the basis of the use of zero emission energy sources, translating to a 5% weighting.
- *Water*: Both internal and external water use is considered with a relatively significant weighting of 18% for the total available score of 10 points.
- *Health and wellbeing*: Ventilation, comfort and ergonomics are measured, and it carries the same weighting as transport at 4% for the 2 points.
- *Waste*: This theme carries the second highest weighting after energy at 11 points, and measures reuse of building materials, domestic recycling facilities, and the disposal of CFC waste. The weighting for this theme is 20%.

The criteria used in this rating system benchmarks make some use of government regulation and standards with the majority being developed by the BRE. The criteria are defined for their goals, assessment procedures and guidelines for measuring a credit. The BREEAM™ was the first system implemented in the early 1990s whilst the LEED™ was implemented in 1999, and the Green Star™ in 2003 (GBCA, 2006a:17; Lockwood, 2006:130).

### 2.2.3 AUSTRALIAN GREEN BUILDING RATING SYSTEM

The Australian rating system is called the Green Star and is under the custodianship of the Green Building Council of Australia. The Green Star series of rating tools includes: (i) office design Version 2 (ii) office as built Version 2 (iii) office interiors Version 1.1 (iv) office existing building Version 1, with shopping centre and health facility developments under pilot (GBCA, 2006b). The Office design tool Version 2 is used to illustrate the considerations of this system.

The system uses a nine theme rating system with a potential score of 129 and 5 bonus points, and having some conditional requirements for energy and ecology. The themes are:

- *Management*: This addresses commitment to environmental management and performance, including the use of an accredited professional and commissioning. The potential number of points for this theme is 12, a weighting of just over 9%.
- *Indoor Environmental Quality*: This theme measures building comfort from ventilation, day lighting, views and materials detrimental to human health. The weighting of this rating system is 27 points, a weighting of 21%.
- *Energy*: The energy theme measures improvement in energy efficiency using an array of indicators and measurement tools. This theme contributes 24 points to the overall score, there is thus 19% contribution to final score
- *Water*: This theme monitors the exterior, interior, and fire hydrant water consumption and contributes 13 points, that is, 10%.
- *Materials*: The maximisation of reuse of building materials, minimisation of waste and material type selection are measured, in this case, it contributes 20 points, 10% to the overall score.
- *Land Use and Ecology*: This measures the change in ecological value of the land, and credits reclamation of contaminated sites. The contribution of this theme to the overall score is 8 points translating to 6%.
- *Transport*: Provision for alternative modes of transport is catered for under this theme and the weighting is 9% from the contribution of 11 points.
- *Emissions*: Pollution from refrigerants, storm water runoff, and light pollution are considered in this theme. The theme contributes 14 points in the system or 11% to total score.
- *Innovation in Design*: This contributes 5 bonus points where the building exceeds a Green Star benchmark, a 4% bonus contribution.

The system demonstrates a strong consideration of air quality impacts, energy, and materials usage. The rating grades buildings from one to six stars, with a grading of four and above requiring accreditation by Green Star. Self assessment is thus excluded.

#### 2.2.4 SUSTAINABLE BUILDING ASSESSEMENT TOOL (SBAT)

For developing countries, the SBAT tool has been developed and proposed in South Africa, albeit not widely used and adopted by industry as yet. The tool draws strongly from sustainable

development criteria addressing five indicators for each of the environmental, social, and economic facets of sustainable development (Gibberd, 2005:1606). The environmental theme assess water, energy, waste and site; the economic theme measures local economy, efficiency of use, adaptability and flexibility, ongoing costs and capital costs; the social theme covers occupant comfort, inclusive environments, access to facilities, participation and control, education health and safety.

The tool is designed to be holistic and simple to implement, a probable reason for it not detailed in measuring the actual requirements, measurements and metrics. According to Burger (2000) cited in Kaatz *et al* (2002), ‘One cannot discuss the state of South African environment and exclude socio-economic reality of the country ... a country aspiring to a higher level of economic development ... improve quality of life’. The SBAT rating tool demonstrates its relevance to a developing country context like South Africa, as it clearly addresses social and economic criteria, otherwise lacking in other rating systems.

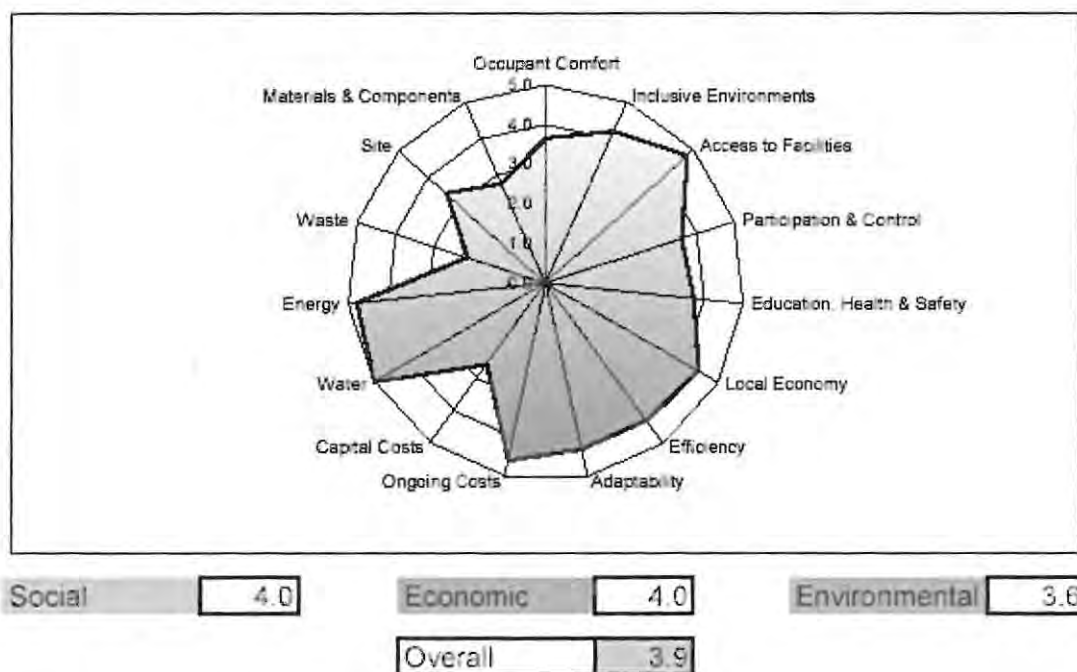


Figure 1: An example of an SBAT Report (Adapted - Gibberd, 2005:1609)

Criticism of the tool is that it assigns equal weighting for all the criteria as can be seen in a sample results shown in **Figure 1**, whereas the review of the State of Environment Reporting in South Africa clearly demonstrated the relative importance of environmental pressures and impacts. The other limitation as cited above is the fact that it is prone to subjectivity and a low replicability as there are no standards to support it - a cost of the inherent flexibility it has.

Supporting the tool is the Sustainable Building Lifecycle (SBL) which suggests a stepwise process of incorporating sustainability in buildings, from initial briefing of the design team to operation and evaluation of reuse, recycling and demolition at the end of the building life cycle (Gibberd, 2005:1610).

### *2.2.5 COMPARISON OF THE RATING SYSTEMS*

Emerging out of the Brundtland Commission and the Rio Summit, sustainable development expounds the three pillars of sustainability of environmental, social and economic considerations. The same is reflected in the indicators frameworks. However, it is observable that the social and economic considerations do not permeate through to the BREEAM<sup>TM</sup>, LEED<sup>TM</sup>, and Green Star<sup>TM</sup> building rating systems for sustainability; however this is the strength of SBAT. This is evident across all three rating systems that were evaluated, showing a strong focus on biophysical and human health, but lacking economic factors like efficiency in application of financial capital, and affordability of the resultant structures. The cultural, historical realm, and social acceptability and contribution are not evident in the three systems.

The strength of the BREEAM<sup>TM</sup> is the management theme as it attempts to change behaviours, which can be a strong mitigation measure compared to seeking technical amendments to buildings as a means of reducing impacts. The Green Star provides a limited recognition of management issues under commissioning exercises, which are also covered under the LEED<sup>TM</sup>. The limitation of both the BREEAM<sup>TM</sup> and the Green Star is on the site selection, with the theme completely absent in the BREEAM<sup>TM</sup>, while the land use and ecology theme covers some biodiversity aspects in the Australian system. Kaatz (2002) reviewed the LEED<sup>TM</sup>, BREEAM<sup>TM</sup>, GBTool, and SBAT for a number of criteria that included comprehensiveness, flexibility, adaptability and other criteria, and the findings showed that none of the criteria was adequate for South Africa, suggesting that the LEED<sup>TM</sup>, and BREEAM<sup>TM</sup> require changes in benchmarks and weighting with the BREEAM<sup>TM</sup> not emphasising water and biodiversity and does not integrate life cycle costs, whereas the LEED<sup>TM</sup> is comprehensive. The criticism of SBAT was the lack of in-depth analysis of environmental issues.

If the weighting of a theme is considered to be an indicator of the relative importance of a criterion, energy use and indoor air pollution are important considerations across the countries, even though air quality is lower in the priority in the UK system. The USA system also emphasises site selection compared to the other two, but is conspicuously low on water

efficiency at 13%, while its 50% of the top rated theme the UK and Australian systems. It can be assumed that the weighting depends on the relative pressure in different countries, with the litigation culture in the USA being a driver for prioritisation of indoor air quality. On the other hand, spatial pressures may be the driver for the high priority for waste, the climate of Australia driving the importance of water efficiency prioritisation. The State of Environment Reporting in South Africa suggest water, human development, biodiversity and waste as being the primary priorities that would require attention (Balance and King, 1999: 11; Mukheibir and Sparks 2003:2).

The application of any rating system is nested on the regulatory regime in a country through legislation and standards, with the next section providing a brief overview of the regulatory regime, and where building sustainability rating tools would fit.

#### *2.2.6 BUILT ENVIRONMENT REGULATORY FRAMEWORK IN SOUTH AFRICA*

The Bill of Rights, Section 26 of the South African constitution guarantees right of access to adequate housing for citizens, (RSA, 1996:13), with the construction industry regulated through the National Building Regulations and Building Standards Act (No 103 of 1977), with the aim of promoting uniformity in law regulating the erection of buildings as well as prescribing building standards and any matters concerned with the erection of building structures (Watermeyer and Milford, 2003). The Act provides for building regulations that local authorities apply when registering buildings (Architectural Directory of South Africa, 2006). The Act further provides for the establishment of bodies like the National Home Builders Registration Council, which provides warranties on building on the basis of having met the regulatory requirements. The Act allows for the Minister of Trade and Industry to regulate procedures for general health, safety of, and convenience to the public, but falls short of prescribing energy efficiency of buildings (Watermeyer and Milford, 2003: 7).

According to Watermeyer and Milford (2003: 8), the South African National Building Regulations are based on the five-level Nordic model (**Figure 2**), with the Act and regulations providing the Level 1 societal objectives. The dimensions of societal objectives are indicated by the categories presented in the National Building Regulations. The National Building Regulations provide administrative procedures for: structural design; dimensions; demolition work; public safety; site operations; excavation; foundations; floors; walls; roofs; stairways; glazing; lighting and ventilation; drainage; non-waterborne sanitation; storm water disposal; disabled persons; fire protection; space heating; refuse collection; and fire equipment

installations (Architectural Directory of South Africa, 2006). It is observable that the criteria identified relate to functionality, and do not represent other broader societal goals like environmental protection, which would be a starting point in introducing sustainability in the system.

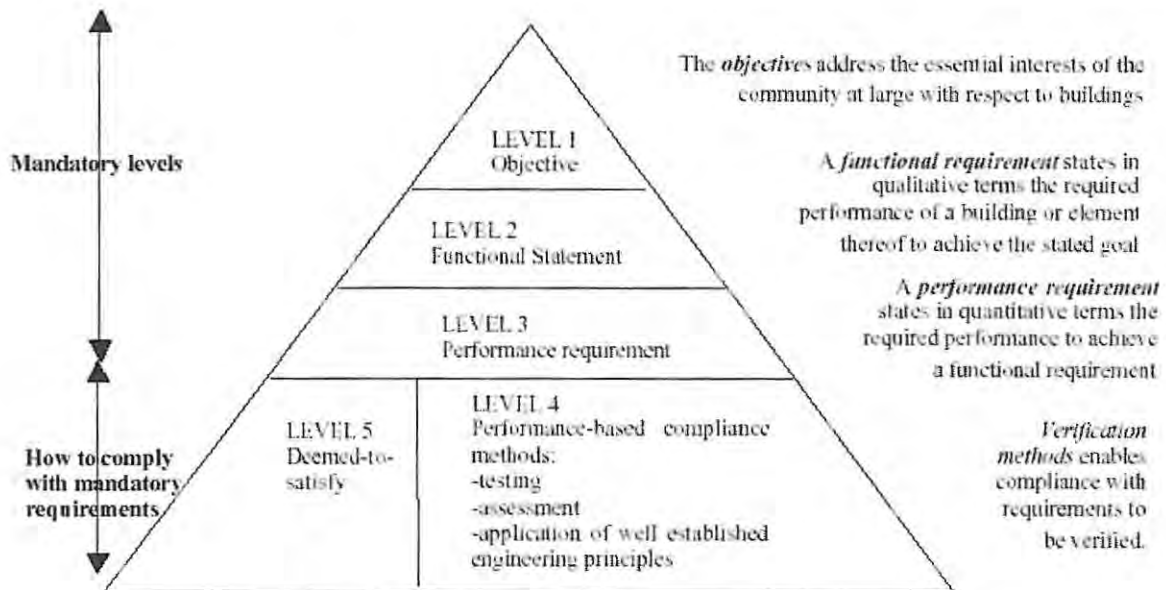


Figure 2: Nordic 5 level performance based codes (Adapted - Watermeyer and Milford, 2003:8)

The Level 2 requirements of the model are represented by the SABS standard SANS 10400:1990, providing qualitative terms required to meet the required objectives and how to comply with the deemed-to-satisfy requirements of Level 5 by monitoring compliance with loading codes for the various structural materials (Watermeyer and Milford, 2003:8). The authors critique the system in that it there are no Level 3 criteria for quantitative performance measurement, and also that the requirements are designed to measure performance of concrete floors, masonry walls, and timber roofing and not geared for alternative construction methods. However, in mitigation of the limitation, Agreement South Africa, SABS, and the CSIR can evaluate the safety of alternative building systems, materials, and methods. However, the alternatives should demonstrate performance equal to or better than the relevant part of SANS 10400 (Watermeyer and Milford, 2003:9).

### 2.2.7 BARRIERS TO ADOPTION OF GREEN BUILDING GUIDELINES

The Green Building Council of Australia categories barriers and challenges to the use of green building rating tools as lack of co-ordination and consistency, cost barriers, and lack of education

GBCA, 2006a:58). The classification followed by the CSIR identifies conceptual, institutional, knowledge and economic barriers on their water and energy guidelines, citing some strategies that can be employed in mitigating those, specifically for energy and water programmes (CSIR, 2005a; 2005b).

The lack of coordination arises from rating tools continuously evolving and increasing benchmarks, which can mean significant investment in meeting the new benchmark. The second contributor is lack of consistency in government codes, which can be either contradictory, or non-existent to support new technologies. Lastly the selection and availability of green certified materials challenge designers as such supply chains are not well developed (GBCA, 2006a:59-60).

The cost barriers are made up of misconceptions that the capital costs of green buildings are significantly higher than conventional construction. Some real cost barriers include the high costs of retrofitting existing buildings, which are a significant stock, due to locked in outdated technologies. The fact that benefits of green building accrue to building operators rather than the developer leads to a mismatch on investment and returns (GBCA, 2006a:64). To mitigate cost barriers, the CSIR suggest increasing awareness from case studies clearly demonstrating benefits and the payback period (CSIR, 2005a)

Lack of knowledge and skills on sustainability by construction professionals restrict the implementation, as well as the lack of research and local data. Also mentioned are financial valuation methods by financial institutions that do not account the value of green buildings, leading to an under-valuation (GBCA, 2006a:65).

Loots and Irurah (2005) also identified weaknesses in the tools used in performance assessment, such as the fact that sustainability performance of buildings is a specialised field in its own right, which is difficult for conventional building practitioners to incorporate in enhancing the design. The fact that rating systems report on decisions made rather than contributing to design limits the contribution to outcomes, which can also be seen as a deterrent.

## CHAPTER 3

### METHODOLOGY

#### **3.1 RESEARCH OBJECTIVES**

The challenges of human development and the environment have been identified and the concept of sustainable development has been coined and accepted globally. In response to sustainability needs, the built environment has responded through green building rating systems, with demonstrated social, economic and environmental benefits. South Africa, despite its growing building footprint and environmental challenges, has not adopted a building rating system, whereas several countries have developed such systems. The study therefore does not provide a hypothesis to be proven, but contributes to the body of knowledge towards the development and acceptance of an appraisal framework for green building rating in South Africa.

The goal of the current research was to obtain an understanding of the extent and motivation for the consideration of green building criteria in the design and construction of the new SAIAB wet collection storage facility in Grahamstown.

The primary objectives of the research have been identified as follows,

- i. Evaluation of sustainability considerations in the design of the SAIAB building, and barriers encountered
- ii. Demonstrating how the building rated against the LEED<sup>TM</sup> building sustainability rating system
- iii. Evaluation of the applicability of the LEED<sup>TM</sup> rating system in the context of South Africa

#### **3.2 RESEARCH APPROACH**

The goals of the research were achieved using a case study of the new SAIAB wet collection storage facility in Grahamstown. The academic philosophy and paradigm underlying the research is discussed, and how that informs the data collection and interpretation tools is presented in the next sections.

### 3.2.1 CASE STUDY RESEARCH

The case study is qualitative in nature as it does not rely on numeric data that is considered objective. Rather, it is based on a subjective worldview of sustainability as encompassed in the rating system framework used, that is, the LEED™. The rating of the building for its sustainability is based on the respondent's views of sustainability considerations, or lack thereof, with the final rating being a subjective view of the researcher. According to Remenyi (1996:31) qualitative research refers to subjective opinions and points of view, and is thus prone to bias, with techniques like triangulation used to improve objectivity. In addressing the second goal of the research, existing literature will be used and applied based on the perspective and understanding of the researcher.

According to (Merriam, 1998 in Winegardner (2005:1), case studies should be restricted and this can only be achieved if there is a limited observation or number of respondents. In the study's population and sampling, the interviewees were limited to stakeholders involved in the design of the building; these were the architect, landscape architect, structural engineer, civil engineer and, importantly, the client. The limited number of respondents is thus consistent with the characteristics of case study methodology. Winegardner (2005:8) citing Patton (1990), indicates that because case studies encompass multi-method data collection, the various sources provide a platform for triangulation, crosschecking and validation of results. The use of a case study as a means of addressing the research goal thus mitigates the bias limitation of qualitative research.

Beyond the case study being qualitative, it also has a descriptive dimension. Robson (1993) cited in Winegardner (2005:6) defines the objective of descriptive research as being to portray the research subject in its natural environment. It thus requires extensive knowledge by the researcher in order to identify areas of investigation. In achieving the goals of research, the research subjects responded to their consideration in the design process, with no 'experimental control' using open-ended questions. Responses were, however, shaped by the LEED™ framework in the collection of information. In order to ensure the researcher is knowledgeable about the subject the process followed literature review and questionnaires. Then interviews were used where necessary to augment information collection.

Gaining the "emic" or insider's perspective is central to qualitative research Winegardner, (2005:2). In this case, the emic view of the design team is the personal sustainability considerations in design of the SAIAB building, and that of the researcher, the latter is the primary instrument for data collection and analysis (Guba and Lincoln, 1994:110). In the

interpretation of qualitative study results, analysis tools include content analysis. Findings are not analysed. Rather, the understanding of the evidence is interpreted (Remenyi, 1996:32). Because data interpretation is subjective, ethical considerations are important. Respondents were thus afforded the opportunity of anonymity and review of the findings prior to their final submission. For appropriate interpretation of the study, the researcher's worldview is presented so as to facilitate the understanding of consistency between methods used and the research philosophy adopted.

### *3.2.2 RESEARCH PARADIGM*

Critical elements in the research method can be identified as the subjective nature, requirement for triangulation to improve objectivity of qualitative research, and interpretation rather than analysis of findings. As case study is typified by limited observations, multiple methods of data collection, and the expression of the research subject in his or her natural state, the departure paradigm of the researcher is discussed. Guba and Lincoln (1994:109) were used as a basis in defining the researcher's paradigm, which is argued to be founded on a postpositivist ontology, where reality cannot be perfectly apprehended thus must be critically examined as much as possible.

The epistemology defines the relationship between the researcher and what can be known (Guba and Lincoln, 1994:108) and is constrained by the ontology. Guba and Lincoln further indicate that postpositivism still assumes an objective reality consistent with positivism, with Remenyi (1996:27) explaining the philosophical stance of positivism: that the researcher is an objective analyst primarily employing falsification rather than induction. The study is thus not truly positivist in approach, as the rating of the building and subsequent recommendations are based on existing literature and triangulation for objectivity and subjective observation in the interpretation of responses, acknowledging the subjective interpretation of reality, and can thus be classified as following a critical tradition based on fit with pre-existing knowledge.

The use of a case study is thus considered consistent with the postpositivist research paradigm as it provides an objective view from which inferences can be made, while still, however, recognising the objective limitations posed by being based on pre-existing knowledge.

### 3.3 RESEARCH SUBJECTS

The case study, SAIAB building, is located at Rhodes University in Grahamstown, Makana Municipality, approximately 145km from Port Elizabeth in the Nelson Mandela Metropolitan Municipality. The Makana municipal area is known to comprise of ten vegetation types, representing all major biomes of Southern Africa with twenty-seven endemic taxa, of which seventeen are vulnerable, five threatened and five critical (LEAP, 2004:6). This makes biodiversity protection an important consideration within the municipality.

The town of Grahamstown also have socio-economic challenges, with Alebiosu (2005:5) indicating that the town of Grahamstown has a high unemployment rate at 49% unemployment rate compared to the national average of 28%. The author further cites lack of access to basic infrastructure, adequate housing and social and economic vulnerability as other socioeconomic challenges facing the town of Grahamstown. Rhodes University play an important part in the economy of the town, contributing approximately 48% of income generated by the two (Alebiosu, 2005:12).

It is within that setting that the building of the SAIAB facility is set, with the design team composed of consulting companies from both Grahamstown and Port Elizabeth.

#### 3.3.1 FUNCTIONALITY OF THE SAIAB BUILDING

The case building is an off-site storage facility, suggesting that it should be isolated from occupied research buildings, and would thus low occupancy. The second aspect is that it is a wet collection storage facility, meaning the aquatic life specimens are stored in organic solvents. The building is classifiable as J1 high risk storage building as the stored materials can lead to extremely rapid combustion and/ or cause explosion with the design population restricted to 1 person per 50m<sup>2</sup> (NBR, 1990:34-35).

Emanating from the use of the building the human safety from fire and explosion risk is one of the design criteria, thus the building should demonstrate both physical and work process safety. This is achieved by minimising opportunities for perimeter breach, isolation of work areas from collection storage and chemical storage areas. The installations in the building should not have the potential to generate static or electricity or an open flame, achieved by installing of non-static appliances, earthing of the metal storage shelves and installation of closed plugs in the high risk areas.

The second design consideration is air quality from fumes of the solvents used, ethyl and propyl alcohol, and formalin (corrosive agent) used in the cleaning and preservation process. This requires adequate ventilation and exhaust systems as well isolation of the work area from storage areas. The installation of a monitoring system for fumes contributes to the monitoring of both the air quality standard as well as an indicator of leaks that may pose a fire hazard.

The third requirement of the design is the maintenance of integrity of the stored specimens, requiring that the room temperature should be maintained at 15 and 18°C, requiring adequate thermal control. The building is also required to minimise light penetration and maintain dark conditions, this is achieved by having no windows except for louvre covered windows for ventilation.

From a work process point of view the reduction of exposure of researchers to chemical storage is of paramount importance with emergency showers and eye wash stations required in every section of the building. This is achieved by designing pumps and mixers inside the storage areas so as to minimise traffic into areas with volatile or corrosive solvents. Minimisation of access points is also considered with direct access from the outside to storage areas for delivery vehicles.

Additionally, the brief in building the structure was cited by the client as primarily, functional standards, as well as the building being representative of the ideals it stands for in terms of science and nature research. The architect further mentioned that ‘... brief from the client stressed the importance of an environmental ethos in design, even though it may not have fully transpired through the design team’. The SAIAB building is the only off-site wet collection in South Africa, albeit there are similar facilities in Europe and America, the implication is that each building is custom made to a specific situation, with no documented standards for construction even though international best practise and experience guides the design process.

### *3.3.2 DESIGN TEAM*

The design process needs to integrate the contributions of various professionals in a team, for sustainability design the LEED™ suggests a team that includes the building owner, tenants or users, building manager and operator, government agencies responsible for enforcement of codes, consultants, engineers, construction manager, testing agency, contractor and utility agents (Bernheim and Reed, 1996). The rendering of these services in the design of SAIAB building and composition of the team is discussed below.

## **Client**

The composition of the client team was made up of the managing director of the institute, senior research scientists and management staff. The client team also had representatives from Rhodes University's Estates Division, and associated scientists from the Department of Ichthyology and Fisheries Science. The role of the client included that of being the building owner, consultant on functionality requirements, user and operator of the building. The client team comprised of ten people, under the leadership of the managing director of the institute, with data collected from the managing director using a questionnaire. The questionnaire sufficed for the requirements of the study, even though augmentation of data was requested at later stage.

