eThekweni Housing Typologies

Sustainable Design Progress Report no. 1

Prepared by WSP GREEN by DESIGN

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Contents

EXECUTIVE SUMMARY

It seems ironic that informal dwellings built by the occupants themselves in informal settlements are often done so in a more sustainable manner than those houses built by contracted builders for the formal housing sector. This is not deliberate or by choice; but by circumstance. Natural resources are used sparingly, materials are reused or recycled, materials used usually have low-embodied energy, waste is recycled, and houses can be disassembled. If this is the case, then the focus on sustainable design of low cost housing needs to be shifted from the typical elements of sustainability, to the specific context of low-cost housing. Since the primary needs of the occupants of low cost housing are their physiological needs (food, water, shelter, clothing), then sustainability must be an intrinsic part of the house's design and functionality, otherwise it will never be addressed. Ultimately sustainability needs to be seen to be an element of desire to the owners of these houses.

The eThekweni Municipality provides households with 9kl free potable water per month. If the occupants of low cost housing could exist within this free water allocation without compromising hygiene, this would prove to be a (i) financially, (ii) environmentally and (iii) socially sustainable solution. A similar philosophy would apply to the use of electricity and alternative forms of heating, lighting and cooking.

1. INTRODUCTION

This report begins by listing ten principles for sustainable cities; known as the 10 Melbourne Principles. The report also presents an overview on main rating tools and their suitability within the context of low-cost housing in South Africa. The draft SANS 204 code for Energy Efficiency in Buildings is introduced. This report highlights a number of requirements from the code that have particular reference to building design and building services; and could influence the design of low-income houses. The report also mentions a list of principles known as for sustainable cities. Finally the report compares the efficiencies of different water recycling systems proposed in terms of water usage and discharge.

2. 10 MELBOURNE PRINCIPLES

UNEP IETC and the Environment Protection Authority of Victoria held an international charette in Melbourne, Australia in 2002, which was instrumental in developing the Melbourne Principles for Sustainable Cities, now known as "The Melbourne Principles". These principles are intended to guide thinking and help build a vision of environmentally healthy and sustainable cities. The principles are:

- **principle 1: vision**
  Provide a long term vision for cities based on sustainability; intergenerational, social, economic, and political equity; and their individuality.

- **principle 2: economy and society**
  Achieve long term economic and social security

- **principle 3: biodiversity**
  Recognise the intrinsic value of biodiversity and natural ecosystems, and protect and restore them

- **principle 4: ecological footprint**
  Enable communities to minimize their ecological footprints

- **principle 5: modelling cities on ecosystems**
  Build on the characteristics of ecosystems in the development and nurturing of healthy and sustainable cities

- **principle 6: sense of place**
  Recognise and build on the distinctive characteristics of cities, including their human and cultural values, history and natural systems

- **principle 7: empowerment and participation**
  Empower people and foster participation

- **principle 8: partnerships**
  Expand and enable cooperative networks to work towards a common, sustainable future.

- **principle 9:sustainable production and consumption**
  Promote sustainable production and consumption through appropriate use of environmentally sound technologies and effective demand management.

- **principle 10: governance and hope**
  Enable continual improvement based on accountability, transparency, and good governance

We believe that all ten principles can be directly translated into the context of low-cost housing, and the design thereof.

3. RATING TOOLS

There are currently many rating tools available to assess the sustainability of a building's design, however very few apply to residential housing. From the review of the main stream tools available, there do not appear to be any tools available to specifically assess low-cost housing.

Among others, the following ratings tools assess residential housing:

3.1 Australian Green Star Multi-Residential Rating Tool

The Australian Green Star Multi-unit residential rating tool assesses the environmental attributes of new and refurbished multi-unit residential facilities. The tool has many credits in common with the Green Star Office suite of tools. These are known as the core credits. There is also a list of key 'sector specific' items specific to the multi-unit residential tool. The following is a list of these sector specific items, including a comment on their relevance to low-cost housing:

- Smart metering: a means of the occupant being able to visibly monitor real time consumption of electricity, water or gas, including a function to analyse the data at regular intervals i.e. on a daily, weekly, monthly basis; and a function that can present the costs associated with the usage. This item is extremely relevant to this project and would be most beneficial to occupants of low-income houses.

