GUIDELINES FOR GREYWATER USE AND MANAGEMENT IN SOUTH AFRICA

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GUIDELINES FOR GREYWATER USE AND MANAGEMENT IN SOUTH AFRICA

A Report

to the Water Research Commission

by

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PREAMBLE

This report is not a prescriptive ‘manual’ or set of rules regarding the use of greywater as a resource in South Africa, but is rather a strategic document aimed at providing a South African context for the inclusion of greywater as a viable, alternative, non-potable resource. A set of guidelines has been included, but these are based on existing knowledge and expert opinion, and are intended merely to provide background information to national and local government policy-makers so that appropriate legislation and local-level guidelines can be drafted by these authorities – with the oversight and duty of care thus remaining with the policy-makers and legislators.

Whilst the potential for using greywater as an additional water resource is acknowledged, it should be stressed that the dissemination of accessible guidelines for the public comprise an important step towards reducing the risks associated with greywater reuse. However, disseminating guidelines does not necessarily mean that greywater harvesting rules will be followed; the institutionalised promotion of greywater use should therefore only be undertaken after an appropriate weighing up of the risks involved and the implementation of effective oversight mechanisms.

It is likely that this document will form the foundation for future research and policy development regarding the use of greywater as an alternative water resource; however, it should be emphasised that not enough is known currently about the long-term effects of greywater use on human health and the environment to make definitive decisions about this practice. The guidelines are specifically targeted towards household-level, onsite (untreated) greywater use within serviced settlements; as well as managed facilities (which could include some form of greywater treatment system) in government buildings, office blocks, schools, hostels etc.

Institutionalised greywater use is not advised in the informal, densely-settled areas of South Africa where conditions are such that the management of the risks involved with this practice becomes too difficult to control. Whilst any improvements in the management of greywater are likely to make the greatest positive impact in these areas, the main focus needs to be on sanitation provision to address issues of untreated sewage being disposed into the environment, as well as dealing with leakage and/or wastage of water (non-revenue water, NRW). Readers of this report should also be aware that these **guidelines apply only to the use of greywater as it has been defined** – and not to other sources of non-potable water (including treated sewage effluent from wastewater treatment works) – as these sources represent different risks.

The report has been divided into two main sections: Part A, which provides the background to the guideline development process and describes the socio-technical considerations that were taken into account; and Part B, which provides a summarised set of guidelines for the use of greywater as a resource in South Africa.

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ACRONYMS & ABBREVIATIONS

BMP	Best management practice
CEC	Contaminants of emerging concern
CFU	Colony-forming units
COD	Chemical oxygen demand
DALY	Disability-adjusted life years
DO	Dissolved oxygen
EC	Electrical conductivity
EDC	Endocrine disrupting chemical
EEQ	Oestrogen equivalent
GDD	Greywater diversion device
GTS	Greywater treatment system
GWH	Greywater harvesting
IUWM	Integrated urban water management
NBR	National building regulations
NGO	Non-governmental organisation
QA/QC	Quality assurance / quality control
QMRA	Quantitative microbial risk assessment
RDP	Reconstruction and development
SABS	South African Bureau of Standards
SANS	South African National Standard
SAR	Sodium adsorption ratio
SuDS	Sustainable drainage systems
TDS	Total dissolved solids
UCT	University of Cape Town
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation
WRC	Water Research Commission
WSD	Water sensitive design
WSUD	Water sensitive urban design

PART A

TECHNICAL BACKGROUND

CHAPTER 1: BACKGROUND

1.1 INTRODUCTION

South Africa faces a range of challenges with respect to water management, including increasing demand for water, resource shortages, environmental degradation, fragmented institutional structures and basic services backlogs (Kok & Collinson, 2006; Turton, 2008; DEA, 2010; UNEP, 2010; RSA, 2011a, 2011b; Fisher-Jeffes et al., 2012; DWA, 2013). Based on projected population growth, economic development rates and the rate of urbanisation, it is unlikely that future demand for water in the country will be sustainable, and the availability of supply is likely to become a major restriction to future socio-economic development.

Internationally, it is becoming increasingly accepted that a new approach to urban water management is needed (Jacobsen et al., 2012). The World Water Analysis Partnership noted that "water management in urban areas can benefit from more comprehensive urban planning and integrated urban water management" (WWAP, 2012). Integrated Urban Water Management (IUWM) is an approach to urban water services that considers water supply, drainage and sanitation as inter-dependent components of the integrated physical system known as the urban water cycle. As a result of this growing awareness of a need for change, the management and use of greywater (and other resource options aimed at diversifying water resources) as a viable alternative source of water for a range of 'fit-for-purpose' end-uses is being considered.

Treated greywater is already used in many countries throughout the world for household purposes, such as toilet flushing and irrigation of gardens; with recent research also considering the use of greywater to maintain 'green walls' (and thereby contributing to urban cooling) associated with large commercial / residential developments (West et al., 2015). In South Africa, the use of (mostly) untreated greywater by individuals and companies has mainly been restricted to areas where alternative water sources are sought – often (but not always) during times of drought. This is partly owing to the fact that there remains little in the way of published local guidance as to how greywater systems should be designed, operated and maintained as part of an integrated water supply system. This project was thus aimed at providing the necessary guidance to support the wider adoption of domestic greywater management and use in South Africa to support the continued integration of the management of the urban water cycle.

The management and use of greywater can pose significant risks, specifically in terms of the potential health and environmental hazards from chemical and microbiological contaminants and disease vectors, depending on the source of the greywater (e.g. serviced or unserviced settlements), the treatment process adopted (if any), and the use for which it is intended. Greywater quality is highly variable, and there is a need to develop guidelines to ensure the safe management and use of greywater as an alternate water resource, and also to limit and manage inappropriate disposal in areas where it has the potential to result in major health hazards; specifically, in low-income / 'gap' housing and informal settlements.

1.2 PROJECT AIMS

Through the development of a set of guidelines, this project aimed to address (and mitigate) the risks associated with the management and use of domestic greywater, and support the wider uptake of this practice in South Africa – such that the diverse benefits that greywater use may offer can be realised. These include building resilience into the water supply system; managing water demand, reducing volumes of greywater to wastewater systems; and reducing diffuse pollution loads from unserviced settlements. Thus the specific objectives of the project were as follows:

1. Compile a report on the legislative context of greywater use and management in South Africa, including; definition of terms and concepts, role of greywater management in water supply and food security; applicable regulations/ordinances/guidelines on greywater use and management; existing greywater use and management systems, and recommendations for sustainable greywater use and management
2. Develop guidelines for greywater use and management, taking into consideration the following aspects; greywater quantity/quality and fitness for use/application; managing risks and uncertainty in greywater use/reuse; use of greywater to supplement irrigation activities; greywater management options, including treatment, disposal and reuse; Protocols for testing and validating treatment technologies; and guidance for household use and municipal greywater program implementation in both sewered and non-sewered settlements.

1.3 METHOD FOLLOWED IN DEVELOPMENT OF GUIDELINES

Greywater harvesting (GWH) is a practice that is commonly adopted at a household scale in areas where potable water use is restricted (for example, during times of drought), to augment potable water supplies. Greywater is also increasingly being included as a resource option in integrated water supply systems around the world, and as part of water sensitive approaches to water management – with appropriate context-specific regulations and guidelines governing its use to manage the potential risks involved.

A key component of the framework that was developed for implementing Water Sensitive Urban Design in South Africa (WRC Project K5/2071) relates to the need for on-going research and capacity building to develop locally-relevant guidelines for the realisation of Water Sensitive Cities / Settlements. The South African guidelines for Sustainable Drainage Systems, WRC project K5/1826 (Armitage et al., 2013), and the Framework and guidelines for Water Sensitive Urban Design (WSUD) for South Africa, WRC project K5/2071 (Armitage et al., 2014) deal broadly with the overarching principles of SuDS and WSUD. They introduce a range of tools, and discuss the different technology options that may be used to develop urban areas in a water sensitive manner. However, there remains an urgent need for the development of (in this instance, greywater harvesting) guidelines that provide in-depth detail for the regulation, design, and operation of each technology. These guidelines are intended to, above all, address any risks associated with the use of greywater, including the possible adverse effects on human health, effects on the environment, and plant growth and yield.

It should be noted that substantial research has already been undertaken with respect to developing guidelines for greywater use in South Africa – most notably the work that was undertaken on greywater use in non-sewered settlements (Carden et al., 2007), the comprehensive technical report as well as the guidance document for sustainable use of greywater in small-scale agriculture and gardens (Rodda et al., 2010a and 2010b), and the use of greywater for toilet flushing in high-density buildings (Ilemobade et al., 2012). This project has consolidated the findings from these and various other Water Research Commission projects that considered different aspects of greywater management, international literature, as well as the outputs from relevant affiliated research projects – links to the various publications are provided in Chapter 5.