## **Project Manager**

The appointed project manager was from a private consulting firm with the responsibility of assembling and appointing the design team as well as signing off designs. Another responsibility of a project manager is to ensure adherence to time and cost constraints of the projects, also playing well into the fact that the project manager provided quantity surveying services to the project.

## **Architect**

The design of the building did not use full architectural services, with the architect having been belatedly co-opted in the design of building for elevation, and a conceptual design of the landscape. Full architectural services include the interpretation of the brief and approach, of which the architect did not offer those services. The architect also provided landscaping services; a questionnaire and interview were conducted with the architect. The fact that design is a combination of client goals and interpretation primarily by the architect make the role of the architect crucial in the design process.

## **Engineering team**

The engineering team was from two companies, one offering civil and structural services, and the other mechanical and electrical engineering services. The structural and civil engineering team role was structural functionality of the design, and the provision of services, water, and sanitation as well as storm water management. On the other hand, the electrical and mechanical engineering team contributed to the design electrical installations, ventilation, fire protection and alcohol handling systems. The engineering team including the project manager comprised of seven people with questionnaires sent to the civil and structural team and the electrical and mechanical team. The civil and structural team did not respond to the questionnaire, however

technical drawings were obtained to infer on decisions made. One response was received from the mechanical engineer.

### **Contractor**

The main contractor was a civil contractor with no contribution to design, but responsible for translating designs to a building, with the latitude of suggesting alterations that however require approval by appropriate professional and the project manager. A questionnaire was also sent to the contractor even though no response was received, and because the LEED™ focus on the design process, with most questions rating the design rather than activities during construction

## **3.4 DATA COLLECTION**

Data collection was undertaken using questionnaires, follow-up interviews, review of technical drawings of the building, and literature particularly in evaluating the applicability of the LEED™ rating system in South Africa.

### *3.4.1 QUESTIONNAIRES AND INTERVIEWS*

The questionnaire (**Appendix 2**), was designed on the basis of criteria used in the LEED™ evaluation of building sustainability using open ended questions to obtain the ‘inside perspective’ of the respondent’s considerations in the design of the building. The first section of the questionnaire was general information with regard to role in the design, as well as affinity to the environmental school of thought, so as to put into perspective the respondents worldview of sustainability. The body of the questionnaire was as per criteria of the rating system, covering criteria for the themes, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor air quality and innovation in design. The LEED™ themes comprise of prerequisites and credits, with prerequisites being must-do’s in a theme even though no points are awarded, whereas credits are those considerations that contribute to the overall score. The last section sought to achieve a subjective weighting of the sustainability.

### *3.4.2. REVIEW OF TECHNICAL DRAWINGS AND BUILDING REGULATIONS*

The technical drawings of the building were analysed to establish evidence of the design considerations indicated in the interviews particularly architectural, and civil designs. The site was also visited during construction to verify site considerations. The National Building Regulations SANS 10400: 1990 were reviewed, including an informal undocumented interview with the staff at the South African Bureau of Standards. The multiple information sources

(questionnaires, literature, technical drawings) provided the required triangulation in a postpositivist case study for objectivity.

### **3.5 DATA ANALYSIS**

The analysis and interpretation of data for Objective 1 used content analysis, where responses for each criterion from the three respondents was analysed to understand the considerations that were taken into account in the design of the building. Barriers identified or implied were recorded on the strength of questionnaires, interviews, technical drawings and literature.

Consideration of the design parameters identified by the respondents was then compared to the requirements of the LEED™ for the awarding of points. Because the LEED™ rating is sometimes based on performance standards established in the US, and there are no performance standards in South Africa, a subjective scoring is awarded on the basis of appropriate literature to satisfy requirements for Objective 2.

The analysis of data for meeting the requirements of Objective 3, were based on sustainable development literature to evaluate the extent to which the LEED™ rating system addresses concepts of sustainability. Even though weighting of criteria was envisaged using a Lickert scale, the ranking offered by respondents even after a follow-up did not meet the requirements for a quantitative assessment, thus content analysis was used for the weighting as well. The State of Environment Report for South Africa was also used to establish the relative importance of criteria in the context of South Africa.

### **3.6 RESEARCH LIMITATIONS**

The main limitation of the study is the case study approach with information collected specific to the SAIAB building, with minimal room for generalisation of the findings. However the value is that it provides insights into the interaction of theory of sustainability, use of performance standards, and practise.

Another limitation of the study is that there are no standards for buildings with the functionality of the SAIAB building, the rating tool used is for new constructions used for high human occupancy rates, and thus different design objectives.

The response rate is also seen as a potential limitation of the study as focused rigour is a critical element of case study research providing more opportunities for cross-examination of responses to the same questions. However the nature of the team is such that each member is responsible for only a particular aspect of the design process, with respondents not comfortable in commenting on considerations that were not part of their brief.

## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

The results are presented in four sections. The first section presents an understanding of sustainability by the design team, as well as general perspectives on the challenges of implementing sustainable development in the construction industry. The conclusion of this section is the identification of high level challenges and barriers to sustainability. The second section is more practical and specific to identifying consideration of sustainability principles in the design of the SAIAB building, and also identifying potential or perceived barriers, particularly as influenced by availability of building standards. The conclusion of this section outlines potential barriers to adoption and practise of building sustainability rating systems in South Africa based on the SAIAB experience.

The third section addresses the second objective on how the building rates against the LEED™ criteria, is informed by the considerations in the design of the building, and provides insights on the current level of ‘greenness’ of the building industry. The fourth section evaluates the applicability of the LEED™ in the South African context as well the relative weighting it assigns to criteria, and their relevance to South Africa. This is achieved by evaluating the extent to which the GRI and JSE SRI indicators filter through, with the weighting addressed to SAIAB responses and the SoER.

The last section addresses the goal of the research and summarises the insights into motivation for green building criteria and potential barriers whether real or perceived. This knowledge will contribute to the body of knowledge on the state of building sustainability rating in the country. Areas of future research are also identified, and particular attention is paid towards mitigation of challenges.

#### **4.1 UNDERSTANDING OF SUSTAINABILITY**

##### ***4.1.1 CLIENT***

The client understood sustainable development as ‘... development that includes social, environmental and economic considerations to ensure continued functioning in the long-term’; thus buildings should meet present and future societal needs. The client cited the main challenge to attaining sustainable development as being the ability to understand and respond to issues. The

relationship between buildings and sustainable development related mainly to the respondent's understanding of sustainable development, particularly intergenerational equity, with the impacts of buildings identified as the use of natural resources for construction materials, space and energy consumption and aesthetic impacts. On how the sustainability can be achieved in the building construction, the client suggested the use of materials and methods that minimise resource expenditure, and harmony of buildings with their context. This suggestion introduced the importance of a social context fit for buildings.

From the understanding of sustainable development, the client demonstrated a strong orientation towards biophysical and social context of buildings as being important aspects of contribution to sustainable development. Other than professional affiliation and the recognition of the constitutional basis of providing scientific information, the respondent was not a member of an environmental interest group. The client indicated that the contribution his profession can make to sustainability is awareness-creation of the human and environmental systems.

#### *4.1.2 ARCHITECT*

The architect's understanding of sustainable development and how it relates to buildings was comprised of the minimisation of building impacts, maximising natural opportunities, optimising the functioning of the building and the cultural context in which the building is being built. The biggest challenge to achieving sustainability in buildings was identified as the current practice, which is delivery driven, with primarily a set time and budget, limiting the exploration of alternatives. To mitigate this challenge and move towards sustainability, the architect suggested clear indication of roles in the design team and value engineering practice to explore alternatives.

The architect demonstrated awareness of the concept of green buildings, primarily from her own research and professional publications. Her membership to organisations such as the Wildlife and Environmental Society of South Africa and the Botanical Society of South Africa, suggest a strong affinity with environmentalism. The contribution of architects to sustainable development was identified as, interpreting the approach and definition of the brief from a client while demonstrating elements of sustainability.

#### *4.1.3 MECHANICAL ENGINEER*

The respondent advanced the understanding of sustainability on the basis of the Brundtland Commission definition, suggesting that buildings relate to sustainability through environmental impacts, economic issues of capital and operational costs, and social issues relating to

employment and relevance to society. The main challenge to sustainable development suggested by the respondent was the short-term financial benefit focus of developers. The respondent cited that this can be mitigated by lobbying government to impose penalties for excessive energy consumption and encourage more research into sustainable design. The respondent also indicated that the regulatory framework does not encourage a move towards sustainable design, and also cited the lack of formal standards guiding implementation as a challenge.

The respondent showed an awareness of environmental considerations in the building industry even though he had no formal membership of an environmental interest group. He was, however a member of the International Federation of Consulting Engineers (FIDIC). The role of mechanical engineers in sustainability was identified as convincing clients to consider long-term sustainability and the associated benefits, above the current driver of short-term financial costs.

#### *4.1.4 CONCLUSION*

The concepts of sustainable development and sustainability were understood by the design team. However, a more thorough understanding and more research on the subject were identified as necessary to improve uptake and implementation. The availability of research information and local data was also regarded as a barrier to the use of green building rating tools in Australia (GBCA, 2006a:65); and is also reiterated in the CSIR energy guidelines, which cite the prevalence of questions such as, ‘we want to know something, but nobody knows anything ... but how do we know it will work?’ (CSIR, 2005a:13).

The design process and roles of the design team were also cited as limiting factors of the implementation of sustainable development. These are considered real challenges with Bernheim and Reed (1996) suggesting that an environmental responsive design process follows the same pattern as conventional design, but includes additional requirements for sustainable design and materials. The authors suggest a process that includes pre-design, design, bid, construction, and occupancy with the importance of the pre-design and design stages arising from the fact that the project’s direction, with regard to sustainability is committed at this stage. In pre-design, the green vision, goals and objectives, and criteria can be established. Importantly, a green team can be assembled, which includes users and operators of the building, code enforcement agencies and utility companies. The design team comprises of architects, engineers, contractors, consultants and testing agencies (Bernheim and Reed, 1996).

Secondly, the design team cited the unavailability of response tools like regulatory incentives and industry standards as limiting the ability to incorporate sustainability in the design process. This limitation was also identified by Watermeyer and Milford (2003), who cite the lack of provisions for energy performance of buildings and note that the National Building Regulations lack quantitative criteria. However, tools like SBAT are available in South Africa as a starting point, but are limited by their lack of technical detail, particularly on environmental issues. Furthermore, manuals can be used to guide designers, rather than rating tools being used only as appraisal tools (Kaatz, 2005).

A barrier arises out of industry practice from developers seeking short-term returns, as well as design professionals operating on a limited scope of costs and time and not evaluating the value of alternatives. This barrier will further be complicated for developers by the fact that the benefits of green building accrue to building operators rather than the developer, which leads to a mismatch in investment and returns (GBCA, 2006a:64). This cannot be an incentive especially if valuation techniques also do not account for the added value. The practice by professionals would primarily be subject to industry performance standards being developed.

## **4.2 CONSIDERATIONS AND BARRIERS IN THE DESIGN OF THE SAIAB BUILDING**

The interpretation of the considerations in the design of the SAIAB should take into cognisance that the designers were not intentionally seeking to meet the LEED™ requirements and the researcher only presents the recorded issues. With the lack of tools and standards identified as one of the major barriers to the incorporation of sustainability in design, some relevant standards and regulations are referred to.

### *4.2 1 SUSTAINABLE SITES*

#### **Prerequisite 1: Erosion and sedimentation control**

This prerequisite requires the control of negative construction impacts on both air and water from dust and silt. The client and architect were not aware of any plans made for storm water management during the construction phase. On a visit by the researcher to the site, no evidence could be established for provision to trap silt from runoff from the site, with the storm water flowing directly into the Kowie ditch, (**Figure 4**), on the north-eastern side of the site. The control of air pollution from dust during construction could not be ascertained, but the assumption was that it was controlled, as this is considered standard practice by contractors in the country.

There are available guidelines in South Africa with the National Building Regulations (R1 and F4) regulating the safe disposal of storm water arising from earthwork such as building and paving. However, they do not specifically refer to sedimentation during construction (NBR, 1990:62,149). For the control of air pollution by dust and noise from construction activities, the regulations (F6) require that dust be reduced to ‘...a reasonable level’ and also indicate appropriate work times to minimise noise pollution (NBR, 1990:62). Even though construction storm water management is not specified in the regulations, Chapter 6 of the Guidelines for Human Settlement Planning and Design provides best practice such as silt fencing using straw bales, geo-mats, temporary check dams, and other technologies like mulching (CSIR, 2000b:1-35). The lack of provisions for construction storm water management could thus be attributed to lack of knowledge of sustainability considerations on the part of the design team.

### **Credit 1: Site selection**

The credit is awarded on the basis of a reduction of building footprint on biodiversity. According to the client, an alternative non-university site in an industrial area on the outskirts of town was considered (**Figure 3**), but this alternative was not selected on the basis of distance from the adjacent offices and potential management difficulties. This was confirmed by the architect. University sites that were considered were earmarked for other developments and could thus not be utilised.

In selecting a site, the respondents cited a preference for a closer site, and noted that alternative sites were being planned for other developments. This should, however, be interpreted against the fact that there was no active consideration of minimising impacts on threatened environments. It can be suggested that the barrier to choice of appropriate sites would be limited by landownership, as developments are likely to be planned within the confines of accessible land to any developer.

Chapter 5.8 of the Guidelines for Human Settlement Planning and Design provides considerations for safer communities, ecologically sound development and fire safety, even though it does not specify protected land types and clearance from water bodies (CSIR, 2000a), the National Building Regulations also refer to service infrastructure information requirements in preliminary designs submitted to the municipality (NBR, 1990:23).



**Figure 3:** Alternative development sites considered for the SAIAB building

(Adapted - Google Earth, 2006)

Even though there is no specific regulatory regime for biodiversity considerations in the building guidelines, the Conservation of Agricultural Resources Act provides standards for development in proximity to wetlands, whereas the National Red List of Endangered Species can serve as guide for habitat protection.

**Credit 2: Urban redevelopment**

The credit intends reducing development on green fields by channelling new construction to developed areas with an existing infrastructure. The selected site was brownfield in a developed area, with transformed vegetation and a pre-fabricated fish tunnel that had to be removed to make way for the building, as shown in **Figure 4**. The area is also fully serviced for water, water-borne sanitation and storm water, all within five meters of the site boundary. There is mixed land use in the environs, adjacent being academic research facilities, lecture halls, residences, and private housing.

Urban redevelopment would, however, be limited to the availability of alternative sites to a developer to facilitate site choice. The urban renewal initiative provides an opportunity for developers in major cities to target urban redevelopment areas for other buildings. In the case of the SAIAB there was neither a conscious effort to achieve redevelopment initiatives nor an urban renewal programme, thus a lack of awareness and incentives can be cited as potential barriers to compliance with this aspect of building sustainability.



**Figure 4:** Development site and environs of the SAIAB building

(Adapted - Google Earth, 2006)

The provisions of a local municipal Spatial Development Framework (SDF) can provide targeted densification targets, as the adopted principle in South Africa encourages densification. Evidence for this is the Buffalo City SDF where densification and interaction of communities is considered high priority (Buffalo City, 2003:3). The densification requirement is reiterated in Chapter 2 of the Guidelines for Human Settlement Planning and Design, as ‘intensification’, forms part of the performance qualities of settlement planning and design (CSIR, 2000a).

### **Credit 3: Brownfield redevelopment**

The intent of this credit is the promotion of rehabilitation of polluted sites, whether from perceived or real environmental contamination, as part of a government incentive scheme in the USA. This criterion is not relevant to the site as there was no real perceived environmental contamination at the site, and rehabilitation as a driver in selection could not be established. The absence of a similar incentive programme in South Africa would limit the applicability of this criterion, and could thus be considered a barrier.

### **Credit 4: Alternative transportation**

This credit addresses the reduction of pollution arising from automobile use through optimising location, facilitating the use of alternative transport and minimising parking space requirements. Even though not intentional, the site is located on a public transportation route (as Somerset Street is a taxi route for people working at Rhodes University) whereas the alternative site is not on a public transport route. That the site could be accessed by public transport potentially reduced automobile related pollution.



**Figure 5:** Proximity of site to general services and amenities

(Adapted - Google Earth, 2006)

The site is also in close proximity to shops and places of worship, thus reducing the transportation needs as the areas are within a 15 minute walking distance. However, no provision was made for parking due to low occupancy, with visitors to the facility parking off-street or in the bays at the existing facility. There are no provisions for alternative transport, like bicycle racks and purpose built showers.

General parking space requirements are governed by municipal ordinance, with the provision for access for disabled people and availability of disabled people parking, given in regulations (S1) and (S2) of the National Building Regulations (NBR, 1990:151). Chapter 2 of the Guidelines for Human Settlement Planning and Design outlines public transport access requirements, which include targeted distances for various forms of public transport and also integration of land use and amenities (CSIR, 2000a). In terms of the provision of general parking in the building, no barriers to implementation of the parking requirements were identified.

#### **Credit 5: Reduced site disturbance**

The objective of this credit is to minimise disturbed areas from the building footprint. The SAIAB building occupies the entire site, and all trees had to be removed, including a yellow wood tree for which a permit had to be obtained, (trees that had to be removed indicated in **Appendix 3**). According to the architect, the building could not meet the municipal open space zoning as it occupied the entire site. In response, the existing building and the development erven were consolidated so as to be within open space standards.

The National Building Regulations allow for the clearing of sites and excavation, emphasising the importance of municipal notification of circumstances such as the depth of excavation and work on public space. These are addressed in regulations (F9) and (G1) (NBR, 1990:63,65). The green space requirement within a building site is stipulated in municipal by-laws, but no standard exists with regard to area developed/ transformed beyond the building walls/ perimeter. No barriers to the minimisation of the building footprint can be cited, as this is a very site specific consideration and only when a performance standard is suggested can there be reasons for non-compliance.

### **Credit 6: Storm water management**

The intent of this credit is to minimise the disturbance of natural water flow, runoff and contaminants. The building occupies the entire site with the remaining perimeter paved, with the exception of a raised plant bed in the front of the building as shown in **Appendix 4**. The building thus the building significantly reduces natural permeation of water which creates an increase in potential runoff with the subsurface drainage provided.

Barriers to the achievement of this objective were cited as the building footprint, even though reduction of runoff was not necessarily a design consideration. The architect mentioned that no standards exist in South Africa for percolation and landscaping, thus a lack of guidelines can be again cited as a limitation, even though there is no conceivable reason for resistance of this criterion that could be peculiar to South African building practice.

No reference was made with regard to the minimisation of impermeable surface in the National Building Regulations as discussed under the erosion and sedimentation control prerequisite. On the other hand, the Guidelines for Human Settlement Planning and Design recommend the use of porous hard surface materials and suggest available technologies, but do not set targets for reducing runoff (CSIR, 2000a).

### **Credit 7: Landscape and exterior design to reduce heat islands**

The intent of this credit is to reduce thermal gradient between developed and undeveloped areas, for the management of micro-climate. The brown heat sink colour with low reflectance was a trade-off for an aesthetic blend with the existing building (**Appendix 5-1** and **5-2**). However, the low angle roof design would acts as a heat radiator in an upward direction. The conceptual design suggested trees to be planted in the north-eastern aspect of the building to provide shade. The barrier to minimising heat islands was a trade-off with another design criterion, thus no specific barrier can be cited.

No specific standards exist in South Africa with regard to controlling the effect of heat islands and related performance criteria, even though information on reflectance and emissivity of materials can be obtained. The same applies for roof characteristics as there are no performance standards like the Energy Star requirements.



### **Credit 8: Light pollution reduction**

This credit aims at reducing light trespass from the building. The SAIAB building has limited light escape as the design criteria is for light exclusion inside with windows covered in louvers. The potential source of light trespass is exterior lighting which, according to the mechanical engineer, was low angle lighting, with the face-brick exterior reducing reflection. Also the trees landscaped for the front part of the building mitigate light trespass. The National Building Regulations make mention of lighting requirements in regulation O1, but the focus is on internal lighting requirements, with no reference to the regulation of 'escaped light' to the building environs being made (NBR, 1990:101).

#### *4.2.2 WATER EFFICIENCY*

### **Credit 1: Water efficient landscaping**

The intent of this criterion is to eliminate the use of potable water for landscape irrigation. For the SAIAB building, only the concept landscape was designed by the architect, with the concept design recommending the use of indigenous plants in the landscape. Also mentioned by the architect is underwater storage that captures all the runoff from the roof with an overflow to the ditch, with the client indicating that the landscape will be irrigated from rooftop runoff. An inconsistency is that **Appendix 6**, showing the water and sewer layout indicates a connection to a university irrigation supply line that uses water from a catchment dam which is not municipal potable water. No barriers to elimination of potable water use were identified by respondents.

The CSIR water efficiency guideline for building managers identifies opportunities for water use reduction from landscaping citing plant selection, mulching and rainwater harvesting as tools that can be utilised (CSIR, 2005a: 13-20).

### **Credit 2: Innovative wastewater technology**

The credit evaluates initiatives to minimise wastewater and potable water demand. The low occupancy of the building translates to minimal water use in the building with only one toilet, hand washing basin and an emergency shower. The client also mentioned specimen-size specific basins will be used during the operation of the building to minimise water use. The reason for not having local wastewater treatment was indicated as being the low volumes of water used in the building.

There are no specific regulatory barriers to water use efficiency reduction mechanisms like dry sanitation. Several technologies, both natural or mechanical are available for the recycling of water in South Africa, with the National Building Regulations making provision for water-borne sewerage design and industrial effluent requirements in regulations (P1) and (P4) (NBR, 1990:115-126). Provision is also made for alternative sanitary methods in regulation (Q1) following permission from the municipality NBR, where ‘... where water-borne sewerage disposal is not available...’ (1990:147). It is noteworthy that there is a salient consideration of water-borne sewerage as being the preferred method. The Guidelines for Human Settlements and Design suggest methodologies for selecting appropriate sanitation systems and design considerations for some of the alternative systems in Chapter 10 (CSIR, 2000b).

### **Credit 3: Water use reduction**

The intention of the credit is the maximisation of water efficiency inside the building through high efficiency fixtures. The minimal use of water as discussed under the section ‘innovative wastewater technology’ above reduced the importance of this consideration.

The LEED™ presents no prerequisite for water efficiency. Applicable to South Africa with regard to water efficiency, would be adoption of water conservation and water demand strategies for the domestic sector to minimise potable water use. A methodology for auditing water use reduction methods has been proposed by the CSIR, which cites benefits for a municipal building in Cape Town whose water demand was halved and minimum night flow completely eliminated with an annual saving that translated to a 1.5 year payment from investment in water conservation (CSIR, 2005b:25).

#### *4.2.3 ENERGY AND ATMOSPHERE*

##### **Prerequisite 1: Fundamental building systems commissioning**

The objective of this prerequisite is to ensure that building elements and systems are installed and calibrated as intended. No formal commissioning plan was in place for SAIAB as per requirements of the rating system; however, there is a project manager audit for installations even though no performance testing is performed, with builder warranties being in place on handover. From a functionality perspective, the building underwent significant rigour with the SABS commissioning functionality and safety, with the architect indicating the acknowledgement of innovation in design by the International Standards Organisation.

The National Building Regulations, through regulation (A19), require the appointment of a person responsible for design, with the undertaking to ensure compliance with the design (NBR, 1990:32,225). Currently the potential hurdle is the adoption and acceptance of verification methods for the country as well as the availability of the necessary expertise.

### **Prerequisite 2: Minimum energy performance**

The intent of the prerequisite is the establishment of minimum energy performance during the design. In the case of SAIAB, no minimum energy performance standards were set for the building. The absence of a target setting process and modelling equipment and techniques are potential barriers to the adoption of the practice.

In South Africa, no energy performance codes are in place, and this aspect was not catered for in the design process. However, the CSIR has proposed an Energy Management Guideline for building managers, providing best practice for increasing the energy performance of existing building through the implementation of an energy management programme. Even though the programme does not address building design issues, nor set performance targets, it proceeds from the premise of setting goals, measurement, analysis and improvement of energy performance. The guidelines cite an Australian case study where savings translated to an energy performance improvement of 12%, with a 2.4 year payback (CSIR, 2005a: 43).

### **Prerequisite 3: CFC reduction in HVAC&R equipment**

The prerequisite requires specifications for new building to use non-ChloroFluoroCarbons (CFC) refrigerants, while the mechanical engineer cited that the Heat Ventilation Air Conditioning (HVAC) system specified uses ozone friendly refrigerants. The combustible nature of non-CFC refrigerants may pose a challenge for implementation in South Africa, especially in some working environments with open flames.

### **Credit 1: Optimisation of energy performance**

The intent of the credit is maximisation of energy efficiency through building envelope design and building systems. The architect cited the cavity walls and lack of windows as contributors to energy efficiency of the building due to the buffering effects of the cavity. Secondly a naturally ventilated attic (**Appendix 7**) acts as an energy buffering zone between the roof and the interior. This is an important aspect, taking into account that most of the heat is lost through the roof. The design also uses the service areas as buffer zone in the west to protect the collection area as shown in **Appendix 8**. From an operational point of view, reduction in energy usage was created

by the design of the lighting system, which allows only a small portion to be switched on at a time, and the use of energy saving lights by the mechanical engineer. Also considered by the architect were earth berms with a tree line for the north and west exposures (the hottest), but the limiting factor was available space.