- Private external space: an external space with a floor area which is a certain % area of the total living area, is adjacent and accessible from the dwelling, and has some means of managed solar access. The relevance of this item to low-cost housing design is debatable.

- Unoccupied areas: a means of monitoring occupancy such that energy use can be eliminated in unoccupied areas. This has some relevance to low-cost housing, however the only source of energy consumption in low-cost housing that could be controlled by means of occupancy monitoring would typically be the lighting, and the technology and cost of occupancy controls might prove a barrier to implementation.

- Energy efficient appliances: a means of improving energy efficiency by encouraging the use of energy efficient appliances (referring to dishwashers, tumble driers, refrigerators and washing machines). Except for refrigerators perhaps, this is of little relevance to low-cost housing.

- Trip reduction – mixed use: a means of reducing the overall number of car trips taken by residents by encouraging the integration of residential developments with or adjacent to local amenities. This has relevance in the sense that by integrating developments with local amenities, residents will be able to walk rather than have to use public transport. Since the scope of this study only considers housing typologies, the choice of site is not addressed here. However, consideration could be given to including a space within the layout of a housing typology that could be used by the owners or let to tenants for the purpose of trading.

- Water efficient appliances: a means of improving water efficiency by encouraging the use of water efficient appliances (referring to dishwashers and washing machines). This is of no relevance to low-cost housing.

3.2 Code for Sustainable Homes, UK

The Code for Sustainable Homes is a rating tool which provides a comprehensive measure of the sustainability of new homes. It was developed by the Department for Communities and Local Government in the UK. The UK Government's ambition for the code is that it becomes the single National standard for the design and construction of sustainable homes. The following elements of sustainability from this tool are of particular relevance to low-cost housing:

- Building Fabric: to future-proof the energy efficiency of dwellings over their whole life time by limiting the heat losses / gains across the building envelope.

- Low or zero carbon technologies: to reduce carbon emissions by encouraging local energy generation from renewable sources to supply a significant portion of the energy demand.

- Home office: to reduce the need the commute to work by providing residents with the necessary space and services to be able to work from home.

- Water use: to reduce the consumption of potable water from all sources, including borehole well water, through the use of water efficient fittings, appliances and water recycling systems.

- Management of surface water run-off from developments: to design housing developments which avoid, reduce and delay the discharge of rainfall to public sewers and watercourses. This will protect watercourses and avoid the risk of localised flooding, pollution and other environmental damage.

- Flood risk: to encourage housing developments in low flood risk areas, or to take measure to reduce the impact of flooding on houses built in areas with a medium or high risk of flooding. This addresses the location more than the housing typology itself.

- Composting: to encourage developers to provide the facilities to compost household waste thereby reducing the amount of household waste sent to landfill.

- Daylighting: to improve the quality of life in homes through good daylighting and to reduce the need for energy to light the home.

- Sound insulation: to ensure the provision of improved sound insulation to reduce the likelihood of noise complaints from neighbours.

- Private space: to improve the occupants' quality of life by providing an outdoor space for their use, which is at least partially private.

- Lifetime homes: to encourage the construction of homes that are accessible and easily adaptable to meet the changing needs of current and future occupants.

- Security: to encourage the design of developments where people feel safe and secure; where crime and disorder, or the fear of crime, does not undermine quality of life or community cohesion.

- Building footprint: to promote the most efficient use of a building's footprint by ensuring that the land and material use is optimised across the development.

4. SANS 204 ENERGY EFFICIENCY IN BUILDINGS

The new SANS 204 Energy Efficiency in Buildings has not yet been promulgated in South Africa. The intention of the standard is to promote and regulate the energy efficiency in buildings by means of prescribing the requirements for the design and operation of buildings. This standard includes artificially or naturally ventilated buildings, but does not cover government subsidised housing. Despite this, it would be prudent to be aware of the various requirements prescribed in the standard, with particular reference to building design and building services. The following points should be noted:

Building design:

- Buildings shall be orientated approximately True North; otherwise orientated to achieve the lowest net energy use;
- Minimum R-values are specified for walls, floors;
- Maximum conductance and solar heat gains are specified for windows;
- Maximum U-values are specified for glazing;
- Minimum total R-values are specified for roofs;
- Minimum R-values are specified for insulation in roofs;
- Permanent external shading is required on North facing facades;
- Maximum permissible air leakage rates are specified for external windows, doors, roofs and floors;

Building services:

- Maximum levels are specified for lighting, power and energy usage;
- All new buildings shall be fitted with solar water-heating systems;
- Minimum R-values are specified for hot water pipe insulation materials

The relevance and legal implications of this code for government subsidised housing would need to be further researched.