A significant body of information exists both locally and internationally on the various aspects of greywater harvesting, use and management. This information can be used to develop greywater resource guidelines that take into account the unique particularities of the South African context. The research method, therefore, began with the compilation of relevant findings from completed research as well as an update to existing literature reviews, taking into account:

- Available literature on the management and use of greywater that has thus far not focused on the South African or other developing country contexts.
- Available South African research that has focused on, inter alia, greywater harvesting, management and use of alternative water resources, water treatment systems / technologies, and community acceptance of greywater within rural and urban contexts.
- Research that highlights the unique particularities of the South African context (e.g. informal settlements, RDP housing, Free Basic Services etc.), to ensure that the guidelines take these context-specific aspects into account.
- The existing legislative context of greywater use and management in South Africa.
- Stakeholder workshops were then held over a period of about 8 months to discuss the development of a set of resource guidelines for greywater use and management in South Africa with interested and affected parties.

The initial stakeholder workshop held in Cape Town on 18 April 2016 served to raise awareness and concerns about greywater use, and discuss what happens 'on-the-ground', how systems are being managed, and whether they work or not. The research inception report was used as a 'prompt' for the workshop – to identify issues / questions (e.g. health risk; impact on sewage systems; incentives for greywater use; legislation etc.) and link these to relevant sections from existing literature and findings from local (and international) projects. These were then used as discussion points and to identify / map thematic areas for further consideration, specifically those pertaining to legislation and health issues and the quantification of the overall risks involved in greywater use and management (see Appendix A: Thematic mapping summary).

A national stakeholder workshop was held at the Water Research Commission's offices in Pretoria on 12 July 2016 and was used to concentrate more closely on the institutional framework for the guidelines, as well as a discussion of the legislative and health review with participants from different stakeholder groups. Follow-on discussions were then held with representatives of the SANS 10400 NBR and SANS10252-1 working groups to consider the incorporation of greywater reuse into these standards.

Two other affiliated research projects were undertaken at the University of Cape Town to support the guideline development process:

- A short survey of greywater users in the suburb of Pinelands, Cape Town (where there has already been a significant uptake of greywater systems) was conducted to determine 'what works and why'.
- An investigation was undertaken into the development of a risk-based assessment tool through the use of greywater classification.

The draft guideline document was circulated amongst the participants from all stakeholder meetings, as well as several other identified 'experts' around the country for their comments and feedback.

1.4 LAYOUT OF THE GUIDELINES

The report has been divided into two main sections:

- Part A, which provides the background to the guideline development process and describes the socio-technical considerations that were considered; and
- Part B, which provides a summarised set of guidelines for the use of greywater as a resource in South Africa.

CHAPTER 2: GREYWATER HARVESTING

2.1 INTRODUCTION

Water shortages are of ever-increasing concern worldwide, and South Africa faces great challenges in this regard. Historically, southern Africa is a dry region and periodic droughts are a recurring crisis in this part of the world. Population increases with attendant industrial expansion, the increasing speed of urbanisation, as well as lack of prospects to expand bulk water storage facilities mean that the shortage of water for basic human needs in South Africa can be expected to worsen with every passing year – and this situation is likely to be exacerbated by the impacts of climate change. These realities also have a negative effect on the price of water. Alternative sources of water are thus a national priority as well as an economic imperative. There is growing recognition of the potential significance of wastewater as a valuable resource and particularly during times of critical drought. This attention tends to wane during years of normal or above-normal rainfall as such usage involves extra work and added costs, and whilst it presents certain advantages, it also has certain risks.

Several socio-cultural issues related to the management, disposal and use of wastewater in general (and specifically to greywater in some instances) have been raised in the literature. Ilemobade *et al*. (2012) refer to the importance of regular awareness-raising and engagement with beneficiaries of greywater reuse systems, as well as the importance of targeting appropriate groups of users. Momba *et al*. (2013) alludes to the value of determining the most important 'influencers' of social acceptance of home-based water treatment systems before implementing such systems. Alcock (2002) also discusses how the use of greywater to increase vegetable growth yields in impoverished areas can have important psychological effects (and therefore encourage acceptance of such use). Conversely, it would also be useful to determine what socio-cultural and religious 'barriers' there are likely to be that would influence uptake of these systems in certain instances.

The recently-published greywater guideline document published by the National Academies of Science in the United States (NAP, 2015) highlights the fact that future research should focus on understanding the behavioural impacts of greywater use on overall water management at a household level. The issue of social dynamics was also raised, albeit in a different context, by Winter *et al*. (2011) in their study of community-level management of greywater in non-sewered settlements; the behaviour of residents of informal settlements regarding water and sanitation services was found to be conditioned to a large extent by their current circumstances (described in more detail in Section 2.6). The overall aim of this study was to develop guidelines for the management and use of greywater in South Africa. The document clarifies the legal position pertaining to the use of greywater, and supports the management of greywater through the provision of a set of summarised guidelines to provide information to a range of stakeholders including national and municipal authorities, individuals etc. These guidelines are intended to be pragmatic and workable – both for those who have the resources to implement sophisticated greywater systems, as well as those with limited resources who seek practical ways in which to safely implement greywater harvesting.

2.2 WHAT IS GREYWATER?

Greywater (also referred to as grey water and sullage in various areas around the world) is untreated household wastewater from all domestic processes other than toilet flushing; i.e. baths, showers, kitchen and hand wash basins, and laundry (Rodda *et al.*, 2010a). The fact that it is defined as 'untreated' differentiates it from other wastewater that originates from domestic processes, e.g. treated sewage effluent.

Greywater can be further classified into 'light' (Class I and Class II) and 'dark' (Class III) greywater, as follows:
Class Ia: Bathroom greywater – greywater sourced from showers
Class Ib: Bathroom greywater – greywater sourced from basins and baths
Class II: Laundry greywater – greywater sourced from: laundry basins and washing machines
Class III: Kitchen greywater – greywater sourced from: kitchen sinks and dish washing machines.

Note:

Class III has been excluded as a potential resource for the purposes of these guidelines for the reasons discussed below.

Whilst it is useful to categorise greywater for purposes of management, it should be noted classifying greywater according to its source (bathrooms, kitchens, etc.) is only *one* way of determining the potential level of contamination of that greywater. The level of risk associated with greywater in any particular household is heavily dependent on many factors – number and ages of inhabitants, their health status, sanitation / personal hygiene habits and needs, plumbing 'hardware' and washing facilities, quality of original potable water source etc. It is therefore stressed that the source of the used water is no guarantee that such water will automatically fall into the above classes.

'Dark' greywater refers to wastewater from kitchen sinks or dishwashers which can be highly alkaline as well as having high concentrations of organic materials. 'Light' greywater refers to all other wastewater from sources such as baths, basins, showers, and washing machines – typically with a lower organic content, although the pathogen and chemical load varies depending on the source. Most guidelines (including these) exclude the dark greywater / Class III fraction (kitchen wastewater) from greywater reuse schemes, because it can be highly polluted with organic material, fats, oils etc. Significant amounts – 50 to 75% of water used in a household – may be greywater (Eriksson *et al*., 2002; Friedler, 2004; Maimon *et al*., 2010), which could potentially be harvested and reused in a productive manner rather than being directed to a municipal sewer. It is estimated that the reuse of greywater for toilet flushing and garden irrigation could reduce household potable water use by up to 50% (Friedler, 2004). Depending on the source of the greywater – i.e. whether it comes from the laundry or bath – it may be associated with different health risks. All water emanating from toilets (including bidets) is contaminated with faecal matter and is considered to be black water; i.e. sewage. Certain classes of greywater may, in certain households, would be better referred to as black water, for example Class II greywater should be treated as black water if a household is using washable nappies. In the same vein, water used for washing babies should not be used as greywater.

2.3 WHY HARVEST GREYWATER?

As outlined in the Introduction, South Africa faces a range of challenges with respect to water management, specifically related to issues of water scarcity. By 2030 parts of the country are predicted to be severely impacted as demand exceeds available supply (Barilla Group *et al*., 2009). Additionally, 2015 was the driest year on record in South Africa[1], leaving many towns with extremely compromised water supply systems whilst also limiting food production across the country. This is placing pressure on the already fragile economy. To avert a future water crisis, the country needs to prevent water wastage and ensure more efficient use. Within urban areas, individuals and municipalities need to find ways to adapt to, and mitigate the threats from, water insecurity resulting from, *inter alia*: droughts, climate change and increasing water demand (driven by population growth and rising standards of living). One such measure is to harvest and reuse greywater in a 'fit-for-purpose manner'.