The mechanical engineer outlined energy performance considerations in the building as being driven by a ‘... balance of energy performance vs. economics ... dictated by the need to exhaust air and fumes’. To further drive the achievement of not only thermal efficiency, but water use, especially storm water management efficiency, the architect suggested the use of futility credits.

### **Credit 2: Renewable energy**

The intent is to promote self supply of renewable energy, reducing reliance on grid electricity. In the design of the SAIAB building, a proposal was formally presented to the design team by the architect, but was not taken forward in the design. The mechanical engineer cited financial non-viability as the barrier to incorporation of solar energy in the design.

The National Energy Regulator provides a policy guideline for the use of renewable energy in the country, with specific areas of interest by the government being outlined. According to Spalding-Fecher (2002:13,14), the priority areas for the South African energy policy are towards increased access and affordability of energy, improved energy governance, stimulation of economic development, management of energy related environmental impacts and diversification of energy sources. Through these priority areas relevant focus areas are the establishment of thermal housing guidelines, promotion of a voluntary appliance labelling programme, evaluation of clean technology options and, importantly, stimulating the use of renewable energy resources.

### **Credit 3: Additional commissioning**

The intent of this credit is the verification and calibration as per requirements of the prerequisite, with the extent of commissioning covered under the commissioning prerequisite. This commissioning is, however, specific to energy systems.

### **Credit 4: Ozone depletion**

The intent of the credit is the reduction of the use of CFC containing refrigerants in building reuse, where a phased approach for the elimination of existing CFC installations is proposed. This criterion is not considered further in this case as the SAIAB building is a new construction.

### **Credit 5: Measurement and verification**

The objective of the credit is to account for the optimised water and energy performance of installations over a period of time, by ensuring that measuring devices are included in the design. This aspect was not considered in the design of the SAIAB building.

### **Credit 6: Green power**

The intent of the credit is to encourage the use of green power from a national grid. This credit was not investigated further as green power from the grid supplier is not available in South Africa.

## *4.2.4 MATERIALS AND RESOURCES*

### **Prerequisite 1: Storage and collection of recyclables**

The prerequisite's intent is the reduction of waste generated that is disposed in landfills. The operations of the SAIAB building generate minimal waste, with a waste disposal system put in place for used formalin, collected and temporarily stored by a waste handling utility. Incidental alcohol waste is trapped in a dilution sump before disposal. Because waste was not an issue in the design of the building no recycled opportunities were considered and no barriers were mentioned.

### **Credit 1: Building reuse**

The intent of the credit is promotion of building recycling extending the life cycle of old buildings. Even though the site was brownfield, there was no potential for incorporating existing structures into the building; however, the fish tunnel materials were kept for reuse by the Rhodes University Fish Farm. No barriers to building shell reuse were mentioned as it was not a parameter in the design of the SAIAB building.

### **Credit 2: Construction waste management**

The intent of the credit is diversion of construction waste to the manufacturing instead of the landfill. Both the client and architect could not ascertain the presence of a construction management plan. The National Building Regulations allow the discretion of a local authority in regulation (F8), requiring a land owner to clear construction rubble, even though they do not indicate the destination (NBR, 1990:63).

### **Credit 3: Resource reuse**

The intent of the credit is to promote the salvage of construction materials; however no responses were received in this regard, and no evidence in general specification can be established. The lack of awareness of suppliers of such materials may be a potential barrier to specification of salvaged materials.

### **Credit 4: Recycled content**

The intent is to contribute to the demand for materials with a recycled content, the criteria was combined with the resource reuse criterion in the questionnaire. The South African building regulations cannot be seen as restrictive to the reduction of virgin construction materials. Conventional building materials in South Africa are considered to be concrete, clay bricks, timber and steel, and these are deemed to satisfy rules of the National Building Regulations based on performance. However alternative materials can be used if certified by the CSIR, SABS, and by Agreement certification or by an acceptable rational design presented by an appropriate engineering professional. The evaluation of any innovative materials is tested by Agreement South Africa for criteria that include strength and stability, fire safety, water penetration, thermal and energy performance, ventilation, lighting, acoustic performance and others (Knoetze *et al*, 2006).

### **Credit 5: Local/ regional materials**

The intent of the credit is the reduction of transport costs of materials. The face-bricks used in the building were supplied by a local manufacturer, Makana Brick. They are, however, not made locally, but ordered from De Hoop in Stellenbosch, approximately 800km away. The roof materials and cement were sourced from Port Elizabeth, approximately 145km away. Minimal material was sourced from local suppliers according to the architect. The reason was that the specified brick is not manufactured locally, suggesting that material availability and local manufacturing capacity can potentially limit the achievement of this criterion.

### **Credit 6: Rapidly renewable materials**

The objective of the credit is to reduce the use of long-cycle renewable materials. In the design of the SAIAB building no rapidly renewable materials were specified as most materials were heavy duty structural materials, and other building components were load bearing metal shelves, with the wall structure made out of cement in line with safety and security considerations.

### **Credit 7: Certified wood**

The objective is to encourage environmentally friendly forest management. The question was not posed to respondents based on the minimal use of wood in the building and a presumption that there is no certification process in the country. However, the South Africa Bureau of Standards in association with the International Soil Association and Woodmark Programme provides certification for timber products in line with the Forestry Stewardship Council and chain of custody certification (SABS, 2006). In the specification of timber (See **Appendix 9**), there was no specific reference to Forestry Stewardship Council requirements, suggesting it was not considered.

#### *4.2.5 INDOOR AIR QUALITY*

##### **Prerequisite 1: Minimum Indoor Air Quality (IAQ) performance**

The intention of this prerequisite is the development of minimum air quality standards for the health of occupants. Air quality was amongst the main considerations in the building, with an SABS agent employed to configure for all air quality requirements, particularly from the alcohol fumes, with the design of a ventilation system for exhaust. The architect further mentioned that all work benches have extraction points and physical protection is provided through Perspex. No barriers to this prerequisite were identified as it was one of the primary design criteria.

The National Building Regulations provide a standard for acceptable air quality that forms the basis of performance assessment, as discussed under the criterion on additional commissioning. The Occupational Health and Safety Act No 85 of 1993 makes provision for workplace health and safety including air quality arising from the indoor air quality of work environments (Department of Labour, 2006). Regulations have been proposed for the construction industry, dealing with activities during construction, covering both physical and chemical danger.

##### **Prerequisite 2: Environmental tobacco smoke control**

The objective is the prevention of exposure of occupants to environmental tobacco smoke. Safety constituted one of the functionality parameters in the design of the SAIAB building, thus smoking rooms were not considered.

##### **Credit 1: Carbon dioxide monitoring**

The credit requires monitoring of carbon dioxide for occupant health and comfort. In the case of the SAIAB building, due to low occupancy this is not a concern. A monitoring system for

organic solvent fumes was designed for installation, both as a safety feature to detect leaks and a human health consideration.

#### **Credit 2: Increasing ventilation effectiveness**

The intention is to maximise the delivery of fresh air, which was considered in the SAIAB building for the work areas in the south-western aspect using louvers on doors to facilitate air exchange. The building uses mechanical displacement ventilation for noxious fumes in the storage and mixing areas, which allows for natural inflow of air using extractor fans, with elevations in **Appendix 5** showing ventilations louvers at building corners.

#### **Credit 3: Construction IAQ management plan**

The objective is to manage air quality problems during construction for installer and occupant health. This refers to construction done in occupied buildings, a different situation for the case study, as a result there was no plan in place.

#### **Credit 4: Low-emitting materials**

The credit aims at minimising the volatile organic compound emissions from construction materials, with no such materials used in the building, even though the operational environment uses ethyl and propyl alcohol for part of the building operation. There was, however, no intentional design to limit low-emitting materials.

#### **Credit 5: Indoor chemical and pollutant source control**

The intent of the credit is avoiding exposure of occupants to potentially hazardous chemicals. Chemical storage areas are physically separated from the work areas as shown in **Appendix 8**, with chemical mixing equipment installed and physically separated from the work area, with mixed chemical transferred by a pipetting system to work areas. Researchers do not have to go the storage area, which minimises the risk of safety threats and health exposures.

#### **Credit 6: Controllability of systems**

The objective of the credit is provision of a high degree of system controllability for thermal, ventilation and lighting systems. The mechanical engineer indicated that light and fans can be switched on in groups or individually. Light controls are also highly controllable, with the ability to isolate even a smaller area in the collection storage room.

### **Credit 7: Thermal comfort**

The objective of the credit is for promoting a thermally comfortable environment. In the design of the SAIAB building, the south-east, north-east, and north-west corners have fresh air intake louvers, as do doors in the work area. There is also a cooling system installed in the building, even though it is considered to be of minimal usage due to the effectiveness of the building envelope.

### **Credit 8: Daylight views**

The objective is the connection of indoor and outdoor spaces using sunlight in occupied areas of the building. This criterion was not adhered to as per the LEED™ requirements in the SAIAB building as functional design requires the exclusion of daylight.

## *4.2.6 INNOVATION AND DESIGN*

### **Credit 1: Innovation in design**

Even though the brief was initially for a single storey building, the design team through foresight built a second level shell for any expansion needs that may arise in the coming years, thus reducing the potential footprint from a building not designed for extension. Secondly, because the building is 'faceless' a cultural fit of the building was achieved by an elevation consistent with the existing building and Rhodes architecture, and also the design of an electronic display on the front of the building representing what is inside for educational purposes. The architect considered sinking the building to achieve security, explosive gas safety, and thermal performance of the building, which was considered expensive even though no value engineering analysis was undertaken.

### **Credit 2: LEED™ accredited professional**

As the building was not specifically designed to address the LEED™ criteria, the commissioning by an SABS official count towards professional responsibility in terms of functional performance. However, a weakness was the limited brief of the appointed architect, primarily that the client required an environmental ethos, with the professional scope of an architect being interpretation of the brief.

## *4.2.7 CONCLUSION*

The consideration in the design of the SAIAB building demonstrates a focus on meeting the functionality requirements of the brief outlined by the client. There was no sustainability goal set

upfront, other than the client's objective of the building 'to demonstrate an environmental ethos'. The considerations made in the design, however, provide an opportunity to understand specific challenges and how they relate to sustainability. With the section on the 'understanding of sustainability', general and high level barriers to sustainability were identified, with this section discussing limitations specific to the SAIAB building, even though some have general relevance.

The first barrier relates to site characteristics; in the case of SAIAB building limited options were available in the selection of the development site. Environmental characteristics of the site were incidental rather than based on design, with landownership and access to land being the primary drivers for site selection. It is conceivable that this would be a potential challenge to developers anywhere in the country, making environmental criteria for the selection of sites a secondary consideration after access to land.

The second aspect with respect to the SAIAB building was cost, manifested in the decision to use renewable electricity over grid electricity supply. Another evidence of cost barriers relate to innovation in design based on the non-consideration of sinking the building as perceived costs were considered higher. This is likely to be generally the case as the building design process cost building on capital investment, with no inclusion of resultant operational costs.

The availability of suitable materials with regard to face-bricks, and general material supply being from Port Elizabeth in the case of SAIAB suggest potential challenges in meeting the objectives the materials and resources theme, as the local availability of building materials, let alone environmentally sensitive and local manufacturing and extraction possibilities, are likely to limit the attainment of sustainability requirements.

Awareness from a design intent perspective, as well for materials specification, also poses a potential challenge to acceptance and practise of sustainable building design. This, associated with the capacity for meeting modelling, design and monitoring of performance, is likely to pose barriers to sustainable building design.

The last barrier is the absence of performance standards, mentioned in the SAIAB building being surface water percolation requirements and the minimisation of thermal gradient, and light pollution present a challenge to the application of sustainability criteria. Also institutional in nature is the lack of incentives, applicable to SAIAB being urban redevelopment, brownfield development and green power.

### 4.3 RATING OF THE SAIAB BUILDING

In rating the SAIAB building using the LEED™ criteria, it should be noted that some were not relevant to South Africa on grounds that they are specific to a USA standard or incentive programme. Some significant relevant criteria are alternative-fuel for cars, incentives for brownfield site redevelopment, appointment of an accredited LEED™ professional. It is also important to note standards which are not necessarily applicable or used in South Africa. Other criteria are based on standards, such as simulation modelling for optimum energy performance, and light reduction. For these criteria, an either full or partial credit was awarded on the basis of the degree of irrelevance to ensure comparable findings to other buildings rated by the USGBC.

#### 4.3.1 SUSTAINABLE SITES

The sustainable sites theme primarily deals with biodiversity and spatial issues associated with buildings, and the minimisation of those impacts or maximisation of opportunities, with only the alternative transport credit being driven by energy considerations.

**Table 1:** Rating of the SAIAB building using LEED™ for the sustainable sites theme

THEME: SUSTAINABLE SITES			
	Potential Score	Achieved Rating	Comments
Erosion and sedimentation control	-	-	Does not meet all the requirements for the prerequisite
Site selection	1	1	Alternative sites evaluated
Urban redevelopment	1	1	Selected site contributes to settlement densification
Brownfield redevelopment	1	1	Awarded on the basis of inapplicability to South Africa
Alternative transportation	4	2 ½	Alternative refuelling station points awarded based on inapplicability
Reduced site disturbance	2	1	Awarded on the basis of limited disturbed area
Storm water management	2	½	Awarded for the captured runoff from the roof
Landscape and exterior design to reduce heat islands	2	½	Awarded on the basis of trade-off and the planting of trees
Light pollution reduction	1	¾	Low angle lights. Simulation not undertaken thus no full credit is awarded
<b>Total</b>	<b>14</b>	<b>8 ¼</b>	<b>2 points allocated for inapplicability</b>

### **Prerequisite 1: Erosion and sedimentation control**

The lack of specific requirements for construction storm water management in contractor documentation, and observation by the researcher of lack thereof suggest that the building did not meet criteria requirements. The reasons for the lack of a construction storm water management can be attributed to the lack of regulation in this regard, as strong adherence to stated regulations characterise the work ethic in the construction industry. On the other hand dust and noise are incorporated in the practise of the construction industry as they are regulated in the National Building Regulations, and the site is deemed to fully comply with this requirement.

### **Credit 1: Site selection**

Elements of this credit are development on prime farmland, development within the 100 year flood line, habitat for endangered species, close proximity to wetlands and land that was used as parkland. The building site is in a small transformed and altered habitat, thus a limited potential for agriculture or for being habitat for an endangered species. The proximity of the building to the Kowie ditch suggests the area is not within a flood line, and not in proximity to any existing wetland. It is on that basis that full credit was awarded to the site.

### **Credit 2: Urban redevelopment**

The criterion is measured in terms of building available square meters per hectare, and does not necessarily refer to occupancy, this means that multi-storey buildings contribute more to the criterion. The building contributes to densification of the Rhodes University precinct, with building available space increased by the two story design. On the strength of the above discussion, full credit is given to the SAIAB building for this criterion.

### **Credit 3: Brownfield redevelopment**

The building site does not have real or perceived environmental pollution issues, and no rehabilitation planned for the site, suggesting that the building should not score points in this regard. The lack of a tax incentive dispensation in South Africa makes rehabilitation an irrelevant criterion in site selection. The developer cannot, therefore, be penalised and the full point is awarded. If there was an urban renewal framework for Grahamstown, fair rating might have been possible.

### **Credit 4: Alternative transportation**

The points in this credit are scored for location relative to public transport, provision for cyclists, alternative-fuel refuelling stations and parking provision that does not exceed local zoning. The

building is located within 10 meters of a taxi route in Somerset Street, thus a full point is awarded. Given the inapplicability of alternative-fuel in South Africa, the building is awarded the full points. Because no provision is made for bicycles, the building is penalised the point, and for parking, the sharing of the parking services with existing building contribute towards objectives of the criterion but fractional points are awarded because it was a result of the building occupying the entire site.

#### **Credit 5: Reduced site disturbance**

The credit is measured two elements, one being cleared area from the building perimeter, and the how the building performs in relation to the municipal zoning open space requirements. The building could not meet the local open space zoning requirement, hence the consolidation with the existing building, so no points are awarded as the building occupies practically the entire site. The development footprint is limited beyond the building perimeter, primarily driven by available space.

#### **Credit 6: Storm water management**

The credit is awarded on the basis of reducing runoff and water quality from the building. The building does not demonstrate an attempt to reduce storm water runoff, but totally transforms the site into an impervious site, and no credit is awarded for reduction in runoff quality. However, from a water quality perspective, the capture of roof runoff and the lined storm water conveyance systems limited the chance of suspended solids. But, as no provision is made for settling runoff from the garden, half a point is awarded. An opportunity existed to grass the service vehicle route instead of paving it as the frequency of the vehicles is quite low. This would have contributed to a reduction in the total impervious surface area.

#### **Credit 7: Landscape and exterior design to reduce heat islands**

The credits are awarded for the use of landscaping which provides shade to hard surfaces and building materials with a high reflectance and emissivity. The conceptual design of the landscaped area suggests the planting of trees which will also provide shade for portions of the wall on the north-eastern façade, with the high sun exposure eastern aspect protected by the existing building. The remainder of the building is not protected leading to half a point being awarded. The building elevation specifies a dark-brown face-brick and other finishes suggest low reflectance, thus exacerbating the thermal gradient. No points are awarded for this element.

### **Credit 8: Light pollution reduction**

The credit evaluates light trespass awarding points for achieving a zero direct-beam illumination leaving the building site. No interior light escapes from the building, the exterior lighting uses low angle lights and building surfaces have low light reflectance. The landscaping can also minimise light trespass out of the site. The credit requires the use of computer modelling to ascertain performance achieved; that this was not undertaken lead to  $\frac{3}{4}$  points being awarded.

#### *4.3.2 WATER EFFICIENCY*

The water efficiency theme is the least stringent and comprehensive theme in the LEED™ with the objective being to minimise water resource extraction. With no prerequisite suggested by the LEED™, it is inconsistent with water being the most limiting resource in South Africa, however all the other criteria used are applicable to South Africa.

**Table 2:** Rating of the SALAB building using LEED™ for the water efficiency theme

<b>THEME: WATER EFFICIENCY</b>			
	<b>Potential Score</b>	<b>Achieved Rating</b>	<b>Comments</b>
<b>Water efficient landscaping</b>	2	2	Awarded on the basis of rainwater harvesting design
<b>Innovative wastewater technology</b>	1	$\frac{1}{2}$	Partial award on the basis of inappropriateness due to volumes
<b>Water use reduction</b>	2	$\frac{1}{2}$	Partial points awarded on basis of installation efficient fixtures
<b>Total</b>	<b>5</b>	<b>3</b>	<b>No points allocated for inapplicability</b>

### **Credit 1: Water efficient landscaping**

The credit is awarded for the reduction in use of potable water. In the case of the SAIAB building, collection of water from roof runoff and storage for irrigation, as well as the augmentation using Rhodes University irrigation water rather than municipal potable water, contributes towards the objective. The building is awarded full credit.

### **Credit 2: Innovative wastewater technology**

This credit requires minimisation of potable water demand and generation of wastewater, with recycling opportunities limited in this building due to the low occupancy, and water use, which does not provide critical mass for a treatment system. If the application of wastewater treatment is analysed from the angle that, low volumes generated provide an opportunity for dry fixtures

such as composting toilets, then the low volumes become an opportunity missed. It is on that basis that half a point is awarded.

**Credit 3: Water use reduction**

The criterion requires minimisation of water use inside the building by setting performance targets and achieving a 10% reduction in potable water demand. Water reduction targets were not set for the SAIAB building, even though water use minimisation was considered in wash basins for specimens, thus half a point was allowed for the first criterion. However, there is no basis for ascertaining performance as exceeding 10% of a reduction in the use of potable water over and above the standard performance requirements.

*4.3.3 ENERGY AND ATMOSPHERE*

The energy and atmosphere theme is the most robust in the LEED™ rating system measuring the impacts of the building in greenhouse gas emissions and ozone depleting materials. Specific standards and practises have been developed in the USA and as a result, a number of criteria that are not relevant to South Africa.

**Table 3:** Rating of the SAIAB building using LEED™ for the energy and atmosphere theme

<b>THEME: ENERGY AND ATMOSPHERE</b>			
	<b>Potential Score</b>	<b>Achieved Rating</b>	<b>Comments</b>
<b>Fundamental building systems commissioning</b>	-	-	Partial compliance
<b>Minimum energy performance</b>	-	-	Not compliant
<b>CFC reduction in HVAC&amp;R equipment</b>	-	-	Full compliance
<b>Optimisation of energy performance</b>	10	4	Arbitral allocation of building envelope performance
<b>Renewable energy</b>	3	0	No renewable energy used in the building
<b>Additional commissioning</b>	1	0	No commissioning plan for the building
<b>Ozone depletion</b>	1	1	Awarded on the basis of inapplicability
<b>Measurement and verification</b>	1	0	No performance measurement installations
<b>Green power</b>	1	1	Awarded on the basis of inapplicability
<b>Total</b>	<b>17</b>	<b>6</b>	<b>2 points allocated for inapplicability</b>

**Prerequisite 1: Fundamental building systems commissioning**

The requirement is the implementation of a commissioning process for all elements and systems of the building. In the design of the SAIAB building, neither a commissioning plan nor inclusion in the construction contract documents was undertaken. Project manager audit for installations for installation according to specification took place, as did functionality by the SABS. The compliance is considered partial because no plan was developed and implemented.

**Prerequisite 2: Minimum energy performance**

The prerequisite requires the development of minimum performance standards, which were not developed in the case of SAIAB, on the back of non-existent energy performance codes in the country. The building thus does not comply with the requirements.

**Prerequisite 3: CFC reduction in HVAC&R equipment**

The prerequisite requires specification of non-CFC refrigerants, with non-CFC refrigerants specified for air conditioning in the SAIAB building. The building thus scores full points for the credit.

**Credit 1: Optimisation of energy performance**

No energy performance modelling was undertaken but some aspects of the building design suggest a contribution to energy performance. The architect mentioned that cavity walls which naturally create a buffer zone between the interior and exterior layers were used. Secondly, the design incorporates a naturally ventilated attic, serving as a buffer between the exterior and interior. On the basis of these considerations, it can be assumed that a 30% improvement was achieved compared to the performance of a basic warehouse.

**Credit 2: Renewable energy**

Various opportunities exist for the use of renewable energy sources, with solar energy being the more prevalent in South Africa, in the light of available technology due to low building energy demand; the opportunity was foregone in the design of the SAIAB building on the basis of capital costs. The building does not score a points for this credit.

**Credit 3: Additional commissioning**

As indicated under general commissioning, no commissioning was planned and undertaken for the building, and the building does not score a point.

#### **Credit 4: Ozone depletion**

No retrofitting was necessary with regard to climate control equipment, making the criterion irrelevant. To maintain a comparable scoring system the point is awarded particularly because the HVAC system specified was CFC free.

#### **Credit 5: Measurement and verification**

There were no installations for continuous measurement of building envelope performance and installed systems, thus no point is awarded. Scope exists for general performance monitoring equipment even though limited by testing capacity of the design team.

#### **Credit 6: Green power**

The point is allocated because of the unavailability of the alternative green electricity and credits from the national grid supplier in South Africa; it is not based on it being realised.

#### *4.3.4 MATERIALS AND RESOURCES*

The materials and resources theme measures the resource extraction for construction materials and identifies the opportunities for minimising the use of virgin materials and maximising the use of recycled and short-cycle materials. The theme straddles resource extraction and biodiversity protection as extraction results in biophysical impacts.

**Table 4:** Rating of the SAIAB building using LEED™ for the materials and energy theme

<b>THEME: MATERIALS AND ENERGY</b>			
	<b>Potential Score</b>	<b>Achieved Rating</b>	<b>Comments</b>
<b>Storage and collection of recyclables</b>	-	-	Full compliance with requirements
<b>Building reuse</b>	3	3	Full compliance awarded for the reuse of the fish tunnel
<b>Construction waste management</b>	2	0	No points awarded due to no evidence of construction waste management plan
<b>Resource reuse</b>	2	0	No points awarded
<b>Recycled content</b>	2	0	No points awarded due to non-specification
<b>Local/ regional materials</b>	2	½	Partial points allocated mainly for roof finishes
<b>Rapidly renewable materials</b>	1	0	None specified
<b>Certified wood</b>	1	0	No points awarded due to non-specification
<b>Total</b>	<b>13</b>	<b>3 ½</b>	<b>No points allocated for inapplicability</b>

**Prerequisite 1: Storage and collection of recyclables**

The use of the building does not generate significant volumes of solid waste, with the provision for handling chemical waste being in place, with provision for temporal storage prior to disposal. From that perspective, the building does not contribute to consumption of landfill space and is thus considered compliant.

**Credit 1: Building reuse**

There was no existing structure on the site that could have been reused for the SAIAB building, making that consideration irrelevant. The building cannot therefore be penalized. The reuse of the fish tunnel further contributes to the award of full points.

**Credit 2: Construction waste management**

The credit seeks to measure the reduction of construction waste going to the landfill. For the SAIAB building, even though there was no demolition, there was no apparent plan for the management of waste and diversion from landfills of cleared materials and building waste, thus no credit was awarded to the SAIAB building.

**Credit 3: Resource reuse**

There were no responses on this criterion. However, there was no specific mention of salvaged materials in the building material specification, leading to a decision of non-compliance with requirements.

**Credit 4: Recycled content**

Similar to the building material reuse credit, there was no specific mention of materials with recycled content on material specification notes. As a result, the building does not score points for the criterion.