5. WATER RECYCLING SYSTEMS

5.1 Introduction

Among the issues highlighted in the rating tools, the provision of sufficient water and the usage thereof is paramount in the design of services for government subsidised housing. Given the fact that the eThekweni Municipality provides households with 9kl free potable water per month, this section investigates various options of providing water reuse systems such that the occupants of the government subsidised housing can exist within the 9kl free water allocation. The following describes these various options:

5.2 Description of the systems

Various water models have been developed to compare the efficiencies of different water recycling systems, in terms of water usage and discharge, for varying occupancies in single storey, double storey and three-storey dwellings. The aim of the exercise is to ascertain (i) whether the occupants can exist within the 9kL free municipal water supply per dwelling per month, and (ii) which water system(s) is the most efficient for a particular dwelling with a particular number of occupants.

The following water systems have been compared:

(i) Potable water supply only:

- Municipal water is used to meet all water demands,
- No waste water is diverted from sewer.

(ii) Rainwater supplemented with potable water supply:

- Rainwater is used for showering, laundry and space cleaning.
- Potable water is used for cooking, washing hands and toilet flushing, and shortfall required for showering, laundry and space cleaning.
- No waste water is diverted from sewer.

(iii) Rainwater supplemented with potable water supply and a dry sanitation system:

- Rainwater is used for showering, laundry and space cleaning;
- Potable water is used for cooking, washing hands and toilet cleaning, and shortfall required for showering laundry and space cleaning;
- No waste water is diverted from sewer.

(iv) Greywater supplemented with potable water supply:

- Greywater is used for toilet flushing, space cleaning and surplus to irrigation;
- Potable water is used for cooking, washing hands, showering and laundry;
- Water from toilets, sinks, space cleaning and laundry drains to sewer;
- Water from showers and basins is diverted from sewer and harvested for grey water use.
- Rainwater and grey water supplemented with potable water supply
- Rainwater is used for showering and laundry;
- Greywater is used for toilet flushing, space cleaning and surplus to irrigation;
- Potable water is used for cooking, washing hands and shortfall required for showering & laundry;
- Water from toilets, sinks, space cleaning and laundry drains to sewer;
- Water from showers and basins is diverted from sewer and harvested for grey water use.

5.3 Water model assumptions

The water model makes the following assumptions regarding water usage per person per day:

- **Toilets:** Dual flush (6/3 litre WC)
  2 toilet flushes (solid) per person per day @ 6 litres per flush
  4 toilet flushes (liquid) per person per day @ 3 litres per flush
  1 litre per day for toilet cleaning (dry sanitation)
- **Whb:** 6 hand washes per person per day @ 6 litres per minute for 10 seconds
- **Shower:** 1 shower per person per day @ 8 litres per minute for 4 minutes
- **Cooking:** 10 litres per person per day (2L for drinking, 4L for cooking, 4L for dishwashing)
- **Laundry:** 3 litres per person per day
- **Space cleaning:** once a week @ 10 litres per clean = 1.4 litres per day (regardless of no. of people)

The model assumes that no water is stored at the end of the month; any surplus is available for irrigation etc.

- **Water collection**

  Potable water is taken from the municipal mains.

  Rainwater is harvested from the dwelling's 40m^2 roof.

  Greywater is collected from showers and wash hand basins.

- **Water usage**

  Municipal water is used for all cooking and wash hand basin water requirements.

  Rainwater is used for showers and laundry water requirements.

  Greywater is used for toilet flushing and space cleaning requirements.

  Any surplus rainwater or greywater is available for irrigation.

- **Free water supply**

  The model assumes that every dwelling receives 9kL free potable water per month.

- **Occupancy**

  A dwelling assumes a minimum occupancy of two people and a maximum occupancy of six people.

- **Roof area**

  A dwelling assumes a roof area of 40m².