Improving water security is one reason for harvesting greywater; another, equally important, reason is the use of greywater as a resource. Economic and environmental benefits are derived from the use of greywater as a productive water source within households, as well as the reduction in wastewater loading (both in terms of quantity and quality) achieved at sewage treatment works – resulting in reduced pumping and treatment costs. An added environmental benefit related to this is that the volume of treated effluent being discharged from sewage works will be reduced.

Since greywater may contain nitrogen, phosphorous and potassium, it can be a potential source of nutrients for plant growth (Eriksson *et al*., 2002; Morel & Diener, 2006). The use of greywater in urban and peri-urban agriculture has in fact been shown to reduce the agricultural requirement for application of plant nutrients

[1] See http://www.reuters.com/article/us-safrica-drought-idUSKCN0US14T20160114 (accessed 13 January 2017)

(Murphy, 2006), and thus contribute to food security, particularly in poor settlements, if cognisance is taken of the potential health risks involved (Rodda *et al*., 2011). A recent study has shown that when greywater diluted by 50% with fresh water is used for irrigation purposes, better, more marketable crops in terms of yield and aesthetic appeal are produced (Mzini & Winter, 2015).

2.4 POTENTIAL IMPACTS OF GREYWATER HARVESTING

Pathogens in greywater can potentially cause diseases through direct contact or through the consumption of irrigated produce (Maimon *et al*., 2010). Aside from these health risks which are described in some detail in Chapter 4, there are several potential negative impacts associated with the use of greywater, as outlined by Murphy (2006) and Maimon *et al*. (2010) – see Table 2-1.

- Reduced crop yield as a result of salinity, nitrogen overload, specific ion effects (e.g. boron, sodium and chlorides), high pH levels, and soil clogging effects from surfactants, oils and grease, phosphates and sodium, as well as lint, hair, etc. if the greywater is unfiltered.
- Soil degradation due to high sodium (sodicity), salinity and other substances – in saline soil, high sodium levels replace magnesium and calcium necessary for plant growth and absorption of water, particularly in sandy soils.
- Groundwater contamination as a result of movement of the greywater through the soil.
- Reduced flows and higher solids content causing blockages in sewerage systems.

Table 2-1: Environmental hazards associated with greywater used for irrigation purposes (Maimon *et al*., 2010)

Parameter	Examples of possible impact
pH	Corrosion of equipment; damage to biota; changes in biochemical processes
Electrical conductivity	Reduction of plant productivity; possible changes in soil properties
Chloride	Accumulation in soil may adversely affect plants
Sodium adsorption ratio	Exacerbation of soil erosion; changing soil hydraulic properties; reduction of plant growth
Boron	Accumulation in soil may be toxic to plants
Phosphorous	Eutrophication if excess concentrations reach surface water; bio-clogging of equipment
Surfactants	Accumulation may change soil hydraulic conductivity; plant toxicity
Oil and grease	Accumulation may change soil hydraulic conductivity
Xenobiotic compounds	Toxicity to biota

Regarding the use of greywater for domestic irrigation, one of the most useful studies in this regard was undertaken on a selected range of bathroom products (solid soaps, liquid body washes, shampoos and hair conditioners) to assess their potential impacts on soil chemistry and structure when they are present in greywater (Meehan & Maxey, 2009). Whilst it was found that the effects of greywater on soil vary depending on the type of soil present, many general observations were made on the basis of the results of chemical testing obtained for the simulated greywater generated by each product:

- Most hard soaps produced high pH greywater which over time could be damaging to plants and soil. The electrical conductivity (EC) levels of this greywater are unlikely to pose long-term problems associated with induced salinity. However, the sodium level of all products tested was very high and poses a 'sodium hazard' to clay soils over time – this is supported by the soil stability results obtained in this study which showed that most of the hard soaps caused extensive dispersion of all the soils tested.
- The sodium level of most shampoos, conditioners and body washes was low although the long-term effects of some of the shampoos would need to be investigated further as low sodium content greywater can still cause long-term problems if the levels of other cations such as calcium and magnesium are low (van de Graaff & Patterson, 2001).
- The levels of potassium found for most products would appear to provide a source of potassic fertiliser and not pose any long-term problems associated with nutrient build-up.
- The levels of zinc in some hard soaps could pose long term problems of zinc accumulation in the receiving soil.
- Most of the products tested produced greywater with low phosphorus levels.
- There was no indication that so called 'eco-friendly' products were more suitable for greywater irrigation systems than mainstream products, possibly due to the increased use of sodium chloride salt in many of these products.

The effects of these and other constituents such as emulsifiers, preservatives, microbeads, etc. in personal care products have not been evaluated in local (South African) soils and under local weather conditions. Greywater from bathrooms also potentially contains products such as medicines, disinfectants, pesticides, dyes, clothes detergents and fabric softeners. The presence and concentrations of these pollutants vary according to the habits of the occupants of the house and the alternative disposal systems available to them. The choice of bathroom products for use in greywater irrigation systems is thus critical to prevent the long-term chemical and structural deterioration of receiving soils. Products with high sodium levels should be avoided due to their destructive effects on clay soils.

2.5 APPROPRIATE USES FOR GREYWATER

2.5.1 Overview

Residential, on-site greywater reuse is a potentially promising alternative water resource if managed correctly – particularly in low-density, high-income areas where health concerns are less pronounced and generation rates are notably higher than in the lower-income, high-density areas (Jacobs et al., 2011). Reuse schemes need to be simple and economical, whilst at the same time protecting the environment and public health (Maimon et al., 2010). Greywater reuse has the potential to result in potable water savings through offsetting the use of such water for non-potable purposes (Coulson, 2014).

From a 'fit-for-purpose' perspective, greywater is most appropriate for activities such as toilet flushing and garden watering / irrigation, where human contact is limited. However, even in these cases, there is potential for health risks; for example, in the context of toilet flushing, water droplets are aerosolised and land on nearby surfaces or can be dispersed into the air. The pathogens are then transferred through hand-to-mouth contact after toilet use, if thorough hand-washing is not observed.

Similarly, it is strongly suggested by many international authors that untreated greywater should only be used for subsurface irrigation purposes, to limit the risks involved (Maimon et al., 2010). In addition to this, discolouration, odours, and negative perceptions about wastewater can also present barriers to its use as an alternative water resource (Ilemobade et al., 2012).

Depending on the availability of potable water resources in a specific area, greywater may also be used for small-scale irrigation – with appropriate risk prevention barriers in place (Rodda et al., 2010b). The complexity of installing and managing these greywater systems presents a challenge for broad-scale adoption within urban catchments. Greywater harvesting is usually heavily decentralised, taking place within the boundaries of individual properties, and the responsibility of managing these systems falls on the property owners. However, in densely populated urban areas and/or informal settlements, management of greywater jointly with other domestic wastewater in a combined collection / treatment system such as constructed wetlands (i.e. a centralised system) may be technically and economically more feasible (Morel & Diener, 2006).

In this regard, proactive participation and involvement from the involved 'community' is essential for the effective implementation of greywater systems (Landcom, 2004). There are likely to be significant differences between the way greywater is used and managed in serviced and un-serviced settlements. Whether greywater reuse is intended or not, particularly in areas that are un-serviced (and rural or peri-urban areas), control and/or risk aversion measures are required to be put in place to ensure safe disposal of greywater. This is to prevent environmental degradation and reduce exposure of the population to health risks (Morel & Diener, 2006).

The most promising domain for institutionalising greywater reuse appears to be in large buildings such as office blocks, public buildings, and hostels. Greywater can be collected and treated under proper supervision and the large amount of (usually) lightly contaminated water originating from such buildings can be used for irrigation of gardens and sports fields, toilet flushing, etc. The water thus saved can make a significant difference, especially during times of water scarcity. If this is to happen, however, the adaptation of building codes for such buildings should be investigated as a matter of priority. The potential to use greywater for a specific end-use is dependent on how and from where the greywater is collected, stored, treated (if at all) and used

2.5.2 Greywater use in formal housing in Cape Town

A short investigative study was undertaken in Cape Town during 2016 (Peel, 2016), to try and determine how greywater is currently being used and managed in typical upper income homes (n=20), the attitudes of the people towards using these greywater systems, and an indication of some of the health risks that may result. All the respondents made use of the same type of proprietary greywater diversion device (GDD) – an example of which is shown in Figure 2-1 – which is designed to divert laundry and bath / shower water to a small storage chamber for immediate disposal by irrigation. A randomised sample was selected from a population of 893 homeowners in study area using a non-probability approach to identify participants – all of whom have had a greywater system installed in their home. Semi-structured interviews were used to elicit information about the way that the home-owners used and managed their greywater systems.