**Credit 5: Local/ regional materials**

The credit measures manufacturing and extraction for the two credits. The main materials used in the construction include bricks, cement, steel, timber, and roofing. The clay bricks specified were from 'De Hoop', which is in the Western Cape in excess of the 500 mile requirement of the LEED™ requirements. This suggests non-compliance for both extraction and manufacturing; the same is true for the timber which probably originated from the Southern Cape or North-Eastern Cape. With regard to concrete, both extraction and manufacturing could have been from within a 500 mile radius. However, for steel, extraction would definitely not have been within a

500 mile radius even though manufacturing may have been from within the region. On that basis half a point is awarded to the SAIAB because of the significance of bricks, steel and cement.

**Credit 6: Rapidly renewable materials**

Due to the nature of the building and the need to reduce combustible materials and security, the finishes specified for the building are either steel or ceramic with no rapidly renewable materials used. As a result, the building does not score any points for this credit.

**Credit 7: Certified wood**

No credit is awarded purely on the basis of the non-specification as a requirement for certified wood in the building even though the quantitative use of wood in the building was limited.

*4.3.5 INDOOR AIR QUALITY*

This criterion is amongst the most important criteria in the LEED™ rating system, with two performance prerequisites. However, its’ applicability to the SAIAB building is limited by the occupancy rates and the nature of the chemicals handled in the building. Some criteria are inapplicable to the operational use of SAIAB, with credits awarded in those cases.

**Table 5:** Rating of the SAIAB building using LEED™ for indoor air quality theme

<b>THEME: INDOOR AIR QUALITY</b>			
	<b>Potential Score</b>	<b>Achieved Rating</b>	<b>Comments</b>
<b>Minimum IAQ performance</b>	-	-	Full compliance with requirements
<b>Environment tobacco smoke control</b>	-	-	Full compliance with requirements
<b>Carbon dioxide monitoring</b>	1	1	Full points awarded for the fume monitoring system
<b>Increasing ventilation effectiveness</b>	1	1	Full points awarded, with design and mechanical equipment installed
<b>Construction IAQ management plan</b>	2	2	Awarded for inapplicability
<b>Low-emitting materials</b>	4	2	Partial credits awarded as the building handles Volatile Organic Compounds
<b>Indoor chemical and pollutant source control</b>	1	1	Full points awarded for the physical isolation system
<b>Controllability of systems</b>	2	2	Full points awarded on the basis of lighting and ventilation system designs
<b>Thermal comfort</b>	2	2	Full points awarded with a cooling system installed
<b>Daylight and views</b>	2	2	Awarded on the basis of inapplicability
<b>Total</b>	<b>15</b>	<b>13</b>	<b>2 points allocated for inapplicability</b>

**Prerequisite 1: Minimum IAQ performance**

The requirement of the prerequisite is the establishment of minimum air quality performance, with provisions for the SAIAB building being sufficient for the requirements as the design focused on managing air quality impacts of formalin and an alcohol. The building as appraised by an SABS official for health safety performance. Design considerations thus suffice for requirements of this prerequisite.

**Prerequisite 2: Environmental tobacco smoke control**

The building complies with this prerequisite as smoking is prohibited for safety reasons, with no provision made for a smoking room.

**Credit 1: Carbon dioxide monitoring**

The building complies with the requirements. Carbon dioxide monitoring is appropriate for occupied buildings; in this case carbon dioxide is not an issue due to low occupancy. The building has a monitoring system for organic fumes for both health and safety purposes.

**Credit 2: Increasing ventilation effectiveness**

The building facilitates natural ventilation for work areas and collection storage areas using displacement ventilation. The use of ventilation louvers at building windows and doors further facilitate natural air exchange. The building is awarded full credit for this criterion even though performance evaluation was beyond the scope of this exercise.

**Credit 3: Construction IAQ management plan**

The full points are awarded because this is a new construction, and there were no occupants during construction. However, the installers will be exposed to dust and other particulates during construction. Occupation Health and Safety Act presents practice by an employers with regard to practice in construction sites, pertaining to the dust, noise, fumes, physical danger exposure (Department of Labour, 2006). Compliance with the regulations could be considered to be a prerequisite in this theme, with any performance criterion that can be identified serving as credit sources.

**Credit 4: Low-emitting materials**

Even though no volatile organic compound emitting materials were specified in the building, the operations of the building handle volatile compounds which will affect air quality and the health of people who use the building. On that basis, half the points were awarded for the building.

#### **Credit 5: Indoor chemical and pollutant source control**

Ingenious physical separation was achieved to separate chemical storage, collection storage, the chemical mixing area, and work areas. This is evident in the design with the separation of chemical storage, mixing, collection storage areas, with a detail for mixing and pumping to the work area as shown in **Appendix 7**, so full points are awarded.

#### **Credit 6: Controllability of systems**

The full award of points is based on the fact that there is adjustable control for ventilation and light systems. Ventilation is adjusted by having separate exhaust areas for the different sections of the building. The mechanical engineer and architect indicated that the illumination systems isolate areas and shelf sections.

#### **Credit 7: Thermal comfort**

The points are awarded as the HVAC system monitors the changes in temperature and respond accordingly. However, humidity is not monitored. As this is immaterial for the building, due to short occupancy periods, full points were awarded.

#### **Credit 8: Daylight views**

The design criterion was based on excluding light, thus daylight views do not contribute to the purpose of the building, thus full points are awarded. This was done without compromising building aesthetics by visually breaking the building using colour and louvers.

#### *4.3.6 INNOVATION AND DESIGN*

The innovation and design theme offers points for any aspects of the building that either surpassed the requirements of the LEED™, or considered aspects that are not rated by the rating tool, such as social, management or economic considerations.

The long-term view in the design of the SAIAB building to make provision for a long-term development requires recognition as it went beyond the initial brief from the client, with adjustments in funding made belatedly to incorporate that aspect. The strength of this consideration goes beyond the LEED™ requirements as the rating system does not necessarily account for the lifespan of a building. The fact that the rating system does not consider the lifespan of a building might bias sustainability checks to those that are demonstrated in the short-term, either during or/ and on completion of construction.

**Table 6:** Rating of the SAIAB building using LEED™ for innovation and design theme

<b>THEME: WATER EFFICIENCY</b>			
	<b>Potential Score</b>	<b>Achieved Rating</b>	<b>Comments</b>
<b>Considerations beyond LEED™ requirements</b>	5	2	Awarded for (i) long-term view of building life and (ii) aesthetics improvement
<b>Total</b>	<b>5</b>	<b>2</b>	

The second aspect is the improvement in aesthetics of an otherwise ‘faceless building’ by blending it in the building culture of the university and its environs through the use of face-brick patterns and louvers on windows. Aspects that could have contributed more to this aspect were the consideration of sinking the building, which might have achieved the functionality, even though it might have cost more. This was a call made by the design team without evaluating the value of alternatives.

#### 4.3.7 CONCLUSION

The functional objectives of the SAIAB building emphasise safety, security and air quality arising from it being a high risk storage building for storage of combustible solvents. The building is also designed for low, infrequent occupancy with a need to minimise daylight into the building, and consistent low temperature. In some cases these design parameters contradict the intent of the standard for new buildings, examples being the exclusion of daylight views and environmental tobacco smoke control. To some degree there is no significant relevance of water use reduction due to limited amounts used from process and low occupancy. The low occupancy also limits the applicability of carbon dioxide monitoring, even though fumes were used instead.

The performance of the building on the sustainable sites is 59% of realisable points, primarily reduced by site characteristics that cannot be changed and the size of the building, with others such as storm water management, heat islands having scope for improvement. As biodiversity protection is one of the most important sustainability considerations in South Africa, this would weigh down the building heavily in a local rating system that prioritises this theme. If the alternative transport credit was to be scored under energy as it measures energy use, the building would perform better in this theme.

The awareness and practice barriers are evident in the water efficiency theme, with the building realising only 60% of potential points. Issues that reduced the score for the building were the lack of goal setting and measurement performance, as well as a consideration of alternative sanitation technologies, which are unfortunately perceived as inferior in South Africa.

The building scores approximately 35% of potential points for energy and atmosphere theme, primarily because of the lack of systems for managing energy performance of buildings, with the systems ranging from goals setting; monitoring and measurement, as well as short-term focus on green power. Development of systems to monitor building envelope would contribute tremendously to an improved score.

The building does not perform well for materials and resources primarily on aspects that require specification, suggesting an awareness and commitment challenge for building design professionals. The building scores just over 25% of total available points, which could be improved through specification, even though there could be supply challenges.

The building performs well on indoor air quality as it constitutes a major aspect of functional design parameters, scoring over 85% of requirements for this criterion. The ability for these findings to be extrapolated to buildings of other functionality would thus be questionable.

The building's relative performance in relation to realisable credits show that the building performed relatively well on air quality, with a fair performance on sustainable sites and water efficiency. However, it performed rather poorly for energy and atmosphere and innovation in design. If these findings are compared to sustainability priorities in South Africa as identified by the national State of Environment Report, they can indicate whether the building contributes to sustainability in the context of the country.

The LEED™ rating classifies buildings into, certified with 26-32 points; silver with 33-38; gold with 39-51, and platinum with 52-69 points. In light of the building functionality limitations, the building could be classified as receiving a silver rating at 35 ¾ points when points were allocated for irrelevant criteria. However, if the principle of allocating irrelevant points is waved, the building would qualify for only a 'certified' status (less six points). Taking into account that there were no set sustainability goals, other than intention by the client, it can be inferred that there is an inherent consideration of sustainability in building design. Recognising the profession of the client, natural scientist, and general awareness of the team on issues of sustainability, it

probably suggests that the building has a better chance of demonstrating sustainability. This highlights the importance of the identified barriers to sustainability incorporation in buildings.

The highest priority of the South African government is human development, which is understood to drive resource extraction with a specific mention of water and pollution. Biodiversity as a resource that needs protection is also considered high on the agenda. Even though the country has 'abundant' energy resources, the pollution associated with the biggest stock, coal, makes air pollution and climate change areas of concern (Balance and King, 1999). The building would thus score lower in the South African context as the priority areas of energy and atmosphere, biodiversity and water are average, with the current score boosted by air quality, which is not necessarily a national priority. The relevance of the LEED™ rating for criteria adequacy in addressing sustainable development and assigned weights in the context of South Africa is discussed in the next section.

Limitations to the presented rating is that it incorporated subjectivity as the various criteria were not investigated in detail, to establish actual metrics, but responses and interpretation of technical drawings formed the basis of opinion by the researcher. Another limitation is that the building was based on design considerations, rather than the as-built status, as some of the proposal and designs may not be carried through to the final building.

#### **4.4 APPLICABILITY OF THE LEED™ IN THE SOUTH AFRICAN CONTEXT**

##### *4.4.1 EXTENT TO WHICH THE LEED™ ADDRESSES SUSTAINABLE DEVELOPMENT*

The role of any rating tool is to assess performance against a set objective, in this case building sustainability rating systems should measure performance towards sustainable development. It is thus critical for the building sustainability rating system to evaluate how earth, life support systems and communities are sustained, as well as how people, the economy, and communities are developed, based on the sustainable development taxonomy suggested by Parris and Kates (2003). The taxonomy covers the three pillars of sustainability, simplifying the various aspects into aspects of development that have to be enhanced, and those that need protection.

The extent to which a rating system contributes to the Habitat Agenda requirements of settlements to provide safety, health, and economic wellbeing by taking into cognisance critical elements aspects of material choice selection also need to be demonstrated in the rating system (Watermeyer and Milford, 2003). In an attempt to develop an appropriate building rating system for South Africa, the considerations of the LEED™ were evaluated against the GRI and JSE

SRI. It was thus possible to identify prerequisites for sustainable development that are not already addressed by the LEED™ rating system. Good practices used in the BREEAM™ and Green star™ were also considered.

**Table 7:** Identification of GRI and JSE SRI environmental indicators not covered in the LEED™

GRI	JSE SRI	THEME IN THE LEED™
Materials usage including recycled content	-	Materials and resources
Supplier environmental performance	Supplier certification with regard to EMS	Materials and resources, only certified wood
Water use, and recycling provisions	Water use, and recycling provisions	Water efficiency
Energy use, direct and indirect usage	Energy use	Energy and atmosphere
Renewable energy	Alternative and renewable energy	Energy and atmosphere
Biodiversity protection, and associated impacts	Biodiversity protection, invasive alien species	Sustainable sites
Emissions, effluent and waste, ozone depletion, greenhouse gases	Emissions, waste and effluent, greenhouse gas trading	Energy and atmosphere
Logistics transport costs in production	-	Materials and energy
Product impacts and recyclables potential	-	Sustainable sites
Compliance with environmental legislation	Environmental impacts assessment and review	Inherent in standards, but not rated
-	Environmental Management Plans	Not catered for
-	Environmental policy and its improvement	Not catered for
-	Management, structure and implementation	Innovation in design, involvement of accredited professionals
-	Provision for environmental liability	No catered for
-	Environmental education and awareness	Not catered for

The LEED™ demonstrates a significant coverage of environmental criteria of sustainable development, covering the full aspects of impacts to the environment, as shown in **Table 7**. The only weaknesses are identified in the practice and behavioural aspects of environmental management such as the use of Environmental Management Plan (EMP) and insurance against environmental liability, even though it can be argued that EMPs and insurance have more relevance during construction. However, in case of building operations that can cause significant environmental impacts arising from use, this would be deemed necessary.

**Table 8:** Identification of GRI and JSE SRI social indicators not covered in the LEED™

GRI	JSE SRI	THEME IN THE LEED™
Employment creation	Employment creation and payroll percentage	Not catered for
Labour relation practises, representation, consultation	Compliance with Dept of Labour requirements	Not catered for
Occupational health and safety, injuries, HIV/AIDS	Health and safety, HIV/ AIDS	Not catered for, albeit indoor air quality caters for some
Diversity in workplace, policy and implementation	Diversity and transformation	Not relevant to buildings
Training investment on employees	Skills development	Not catered for
Human rights policies, policy, child and forces labour, indigenous people	Human rights	Not catered for, albeit implied in certified wood
Societal issues and ethics	Policy and societal issues and ethics	Not catered for
Product stewardship	Consumer protection and awareness	Not catered for
-	Black Economic Empowerment	Not catered for
-	Community development	Not catered for

The LEED™, significantly is weak in taking into cognisance the social aspects of building, as demonstrated by a lack of consideration of even one aspect of this element of sustainable development; as **Table 8** shows, not a single consideration is made. This could be attributed to the fact that, generally sustainable development is associated with the protection of resources, primarily the biophysical environment. However, sustainable development has been defined to include social considerations, with the consequence of non-inclusion of social issues being biophysical environment degradation due to emanating social ills from unequal distribution of wealth and poor human capital.

From a social perspective, local employment creation; diversity in workforce; compliance with Department of Labour polices on health and safety, skills development, black economic empowerment and other relevant legislation; and societal issues are proposed for a South African rating system. Other considerations such as market share dominance are addressed by the GRI and the JSE SRI, however were not considered as they are not directly relevant to buildings.

The LEED™ also demonstrates a strong limitation on economic consideration of buildings, which is quite anomalous especially given that green buildings have been justified along the lines of their making financial sense in the long-term. It would therefore be pragmatic to rate building for the extent to which financial resources are better utilised. **Table 9** shows that the sourcing of local materials is considered in the LEED™. Criticism of this is that the intent is not to measure

local economic development contributions, but embedded energy in construction materials. Secondly, general legal compliance and product stewardship suggested by the JSE SRI are considered to an extent by the LEED™, even though product stewardship considered relates to commissioning, which is the functioning of installations and design, rather than a life cycle analysis of the building being rated.

**Table 9:** Identification of GRI and JSE SRI economic indicators not covered in the LEED™

GRI	JSE SRI	THEME IN THE LEED™
ECONOMIC		
Market share dominance	-	Not relevant to buildings
Geographic purchasing spread from suppliers	Supplier management	Materials and resources, but not by value
Employee payroll	Employee payroll	Not catered for
Sources of capital	Owners and investors	Not catered for
Social investment and spending	Social responsibility	Not catered for
Externality costs of operation impact	-	Not catered for
-	Policy to manage risk, investor relations, procurement	Not relevant to buildings
-	Governance, board responsibility and accountability	Not relevant to buildings, except for design team
-	Remuneration of executives and board	Not relevant to buildings
-	Human resource management and retention of skills	Not catered for
-	Knowledge management, and	Not catered for
-	General legal compliance	Inherent in standards
-	Reporting, auditing and accounting	Not relevant to buildings
-	Contractor management policy	Not catered for
-	Product stewardship	Energy and atmosphere, commissioning
-	Insurance and contingency plan	No catered for

There is scope for the incorporation of economic criteria in a rating system, albeit most of the criteria are not necessarily relevant to buildings. Proposed additions on economic aspects are financial benefits of green design, local economic development in terms of value of materials purchased locally, minimisation of social externalities of the building, life cycle cost of the building and any social contribution from the construction of the building.

**Table 10:** Identification of other sustainable development criteria not covered in the LEED™

OTHER CRITERIA	SOURCE	THEME IN THE LEED™
Contribution to reduction of slums and homelessness	Habitat Agenda	Not catered for
Economically reasonable in cost	Habitat Agenda	Not catered for
Contribution to Millennium Development Goals	MDG	Not catered for
Environmental management policy and awareness	BREEAM™	Not catered for
Use of local human resource	Habitat Agenda	Not catered for
Local culture and indigenous preferences	Poststructuralist theory	Not catered for

The behavioural aspect of policies and practice towards creation of awareness is thus considered the significant shortfall of the LEED™, with the BREEAM™ demonstrating a more proactive approach as shown in **Table 10**. The environmental policy and awareness, monitoring of EMPs, and environmental liability insurance are proposed for incorporation in a South African rating system. Based on the considerations in **Table 10**, proposed aspects to be incorporated in a South African rating system are, the extent to which the building directly contributes the reduction of slums, minimisation of cost for provision of basic services, and the ability of the building to reflect and respect the local culture, and lastly, the environmental awareness and policy from the BREEAM™.

On the basis of the above assessment, proposed additional criteria would yield a rating tool that better addresses sustainability. The only shortcoming of that improved rating tool would be the criteria weighting relevance to South Africa, with the next section outlining weighting considerations.

#### *4.4.2 WEIGHTING OF SUSTAINABILITY CRITERIA*

Recognising that rating systems allocate weight to the various assessment criteria, the context for which the rating system is developed is very important. In the case of South Africa, the State of Environment Report outlines the key pressures in our environment as being increased demand for resources due to increased economic growth and export, population factors, and national development priorities with the availability of water being of particular concern (Balance and King, 1999:9,12).

The SoER also identifies the conversion of natural habitat due to economic growth and export requirements as an important environmental pressure in South Africa. The driver of this pressure is cited as the resulting agricultural monocultures in forestry and food production required in achieving the economic growth requirements. Pollution and waste arising from the economic growth needs and macro-economic policies and sectoral needs are also regarded as important threats facing the country, so do rapid urbanisation and movement to coastal areas as it leads to the concentration of waste in densely populated areas.

The government has accepted and prioritised the improvement of the quality of life of its citizens through provision of services, equitable distribution of wealth, employment, which requires economic growth, as what has to be developed (Balance and King, 1999). This means that any rating system that is developed for the country should demonstrate how it addresses the protection of resources under pressure, and the accepted development aspects. The prioritisation by the professionals involved in the design of SAIAB is also factored into the weighting system for South Africa.

The State of Environment Report (SoER) does not prioritise the importance of various issues, such as pollution over biodiversity or resource extraction, but the value that can be extracted is that social and economic considerations outweigh environmental issues. This is demonstrated by socio-economic issues being national priorities, and also that accompanying environmental degradation as a result of socio-economic development is tolerated, and seen as something that can be mitigated through policies and enforcement (Balance and King, 1999:11). It can thus be assumed that order of priority for the South African government is social development as top priority, with further assessment being necessary to establish the relative importance of environmental protection and economic development.

The weighting of the US, UK, and Australian systems is presented in **Table 11**, showing that all the rating systems place energy consumption as a high priority material together with resource use, air quality, waste and water. All the evaluated rating systems consistently rank energy and atmosphere and indoor air quality in the top three issues for consideration, with the with Australian and UK systems ranking water highest whilst the US system ranks sustainable sites higher. It can thus be inferred that the top four environmental themes are energy and atmosphere, indoor air quality, water efficiency and sustainable sites.

Critically lacking in all the reviewed rating systems is the economic and social considerations. If the national priority in South Africa is recognised as improving the quality of life of citizens, its is important to understand the contribution of any buildings towards that objective. The absence of socio-economic criteria in the UK and US systems makes them unsuited to evaluating building in South Africa. The importance of developing countries such as South Africa to improve the standard of living whilst protecting the environment, i.e. tunnelling through the Kuznets curve has been emphasised in the theory of sustainable development. It is therefore important that all social, economic and environmental indicators are monitored by a rating tool.

**Table 11:** Relative weights assigned by the US, UK, and Australian rating systems

(Adapted - USGBC, 2005; BRE, 2006; GBCA, 2006)

RANK	LEED™		BREEAM™		GREEN STAR	
	Theme	Weight %	Theme	Weight %	Theme	Weight %
1	Energy and atmosphere	25	Energy	36	Indoor Air Quality	19
2	Indoor Air Quality	22	Waste	20	Energy	21
3	Sustainable Sites	20	Water	18	Materials	16
4	Materials and resources	19	Management	14	Emissions	11
5	Water	7	Pollution from emissions	5	Water	10
6	Innovation in design	7	Transport	4	Management	9
7			Human well being	4	Transport	9
8					Land use and Ecology	6
9					Innovation Bonus	4
		100		100		100

On the other hand, the respondents in the study also provided a ranking of the relative importance of the various sustainability criteria of the LEED™, and the findings are presented in **Table 12**, with the raw data from which the rankings were computed attached in **Appendix 10**. The mean scores show that water efficiency and energy and atmosphere are top ranking scores, with a lower standard deviation (i.e. greater level of agreement) for the energy and atmosphere theme. It can thus be inferred that, in the opinion of the client and architect energy and atmosphere is the most important theme, followed by water efficiency. It should, however, be noted that none of the respondents ranked the energy and atmosphere themes as top priority whereas water efficiency received top ranking from the client.

Site selection received a mean ranking of three even though prioritisation varied relatively significantly, with the architect having ranked it as the top theme. The affinity to environmentalism of the architect may have had an influence on the prioritisation of this theme as it refers to biodiversity protection. Air quality received the fourth position, with the architect ranking it the lowest; the higher ranking by the client should be interpreted against the professional inclination of the client characterised by a working environment that includes fumes. The fifth mean position is the innovation in design and materials and resources, with the client ranking innovation in design as the least important theme, whilst the architect ranked the theme fourth and materials and resources last.

**Table 12:** Relative weighting of the LEED™ themes by respondents

THEME	Architect	Client	Mean	Std Dev
1. SITE SELECTION	1.0	5.0	3.0	2.8
2. WATER EFFICIENCY	3.0	1.0	2.0	1.4
3. ENERGY & ATMOSPHERE	2.0	2.0	2.0	0.0
4. MATERIALS & RESOURCES	6.0	4.0	5.0	1.4
5. AIR QUALITY	5.0	3.0	4.0	1.4
6. INNOVATION IN DESIGN	4.0	6.0	5.0	1.4
				n=2

It can thus be inferred that the ranking of criteria by respondents indicates that the most important criterion is energy and atmosphere followed by water efficiency, then site selection, then air quality, with materials and resources and innovation in design being tied, and there being no basis of prioritisation one over the other. The ranking by the respondents was consistent with

identified environmental priorities in South Africa as outlined in the SoER, as it highlighted the importance of energy, water and biodiversity.

In interpreting the results presented in **Table 12**, it is important to note that the data presented does not have statistical significance since it is based only on two respondents. Another limitation is that the respondents ranked only criteria listed on the LEED™, with no opportunity for including social or economic criteria. Nevertheless, the ranking of the various criteria by the client and architect provides further insight into the considerations during the planning of the SAIAB building.

#### *4.4.4 CONCLUSION*

This section demonstrated the strength of the LEED™ with regard to environmental considerations, with additional criteria on environmental policy and awareness, monitoring of EMPs, and environmental liability insurance. The LEED™ rating system demonstrated a complete weakness on social aspects of sustainability as it does not measure local employment creation, diversity in workforce, compliance with Department of Labour policies, and societal issues and ethics. These aspects were considered to be important in the context of South Africa as they form part of the relevant considerations from the JSE SRI. From an economic perspective, financial benefits of green design, local economic development, minimisation of social externalities, life cycle cost of the building and any social contribution were suggested as necessary in a South African system.

From a weighting perspective, the SoER demonstrated that at theme level, social considerations are more important than environmental and economic issues in South Africa. Furthermore, on the criteria level, both the evaluated systems (LEED™, BREEAM™, Green Star) and respondent ratings highlighted the importance of energy and atmosphere, water efficiency, sustainable sites, and indoor air quality. The respondents in the SAIAB case prioritised the criteria in that order.

## CHAPTER 5

### GENERAL DISCUSSION

#### **Conceptual framework for building sustainability rating tools**

The current worldview of sustainable development has its foundations on the findings of the Brundtland Commission, with South Africa demonstrating the permeation of the commission's recommendations. The constitution of the country confers environmental rights in Section 24(a) (RSA, 1996:11), a tenet outlined in Section 5.1 of the Brundtland Report that '... man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being' affirming a principle emanating from the 1972 Stockholm Declaration (WCED, 1987:322).