  Single storey assumes 1 dwelling (2, 4 or 6 occupants in total)

  Double storey assumes 2 dwellings (4, 6, 8, 10 or 12 occupants in total)

  Three-storey assumes 3 dwellings (6, 8, 10, 12, 14, 16 or 18 occupants in total)

5.4 Graphical results: Net annual water demand

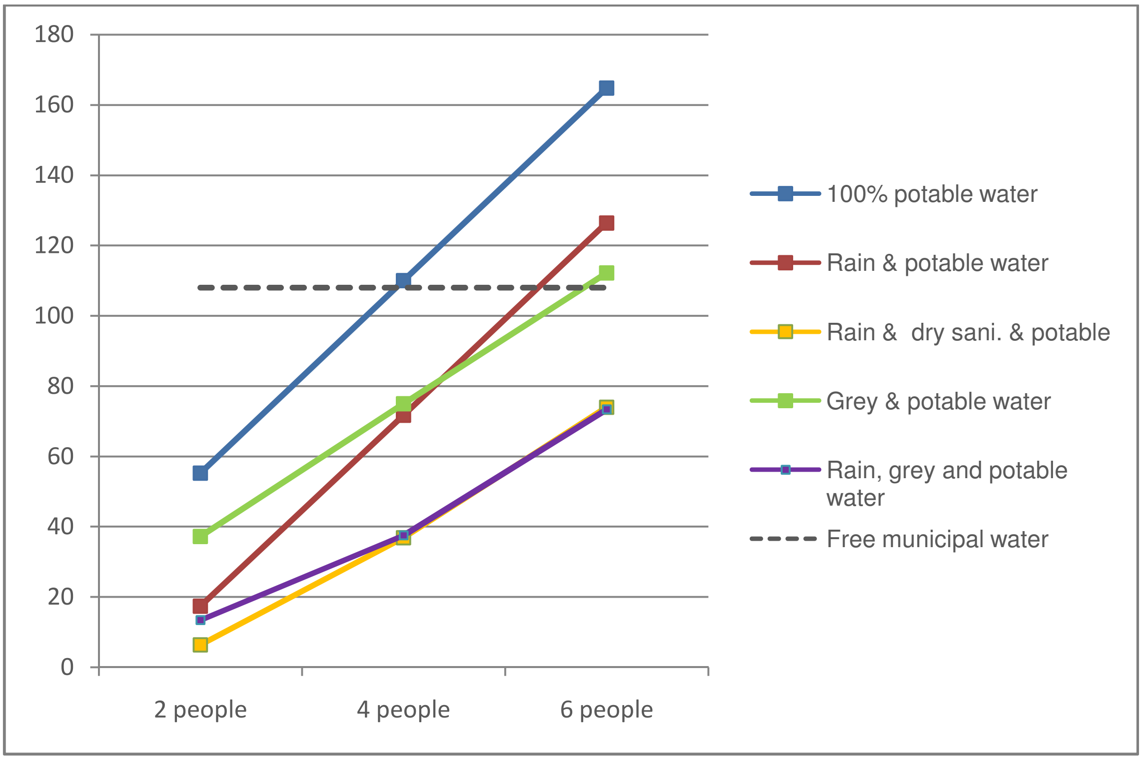

Figure 1 Single storey: Net annual municipal water demand

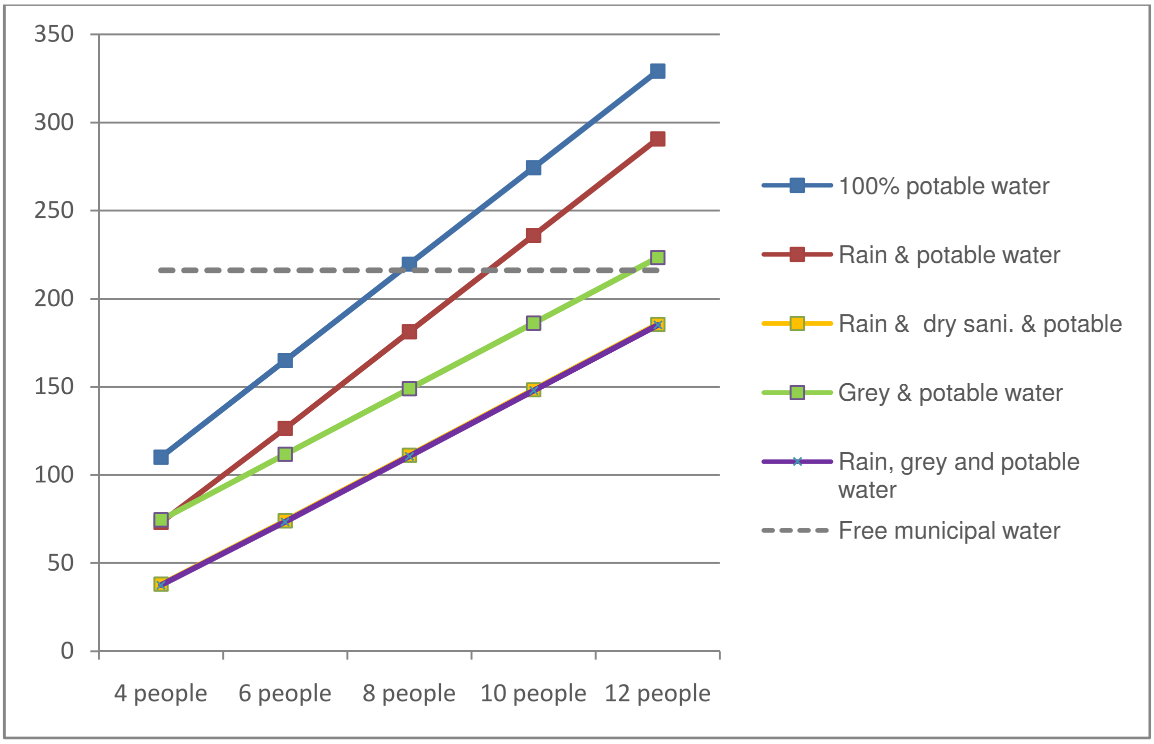

Figure 2 Double storey: Net annual municipal water demand

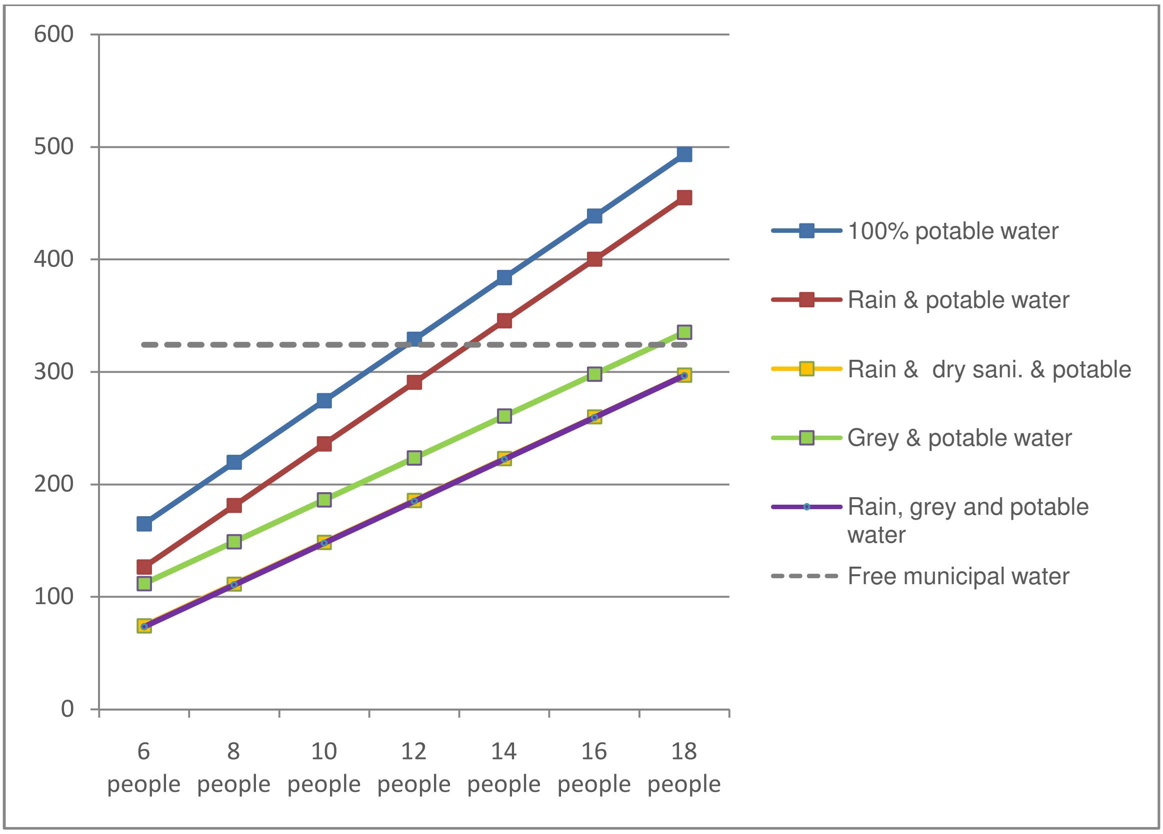

Figure 3 Three-storey: Net annual municipal water demand [kL]