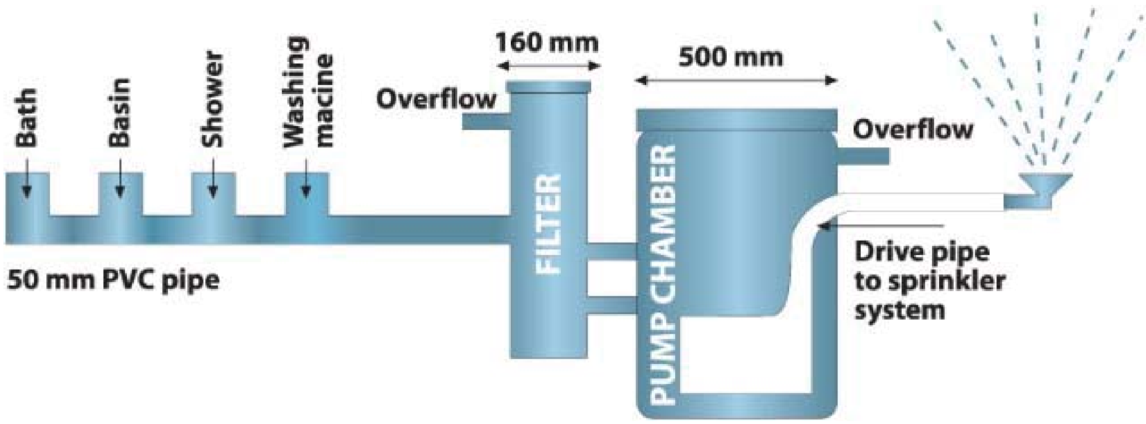

Figure 2-1: Example of proprietary greywater harvesting system. (Source: http://www.waterrhapsody.co.za)

The themes most commonly raised were: the financial benefit of the system, the year-round flourishing gardens, few concerns about exposure to greywater, perceptions about the quality of the greywater, and the ease of use when operating their greywater system. 8 different houses were then sampled for greywater quality analysis in which water was sampled over three different days, and a total of 24 nutrient samples were collected. These samples were taken from the greywater tank / chamber at the same time each day and stored in dark glass bottles, at room temperature. Samples for the testing of *Escherichia coli* were taken from the same 8 houses as the nutrient samples on the day of the third test. It was evident among the interviewed participants that there were similarities in the way home-owners use, perceive, treat, and manage greywater.

Specifically, 95% of the participants were happy with how their greywater has kept their gardens green and reported no concerns to human health. Only one participant removed their system due to foul odours. It was also found that each household had the same primary sources of greywater attached to their system: baths, shower, hand basins and washing machines. In each case greywater is stored and flushed from the greywater chamber on a daily basis and is used to irrigate lawns, flower beds, fruit trees and vegetable gardens. Only a handful of respondents indicated that they would not use greywater to irrigate edible plants. Those who do use greywater to irrigate vegetable patches, explained that they were conscious of the household products they use to wash and clean. These users would avoid acid-based detergents and rather opt for organic, eco-friendly and biodegradable products.

The sampling of greywater was a useful indicator of hazardous nutrients and contaminants (Table 2-2), even though the sample size was small. These contaminants either enter the system directly through the sources (i.e. faecal matter through the laundry greywater), or develop within the system as it experiences temperature, pressure and oxygen changes. *E. coli* served as an indicator organism of microbial activity, with the results of this study showing a wide range of *E. coli* concentrations that may be related to household size and the inputs at each source (e.g. one household included their kitchen basin as a source of greywater). The qualitative analysis indicated that in some instances, greywater could pose a risk to human health, soils and the environment. An example of this is that many users do not switch off their system during periods of high rainfall and saturated conditions resulting in some pooling of greywater in their garden.

The results showed that, whilst most respondents were successfully using their greywater and did not report problems with the systems, many residents do not follow some of the basic rules regarding handling of greywater (e.g. switching off the system during periods of rainfall) – and could thus be exposing themselves to various levels of risk. This reaffirms the difficulties in quantifying and qualifying greywater risk to humans, soils and the ecology of the environment. However, assessing the use and management of greywater in a private space that is managed by purpose-built technologies identifies how these risks are being managed within domestic households. The study therefore provides another snapshot into considerations for guidelines towards safer and sustainable use of domestic greywater.

Table 2-2: Greywater quality results for 8 sewered households in Pinelands, Cape Town

Sample	Parameter – mean values						
	Phosphorous (mg/l)	Nitrate (mg/l)	pH	TDS (mg/l)	DO (mg/l)	Ammonia N (mg/l)	*E. coli* (counts /100 ml)
House 1	1.4	5.7	6.7	121	1.8	>3.5	214
House 2	0.9	1.0	7.2	66	2.8	0.46	<1
House 3	0.8	1.5	6.7	80	0.8	0.58	<1
House 4	4.0	14.2	6.4	331	1.0	0.95	>2419*
House 5	1.3	3.4	8.5	680	1.0	>3.5	3
House 6	0.8	3.0	7.5	160	0.6	0.98	921
House 7	0.9	2.2	6.5	106	1.1	-	980
House 8	1.5	12.0	6.7	139	0.7	-	980
Mean values	1.45	5.4	7.0	210	1.2	-	-

* *E. coli* testing was carried out without diluting the samples; hence this figure may not represent the true value

2.5.3 Uses for which greywater is inappropriate

Specific guidance in respect of greywater use will be provided in Part B of this report, but the general rule is that greywater should never be used in any manner where it may easily come into contact with susceptible individuals and/or ingested. Therefore, it is **totally inappropriate** for use in the following situations:

- Drinking or cooking.
- Irrigating of any produce eaten raw or minimally processed, such as leafy produce or root vegetables (e.g. carrots and beetroot) growing in soil frequently irrigated with greywater.
- Washing / cleaning pavements – especially those draining to storm water systems.
- Irrigating gardens during or immediately subsequent to rainfall.
- Irrigating areas in gardens such as lawns where children play. Children are the group most susceptible to picking up infections from greywater.

2.6 MANAGEMENT OF GREYWATER IN UNSERVICED SETTLEMENTS

Greywater quality is closely linked to the amount (quantity) of greywater generated, with the volumes of greywater generated per household varying greatly, i.e. lowest in low-income households (20ℓ/d to 30ℓ/d) and highest in households with in-house taps and an affluent lifestyle (Morel & Diener, 2006). The mean greywater return in unserviced settlements in South Africa is 75% of household water consumption; and the housing density in these settlements generally means that there is high overall volumes of greywater generated, even when the amount of water used per dwelling is relatively low (Carden *et al*., 2007). Combined with the high concentration of pollutants in greywater in informal settlements, greywater use in these areas is generally not recommended; rather, efforts should be focused on its effective management.

In other words, greywater management in these areas should be directed at disposal or off-site treatment, rather than considering it as a resource that could be used productively (refer to Carden *et al*., 2007 for specific guidance in this regard). This is because water in these areas is generally already 'reused' many times before it is disposed (e.g. bath water used to wash laundry; laundry water used to clean floors, etc.). The greywater emanating from non-sewered settlements is very often of a quality resembling 'black' water (i.e. sewage) and is thus considered hazardous from a pathogenic and chemical perspective.

Most of the unserviced settlements in South Africa are in the form of high-density informal settlements. The management of greywater in these areas is of utmost importance and concern as it can pose a significant public health risk to persons residing in these settlements. As described by Winter *et al*. (2011, pg. 1-1), when reporting on WRC project No. K5/1654, *'Sustainable options for community-level management of greywater in Settlements without on-site waterborne sanitation'*:

"In non-sewered informal shack settlements in South Africa, including those with limited waterborne services and drainage, is that greywater often merges with toilet water and other effluent flows thus creating a toxic mix of contaminated water that poses a danger to human health and the environment. Although the per capita volume of greywater disposed on the ground in the vicinity of shack dwellings is low, greywater runoff often carries solid and liquid waste contaminants that accumulate in ponds in and around settlements and are then discharged via storm water systems into surrounding surface water systems."

These settlements typically have no or insufficient basic services for water, sanitation, storm water management and solid waste disposal. In such an environment, it is difficult even to identify greywater as a separate waste stream that can be diverted (even if the quality was such that it was suitable for further use), let alone to interest individuals in trying to put it to beneficial use. Furthermore, the socio-economic constraints under which individuals in such settlements typically live make it near impossible for them to divert financial resources to establishing or maintaining greywater use (e.g. irrigation) projects. This burden would then fall on the local authority which is often operating under constraints of its own.