The incorporation of the current worldview in South African thinking is also demonstrated by Section 24(b) of the South African Constitution echoing the definition of sustainable development on protection of the environment to meet present needs and those of the future generations. The first part of the definition suggests that the driver of environmental protection is the ability to meet the current generation's needs. This can be interpreted as a salient assumption that the current consumption patterns should not be changed. Thus current worldview of sustainable development is consistent with Paul Ehrlich and Barry Commoner's assertions that, the environmental burden is a function of population, affluence and technology, and that '... global population is set to increase substantially ... reducing affluence is not an option ... [T]his leaves technology' (in Starkey and Wellford, 2001:3).

This has been the source of contention, particularly from the poststructuralist theorists, suggesting that mainstream sustainable development predetermines the destination of developing countries towards consumerism, which is unsustainable (Castro, 2004). The unsustainable nature of developed societies is anomalously recognised by mainstream sustainable development authors as they recognise that the ecological footprint of developed nations is too large, '... the Dutch ecological footprint covers 15 times the area of the Netherlands ... if the entire world lived like the North Americans, it would take three planet earths to support the present world population' (Hart, 2001:9) citing Meadows (1996). This raise questions on the appropriateness of the current worldview to achieve sustainable development.

The building blocks or operational systems of mainstream sustainable development have been particularly challenged by the dialectical materialism school of thought, particularly, the economics of private property and market economy, elements that are entrenched in the South African constitution, with Section 25 conferring private property rights (RSA, 1996: 11), and freedom of trade and occupation in Section 22 (RSA, 1996:10). The macro-economic policy of the country is also driven by globalisation, with Hough *et al* (2003:42) indicating that, 'Today the South African government is fully committed to a competitive free market system'. The historical failure of free markets to protect the environment is ascribed to commodisation of nature by dialectical materialism theorists (Castro, 2004). They further challenge the benefits of global trade, suggesting it can lead to a metabolic rift from production and consumption sites, the underdevelopment of developing nations and the 'mining' of environmental resources in the developing world to finance economic development transition (Castro, 2004). The economic principles underlying the current worldview of sustainable development thus need to be examined for their ability to meet sustainable development goals.

The application of sustainable development is operationalised by the use of indicator frameworks, with that recognised in Chapter 40 of Agenda 21, which makes provision for public and private institutions to develop sustainable development indicators to guide decision making (Shah, 2004:1). Several indicator frameworks have been developed with the State of Environment Reporting having been adopted in South Africa. In fact the country was one of the volunteer testing countries of the indicators outlined in the 1996 United Nations framework '*Indicators of Sustainable Development: Framework and Methodologies*' (UN-DSD, undated: 5). Because indicators inform decision-making, they should demonstrate the goals of the underlying theoretical framework. The GRI demonstrates requirements of mainstream sustainable development, such as that, on economic issues, market dominance is measured [to establish monopoly status, an undesirable element in a free-market system] (GRI, 2002:47). The tenets of mainstream sustainable development are also evident in the GRI social performance criteria, measuring aspect such as employment creation, civil liberties [measures of growth and development] (GRI, 2002:52). The environmental considerations are also carried through from theory to GRI with indicators measuring aspects such as extraction of resources and pollution generation [demonstrating the need for environmental protection] (GRI, 2002:48). This follow-through ensures that development decisions contribute to sustainable development.

It is therefore important that any building rating tool purported to be contributing to sustainable development demonstrate a similar follow-through of theoretical concepts in the measurement

dimensions. This was considered in the review of building sustainability rating tools, the LEED™, BREEAM™, Green Star™ and SBAT. The review of the rating systems demonstrated that the UK, USA and Australian systems cover only the environmental criteria, whereas the SBAT covers all three aspects of sustainability. Following the assessment of the LEED™, BREEAM™, GBTool and SBAT, Kaatz (2002) concluded that the LEED™ and BREEAM™ were developed in the context of developed countries with no focus on socio-economic and cultural issues, which are important aspects for developing countries such as South Africa. The lack of follow-through of social and economic aspects in the developed rating systems suggests a weakness in comprehensively covering the requirements for sustainable development. Further analysis of the rating tools by Kaatz (2002) mentioned that the SBAT is adaptable and responsive to local conditions, criticism being that, in striving for flexibility the different benchmarks for buildings limit comparison of similar buildings and also that for simplicity the comprehensiveness of the biophysical criteria were sacrificed.

Another observable flaw of the SBAT is that, the tool assumes equal weighting across the economic, social, and environmental themes and criteria that comprise them. The importance of weighting in a rating system is evident in the fact that all the tools developed for the developed countries only focus on the environmental themes as it is the most pressing sustainability issue. Even within the environmental criteria, certain receive higher priorities than others such as the prioritisation of waste in the UK, which may be ascribed to high affluence and limited space. The review of the national State of Environment Report for South Africa provides a starting point for assigning weights to local themes. The SoER identify national priority as the improvement in the quality of life, economic growth, employment and provision of basic services, also appreciating the resulting increase in resource use and consumerism (Balance and King 1999:11). This suggests an 'acceptable' trade-off of human development with the environment suggesting a higher weight for social factors. The ability to address the imperatives of sustainable development, and assigning appropriate weights depending on a particular context can thus be seen as important aspects for the effectiveness of a rating tool.

### **Practical application of building sustainability rating tools**

Even though the theoretical grounding of a rating tool is important, it is pragmatic to understand the implementation environment, so as to exploit opportunities and mitigate potential barriers to the use of building rating tools. The current goal of the research sought to understand the motivation and consideration of green building criteria in the design of the SAIAB building. The understanding of motivation and consideration thus provided an opportunity to understand

sustainability performance of the building, appropriateness of available rating tools and barriers to adoption of sustainability practises in building design. Responding to the building sustainability performance of the SAIAB building objective, it transpired that there is an inherent, non-targeted consideration of sustainability in building design. This is demonstrated by that the building scored approximately half the potential points using the LEED™ criteria, when inapplicable criteria credits were awarded. This is despite sustainability awareness of the client and the design team. The SAIAB building was awarded a silver rating, which is on the lower end of the compliance hierarchy. The low overall environmental rating was however comprised of good scores in air quality, and particularly poor scores for energy and atmosphere and design innovation, receiving average scores for water and sustainable sites. Recognising the functionality of the building as being safety and health from the handling of volatile organic compounds, this demonstrates a strong influence and focus on functional design of the building. Recognising the importance of biodiversity, water and energy in South Africa, a rating system that prioritises those criteria would have resulted in even lower sustainability rating of the building. With regards to the research objective on appropriateness of the LEED™ rating and other rating systems reviewed such as SBAT, it was established that there are areas of improvement with regards to the comprehensiveness of the tools, as well the criteria weighting.

With regards to the research objective of evaluating sustainability considerations and barriers to adoption, the findings showed that there is a general understanding of sustainable development as a concept, even though barriers to application in the building construction industry were identified. The barriers identified from the design of SAIAB building experience can be classified into institutional, conceptual and awareness, information and awareness, and economic and capacity barriers.

*Institutional barriers* include lack of regulations and standards, lack of incentives and limited access to land. The identified lack of regulations and standards identified in the SAIAB building case included the absence of an energy performance requirement in building regulations, a regulatory regime for the use of CFCs, construction waste management and permeability requirements. The importance of regulation in achieving social benefits was identified by Porter and van der Linde (1995, in Starkey and Welford, 2001:49) as stimulant that can lead to firms seeking solutions that improve their competitiveness and in the process achieving social benefits, subject to a properly designed regulatory regime.

This suggests an unexplored opportunity in using a regulatory regime to achieve building sustainability in South Africa. The lack of regulatory stimuli can also lead to non-adoption of readily available green technologies, with Allderdice (2003) mentioning that outdated regulation can not only stifle the adoption of buildings, but increase the building costs based on experiences in Canada. Similar experiences were observed in Australia with regards to sustainability inconsistencies with building standards, with the mitigation cited as the development of building codes that are quantitatively responsive to environmental considerations (GBCA, 2006a).

The lack of external incentives to promote a trend towards sustainable buildings in South Africa was also identified as a barrier. The US rating system awards credits for buildings that take advantage of incentive systems such as tax rebate on urban re-development, brownfield site rehabilitation and green-power credits, elements that are not widely available in the country. An exception is however urban redevelopment incentives in some major cities. The importance of market driven incentives is also an important component of incentives due to the prestige and differentiation that clients can achieve from green rated buildings. The ability to differentiate based on environmental performance is outlined by Reinhardt (2001:54).

In case of the SAIAB building, it was evident that the selection of the final site was strongly influenced by access and availability. Landownership drives site selection, which is primarily dependent on access to development sites, limiting developer options. This can however not be directly mitigated even though incentives can increase the opportunities for evaluation of alternative sites. For example, tax incentives can make less financially attractive sites worthwhile to investigate thus increasing stock from which a developer can select.

*Conceptual and awareness barriers* include relevant professional codes, design process and research information. The role of professional codes is to provide professionals with guidance as to their responsibility and accepted practice. The lack of codes relating to building sustainability limits the incorporation of the concepts in the appointment of the design team and design process. The appointment of a team with established and known roles has the biggest opportunity of incorporating sustainable design as shown by Bernheim and Reed (1996). The practice and attitude in construction is driven by the time and cost constraints, with the primary objective being the maximisation of performance against those criteria, with no value engineering and evaluation of alternatives forming part of the design process. Bernheim and Reed (1996) further mention that once a design team is appointed, the next important step is the development of sustainability goals prior to the pre-design stage, with the pre-design stage outlining design

interventions to meet the goals. The Sustainable Building Lifecycle proposed by Gibberd (2005) also provides a design process that could be followed, whereas lessons can be learnt from the Bernheim and Reed (1996) team composition and responsibilities.

*Information and awareness barriers* probably contribute the most to the implementation of building sustainability, as all the respondents demonstrated awareness and intent towards sustainability, however cited lack of knowledge on how to respond to building impacts and the need for research and information on building sustainability. Awareness also transpired during the rating of the SAIAB building, with the requirements of some criteria not achieved intentionally, such as transport benefits from the selected site. In some cases, there was no intent to achieve sustainability, for example with regards to heat island management and the specification of certified wood. An institutionalised design process that includes setting sustainability objectives in design could well contribute to the understanding of what has to be protected and enhanced. The GBCA (2006) suggest that building professionals need to be educated on green buildings, so as increasing public awareness in order to increase the demand for green buildings.

*Economic and capacity barriers* relate to building sustainability costs and capacity to implement green technologies. The cost barriers were the more conspicuous of the two in the design of the SAIAB building, as this was cited as a limitation to the use of renewable energy and the considered design of sinking the building. . Goldberger and Jessup (1996) also identified cost barriers in local government institutions in USA as being driven by higher upfront costs, which are sometimes seen as unjustifiable when the contribution to the operational budget of the saving is small. The authors further mentioned that in cases where the accrued benefits lead to a decrease in the operational budget for the next year limits adoption. The cost reduction benefits of the adoption of green technologies were also identified by Reinhardt (2001:59) particularly on water and energy usage. These are the internal incentives. The availability of tools and expertise for measurement and verification of performance also proved to be a potential limiting factor in achieving some of the criteria, particularly if the requirement is the use of simulation technology, which is not widely used in the South African construction industry.

A common thread across all these barriers is awareness of the potential and practice of sustainability in design of buildings, as the regulatory framework, standards, professional codes contribute to stakeholder awareness and commitment. A notable feature of existing rating systems in other countries is that, the rating is undertaken by an independent industry-initiative

that receives support of the industry. Secondly there is a market driven by prestige for a certified green building and/or internal benefits to the developer and thirdly, the rating system is supported by technically sound and comprehensive standards and codes of good practice. The combination of these three elements is thus purported to be the triad necessary for successful implementation of a rating system in any country.

## CHAPTER 6

### CONCLUSIONS AND RECOMMENDATIONS

The findings of the chapters on understanding of sustainability and sustainability considerations in the design of the SAIAB building demonstrated an understanding of the concept of sustainable development and impacts of buildings. Despite the understanding, barriers to achieving the intent were identified institutional, conceptual and awareness, information and awareness and economic and capacity barriers. The institutional barriers pertained to external motivation of developers to embark on sustainable building through regulations and incentives. Whereas the conceptual and awareness barriers addressed implementation processes by design professionals through the development and use of codes. The role of information and awareness was also identified as hindering adoption of green buildings due to the lack of research information and professional development. Further awareness requirements pertained to general awareness of green building to increase market demand.

The chapter on the rating of the SAIAB building demonstrated a lack of stipulated goals towards sustainability, but demonstrated a strong bias towards functional considerations in the design, particularly air quality. This can be attributed to some of the barriers to implementation indicated above, such as institutional barriers and awareness. As a result, the building scored on the low end of the LEED™ criteria, even though it performed well on functional design aspects. The building obtained a ‘silver rating’ achieving just more than half of potential points. It is important to note that, if the building was rated on a rating tool that takes into cognisance South African environmental issues, it would have probably scored even lower than the achieved rating.

The findings of the chapter on applicability of the LEED™ in the context of South Africa were grounded on the theoretical framework discussed in the literature review. The permeation of sustainable development criteria in building rating tools was analysed as well as the assigning of weights to criteria against South Africa priorities as outlined in the SoER. The SoER clearly demonstrated the importance human development in South Africa, suggesting that the social theme in sustainable development requires a higher relative weighting to environment and economic considerations. It is from that premise that the focus of the LEED™ on environmental issues was identified as a major limitation, also that the weighting of criteria is also not necessarily consistent with the priorities in South Africa. Furthermore the South African

developed tool, SBAT was also reviewed, demonstrating strength in covering social, environmental and economic aspects of building sustainability, however criticised for the lack of depth in measuring sustainability dimensions, as well as the equal assignment of weights to criteria.

The findings on the three objectives of the research provided insights on the state of building sustainability rating in South Africa. The first aspect being that, SBAT provides an opportunity for building rating in South Africa albeit there is room for improving the tool to make it more effective and comprehensive. Another insight gained was that, there is a general understanding and intent towards building sustainability, however there is no national framework that outlines the strategy, structure and systems for implementation.

In response to the findings, it is recommended that a strategy be developed for understanding building sustainability for the country, covering the understanding and goals of sustainable development specific to South Africa. These goals can thus be translated into policies and strategies that pave way for regulation and incentives. It is also recommended that a structure for implementation be developed, outlining roles and responsibilities of stakeholder institutions such as design professionals, standards bodies, government and an industry organisation to undertake the rating exercise. The last recommendation is on the development of systems, that will include a rating tool and performance standards that will culminate in a design appraisal manual for the rating body.

Closely linked to the recommendations will be research opportunities in the definition of sustainability goals for the country, and the development of an appropriate rating tool and performance standards for building sustainability rating.

## CHAPTER 7

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**CHAPTER 8**  
**APPENDICES**

**APPENDIX 1: LEED™ RATING SYSTEM CRITERIA**



# LEED-NC

Green Building Rating System  
For New Construction &  
Major Renovations

Version 2.2

For Public Use and Display

October 2005

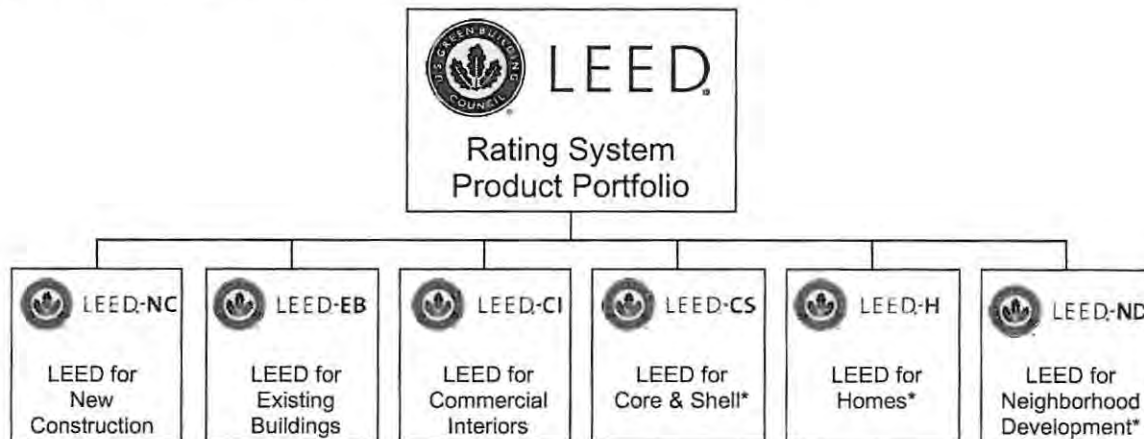


## Leadership in Energy and Environmental Design (LEED®)

Buildings fundamentally impact people's lives and the health of the planet. In the United States, buildings use one-third of our total energy, two-thirds of our electricity, one-eighth of our water, and transform land that provides valuable ecological resources. Since the LEED Green Building Rating System for New Construction (LEED-NC version 2.0) was first published in 1999, it has been helping professionals across the country to improve the quality of our buildings and their impact on the environment.

As the green building sector grows exponentially, more and more building professionals, owners, and operators are seeing the benefits of green building and LEED certification. Green design not only makes a positive impact on public health and the environment, it also reduces operating costs, enhances building and organizational marketability, potentially increases occupant productivity, and helps create a sustainable community. LEED fits into this market by providing rating systems that are voluntary, consensus-based, market-driven, based on accepted energy and environmental principles, and they strike a balance between established practices and emerging concepts.

The LEED rating systems are developed by USGBC committees, in adherence with USGBC policies and procedures guiding the development and maintenance of rating systems. LEED-NC version 2.2 is only possible due to the generous volunteer efforts of many individuals, and has been in development for over 2 years. LEED-NC is one of a growing portfolio of rating systems serving specific market sectors.



*\*Under development as of October 2005*

### LEED for New Construction (& Major Renovations)

The LEED-NC Rating System is applicable to new commercial construction and major renovation projects.

#### Why Certify?

While LEED Rating Systems can be useful just as tools for building professionals, there are many reasons why LEED project certification can be an asset:

- Be recognized for your commitment to environmental issues in your community, your organization (including stockholders), and your industry;
- Receive third party validation of achievement;

- Qualify for a growing array of state & local government initiatives;
- Receive marketing exposure through USGBC Web site, Greenbuild conference, case studies, and media announcements.

### **Certification Process**

Project teams interested in obtaining LEED certification for their project must first register online. Registration during early phases of the project will ensure maximum potential for certification. The LEED website, [www.leedbuilding.org](http://www.leedbuilding.org), contains important details about the certification review process, schedule and fees. The applicant project must satisfactorily document achievement of all the prerequisites and a minimum number of points. See the LEED-NC project checklist for the number of points required to achieve LEED-NC rating levels.

### **Additional LEED Resources**

Visit the LEED Web site for available tools and support, such as the LEED-NC Version 2.2 Reference Guide (essential for all LEED-NC project teams), technical support via Credit Interpretations, and training workshops.

### **Disclaimer and Notices**

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October 2005

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# Project Checklist

## Sustainable Sites

## 14 Possible Points

Prereq 1	<b>Construction Activity Pollution Prevention</b>	Required
Credit 1	<b>Site Selection</b>	1
Credit 2	<b>Development Density &amp; Community Connectivity</b>	1
Credit 3	<b>Brownfield Redevelopment</b>	1
Credit 4.1	<b>Alternative Transportation</b> , Public Transportation Access	1
Credit 4.2	<b>Alternative Transportation</b> , Bicycle Storage & Changing Rooms	1
Credit 4.3	<b>Alternative Transportation</b> , Low Emitting & Fuel Efficient Vehicles	1
Credit 4.4	<b>Alternative Transportation</b> , Parking Capacity	1
Credit 5.1	<b>Site Development</b> , Protect or Restore Habitat	1
Credit 5.2	<b>Site Development</b> , Maximize Open Space	1
Credit 6.1	<b>Stormwater Design</b> , Quantity Control	1
Credit 6.2	<b>Stormwater Design</b> , Quality Control	1
Credit 7.1	<b>Heat Island Effect</b> , Non-Roof	1
Credit 7.2	<b>Heat Island Effect</b> , Roof	1
Credit 8	<b>Light Pollution Reduction</b>	1

## Water Efficiency

## 5 Possible Points

Credit 1.1	<b>Water Efficient Landscaping</b> , Reduce by 50%	1
Credit 1.2	<b>Water Efficient Landscaping</b> , No Potable Use or No Irrigation	1
Credit 2	<b>Innovative Wastewater Technologies</b>	1
Credit 3.1	<b>Water Use Reduction</b> , 20% Reduction	1
Credit 3.2	<b>Water Use Reduction</b> , 30% Reduction	1

## Energy & Atmosphere

## 17 Possible Points

Prereq 1	<b>Fundamental Commissioning of the Building Energy Systems</b>	Required
Prereq 2	<b>Minimum Energy Performance</b>	Required
Prereq 3	<b>Fundamental Refrigerant Management</b>	Required
Credit 1	<b>Optimize Energy Performance</b>	1-10
Credit 2	<b>On-Site Renewable Energy</b>	1-3
Credit 3	<b>Enhanced Commissioning</b>	1
Credit 4	<b>Enhanced Refrigerant Management</b>	1
Credit 5	<b>Measurement &amp; Verification</b>	1
Credit 6	<b>Green Power</b>	1

## Materials & Resources

## 13 Possible Points

Prereq 1	<b>Storage &amp; Collection of Recyclables</b>	Required
Credit 1.1	<b>Building Reuse</b> , Maintain 75% of Existing Walls, Floors & Roof	1
Credit 1.2	<b>Building Reuse</b> , Maintain 95% of Existing Walls, Floors & Roof	1

Credit 1.3	<b>Building Reuse</b> , Maintain 50% of Interior Non-Structural Elements	1
Credit 2.1	<b>Construction Waste Management</b> , Divert 50% from Disposal	1
Credit 2.2	<b>Construction Waste Management</b> , Divert 75% from Disposal	1
Credit 3.1	<b>Materials Reuse</b> , 5%	1
Credit 3.2	<b>Materials Reuse</b> , 10%	1
Credit 4.1	<b>Recycled Content</b> , 10% (post-consumer + 1/2 pre-consumer)	1
Credit 4.2	<b>Recycled Content</b> , 20% (post-consumer + 1/2 pre-consumer)	1
Credit 5.1	<b>Regional Materials</b> , 10% Extracted, Processed & Manufactured Regionally	1
Credit 5.2	<b>Regional Materials</b> , 20% Extracted, Processed & Manufactured Regionally	1
Credit 6	<b>Rapidly Renewable Materials</b>	1
Credit 7	<b>Certified Wood</b>	1

## Indoor Environmental Quality      15 Possible Points

Prereq 1	<b>Minimum IAQ Performance</b>	Required
Prereq 2	<b>Environmental Tobacco Smoke (ETS) Control</b>	Required
Credit 1	<b>Outdoor Air Delivery Monitoring</b>	1
Credit 2	<b>Increased Ventilation</b>	1
Credit 3.1	<b>Construction IAQ Management Plan</b> , During Construction	1
Credit 3.2	<b>Construction IAQ Management Plan</b> , Before Occupancy	1
Credit 4.1	<b>Low-Emitting Materials</b> , Adhesives & Sealants	1
Credit 4.2	<b>Low-Emitting Materials</b> , Paints & Coatings	1
Credit 4.3	<b>Low-Emitting Materials</b> , Carpet Systems	1
Credit 4.4	<b>Low-Emitting Materials</b> , Composite Wood & Agrifiber Products	1
Credit 5	<b>Indoor Chemical &amp; Pollutant Source Control</b>	1
Credit 6.1	<b>Controllability of Systems</b> , Lighting	1
Credit 6.2	<b>Controllability of Systems</b> , Thermal Comfort	1
Credit 7.1	<b>Thermal Comfort</b> , Design	1
Credit 7.2	<b>Thermal Comfort</b> , Verification	1
Credit 8.1	<b>Daylight &amp; Views</b> , Daylight 75% of Spaces	1
Credit 8.2	<b>Daylight &amp; Views</b> , Views for 90% of Spaces	1

## Innovation & Design Process      5 Possible Points

Credit 1.1	<b>Innovation in Design</b>	1
Credit 1.2	<b>Innovation in Design</b>	1
Credit 1.3	<b>Innovation in Design</b>	1
Credit 1.4	<b>Innovation in Design</b>	1
Credit 2	<b>LEED Accredited Professional</b>	1

## Project Totals      69 Possible Points

Certified 26–32 points   Silver 33–38 points   Gold 39–51 points   Platinum 52–69 points

**APPENDIX 2: QUESTIONNAIRE USED IN THE STUDY**



**CASE STUDY QUESTIONNAIRE FOR EVALUATING SOME GREEN BUILDING CONCEPTS  
AS THEY APPLY TO THE SOUTH AFRICA AQUATIC BIODIVERSITY (SAIAB) WET  
COLLECTION FACILITY**

RESEARCHER : Xolisa Ngwadla

QUALIFICATION : Towards MBA (Environmental) short thesis

CONTACT DETAILS : [xolisa.j.ngwadla@dupont.com](mailto:xolisa.j.ngwadla@dupont.com) or 082 907 8188

BACKGROUND :

The concept of sustainability transcends all facets of human life, including the provision of amenities and shelter. In response to challenges associated with the footprint of buildings on the environment, some countries have made moves towards mitigating the challenges; the United States Green Building Council (USGBC) took lead by developing a framework for rating buildings, called the Leadership in Energy & Environmental Design™. Other countries have followed suit and adapted the rating system to better suit local conditions.