5.5 Observations: Net annual water demand

- Up to 4 people per dwelling (ie 4 people in single storey; 8 people in double storey; 12 people in 3-storey) could almost exist on the 9kL free potable water allocation per month, without the requirement for any additional water recycling system.
- A rainwater harvesting system is more water efficient than a grey water system (ie a rain water harvesting system would require less top-up from potable source than a grey water system would require), only for 2 or 4 occupants in a single storey building. In all other cases a grey water system is more efficient since the amount of grey water harvested is greater than the amount of rainwater harvested.
- A system which combines rainwater and greywater is as water efficient as a system with rainwater harvesting and dry sanitation. This is because in the first system the greywater is used for toilet flushing and in the second system the sanitation is non-water borne.
- Both the rainwater / greywater system and rainwater / dry sanitation system are more water efficient than either the rainwater system or the greywater system on their own.
- A maximum of 6 occupants in a single storey dwelling could exist on the 9kL free potable water allocation per month, provided
  (i) a rainwater/greywater system or
  (ii) a rainwater / dry sanitation system is provided; ie the occupants would not have to pay for water usage.
- A maximum of 12 occupants in a double storey dwelling (6 occupants per floor, 2 dwellings) could exist on the 9kL free potable water allocation per month (2 dwellings x 9kL each = 18kL) provided
  (i) a rainwater/greywater system or
  (ii) a rainwater / dry sanitation system is provided; ie the occupants would not have to pay for water usage.
- A maximum of 18 occupants in a three storey dwelling (6 occupants per floor, 3 dwellings) could exist on the 9kL free potable water allocation per month (3 dwellings x 9kL each = 27kL) provided (i) a rainwater/greywater system or (ii) a rainwater / dry sanitation system is provided; ie the occupants would not have to pay for water usage.
- Below is a summary of the maximum occupancy levels achieved within 9kL free potable water allocation per dwelling per month:

Max occupants per dwelling, using:					
	Potable water	Potable & rain	Potable & rain & dry san	Potable & grey	Potable & rain & grey
Single storey	4	4	6	4	6
Two-storey	8	8	12	10	12
Three-storey	12	12	18	16	18