The paradox here is that greywater offers great potential for improvement in household nutritional status and social functioning in poor rural settlements, and in urban and peri-urban settlements around the major metropoles of South Africa (Van Averbeke, 2007). The challenge, then, lies in identifying conditions and limitations under which greywater could potentially be used beneficially in such settlements. Additional precautions therefore need to be taken if use of greywater for irrigation or other non-potable purposes in informal settlements is to be considered. Aside from the precautions with respect to greywater management, quality and quantity, as outlined in the remainder of this report, the creation of a sense of community and the engaging of such a community with the concept of the potential dangers of greywater use are critical pre-requisites for any greywater irrigation implementation.

Specifically, potential users should be informed that greywater should be:

- Limited in terms of the number of uses within the household prior to use, and must not be collected for use after discharge into the environment.
- Isolated at source before reuse.

Recent research being undertaken as part of a Western Cape Government project referred to as 'Genius of Place' (DEDT, 2016) is investigating the potential for decentralised / off-site treatment of polluted runoff from informal settlements – using biomimicry and green infrastructure options. The pilot project is aimed at separating out the greywater from the combined runoff flows from the informal settlement of Langrug, Franschhoek, to reduce pollution levels in the Berg River, and help to improve health issues within the settlement. Screens are used to remove solid waste material and the greywater is then directed into 'bioremediation filter tanks' and tree pits which act as treatment facilities. In this way, it is hoped that the environmental and health risks associated with the unmanaged disposal of greywater can be reduced, whilst also resulting in secondary benefits associated with greening of informal settlements.

2.7 GENERAL RULES FOR HARVESTING GREYWATER

There are various challenges relating to the technical aspects of designing, managing and maintaining greywater systems in terms of treatment and subsequent storage. Some of these are highlighted in existing guidance documents, such as have been provided by Wood *et al*. (2001), City of Cape Town (2005) and Murphy (2006). These include design aspects – of both the treatment facility (including reference to quantity and quality) and the greywater system as a whole – as well as operation and maintenance guidelines to ensure the sustainable management of the system.

There are also basic handling rules to be followed when disposing or reusing greywater (for example, using eco-friendly / 'natural' / biocompatible cleaning products, and limiting storage time before use). The economic viability of greywater harvesting systems is a key consideration; for example, Ilemobade *et al*. (2012) suggest a maximum payback period of 8 years for greywater reuse for toilet flushing. Consideration of any legislative (e.g. municipal by-laws) or policy requirements and the linkages to other water services (e.g. sewerage or irrigation systems) is also important when designing a greywater system – particularly in respect of their potential impact on these systems.

Considering the lack of any code of practice for the use of greywater in South Africa, it is useful to summarise the main "*Do's and Don'ts*" in the regulations used by the world leaders in greywater reuse, for example: Australia (State of Victoria, 2004), Jordan (CSBE, 2003) and the United States of America (Water Conservation Alliance of Southern Arizona, 2003), as follows:

- Avoid direct human contact with greywater, or soil irrigated with greywater.
- Water that comes into contact with a toilet, urinal or a toilet fixture such as a bidet should never be used as greywater.
- Water that has been used to wash nappies or other clothing soiled by faeces and/or urine should not be used; nor should that generated by cleaning in the laundry or bathroom, or when using hair dye or other chemicals.
- Water from the kitchen sink or used in the kitchen to wash dishes or food should not be used (it is too highly contaminated with grease, bacteria, blood and chemicals). Also, do not use greywater that is generated by washing cloths / brushes used for painting or for maintaining machinery and vehicles.
- Preferably use only 'low risk' greywater – e.g. warm-up water from hot taps, rinse water, bath or shower water.
- Store warm water in a holding tank to cool down and use within 24 hours; otherwise the bacterial load will rise too high for safety. This tank should be classified as a septic tank and all the regulations for septic tanks should apply to such a system. Water stored for longer than 24 hours should be treated before use, especially if applied to garden areas where humans and animals can come into contact with such water.
- Greywater should never be applied to uncooked edible crops – such as vegetables eaten raw or lightly cooked, such as in salads. It should also be avoided for root crops such as carrots, since the pathogens can accumulate in the topsoil.
- Care should be taken to ensure greywater never comes in contact with the produce being irrigated. This may be achieved through drip irrigation, subsurface irrigation, or irrigation under a heavy mulch cover.
- Greywater should only be used in locations where groundwater is at least five feet (approximately 1.5m) below the surface.

- Surface accumulation of greywater must be kept to a minimum. Care should be taken to ensure greywater does not run off irrigated surfaces into water courses, storm water drains, swimming pools or dams.
- Greywater should not be allowed to leave the boundaries of the property. Excess greywater should be disposed of into the sewerage system during rain periods or when too much greywater is produced for the garden to absorb.
- Children and pets should be kept away from areas that are irrigated with greywater. Children are the highest risk group for acquiring infection from greywater.
- Encourage every person living on the premises where gardens are irrigated with greywater to wash their hands without fail before eating or drinking.
- Label pipes carrying greywater under pressure to eliminate confusion between greywater and potable (drinking) water pipes.
- Greywater should never be allowed to pond or pool where mosquitoes and other insect vectors of disease can breed.
- Water used to wash animals such as domestic pets should not be used – it typically has high concentrations of organisms able to cause disease.
- Greywater should not be used if anybody living on the premises is suffering from diarrhoea, ear or skin infections.
- Never use hosing, spraying or misting methods when irrigating with greywater.

2.8 GREYWATER HARVESTING TECHNIQUES

2.8.1 Bucketing

A bucket may be used to manually harvest and use greywater, by for example, collecting shower and laundry water and using it for irrigation purposes (taking into account the general rules for greywater harvesting provided in section 2.8). Such an approach is generally considered to be low risk due to the relatively small volumes of water and associated contaminants. It is also unlikely to be undertaken during wet weather (thereby reducing the risk of runoff). Whilst the use of buckets to harvest and reuse water is generally considered low risk, there are several important rules governing this use, in addition to the general rules for harvesting:

- Make use of garden-friendly detergents low in phosphorus, sodium, boron and chloride.
- Spread the greywater around different areas in the garden to prevent pooling.
- Monitor plant and soil response to greywater irrigation – if your plants show signs of yellowing, wilting or mottled colour, consider the above points or stop applying greywater altogether. For example, alternate irrigation with freshwater to leach out salts if plants show symptoms of stress; apply

agricultural gypsum and compost to ameliorate soils if infiltration rate decreases as a result of high salt content.

- Consider applying a soil wetting agent every sixth month to assist in the absorption of greywater by the soil (soils can become hydrophobic or water repellent when they are dry for extended periods).
- Ensure that hands are properly washed, without fail, after bucketing of greywater is finished.

2.8.2 Greywater diversion devices

The Government of Western Australia Department of Health (DoHWA, 2011) provides comprehensive information on options for greywater diversion. A greywater diversion device (GDD) diverts greywater *without storage* (apart from a temporary holding / surge tank) or *treatment*; it incorporates a float- or hand-activated switch or tap to divert the greywater to the garden or the sewer. GDDs are the most commonly-used greywater reuse systems within sewered households in South Africa. Greywater from a GDD should only be used to irrigate gardens via sub-surface irrigation, which means that the irrigation should be buried at least 10cm below the surface of soil or mulch. There are two common types of GDDs, as follows:

- Gravity GDDs make use of gravity to provide adequate pressure to move the water from the house to the irrigation system. Such systems require the house to be elevated or the garden to slope away from the house.
- Pumped GDDs make use of a pump to convey the water and provide pressure to irrigate the garden. Such systems typically include a surge tank, which holds the greywater until it has been used to irrigate the garden.

GDDs are most appropriate for harvesting greywater in single residential domestic properties where it is possible to keep the greywater within the confines of the property on which they are generated. The harvesting of greywater using a GDD in commercial or multi-dwelling properties should be managed by properly appointed and trained personnel who can oversee the process in a safe manner. In addition to the general rules for harvesting greywater set out in Section 2.8.1, the following applies to the use of GDDs:

- Use diverted, untreated greywater for sub-surface irrigation only (at least 10 cm below the surface of soil or mulch).
- Ensure the greywater diversion device is switched back after irrigation periods so that greywater is diverted to sewer.
- Make use of a filter to screen solids when using a diversion device.
- Ensure that regular maintenance is undertaken, including cleaning out the GDD filter weekly and maintaining the sub-surface irrigation system. Regularly clean the whole irrigation system as greywater causes bio-slimes to build up in the filter and pipes, leading to blockages. Take care to use gloves and

avoid splashing as there may be considerable numbers of disease-causing organisms that have built up in the bio-slimes over time.