As South Africa has no such framework, this study uses the South African Institute for Aquatic Biodiversity (SAIAB) building as a case to evaluate challenges facing the building construction industry in adopting 'green building' technologies. This is done by identifying key issues and how they were mitigated in the SAIAB case

**INSTRUCTIONS ON FILLING THE QUESTIONNAIRE:**

1. The questionnaire is divided into three parts; (1) general information, (2) considerations and experiences in the SAIAB case, and (3) rating of green building criteria
2. The questionnaire should be filled in sequentially i.e. from part 1 to 3, and should take approximately 1 hour of your time
3. The questionnaire will be followed by an interview that I will arrange pending the receipt of the completed questionnaire
4. Please send back the completed questionnaire before the 18 August 2006, either fax or email, 012 683 6886 or [xolisa.j.ngwadla@dupont.com](mailto:xolisa.j.ngwadla@dupont.com), or phone 082 907 8188 for alternative arrangements
5. All responses will be regarded as **confidential** so please be as honest as possible when completing the questions.

**SECTION 1: GENERAL INFORMATION**

1. SURNAME \_\_\_\_\_

2. NAME \_\_\_\_\_

3. ROLE PLAYED DURING THE DESIGN / CONSTRUCTION OF THE SAIAB BUILDING

(Tick appropriate blocks)

Client	Architect	Structural Engineer
Civil Engineer	Electrical Engineer	Mechanical Engineer
Landscaper	Civil contractor	Other (specify) _____

4. WHAT WERE YOUR RESPONSIBILITIES OR BRIEF IN THE PROJECT?

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5. ARE YOU A MEMBER OR SYMPATHISER OF ANY ENVIRONMENTAL ORGANISATION OR GROUP, YES NO?

Whether yes or no, please provide more information as to why

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6. WHAT IS YOUR GENERAL UNDERSTANDING OF "SUSTAINABLE DEVELOPMENT"?

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7. HOW DO YOU THINK SUSTAINABLE DEVELOPMENT GENERALLY RELATES TO THE DESIGN AND CONSTRUCTION OF BUILDINGS?

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8. WHAT ROLE DO YOU THINK YOUR PROFESSION SHOULD CONTRIBUTE TO YOUR ANSWER IN 6?

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9. WHAT DO YOU CONSIDER TO BE MAJOR ENVIRONMENTAL IMPACTS OF BUILDINGS LIKE SAIAB?

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10. WHAT CHALLENGES DO YOU FORESEE FOR PROFESSIONALS IN YOUR FIELD IN ACHIEVING THE IDEALS OUTLINED IN 6 & 7?

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11. WHAT WOULD YOU SUGGEST TO OVERCOME THE CHALLENGES OUTLINED IN 9?

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12. HAVE YOU EVER HEARD OF GREEN BUILDINGS, YES NO,

If yes, are you aware of any standards related to green buildings?

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13. WHAT PROFESSIONAL STANDARDS ARE USED IN SOUTH AFRICA FOR THE SERVICES YOU RENDERED IN THE PROJECT?

Do you consider them to contribute to environmentally friendly practice, explain

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14. ANY OTHER COMMENTS

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**SECTION 2: CONSIDERATIONS IN THE DESIGN OF THE SAIAB BUILDING**

Please answer those questions that you feel are relevant to your role in the project,

**1. SITE CONSIDERATIONS**

1.1 Were there any alternative sites for the SAIAB building? Yes No,

If "yes", why were they not chosen?

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1.2 What were erosion and sedimentation issues on site, and how they were mitigated?

Temporal 

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Permanent 

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1.3 Was the site green- or brown-field? Green field Brown field

If brown-field, was any remediation of the site or removal of existing structures necessary prior to the construction of the new building?

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1.4 Were there any issues regarding sensitive areas, Yes No,  
If so, what efforts were made to minimise negative impacts on those areas?

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1.5 By how much did the site increase people and use density compared to surrounding buildings, and how does the building density compare to surrounding building

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1.6 With respect to transport to / from the building, which of the following were considered during the design of the building?

- Proximity to public transport routes
- Facilitation of alternative transport eg. Inclusion of bicycle racks
- Access by disabled persons
- Densification of existing parking spaces
- Other (please specify)

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1.7 What considerations were made to reduce storm water/ unnatural flow of water and water quality, and how those considerations were incorporated in the design

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1.8 Were heat island generated by the building a threat from hard surfaces like the wall roof and paving, and how was the threat controlled / mitigated in terms of design and specification?

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1.9 Was light pollution to surrounding areas identified as a threat prior to the design, Yes No  
How was it minimised

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## 2. WATER EFFICIENCY

2.1 What were the criteria for the selection of plants used in landscaping?

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2.2 What irrigation technology was selected, and why was it selected over alternatives considered?

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2.3 Is there any runoff captured for irrigation purposes, Yes No,  
If not why

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2.4 What water use reduction technologies were implemented in the building?  
If none were included in the design what were the reasons for this?

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2.5 During the design of the building was recycling of water considered? Yes No  
If not, why not?

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3 ENERGY & ATMOSPHERE

3.1 What was the commissioning plan for all aspects of the building

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3.2 Was energy efficiency considered in the design of the building envelope, Yes No,  
How was this manifested in the final design?

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3.3 What consideration were made in designing the temperature control system, refrigerant specifications, e.g. CFC, cooling-heating mechanisms, etc

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3.4 What were considerations in designing the lighting system, e.g. energy saving light bulbs, etc

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3.5 Was renewable (solar) energy considered during the design of the building? Yes No,  
If not why, if considered what were challenges in implementing it

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3.6 What solid waste reduction measures and reception facilities, practices were identified during construction?

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3.7 Were any existing structures moved or removed? Yes No,  
If "yes", what happened to the materials?

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3.8 Is/ was there a construction waste plan, Yes No,  
How is construction debris is disposed of?

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3.9 Was there any salvage or re-use of some of the building materials, or recycled content specified for the materials used in the construction of the building? Yes No,  
Whether yes or no, please indicate why?

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3.10 How would you describe the spread of structural material (wood, concrete, steel) availability in terms of final assembly point/ manufacturing process in distance from the site

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3.11 Can you estimate materials specified that are rapidly renewable, e.g.  
Bamboo mats, straw insulation, etc  
Certified green products, e.g. timber,  
If not why,

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4 INDOOR AIR QUALITY (IAQ)

4.1 What potential IAQ issues were considered and how were they addressed?

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4.2 Is there provision of smoking rooms, chemical storage rooms, etc, and how are those areas exhausted out of the building

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4.3 What type of ventilation was selected, and what was the basis of choice?

- Displacement,
- Low velocity,
- Operable windows,
- Plug flow,

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4.4 Is there a CO<sub>2</sub> or a Volatile Organic Compound (VOC) monitoring system, Yes No,  
If not why

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4.5 Were low VOC materials specified, or was that not a consideration, which VOC emitting materials was included in the final design?

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4.6 Is there any physical separation of contaminants between, and how does that show on the design

Risk areas

Ventilation exhaust

Plumbing

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4.7 How much individual control is there for lights, ventilation etc?

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4.8 How were daylight and views optimized?

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## 5 INNOVATION IN DESIGN

5.1 What was the basis of specifying materials used, e.g. concrete instead of wood, PVC pipes instead of steel, etc

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5.2 What comments can you make with regards to sustainability and type of building materials used?

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### SECTION 3: RATING THE IMPORTANCE OF GREEN DESIGN CRITERIA FOR SOUTH AFRICA

RANK IN THE ORDER OF IMPORTANCE THE FOLLOWING FROM 1 TO 5

SITE SELECTION	WATER EFFICIENCY	MATERIALS & RESOURCES	AIR QUALITY	INNOVATION IN DESIGN
----------------	------------------	-----------------------	-------------	----------------------

#### 1. SITE SELECTION

Of the criteria listed below, please indicate the relative importance of each by ticking the relevant box. Note that only a single criterion can be given a relative ranking of eg. 1.

1.1 Ecologically Sensitive Areas 

1	2	3	4	5	6	7	8
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1.2 Densification 

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

1.3 Brownfield vs Greenfield 

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

1.4 Transportation 

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

1.5 Site disturbance 

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

1.6 Stormwater management 

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

1.7 Landscape & exterior design 

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

1.8 Light pollution 

1	2	3	4	5	6	7	8
---	---	---	---	---	---	---	---

#### 2. WATER EFFICIENCY

2.1 Water efficient landscaping 

1	2	3
---	---	---

2.2 Wastewater control 

1	2	3
---	---	---

2.3 Water use reduction 

1	2	3
---	---	---

#### 3. ENERGY & ATMOSPHERE

3.1 Commissioning 

1	2	3	4
---	---	---	---

3.2 Energy performance 

1	2	3	4
---	---	---	---

3.3 Renewable energy 

1	2	3	4
---	---	---	---

3.4 Ozone depletion 

1	2	3	4
---	---	---	---

#### 4. MATERIALS AND RESOURCES

4.1 Materials salvage 

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.2 Construction waste 

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.3 Reuse and recycling 

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.5 Local/ regional materials 

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.6 Rapidly renewable materials 

1	2	3	4	5	6	7
---	---	---	---	---	---	---

4.7 Certified products 

1	2	3	4	5	6	7
---	---	---	---	---	---	---

#### 5. AIR QUALITY

5.1 CO<sub>2</sub> monitoring 

1	2	3	4	5	6
---	---	---	---	---	---

5.2 Ventilation effectiveness 

1	2	3	4	5	6
---	---	---	---	---	---

5.3 VOC emitting materials 

1	2	3	4	5	6
---	---	---	---	---	---

5.4 Indoor population control 

1	2	3	4	5	6
---	---	---	---	---	---

5.5 Controllability of systems 

1	2	3	4	5	6
---	---	---	---	---	---

5.6 Daylight & views 

1	2	3	4	5	6
---	---	---	---	---	---

#### 6. INNOVATION OF DESIGN

Material type choice 

Nealiable	Low	Neutral	High	V High
-----------	-----	---------	------	--------

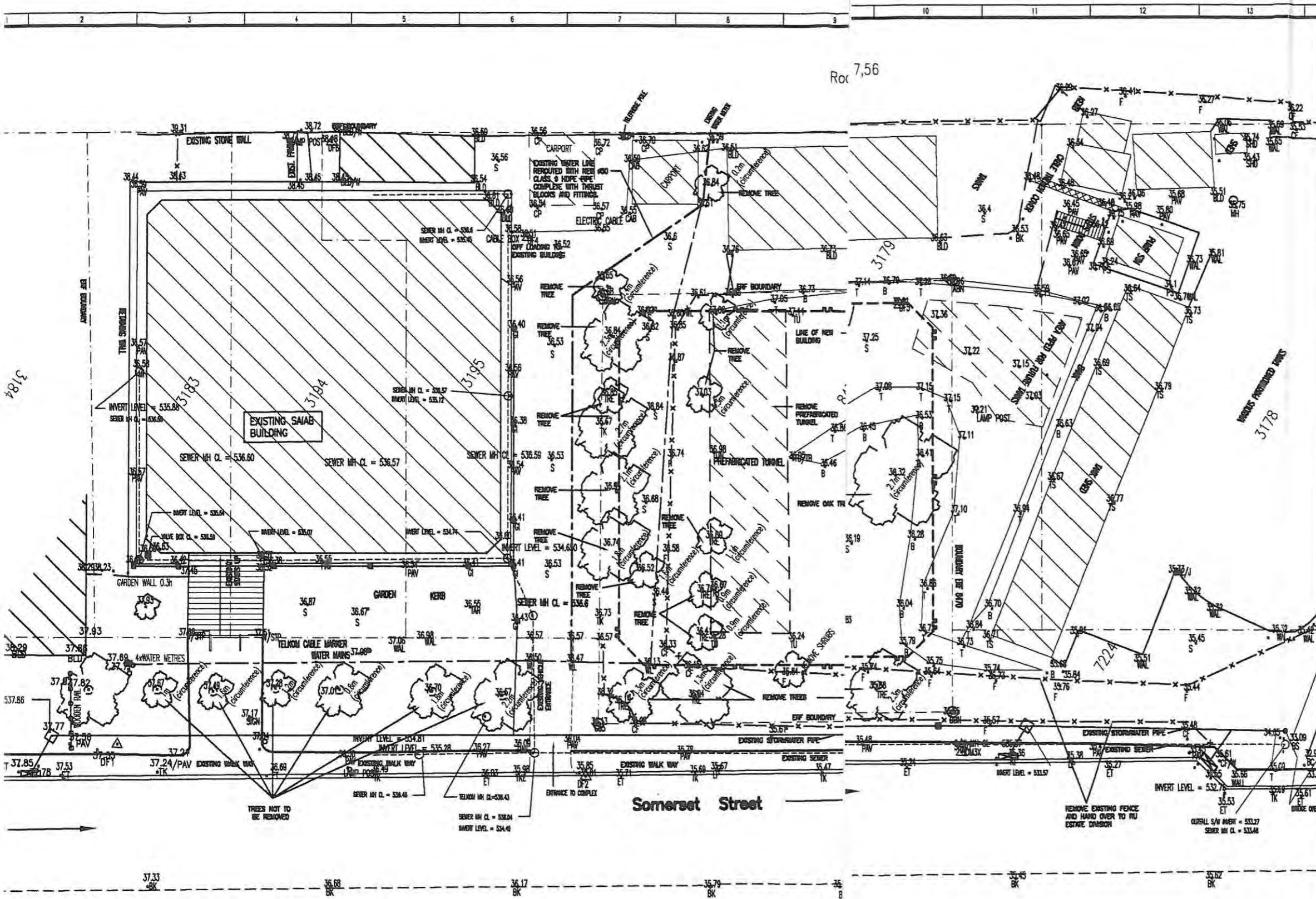
THANK YOU FOR YOUR TIME

**APPENDIX 3: SITE PLAN PREPARATION PLAN**

**APPENDIX 4: SITE PLAN**

1059

Ro 7,56



- LEGEND**
- EXISTING SEWER LINE AND MANHOLE
  - EXISTING STORMWATER PIPE AND CATCHPIT
  - EXISTING FENCE LINE

- NOTES:**
- ① EXISTING LEVELS EG. 36.53 REFER TO OSMU SITE SURVEYED LEVELS. ADD 500.000 TO REDUCE TO MSL.
  - ② REMOVE ALL TREES, FENCES AND RELOCATE TUNNELS AND PIPES AS INDICATED ON THE DRAWING.
  - ③ POSITION OF WATER MAIN TO BE REROUTED TO BE DETERMINED ON SITE BY ENGINEER.

Rev.	Date	Grid	Description	O.A.
REVISIONS				

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For: MBB CONSULTING SERVICES (EC) INC.  
 Per: Eng. \_\_\_\_\_ Date: \_\_\_\_\_

**SA INSTITUTE FOR AQUATIC BIODIVERSITY**  
**NEW WET COLLECTION FACILITY**  
**GRAHAMSTOWN**

**SITE PREPARATION PLAN**

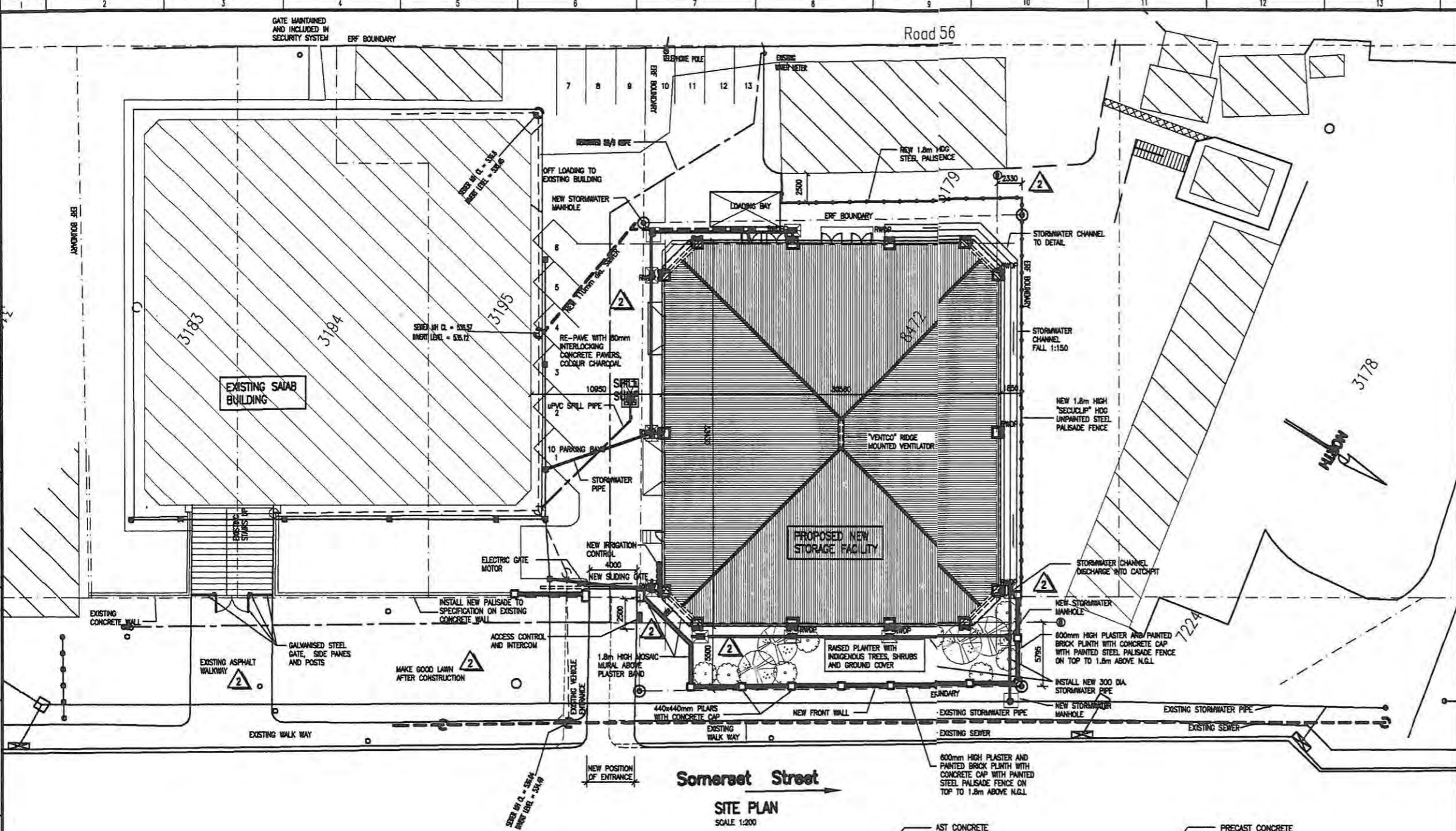
Drawn	J.VOS	Surveyed	—
Date	JULY 2004	Designed	P.ELLIS
Scale	1:200	Checked	P.ELLIS

DRAWING NUMBER	PROJECT NUMBER	REP. DATE	REV. DATE	OWNER DATE	ISSUED BY
G2066	02A1	201	R00		

ISSUED FOR CONSTRUCTION PURPOSES 13 SEPT. 2005

**SITE PLAN**  
 SCALE 1:200

1056



- LEGEND**
- EXISTING SEWER LINE AND MANHOLE
  - NEW SEWER LINE AND MANHOLE
  - EXISTING STORMWATER PIPE AND CATCHPIT
  - NEW STORMWATER PIPE AND CATCHPIT
  - NEW 50mm HDPE WATER PIPE REROUTED

- NOTES:**
1. DESIGN OF PALISADE AND EXTERNAL BOUNDARY WALL TO BE APPROVED BY CLIENT BEFORE ERECTION.
  2. SPILL SUMP DESIGN NOT FINALISED, CONSTRUCT ON THE ISSUING OF SITE INSTRUCTION.
  3. EXTERNAL ACCESS CONTROL STILL NEEDS TO BE APPROVED BY THE CLIENT.
  4. WATER SUPPLY TO THE BUILDING MUST BE EARTHED.

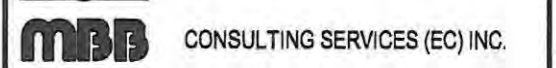
**Somerset Street**  
**SITE PLAN**  
SCALE 1:200

Rev.	Date	Grid	Description	Q.A.
R02	20.10.05		AMENDMENTS	P.J.E
R01	14.06.05		SPILL SUMP ADDED	P.J.E

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Email: mbbg@imagine.co.za



For: MBB CONSULTING SERVICES (EC) INC.

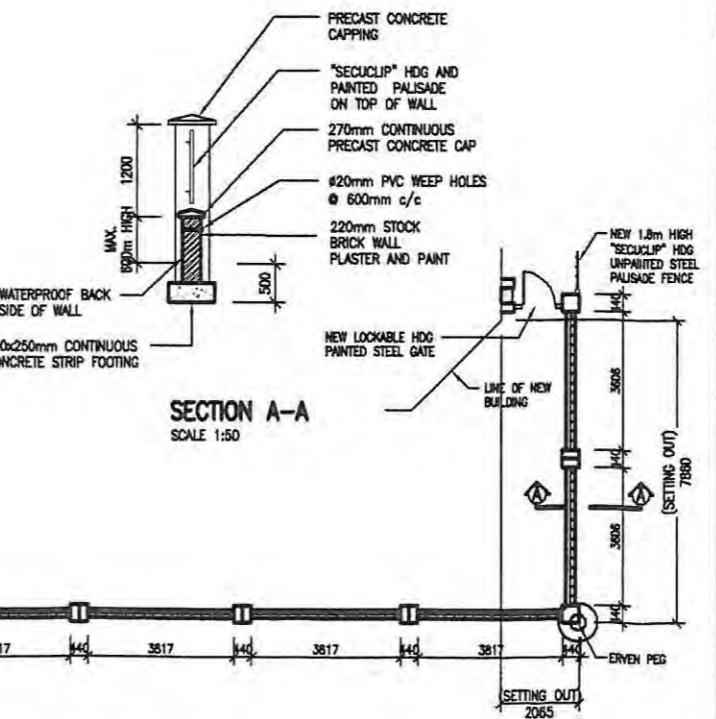
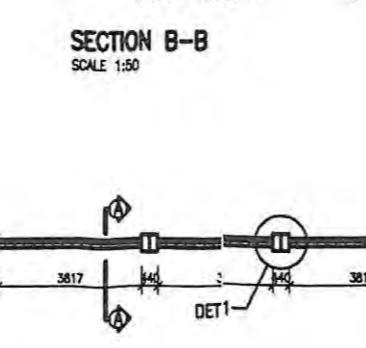
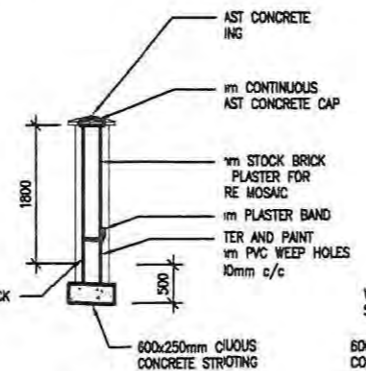
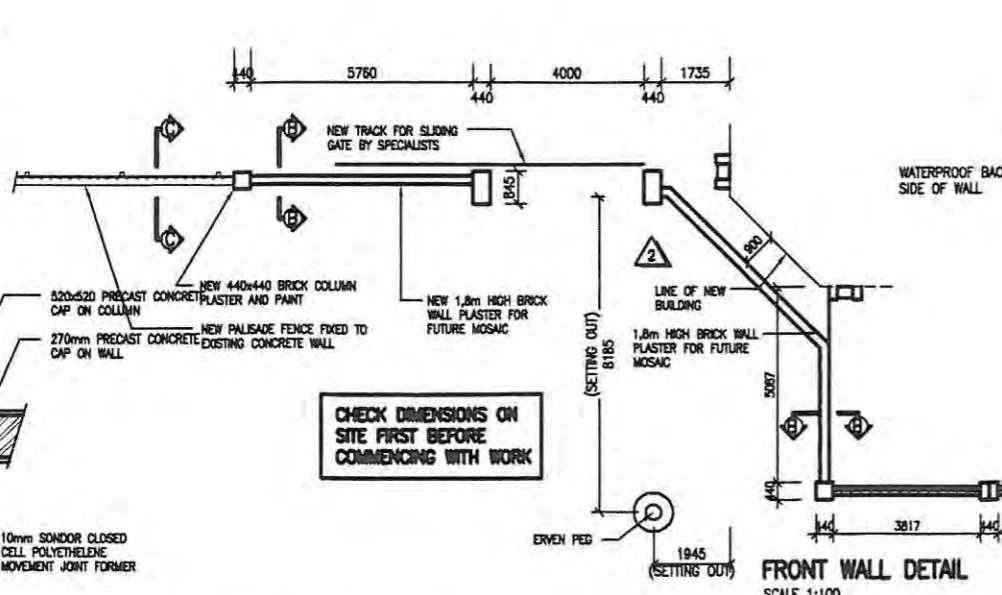
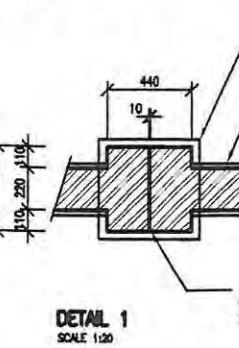
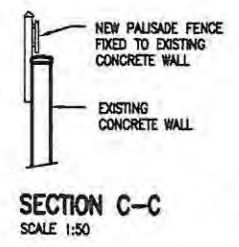
Pr Eng: *[Signature]* 24 Oct '05