5.6 Graphical results: Net annual water to sewer

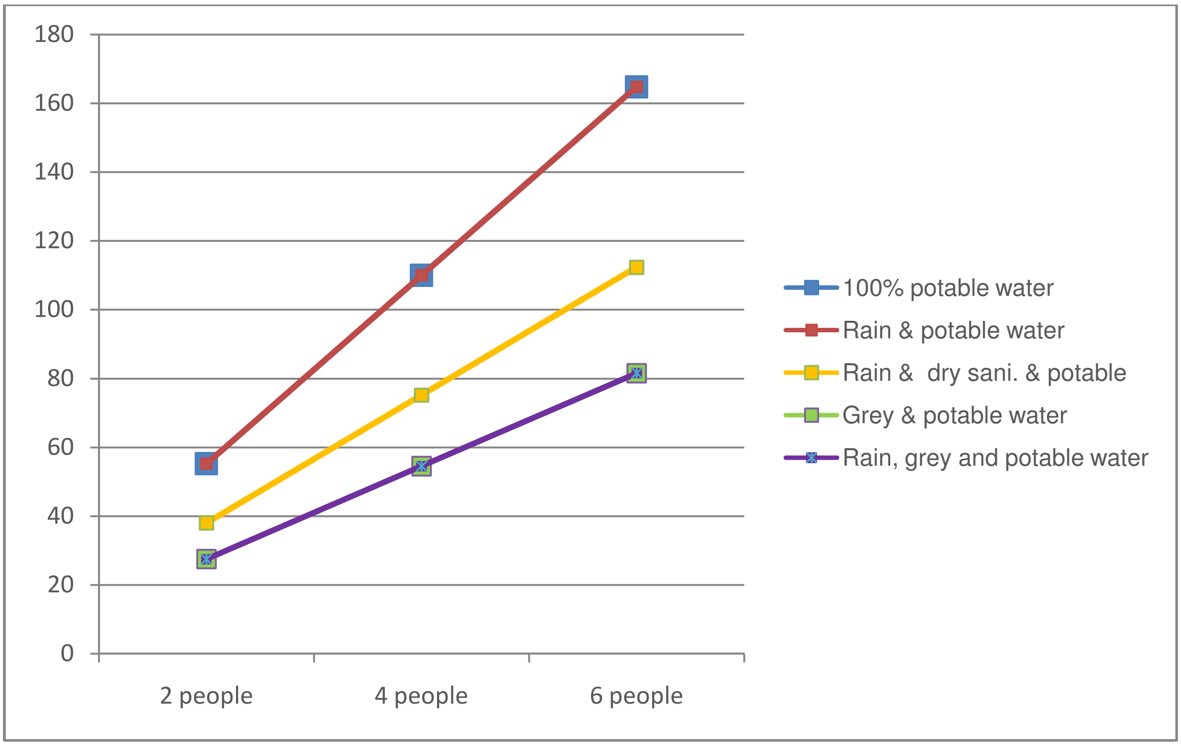

Figure 4 Single storey: annual water to sewer [kL]

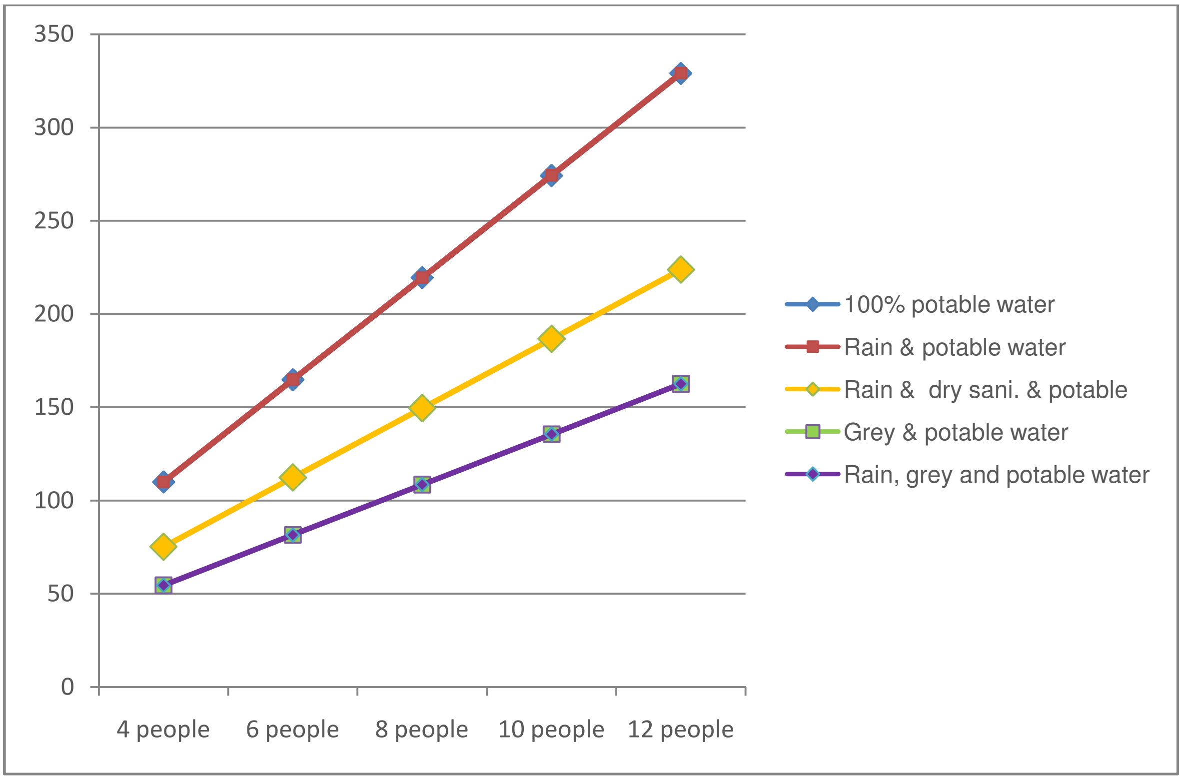

Figure 5 Double storey: annual water to sewer [kL]