- Mark / label all pipes and use signs to indicate greywater reuse

When using a GDD to harvest greywater do not leave the device on continuously. Treat it like a garden tap and only reuse greywater when the garden needs watering. Greywater is for reuse, not disposal. It is also particularly important – as a GDD offers no form of treatment – to recognise that GDDs should have a device that allows the greywater to be diverted to the formal sewerage system. This should be done under the following circumstances: when nappies or pets are being washed; when someone in the household is ill; during wet weather or when the water is likely to pool and runoff; and when any harmful chemicals have been used that would otherwise drain directly to the garden. Once installed, it is necessary to maintain the GDD regularly. General maintenance guidelines are provided in Table 2-3.

Table 2-3: GDD Maintenance requirements

Greywater diversion device component	Maintenance required	Frequency
Filter	Clean filter – filter should be removed and cleaned, removing physical contaminants (sand, lint, hair, slime etc.)	Weekly
	Replace filter	As recommended by the manufacturer or as required (usually every 6–12 months)
Surge Tank	Clean out sludge from surge tank	Every 6 months
Sub-surface irrigation distribution system	Check that water is dispersing – regularly monitor soil to ensure all areas are wet after an irrigation period.	Weekly
Soil condition	Check that soil is healthy. Signs of unhealthy soil include: • damp and boggy ground hours after irrigation • surface ponding and run-off of irrigated water • poor vegetation growth • unusual odours • clumping of soil • fine sheet of clay covering surface	Monthly
Sensor probe (if applicable)	Clean sensor to ensure correct readings and therefore pump operation	Weekly

2.8.3 Greywater treatment systems (GTS)

A greywater treatment system (GTS) collects and treats greywater – the range of treatment processes vary according to the level of sophistication of the system and the intended use of the greywater. Currently in South Africa, the level of treatment in these systems is limited to fine sieving or filtration and chlorination (see for example Ilemobade *et al*., 2012). Where the treated greywater is not disinfected, it should only be reused via subsurface irrigation – as with GDDs. Where the treated greywater from a GTS is (i) disinfected (e.g. by UV / chlorination), and (ii) meets required standards, additional uses such as: surface irrigation, toilet flushing, and cold-water laundry washing machine use may be considered.

Throughout the world there are numerous systems (some patented) which aim to treat greywater to acceptable standards for reuse – a review of some of these systems is available in Carden et al., (2007). The cost implications, maintenance requirements and social acceptability of such systems would however have to be considered before deciding which treatment technology to adopt.

Note: How to safely use GTSs

To safely use GTSs to harvest greywater, it is important to observe many specific rules, including:

- **Ensuring that the GTS is maintained regularly by a trained service agent.**
- **Only use harvested greywater for the end uses approved**
- **Mark / label all pipes and use signs to indicate greywater reuse – see Chapter 5.**

It is particularly important, as with GDDs, to ensure that GTSs have a device that allows greywater to be diverted to the formal municipal sewer, should the GTS fail or be overwhelmed. Similarly, if the GTS is supplying greywater for toilet flushing, there needs to be a back-up in the form of municipal supply into the cistern for situations when the greywater system fails. This is particularly relevant in South Africa, where the threat of electricity outages may interfere with the proper functioning of a GTS. Furthermore, care should be taken to ensure the GTS provides adequate treatment. When uncertain, greywater should not be harvested in the following circumstances: when nappies or pets are being washed; when someone in the household is ill; during wet weather or when the water is likely to pool and runoff; and when any harmful chemicals have been used that would otherwise drain directly to the garden. Once a GTS is installed, it needs to be maintained. This is the responsibility of the property owner / occupier, who should arrange for an appropriately-trained service company or person to maintain their system. At a minimum, a GTS should be inspected annually. Regular maintenance (as for GDDs) may be required and can be undertaken by the property owner / occupier.

CHAPTER 3: LEGAL CONSIDERATIONS WHEN USING GREYWATER

3.1 INTRODUCTION

This section provides an overview of the regulatory and legislative framework in South Africa, particularly in the context of the regulation of the use of greywater. It discusses the relevant national legislation to provide the context for such regulation. The national legislation provides the framework of law that is to be applied throughout the country. Municipalities have the constitutional competence to enact laws in respect of water and sanitation services, limited to potable water supply systems, and domestic wastewater and sewage disposal systems (Part B of Schedule 4 and Part B of Schedule 5 of the Constitution). An overview of the extent to which greywater is regulated at a municipal level is set out in the tables shown in Appendix B, which are based on an audit of all municipal by-laws in the country. A brief overview of the approaches followed by foreign jurisdictions is provided. Finally, many key recommendations are set out in respect of the regulations that should govern the use of greywater.

3.2 NATIONAL LEGISLATIVE FRAMEWORK

3.2.1 Overview

The most extensive content provided on the management and use of greywater is contained in the following regulations:

- Revision of General Authorisations in terms of section 39: GN 665 of 6 September 2013: Government Gazette No. 36820
- Regulations Relating to Compulsory National Standards and Measures to Conserve Water (GNR.509 of 8 June 2001)
- National Sanitation Policy (GN 70 of 12 February 2016: Government Gazette No 39688)
- National Environmental Health Norms and Standards for Premises and Acceptable Monitoring Standards for Environmental Health Practitioners (GN 1229 of 24 December 2015: *Government Gazette* No. 39561)

The Constitution of the Republic of South Africa, 1996, provides that everyone has a right of access to water.[2] No equivalent right exists in the context of sanitation. The right of access to water is given effect through the enabling legislative framework, namely the National Water Act 36 of 1998. Together with the Water Services Act 108 of 1997, the powers and duties of the state in respect of the management of water and the provision of water services are set out.

3.2.2 The National Water Act (Act 36 of 1998)

The National Water Act acknowledges the scarcity and uncertainty of South Africa's water supply in its preamble, as well as the importance of managing water in a sustainable and integrated manner. In addition, the preamble to the Act appropriately identifies that water occurs in many different forms, but all forms are part of the same unitary and interdependent cycle. The Act does not provide definitions for different forms of water, though it does define different water sources, specifically aquifers, boreholes, catchments, estuaries, water courses and wetlands. A water resource is defined as including a "*watercourse, surface water, estuary, or aquifer*". No definition is provided for greywater or black water. This notwithstanding, the National Water Act is still of relevance to the extent that it makes provision for the sustainable use of water resources and aims to provide for the management of all water resources.[3] At the outset, it is clear that there is no explicit reference to 'greywater' contained in the National Water Act. Despite this fact, the Minister still has the authority to regulate this form of water, particularly when the purposes of the Act are considered.

The overarching guiding principles that inform the interpretation of the National Water Act include sustainability and equity. The objectives set out in the preamble are echoed by the purposes of the Act, set out in section 2, which provide, *inter alia,* that water must be used, protected, developed, conserved, controlled and managed in such a way as to promote "*the efficient, sustainable and beneficial use of water in the public interest*". In accordance with the trusteeship model, the state is empowered to, and must ensure, the use, protection, development, conservation, management and control of water resources.[4]

In terms of this trusteeship model, the legislative framework provides for the nature of authorizations that the state may grant. No license is required for domestic water use as it is generally authorized in terms of schedule 1 of the Act.[5] Domestic use of water includes the use of water in a household, for reasonable domestic use or gardening, the watering of animals (subject to the grazing capacity of the land, and excluding feedlots), the

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[2] S27.
[3] National Sanitation Policy, 23.
[4] Section 3.
[5] Read with s 21 and 22.

storage and use of roof runoff water, and the discharge of water containing waste and runoff.[6] Such water use is subject to any limitation, prohibition or restriction in terms of the Act itself, or any other law.[7] The water user is required to "return any seepage, runoff or water containing waste which emanates from that use, to the water resource from which the water was taken, unless the responsible authority directs otherwise".

Relevant definitions in this context include the definition of conservation, pollution, protection of water resources, waste and waterworks, as follows:

- Conservation is defined in the Act *as "the efficient use and saving of water, achieved through measures such as water saving devices, water efficient processes, water demand management and water rationing".*
- Pollution is defined in the Act as meaning *the "direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it (a) less fit for any beneficial purpose for which it may reasonably be expected to be used; (b) harmful or potentially harmful (aa) to the welfare, health or safety of human beings; (bb) to any aquatic or nonaquatic organisms; (cc) to the resource quality; or (dd) to property".*
- Protection of water resources is defined in the Act as meaning *the "(a) maintenance of the quality of the water resource to the extent that the water resource may be used in an ecologically sustainable way; (b) prevention of the degradation of the water resource; and (c) the rehabilitation of the water resource".*
- Waste is defined in the Act as including *"any solid material or material that is suspended, dissolved or transported in water (including sediment) and which is spilled or deposited on land or into a water resource in such volume, composition or manner as to cause, or to be reasonably likely to cause, the water resource to be polluted".*
- Waterworks is defined as including *"any borehole, structure, earthwork or equipment installed or used".*

The Act requires the establishment of a National Water Resource Strategy (section 5), which sets out the "*strategies, objectives, plans, guidelines and procedures of the Minister and institutional arrangements relating to the protection, use, development, conservation, management and control of water resources within the framework of existing relevant government policy*". The NWRS must include information pertaining to *"(iii) actions to be taken to meet projected future water needs; (iv) water use of strategic importance; (h) set out principles relating to water conservation and water demand management;(i) state the objectives in respect of water quality to be achieved through the classification system for water resources provided for in this Act*".