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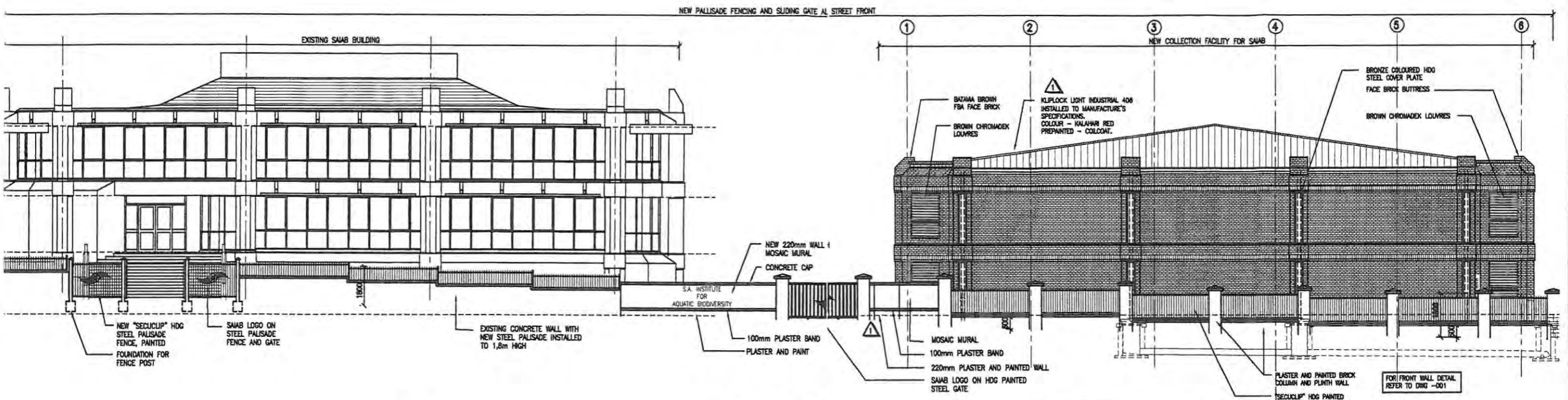
**SITE PLAN**

Drawn	J.VOS	Surveyed	—
Date	MAY 2005	Designed	P.ELIJAS
Scale	AS SHOWN	Checked	P.ELIJAS

DRAWING NUMBER	PROJECT NUMBER	REV. DATE	REV. DATE	REV. DATE	REV. DATE
G206600A1001R02					



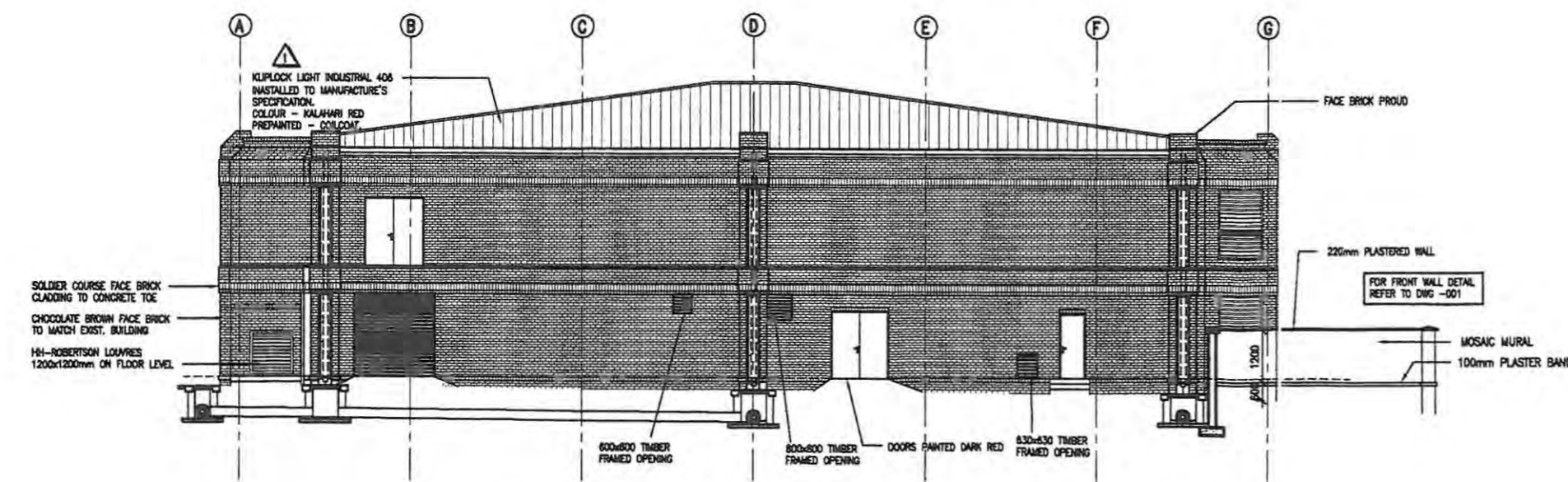
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**NOTES:**  
REFER TO MECHANICAL AND ELECTRICAL DRAWINGS FOR BRICKWORK / CONCRETE PENETRATIONS TO FACADES AND INTERNAL STRUCTURE OF THE BUILDING.  
ALL EXTERNAL STEEL DOORS PAINTED DARK RED TO ENGINEERS APPROVAL.


**EAST ELEVATION  
(STREET ELEVATION)**  
SCALE 1:100

**STONE CLADDING:**  
RANDOM ASHLAR PATTERN, FIXED TO 230mm BRICK WALL WITH WIRE TIES.  
STONES TO BE MINIMUM 250mm LONG AND MAX. 400mm LONG.  
HEIGHT 200mm MAX.  
THICKNESS 125mm VENEER.



**SOUTH ELEVATION**  
SCALE 1:100

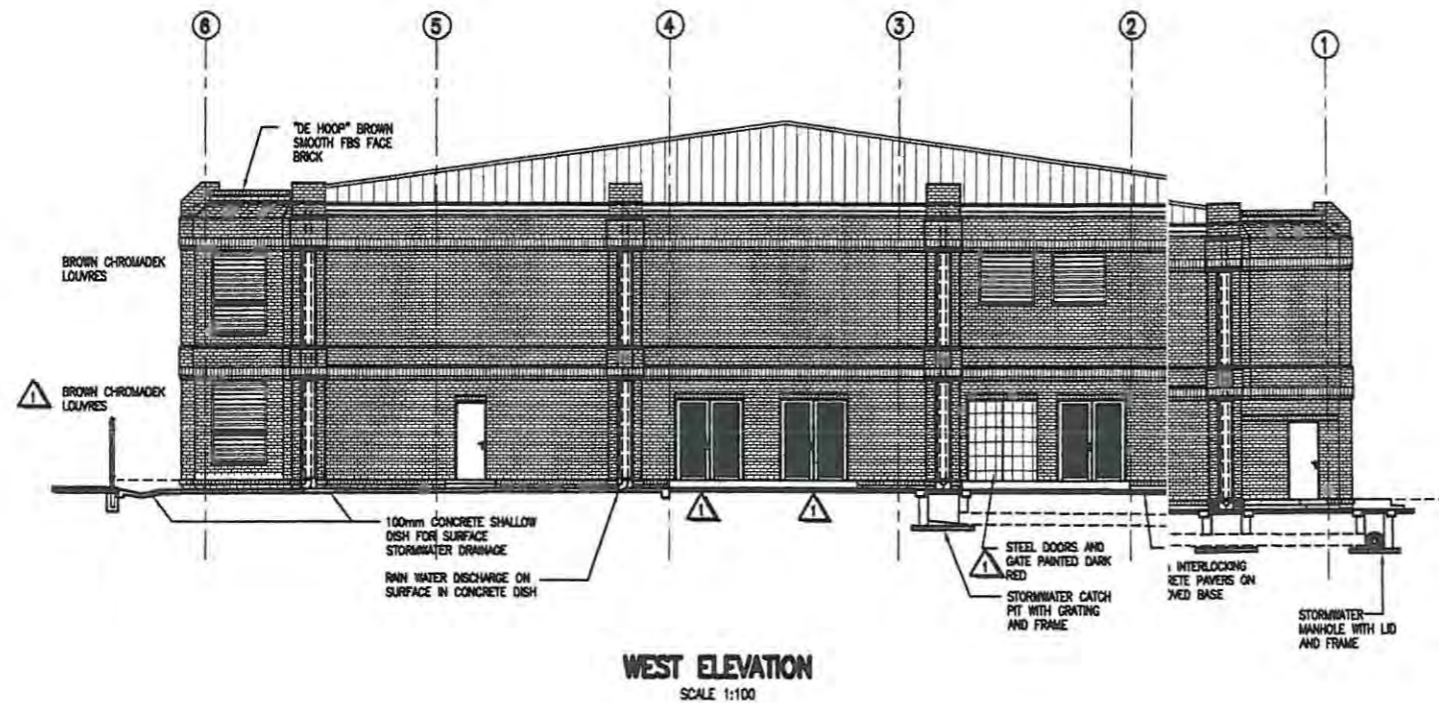
Somerset Street

Rev.	Date	Grid	Description	Q.A.
RC3	14.12.05		FIRST FLOOR ADDED TO ELEVATION	P.J.E.
RC2	02.12.05		FIRST FLOOR ADDED TO STREET ELEVATION	P.J.E.
RC1	20.10.05		INCLUDE BRICK WORK PENETRATIONS TO FACADES AND ROOF SHEETING SPECIFICATION	P.J.E.
<b>REVISIONS</b>				
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For: MBB CONSULTING SERVICES (EC) INC.				
<b>SA INSTITUTE FOR AQUATIC BIODIVERSITY</b> <b>NEW WET COLLECTION FACILITY</b> <b>GRAHAMSTOWN</b>				
<b>ELEVATIONS:</b> SOUTH ELEVATION, EAST ELEVATION				
Drawn	J.VOS	Surveyed	-	
Date	MAY 2005	Designed	P.ELLIS	
Scale	1:100	Checked	P.ELLIS	
DRAWING NUMBER	G206600A1004R03			

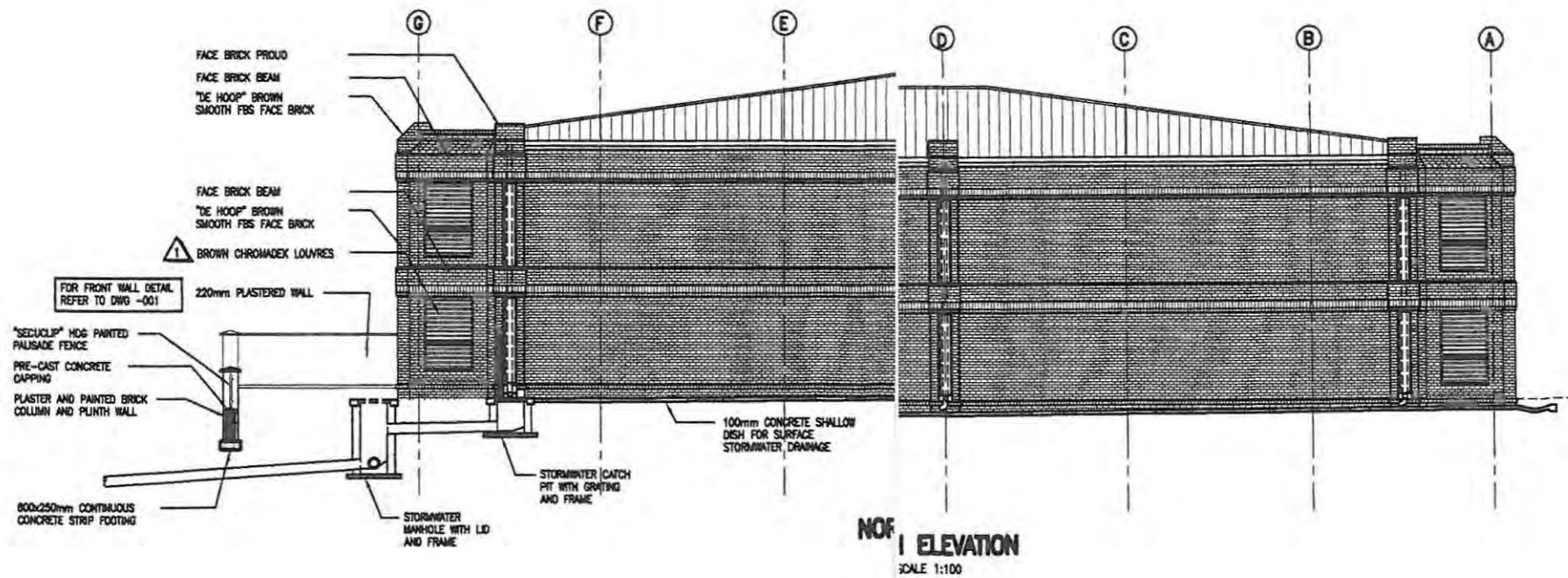
**APPENDIX 5: SAIAB ELEVATIONS**

**- 1 SOUTH ELEVATION, EAST ELEVATION**

**- 2 NORTH ELEVATION, WEST ELEVATION**



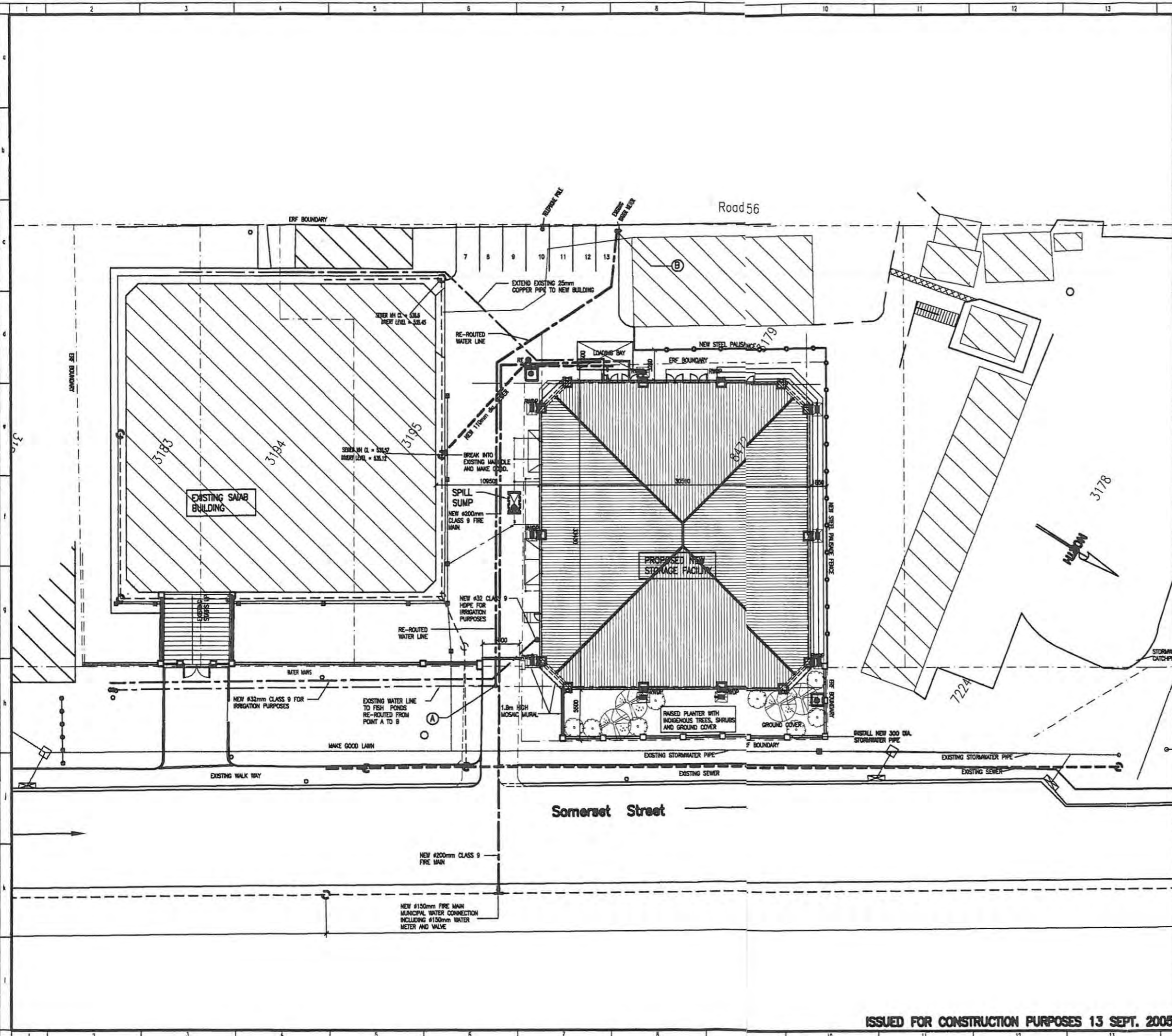
NOTES:  
 REFER TO MECHANICAL AND  
 BRICKWORK / CONCRETE FINISH DRAWINGS FOR  
 AND INTERNAL STRUCTURE (JOINTS TO FACADES  
 ALL EXTERNAL STEEL DOORS TO BUILDING.  
 ENGINEERS APPROVAL. PAINTED DARK RED TO



Somerset Street

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<b>MBB CONSULTING SERVICES (EC) INC.</b>		For: MBB CONSULTING SERVICES (EC) INC.		
Dr Eng:		Date:		
<b>SA INSTITUTE FOR AQUATIC BIODIVERSITY</b>				
<b>NEW WET COLLECTION FACILITY</b> <b>GRAHAMSTOWN</b>				
<b>ELEVATIONS:</b> <b>NORTH ELEVATION, WEST ELEVATION</b>				
Drawn	J.VOS	Surveyed	-	
Date	MAY 2005	Designed	P.ELLIS	
Scale	1:100	Checked	P.ELLIS	
DRAWING NUMBER	G2066	PROJECT NUMBER	000A11013	REVISION NO.

**APPENDIX 6: WATER AND SEWER LAYOUT**



**LEGEND**

- EXISTING SEWER LINE
- NEW SEWER LINE
- EXISTING STORMWATER PIPE
- EXISTING WATER LINE
- NEW 32mm HDPE WATER PIPE
- NEW 50mm HDPE WATER PIPE
- NEW 200mm HDPE/12 WATER PIPE

- NOTES:**
- FOR SPILL SUMP DIMENSIONS, REFER TO BUILDING DRAWINGS -002 AND -003
- WATER FITTINGS:**
- ① USE HDPE CLASS 9 PIPE AS INDICATED ON THE DRAWING WITH PLASSON FITTINGS THROUGHOUT.
  - ② REFER TO DWG. 204 FOR WATER RETICULATION DETAILS.
  - ③ THE MAKANA MUNICIPALITY TO BE APPROACHED TO INSTALL THE MUNICIPAL CONNECTION WITH WATER METERS AND VALVES.
  - ④ CLINKSCALES MAUGHAN-BROWN TO INSTALL AIR RELEASE VALVES IN THE BUILDING RETICULATION SYSTEM.
  - ⑤ ALL WATER MAINS TO BE PRESSURE TESTED AND APPROVED BY THE ENGINEER BEFORE BACKFILLING AND COMPACTING THE TRENCHES TO 95% MOD AASHTO. INSTALL AND BACKFILL PIPES ACCORDING TO SABS 1200L AND LB.
  - ⑥ CONNECT #32mm HDPE FOR IRRIGATION PURPOSES TO THE EXISTING DOMESTIC SUPPLY OFF TAKE.
  - ⑦ THE SIZE AND CLASS OF FIRE MAIN TO BE APPROVED BY CLINKSCALES MAUGHAN-BROWN BEFORE ORDERING ANY MATERIAL.

Rev.	Date	Grid	Description	Q.A.
R01	13/09/05		FIRE MAIN SIZE AND POSITION AMENDED	PJE

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 By Eng: \_\_\_\_\_ Date: \_\_\_\_\_

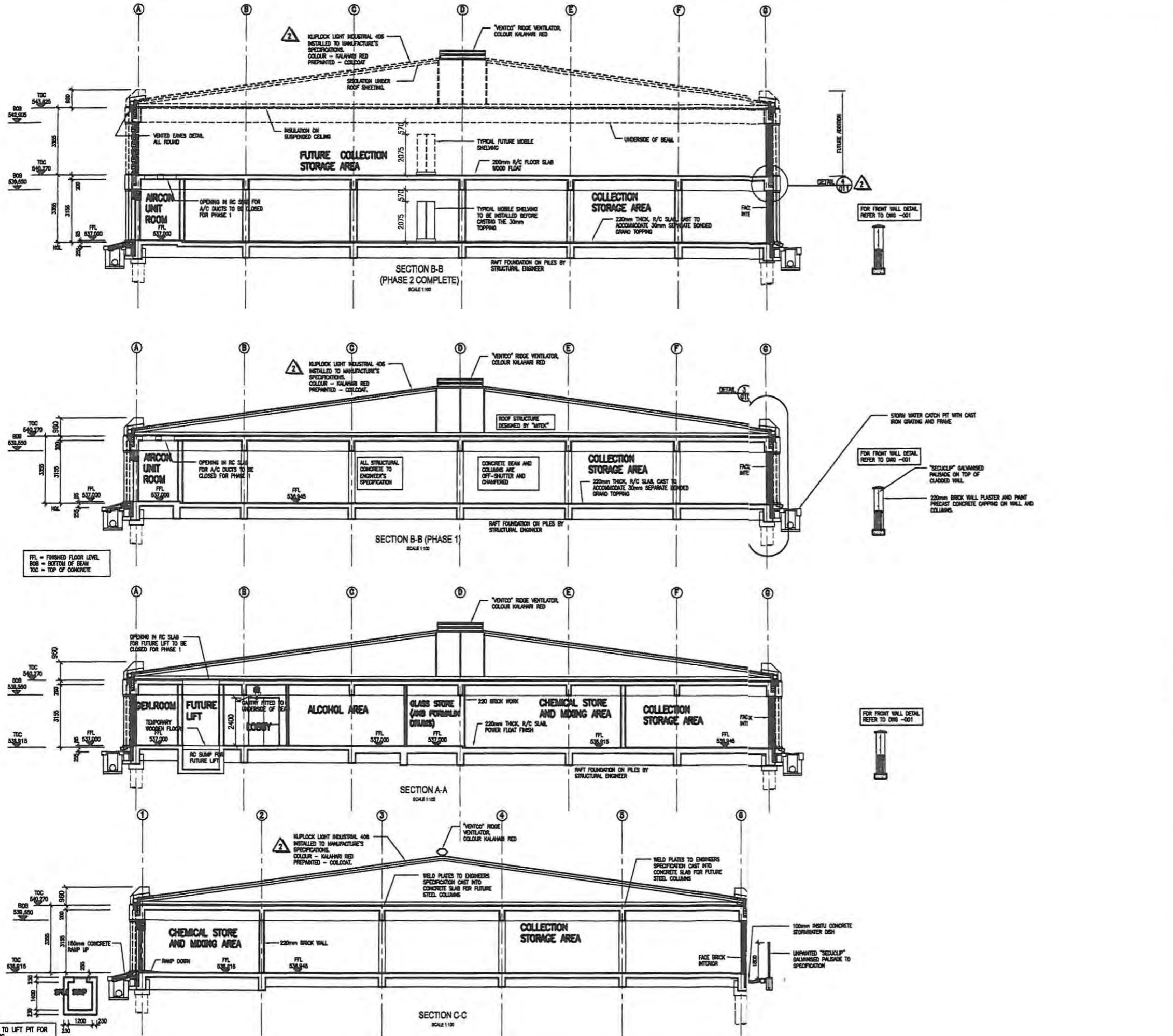
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**GRAHAMSTOWN**

**WATER AND SEWER LAYOUT**

Drawn	J.VOS	Surveyed	-
Date	MAY 2005	Designed	P.ELLIS
Scale	1:200	Checked	P.ELLIS

ISSUED FOR CONSTRUCTION PURPOSES 13 SEPT. 2005  
 DRAWING NUMBER **G206600A1203R01**

**APPENDIX 7: BUILDING SECTION SHOWING ROOF AND ATTIC**



- NOTES:**
1. SPILL SUMP STILL NOT TO BE CONSTRUCTED UNTIL SITE INSTRUCTION HAS BEEN ISSUED.
  2. STRUCTURAL DESIGN OF ROOF SYSTEM FOR PHASE 2 SHALL TAKE INTO ACCOUNT ISSUES LIKE FIRE PROTECTION, INSULATION AND VENTILATION

Rev.	Date	Grid	Description	Q.A.
RO2	20.10.05		REMOVE FLOOR DRAINS AND AMEND ROOF SHEETING SPECIFICATION	P.J.E
RO1	14.06.05		SPILL SUMP DETAIL ADDED	P.J.E

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**MBB CONSULTING SERVICES (EC) INC.**

For: MBB CONSULTING SERVICES (EC) INC.  
 24 Oct '05

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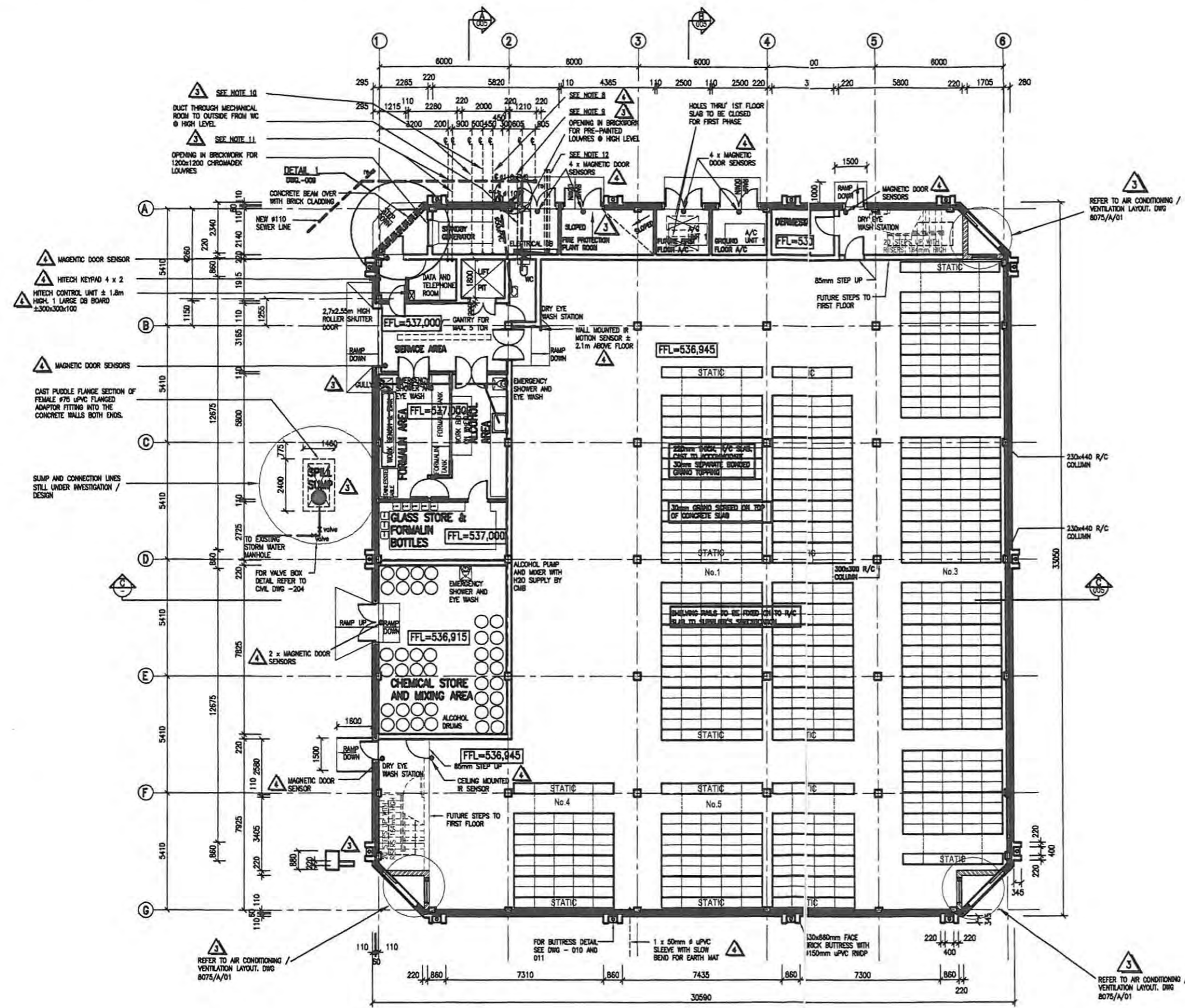
**SECTION A-A**  
**SECTION B-B**  
**SECTION C-C**

Drawn	J.VOS	Surveyed	-
Date	MAY 2005	Designed	P.ELLIS
Scale	1:100	Checked	P.ELLIS
DRAWING NUMBER	G2066010A10015R02	PROJECT NUMBER	0071 USE 305-001

NOTE: REFER TO LIFT PIT FOR SPECIFICATIONS. USE 30/18MPa CONCRETE.