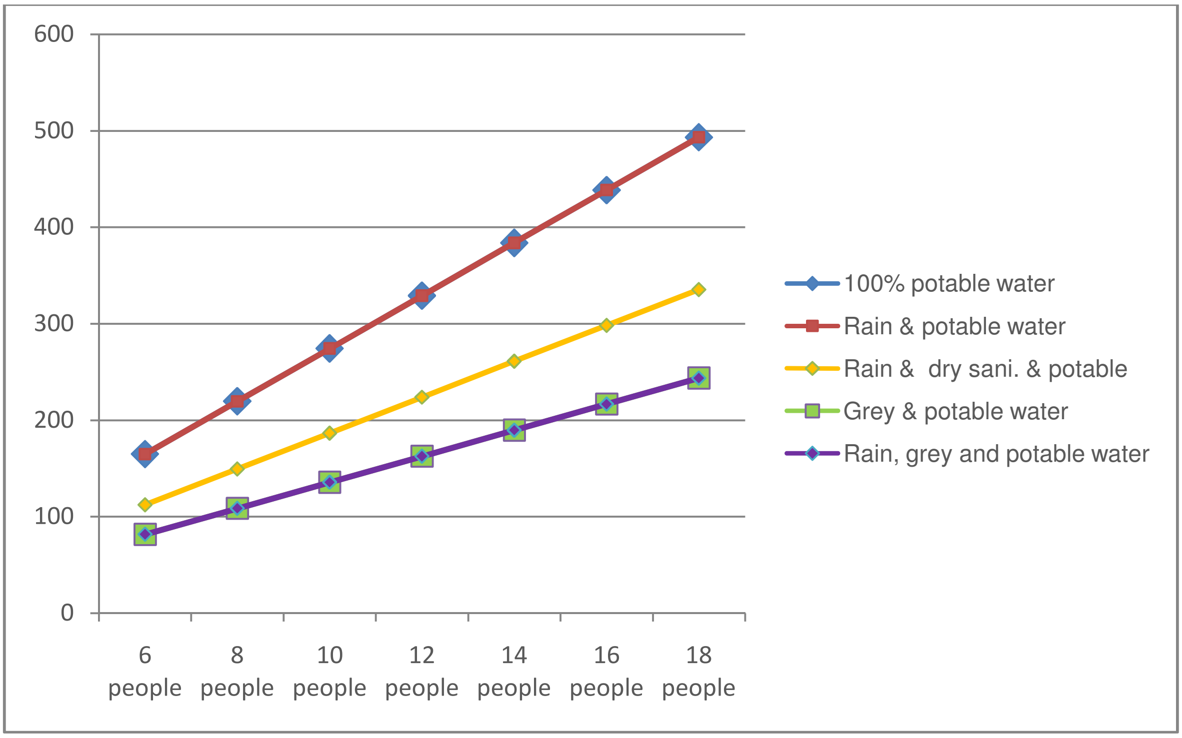

Figure 6 Three storey: annual water to sewer [kL]

5.7 Observations: Net annual water to sewer

- A rainwater harvesting system provides no net reduction in sewer discharge.
- Volume of discharge to sewer is marginally improved by dry sanitation. Relative to a water-borne sewer system, using either rainwater or potable water, the benefit increases as the number of people increases.
- The greatest benefit to reducing volume of discharge to sewer is made by a greywater system. Relative to a water-borne system (ie using either rain water or potable water for flushing), and relative to a dry sanitation system; this benefit of a greywater system increases as the number of people increases.

5.8 Recommendations: Water demand and water to sewer

(i) The maximum number of occupants per dwelling, living within the 9kL free potable water allocation per dwelling per month) is achieved with either:
- A potable water + rain water + dry sanitation system, or
- A potable water + rain water + grey water system

(ii) The greatest reduction in volume of discharge to sewer is achieved with a grey water system.

(iii) The greatest combined benefit of maximising alternative water production and minimising discharge to sewer has a grey water system in common.

(iv) The various combinations of systems should be costed for the various dwelling sizes and the costs compared with the benefits highlighted above.