[6] Sched 1(1).
[7] S22(2)(b).

In terms of this Strategy, a definition is provided for a 'greywater footprint', which is defined as "*the volume of freshwater required to assimilate a pollution load to at least comply with acceptable water quality standards*".[8] Greywater is also considered as part of the 'water footprint', and is defined in this respect as the "*volume of polluted water, calculated as water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards*".[9] Beyond these definitions, no specific reference is made to the use, control or standards for greywater usage. Water re-use is referred to in the Strategy, but only in the context of the provision of water treated by waterworks plants to potable standards for purposes of water provision services.[10]

The National Water Act makes specific reference to the reuse of water for the purposes of irrigation of land, where such wastewater has been generated by industrial activities or a waterworks.[11] This is listed as a specific controlled activity, for which a general authorization or license is required. This provision in the Act does not extend to the use of greywater in the context of domestic uses of water. However, the Minister does have the power to declare any use of water a 'controlled activity' for purposes of the Act,[12] provided that such activity will impact the resource detrimentally.[13] In such circumstances, the Minister is required to specify the waste treatment, pollution control and monitoring equipment, as well as the management practices to be followed to prevent pollution of any water resources.[14]

In terms of the authority to provide for general authorisations, the Minister published a notice revising general authorisations [Revision of General Authorisations in terms of section 39: GN 665 of 6 September 2013: Government Gazette No. 36820]. This notice makes specific reference to 'greywater'. No explicit guidelines are provided in these regulations for the domestic use of greywater, save for the disposal to an onsite facility and the permission to reuse domestic wastewater.

In respect of this notice, a general authorisation has been granted in terms of section 38 of the Act to the lawful occupier of land, or person/s who have lawful access to the land, for the disposal of water. In terms of greywater, the general authorisation provides that the lawful owner or occupier of land, or person/s who have lawful access to land, may dispose of wastewater to an onsite disposal facility for greywater generated by a single household. There are restrictions on this general authorisation insofar as the onsite disposal facility is located close to a

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[8] NWRS, 107
[9] NWRS, 109.
[10] NWRS, 31.
[11] S37(1)(a).
[12] S38.
[13] S38(2).
[14] S29(1)(d).

watercourse, wetland, over an aquifer, or below the one in a hundred-year flood line.[15] The notice provides the following relevant definitions:

- Wastewater: water containing waste, or water that has been in contact with waste material.
- Domestic wastewater: wastewater arising from domestic and commercial activities and premises, and may contain sewage.
- Greywater: wastewater generated through domestic activities and premises, including washing, bathing and food preparation, but does not contain sewage.
- Onsite disposal: refers to the disposal of wastewater on individual properties not permanently linked to a central waste collection, treatment and disposal systems, such as septic tank systems, conservancy tank systems, soakaway systems, French drains, pit latrines, some package plants and related activities.

The general authorisation set out in this notice also extends to the storage of domestic wastewater for the purposes of reuse. Though specific reference is not made to greywater within the ambit of this provision, it is arguable that greywater falls within the wider definitions of wastewater and domestic wastewater. Greywater is more narrowly defined, excluding sewage. Given that this general authorisation is in respect of domestic wastewater, which definition includes sewage, greywater is necessarily included within its scope. This authorisation provides that the owner, lawful occupier, or person/s lawfully entitled to access land may store up to 5000 cubic metres of domestic wastewater for reuse. This is subject to the requirement that the stored wastewater does not impact a water resource, any other person's water use, property or land. In addition, the storage of wastewater must not be detrimental to the health and safety of the public near said storage.

3.2.3 The Water Services Act (Act 108 of 1997)

Insofar as the Water Services Act is concerned, no reference is made to greywater. This Act pertains to the provision of water supply and sanitation services. It is concerned with the powers and duties of the various administrative bodies that are required to provide such services. The Department of Water and Sanitation considers greywater to fall within the ambit of sanitation services, in terms of the Water Services Act (see the National Sanitation Policy, 2016, discussed below). The Regulations relating to Compulsory National Standards and Measures to Conserve Water (GNR.509 of 8 June 2001) provide for the disposal of greywater. In respect of these regulations, a water services institution is empowered to provide the limitations for the use of greywater, in circumstances where the use thereof will have a negative impact on the environment, health or other water

[15] Reg 3.13.

resources.[16] A water services institution includes a water services authority, a water services provider, a water board, and a water services committee.[17]

Greywater is defined as "*wastewater resulting from the use of water for domestic purposes, but does not include human excreta*". These regulations also include greywater within the definition of 'effluent'. The regulations provide that it is permissible to use effluent upon approval from a water services institution. The obligation falls on the water services institution to ensure that use of such effluent does not pose a health risk, prior to approval of this use.[18] Where effluent or non-potable water, including greywater, is accessible via a tap, a sign must be clearly and permanently displayed that states that the water is non-potable (*ibid*).

3.2.4 National Sanitation Policy (GN 70 of 12 February 2016: Government Gazette No 39688)

The National Sanitation Policy (GN 70 of 12 February 2016: Government Gazette No 39688) also makes reference to greywater, defining it as "*wastewater resulting from the use of water for domestic purposes, but does not include human excreta*".[19] The Policy states further that, in the context of the management of greywater where there is on-site sanitation, *"[Water Services Authorities] are responsible for ensuring that national greywater guidelines are adhered to, and DWA monitors this adherence. There is, however, no enforcement mechanism to ensure compliance, and legislative reform around the Compulsory National Standards is needed to address the issue of greywater*."

This policy acknowledges the importance of proper management, storage and treatment of greywater, given the potential health implications.[20] The policy also acknowledges the important role that reuse of greywater can serve in alleviating the pressures on demand for water resources and encourages greywater recycling by decentralised and centralised systems (*ibid*). In this respect, the policy provides that the Minister will develop regulations for the "*use, re-use recycling and recovery of the liquid, solid and gaseous constituents of human wastewater and excreta*".[21] The policy also actively advocates the reuse of wastewater.

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[16] Reg 7 of the Regulations relating to compulsory national standards and measures to conserve water.
[17] S 1 of the Water Services Act;
[18] Reg 8 of the Regulations relating to compulsory national standards and measures to conserve water.
[19] National Sanitation Policy, 6.
[20] National Sanitation Policy, 23.
[21] National Sanitation Policy, 24.

3.2.5 National Environmental Management Act (Act 107 of 1998)

The publication of the Environmental Impact Assessment Guideline for Aquaculture in South Africa (GN 994 of 3 October 2013: *Government Gazette* No. 36894), published in terms of the National Environmental Management Act 107 of 1998, actively encourages the use of greywater for the irrigation of landscapes. Greywater in this context refers to water "*generated by washing and other non-sewerage activities*".[22] The Environmental Impact Assessment Guideline for Renewable Projects (GN 989 of 16 October 2015: *Government Gazette* No. 39297) similarly encourages consideration of the use of greywater in the context of mitigating environmental impacts in the context of biomass energy projects.[23]

3.2.6 National Building Regulations (SANS 10400-Q: 2011, Third Edition)

According to the application of the National Building Regulations (SANS 10400-Q: 2011, Third Edition), greywater is defined as "*domestic wastewater excluding toilet water*". The standards further provide that greywater must be disposed of in a separate system to a ventilated pit toilet.[24] There is no definition provided for greywater in the National Building Regulations and Building Standards Act No. 103 of 1977, nor any of the Act's concomitant regulations (in particular, GNR.2378 of 12 October 1990: Regulations in terms of section 17(1) of the Act). The Act recognises only storm water and sewage ("*domestic wastewater including toilet waste*") as water leaving a property and provides regulations for how each is to be managed. In terms of the NBR, there is therefore no provision for the storage and use of greywater within the boundaries of a property, nor are there ways in which to certify and manage such activity.