**APPENDIX 8: GROUND FLOOR LAYOUT**

109 a



- NOTES:**
- FOR SIZE AND LOCATION OF ALL EXTRACTION LOUVRES REQUIRED IN WALLS, REFER TO MECHANICAL DRAWINGS.
  - FOR ALL DUCTING REQUIREMENTS THROUGH WALLS AND ROOF, REFER TO MECHANICAL DRAWINGS.
  - FOR BRICK WORK SPECIFICATION, REFER TO ROOM FINISHING SCHEDULE ON DWG.NR. -006
  - REFER TO AIR CONDITIONING / VENTILATION LAYOUT DWG 8075/A/01 FOR ALL DUCT AND LOUVER PENETRATION THROUGH WALL
  - FIRE PROTECTION PLANT ROOM FLOOR TO BE SLOPED TO DRAIN THROUGH STEEL ACCESS GATES.
  - FIRE PROTECTION MAIN TO ENTER THE BUILDING THROUGH FACADE BRICKWORK, NOT UNDER FLOOR SLAB.
  - REFER TO ELECTRICAL ENGINEERS DRAWINGS FOR EARTH CONDUCTOR SLEEVES IN THE FLOOR AND THROUGH THE WALLS OF THE BUILDING.
  - 1 x 50mm Ø uPVC SLEEVE FOR ACCESS CONTROL / MONITORING SERVICES.
  - INSTALL 110 uPVC SEWER PIPES. IF THESE HAVE TO GO THROUGH A BEAM PLEASE INFORM THE ENGINEER PRIOR TO CASTING THE CONCRETE BEAM.
  - INSTALL 2 x 110 uPVC SLEEVES AND SLOW BENDS FOR ELECTRICAL CABLE TO UNDERSIDE OF ELECTRICAL DB BOARD.
  - INSTALL 2 x 50 uPVC SLEEVES FOR TELEPHONE AND DATA CABLES INCLUDE A DRAW WIRE.
  - INSTALL 2 x 110 uPVC SLEEVES UNDER GROUND.

Rev.	Date	Grid	Description	D.A.
R04	26.10.05		1 x 50mm DIA. uPVC SLEEVE AND DOOR SENSORS ADDED	P.J.E
R03	20.10.05		REMOVE FLOOR DRAINS AND PIPES, SLOPE FIRE PROTECTION PLANT ROOM FLOOR, INCLUDE AIR CONDITIONING ENGINEER DETAILS AND SLEEVES	P.J.E
R02	18.07.05		RACKING LAYOUT REVISED	P.J.E
R01	14.06.05		SPILL SUMP DETAIL ADDED	P.J.E

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For: **MBB CONSULTING SERVICES (EC) INC.**

Pr Eng: \_\_\_\_\_ Date: \_\_\_\_\_

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**GRAHAMSTOWN**

**GROUND FLOOR LAYOUT PLAN**

Drawn	J.VGS	Surveyed	-
Date	MAY 2005	Designed	P.E.LUS
Scale	1:100	Checked	P.E.LUS

DRAWING NUMBER	G206600A1002R04
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**GROUND FLOOR LAYOUT PLAN**  
**(1st PHASE)**

SCALE 1:100

Somerset Street

**APPENDIX 9: GENERAL NOTES ON SPECIFICATIONS**

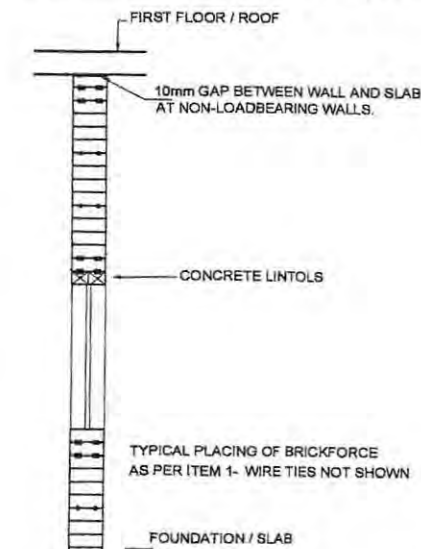
**GENERAL NOTES ON STRUCTURES.**

THE FOLLOWING NOTES ARE APPLICABLE TO ALL DRAWINGS AND WORK, EXCEPT WHERE SHOWN DIFFERENTLY ON DRAWINGS OR SPECIFICATIONS.

- REFER TO THE ARCHITECT'S DRAWINGS FOR THE SETTING OUT OF BUILDING ON SITE.
- KNOWN DISCREPANCIES BETWEEN ENGINEER'S AND ARCHITECT'S DRAWINGS SHALL BE POINTED OUT BY THE CONTRACTOR PRIOR TO EXECUTION OF ANY WORK.
- ALL SHOWN/KNOWN SITE SERVICES SHALL BE LOCATED BY THE CONTRACTOR AND RECORDED BEFORE COMMENCEMENT OF OTHER WORK. DISCREPANCIES BETWEEN DRAWINGS AND SUCH ACTUAL LOCATIONS SHALL BE REPORTED TO THE ENGINEER.
- DIMENSIONS SHALL NOT BE SCALED; ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
- THE POSITION OF SERVICE SLEEVES AND OPENINGS SHALL BE VERIFIED BY THE CONTRACTOR BEFORE CONCRETING, BY COMPARING STRUCTURAL AND ARCHITECTURAL OR OTHER DISCIPLINES DRAWINGS.
- CONSULT THE ENGINEER ON ANY UNCLARITY OR DISCREPANCY ON THE DRAWINGS, BEFORE MATERIALS ARE ORDERED OR BUILDING WORK IS DONE IN A PARTICULAR AREA.

**NOTES ON LOADBEARING BRICKWORK.**

- BUILD IN 2.5mm DIA BRICKFORCE AS FOLLOWS:
  - DOUBLE LAYER IN 2 COURSES ABOVE FOUNDATIONS.
  - DOUBLE LAYER IN 2 COURSES ABOVE CONCRETE SLABS.
  - DOUBLE LAYER IN 2 COURSES ABOVE DOORS.
  - DOUBLE LAYER IN 2 COURSES BELOW SLABS AND ROOF.
  - 1 LAYER EVERY 4th COURSE GENERALLY.
  - WALL WIRE TIES @ 2 PER SQ. METER IN SOLID WALLS
  - WALL WIRE TIES @ 5 PER SQ. METER IN CAVITY WALLS.
  - BRICKFORCE SHALL BE CONTINUOUS FROM WALL TO WALL TO FORM "RINGS" AROUND CORNERS.
- CAVITY WALLS SHALL HAVE BRICK PIERS INSIDE CAVITY LINKING SKINS @ 3.0 m c/c.
- STRENGTH OF BRICKS SHALL BE AT LEAST 10MPa AND TO THE REQUIREMENTS OF SABS 021.
- MORTAR SHALL BE CLASS II, OR WITH A MIXING RATIO CEMENT TO SAND OF AT LEAST 1 : 5. ADDITION OF BUILDING LIME IS RECOMMENDED. ALL COMMERCIAL READY-MIX BLENDS SHALL BE APPROVED BY ENGINEER IN WRITING. MIN. COMPRESSION STRENGTH: 10 MPa FOR DESIGN MIX AND 8 MPa FOR PRODUCTION OR WORKS TESTS. THREE TEST CUBES SHALL BE TESTED BY SABS METHOD AND RESULTS SUBMITTED TO ENGINEER.
- MORTAR SAND SHALL SATISFY SABS 1060 REQUIREMENTS.
- ALL MORTAR JOINTS SHALL BE FULLY FILLED, FLUSHED FINISH.
- ALL LOADBEARING BRICKWORK TO BE ERECTED ACCORDING TO SABS 0164 REQUIREMENTS.
- BRICK WALLS SHALL BE TIED TO CONCRETE COLUMNS WITH 1.6mm x 40 GALV. HOOP IRON TIES SHOT FIXED TO COLUMNS EVERY 4th COURSE.
- BRICK WALLS SHALL BE TIED TO CONCRETE WALLS WITH 100x50x3mm x 40mm LONG GALV. COLD-FORMED ANGLE TIES SHOT FIXED TO CONCRETE EVERY 6th COURSE @ 1.5m c/c. ALTERNATIVE TYPE TIE SHALL BE TO APPROVAL OF ENGINEER.
- NO GROOVES MAY BE CHISELED INTO BRICKWORK FOR THE INSTALLATION OF ELECTRICAL DUCTS OR PIPES. GROOVES MUST BE CUT BY ANGLE GRINDER FOR INSTALLATION OF SERVICES ONLY AT POSITIONS APPROVED BY THE ENGINEER.



**NOTES ON CONCRETE WORK**

- ALL MATERIALS AND WORKMANSHIP MUST COMPLY WITH SABS 0100, SABS 1200G AND SABS 920, WHERE APPLICABLE
- THE CONTRACTOR SHALL ENSURE THAT HIS QUALITY CONTROL ON LEVEL MEASUREMENT IS DOCUMENTED PROPERLY PRIOR TO STRIPPING OF SUPPORT WORK. THE ENGINEER MAY REQUEST THESE MEASUREMENTS FOR EVALUATION AT ANY TIME.
- EXCAVATIONS FOR FOUNDATIONS: ALL FOUNDATION EXCAVATIONS TO BE INSPECTED AND APPROVED IN WRITING BY THE ENGINEER BEFORE CASTING OF ANY BLINDING LAYERS, BLINDING LAYER TO BE 50mm MINIMUM THICKNESS, 15MPa. ALL FOUNDATION LEVELS TO BE VERIFIED BY THE ENGINEER ON SITE.
- CONCRETE MIX DESIGNS FOR EACH CLASS OF CONCRETE SHALL BE SUBMITTED TO THE ENGINEER FOR HIS APPROVAL PRIOR TO POURING OF ANY CONCRETE. THE MIX-DESIGNS SHALL BE REPORTED ON A STANDARD FORM OBTAINABLE FROM THE ENGINEER.
- NO SLAGMENT OR FLY-ASH SHALL BE USED WITHOUT PERMISSION FROM THE ENGINEER.
- CONCRETE STRENGTHS: (28 DAYS)
 

BLINDING LAYERS	15MPa
UNREINFORCED FOUNDATIONS	15MPa
REINFORCED FOUNDATIONS	30MPa
SURFACE BEDS (UNSCREEDED)	30MPa
SURFACE BEDS (SCREEDED)	15MPa
SUSPENDED SLABS	30MPa
POST TENSION (TRANSFER)	N.A.
POST TENSION (FINAL)	N.A.
OTHERS	N.A.
BEAMS	30MPa
COLUMNS	30MPa
WALLS	30MPa
- CONCRETE COVER TO REINFORCING STEEL:
 

FOUNDATIONS/PILE CAPS	50mm
RETAINING WALLS (GROUND SIDE)	50mm
WALLS BELOW GROUND	N.A.
WALLS ABOVE GROUND	N.A.
COLUMNS	40mm
SLABS	20mm
BEAMS	40mm
CONCRETE FILLED CAVITY WALLS	N.A.
- TOLERANCES TO BE IN ACCORDANCE WITH SABS - 1200 G
- WRITTEN PERMISSION TO STRIP ANY SUPPORTWORK SHALL BE OBTAINED FROM THE ENGINEER PRIOR TO STRIPPING.
- THE MINIMUM PERIODS FOR SHUTTERING TO BE KEPT IN POSITION, AFTER CONCRETE HAS BEEN POURED ARE AS FOLLOWS:
 

SIDES OF COLUMNS, BEAMS & WALLS	3 DAYS
UNDERSIDE OF SLABS	14 DAYS
UNDERSIDES OF BEAMS AND ARCHES	21 DAYS
UNDERSIDES OF COLUMNSTRIPS IN SLABS	21 DAYS
- CONCRETE TO BE CURED CONTINUOUSLY WITH CLEAN WATER FOR AT LEAST 7 DAYS AFTER CASTING.
- COLD CONSTRUCTION JOINTS: COURSE AGGREGATE TO BE EXPOSED, CLEANED AND CEMENT WATER SOAKED BEFORE POURING THE NEW CONCRETE. LOCATION OF JOINTS TO BE APPROVED BY ENGINEER.
- EXPOSED CONCRETE FINISHES SHALL BE ACCORDING TO ARCHITECT'S DRAWINGS, OR AS INSTRUCTED BY THE ENGINEER.
- REINFORCING STEEL TO COMPLY WITH SABS 920
  - "R" = ROUND MILD STEEL fy:250MPa (MIN)
  - "Y" = HIGH YIELD STEEL fy:450MPa (MIN)
- CONTRACTOR SHALL RECORD LEVEL MEASUREMENTS OF SLABS AND COMPARE WITH SPECIFIED TOLERANCES BEFORE REMOVING ANY SUPPORT WORK.
- PORTION OF COLUMN BELOW GROUND LEVEL (UNEXPOSED) WITHOUT ADDITIONAL CONCRETE COVER SHALL BE PAINTED WITH TWO COATS OF EPOXY TAR.
- CONTACT BREAKER TO CONSIST OF TWO LAYERS OF 375 MICRON DPC PLACED ON SOLID LEVELLED SURFACE
- ALL FIXED IN POSITION REINFORCEMENT TO BE CHECKED AND APPROVED BY THE ENGINEER IN WRITING, BEFORE ANY CONCRETE IS POURED.
- SPECIFICATIONS FOR POWER FLOATING AND SEPARATE BONDED TOPPING INCLUDED IN THE CONTRACT DOCUMENTS

**NOTES ON**

- ALL MATERIALS SABS 857 AND
- HEXAGON-HEAD
- ALL WELDING M
- BEFORE COMMEN ANCHOR BOLTS I THE OVERALL LE
- ALL MATERIAL M (FOR CLEANING O
- UNLESS OTHERWISE D, USE 6mm CONTINUOUS FILLET WELD, WHICH MUST ROUND THE PERIMETER OF THE CONTACT AREA.
- THE CONTRACTOR (SW IN HIS TENDER FOR:
  - TEMPORARY STRUTS DURING ERECTION.
  - X-RAY TESTING FOR WELD CONNECTIONS, IF REQUIRED BY THE ENGINEER.
  - WORKSHOP DRAWINGS REQUIRED.
- PAINT SPECIFICATION:
  - WIRE BRUSH.
  - ONE COAT RED OXIDE PRIMER.
  - TOUCH-UP WITH RED OXIDE AFTER ERECTION.
  - FINAL COAT ACCORDING TO ARCHITECT'S SPECIFICATION
- CATLADDER, GANTRY, RAPE AND ALL STEEL EXPOSED TO THE (OUTSIDE) TO BE H.D. ZED
- ALL INTERNAL STEEL TO BE TREATED TO HAVE A 2 HOUR FIRE RATING

**RAL STEELWORK.**

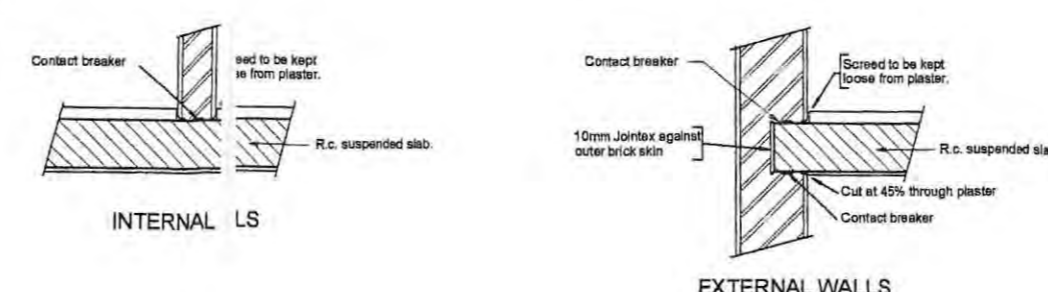
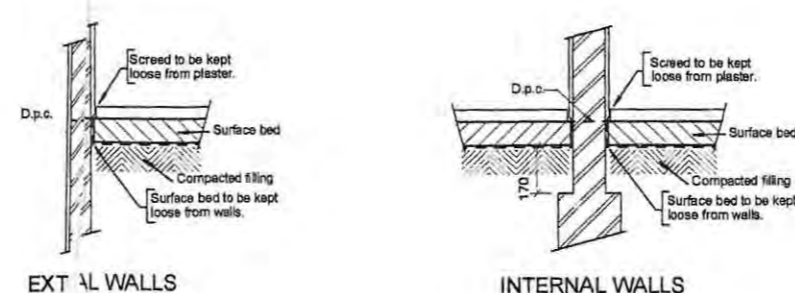
SHIP MUST COMPLY WITH SABS 0162, SABS 1200HA. ITS MUST COMPLY WITH SABS 135. IYH SABS 455. ABRICATION, THE POSITION OF THE KEED ON SITE, AS THIS MAY EFFECT IMNS AND ROOF TRUSSES.

**NOTES ON TIMBER CONSTRUCTION.**

- MATERIAL AND WORKMANSHIP MUST COMPLY WITH THE APPLICABLE STANDARDS REFERRED TO IN SABS 0163
- ALL TIMBER SHALL BE OF GRADE 5 OR BETTER - MAXIMUM MOISTURE CONTENT OF 17%
- TRUSSES MADE, ERECTED AND FIXED TO SUPPORTING R.C. FLOOR SLAB TO MITEK SPECIFICATIONS

**LIST OF STRUCTURAL DRAWINGS :**

DRAWING NO.	DESCRIPTION
101/R00	GENERAL NOTES
102/R03	PILE LAYOUT
103/R02	GROUND FLOOR SLAB LAYOUT AND DETAILS
104/R00	FIRST FLOOR SLAB LAYOUT AND DETAILS
105/R00	GROUND FLOOR SLAB - REINFORCING FIXING



Rev.	Date	Revised	Grid	Description	G.V.

**WYSIGINGS/REVISIONS**  
 Hoping van handle ontwerp en tekening wordt voerzorgd.  
 The copyright of this design and drawing is reserved.  
 Korteliker tekeninges voor verduurloering. Geskiede maats is oorsigdig.  
 Check drawing measurements before commencing work. Scaled measurements are not valid.

Nemene/For: MBB CONSULTING SERVICES (EC) INCORPORATED  
 Pring / Pr Eng: Datum/Date

**SA INSTITUTE FOR AQUATIC BIODIVERSITY**  
**NEW WET COLLECTION FACILITY**

**GENERAL NOTES**

Drawn	L.J.C.	Surveyed	
Date	13/01/2005	Designed	L.J.C.
Scale	AS SHOWN	Checked	P.J.E.
DRAWING NUMBER	G 2 0 6 6	REV. NO.	1 0
	A 1 1	DATE	1 0 1
	R 0 0		

**APPENDIX 10: RAW DATA FOR CRITERIA WEIGHTING**

THEME/ CRITERIA	RANKS				
	Architect	Client	Mean	Standard deviation	Mech Engineer
<b>1. SITE SELECTION</b>	1.0	5.0	3.0	2.8	
1.1 Ecologically sensitive areas	1.0	1.0	1.0	0.0	8.0
1.2 Densification	2.0	6.0	4.0	2.8	6.0
1.3 Brownfield redevelopment	3.0	3.0	3.0	0.0	5.0
1.4 Transportation access	8.0	1.0	4.5	4.9	6.0
1.5 Site disturbance	5.0	5.0	5.0	0.0	6.0
1.6 Storm water management	6.0	4.0	5.0	1.4	6.0
1.7 Landscape and exterior desi	7.0	4.0	5.5	2.1	8.0
1.8 Light pollution	4.0	4.0	4.0	0.0	5.0
	<b>4.5</b>	<b>3.5</b>	<b>4.0</b>	<b>0.7</b>	<b>6.3</b>
<b>2. WATER EFFICIENCY</b>	3.0	1.0	2.0	1.4	
2.1 Water efficient landscaping	3.0	1.0	2.0	1.4	3.0
2.2 Wastewater management	2.0	1.0	1.5	0.7	3.0
2.3 Water use reduction	1.0	1.0	1.0	0.0	2.0
	<b>2.0</b>	<b>1.0</b>	<b>1.5</b>	<b>0.7</b>	<b>2.7</b>
<b>3. ENERGY &amp; ATMOSPHERE</b>	2.0	2.0	2.0	0.0	
3.1 Commissioning	2.0	3.0	2.5	0.7	3.0
3.2 Energy Performance	4.0	1.0	2.5	2.1	3.0
3.3 Renewable energy	3.0	2.0	2.5	0.7	3.0
3.4 Ozone depletion	1.0	2.0	1.5	0.7	4.0
	<b>2.5</b>	<b>2.0</b>	<b>2.3</b>	<b>0.4</b>	<b>3.3</b>
<b>4. MATERIALS &amp; RESOURCE</b>	6.0	4.0	5.0	1.4	
4.1 Materials salvage	3.0	4.0	3.5	0.7	5.0
4.2 Construction waste	4.0	4.0	4.0	0.0	6.0
4.3 Reuse and recycling	6.0	3.0	4.5	2.1	5.0
4.4 Local/ Regional materials	2.0	3.0	2.5	0.7	7.0
4.5 Rapidly renewable materials	1.0	4.0	2.5	2.1	5.0
4.6 Certified timber products	5.0	1.0	3.0	2.8	5.0
	<b>3.5</b>	<b>3.2</b>	<b>3.3</b>	<b>0.2</b>	<b>5.5</b>
<b>5. AIR QUALITY</b>	5.0	3.0	4.0	1.4	
5.1 Carbon dioxide monitoring	1.0	4.0	2.5	2.1	4.0
5.2 Ventilation effectiveness	2.0	1.0	1.5	0.7	6.0
5.3 VOC emitting materials	3.0	2.0	2.5	0.7	5.0
5.4 Indoor pollution control	6.0	3.0	4.5	2.1	3.0
5.5 Controllability of systems	4.0	1.0	2.5	2.1	5.0
5.6 Daylight & views	5.0	2.0	3.5	2.1	5.0
	<b>3.5</b>	<b>2.2</b>	<b>2.8</b>	<b>0.9</b>	<b>4.7</b>
<b>6. INNOVATION IN DESIGN</b>	4.0	6.0	5.0	1.4	
6.1 Materials type choice	4.0	3.0	3.5	0.7	4.0