As noted above, in terms of the National building regulations (NBR), there is no provision for the storage and use of greywater within the boundaries of a property, nor are there ways in which to certify and manage such activity. Similarly, there are currently no SABS standards governing the management and use of greywater. The SABS Standards Division is consequently initiating the development of a national standard under its Technical Committee SABS/TC224 on greywater reuse – for greywater treatment systems and reticulation infrastructure. SANS10400-XB will address all water systems in a building and will be included and implemented under the NBR. In this way, the implementation of guidelines for greywater harvesting systems will fall within the design requirements for buildings; and the installation of greywater reuse systems will have to be done to specifications by a registered plumber. Responsibility for the maintenance of these systems should remain with the property owner / occupier. In circumstances where there is a transfer of ownership the new property owner becomes liable for maintenance. It is worth considering whether the plumbing certificate

[22] 20.5.
[23] Table 2.
[24] 4.4.6.

required for transfer of ownership of property should also include inspection of the greywater system if one is installed. The initial standard will focus on the requirement for all greywater reuse systems in buildings to include proper design components such as treatment options and flow diversion to sewer.

3.2.7 National Health Act (Act 61 of 2003)

The National Environmental Health Norms and Standards for Premises and Acceptable Monitoring Standards for Environmental Health Practitioners (GN 1229 of 24 December 2015: *Government Gazette* No. 39561), published in terms of the National Health Act 61 of 2003, provides the norms and standards for environmental health, which is applicable at the provincial and local level.[25] These norms and standards provide a definition of greywater as follows: "*Refers to wastewater that does not contain significant amounts of faecal pollution (i.e. not sewage discharges). Typically, it consists of water discharged from baths, showers and/or sinks*".

In terms of these published norms and standards, the Standards for Health-Related Water Quality Management on Premises are set out. Safe water is defined as "*water that has been tested and does not present any significant risk to health over a lifetime of consumption (microbiological, physical and chemical quality)*". Standards are provided for the use of greywater. The use of greywater is limited to the flushing of toilets and for irrigation and must not be used for the purposes of drinking, cooking, personal hygiene.[26] The norms and standards provide that any household water created from laundry, dishwashing and bathing should be recycled prior to its use for irrigation purposes and constructed wetlands.[27] The disposal of greywater must be safe.[28] Education of users and communities is required in terms of the health and hygiene implications of the use thereof.[29] The norms and standards suggest that any use of greywater should be subject to prior approval being obtained from a Water Services Institution.[30]

They also provide that the Water Services Institution should consult with an Environmental Health Practitioner prior to granting any approval, in terms of which the Health Practitioner should test the effluent for compliance monitoring purposes (*ibid*). Any point at which the greywater could be accessed, for example, a tap or point of access, must be clearly marked indicating the presence of effluent and its non-potability.[31] The norms and standards also caution against the cross-connection of systems to avoid the contamination of potable water.[32]

[25] 5.
[26] 10(2).
[27] 10(2)(b).
[28] 10(2)(a).
[29] 10(2)(c) read with 12(2)(a).
[30] 10(2)(d).
[31] 10(2)(e).
[32] 10(2)(f).

3.3 PROVINCIAL REGULATIONS

There are no provincial regulations governing the use of greywater. The Ikapa Growth and Development Strategy (Ikapa Gds), which serves as a white paper for the Western Cape (*Provincial Gazette* No. 6500: Local Authority Notice of 2008), does, however, acknowledge the importance of using greywater, and recommends that greywater be re-used to flush toilets.[33]

3.4 MUNICIPAL / LOCAL REGULATIONS

Some local authorities in South Africa, e.g. Cape Town Municipality, have introduced policies and by-laws (many in draft form) which provide guidance relevant to the management and use of greywater for irrigation, either explicitly or implicitly (City of Cape Town, 2005) – see Appendix B for full details in this regard. However, the status of such guidance remains in doubt if the status of greywater use in terms of the national legislation is not clarified.

3.5 COMPARATIVE LAW APPROACHES

This section aims to provide a brief overview of the approaches adopted in foreign jurisdictions to the regulation of greywater. The jurisdictions discussed have been chosen on the basis that they specifically and directly regulate the use of greywater. By contrast, some jurisdictions indirectly regulate the usage of greywater through health and safety laws, building or plumbing regulations.[34] There are a variety of approaches adopted to the regulation of greywater across the globe, ranging from an outright ban on the reuse of greywater to mandatory and incentivised use of such water.[35] The countries discussed below all allow for reuse under specified circumstances. According to Gross *et al.*, regulation of greywater usage should essentially aim to reduce the risk of using this water source.[36] The way this can be achieved through legislation is threefold:

i. *"Prevention at source (e.g., removal of toxic substances that may harm the environment or negatively affect the treatment process)*
ii. *Treatment to remove pollutants (e.g., biodegradation and disinfection)*
iii. *Reduction of exposure (e.g., subsurface drip irrigation and banning the use of greywater for irrigating vegetables)"*

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[33] 7.2.
[34] L Allen, C Christian-Smith & M Palaniappan Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management Pacific Institute (2010) 17.
[35] L Allen, C Christian-Smith & M Palaniappan Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management Pacific Institute (2010) 17-18.
[36] A Gross, A Maimon, Y Alfiya, E Friedlander *Greywater Reuse* (2015) CRC Press 170.

A distinction can be drawn in the prevalence of use of greywater in high and low water availability areas. For example, in the UK and Germany, the use of greywater is permitted, though usage of these systems remains low given the abundance of water.[37] Germany is one of the leaders of the progression towards reuse of greywater on the European continent.[38] Local legislation specifically draws a distinction between black and greywater (*ibid*). Similarly, Norway does not experience any difficulties related to the quantity of available water, yet it is actively pursuing the use of greywater systems to be more environmentally conscious.[39]

3.5.1 **Australia**

Australia is considered to be the world's largest supporter of the use of greywater.[40] While the Australian government has published general guidelines for the usage of greywater, each state with Australia has individual competence to enact its own regulations governing the use of greywater.[41] This means that the permissible usage of greywater will vary from state to state: for example, Tasmania requires all water to be treated prior to re-use, whilst New South Wales allows for the re-use of untreated greywater for the purposes of subsurface irrigation (*ibid*); Canberra requires the installation of greywater system to be inspected post-installation, while the installation and/or usage of a greywater system without prior approval is an offence in Western Australia.[42] The usage of greywater by domestic users is incentivised by the national government through a rebate programme.[43]

3.5.2 **California and Arizona, USA**

California generally requires a permit for the use of greywater, though no permit is required for the use of greywater in instances of single or two-family dwellings.[44] Initially, Californian law provided a strict and

[37] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 615.
[38] A Gross, A Maimon, Y Alfiya, E Friedlander *Greywater Reuse* (2015) CRC Press 170.
[39] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 615.
[40] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 609.
[41] L Allen, C Christian-Smith & M Palaniappan Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management Pacific Institute (2010) 18.
[42] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 609.
[43] L Allen, C Christian-Smith & M Palaniappan *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management* Pacific Institute (2010) 18; R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 609.
[44] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 602.

cumbersome framework, with the result that thousands of installed greywater systems were, in effect, illegal (*ibid*). Following urgent legal interventions in the face of a serious and crippling water shortage, less draconian requirements were implemented, which had the effect of reducing the cost of installing a legal greywater system from approximately $20,000 to $150 (*ibid*). For example, whereas previously the greywater system had to be buried no less than nine inches underground, the new codes provide that water may be released above ground, provided that 2 inches of material such as rock or mulch cover the release point (*ibid*).

Other restrictions include the prohibition of re-use of water used for washing of car parts or any other activity where grease or oil are used (*ibid*). The use of kitchen water and water from dishwashers is not permitted.[45] Arizona is cited as having the best regulations governing greywater in the USA.[46] In circumstances where less than 1514 litres of greywater is used per day, and a 13-point checklist is satisfied (set out in Table 3-1), a blanket permit is issued and no application is required for permission.[47] This first tier use is subject to the requirement that human contact with greywater is limited, any greywater storage tanks must be covered and the ability of greywater to stagnate in standing pools must be minimized.[48] In addition, any use of greywater for irrigation purposes may not use any water that has been used to wash diapers (and other soiled items) unless it has been disinfected (*ibid*). Irrigation may only occur via flood or drip-irrigation (*ibid*).

The second tier of permits are awarded to those who are not entitled to a blanket permit, and in circumstances where the user is institutional, commercial or multi-family.[49] Any greywater system that processes more than 11,356 litres of water per day is required to apply for an individual permit in respect of the third tier of permissions (*ibid*). The use of greywater is incentivized through a taxation subsidy scheme.[50]

[45] J Steele "Plumbers To The Rescue: Incentivizing Experts To Proliferate Graywater" 36 U. La Verne L. Rev. 323 2014-2015 328.

[46] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 603; CS Bronin "The Quiet Revolution Revived: Sustainable Design, Land Use Regulation, and the States" 93 Minn. L. Rev. 231 2008-2009 271.

[47] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 604; CS Bronin "The Quiet Revolution Revived: Sustainable Design, Land Use Regulation, and the States" 93 Minn. L. Rev. 231 2008-2009 272.

[48] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 605.

[49] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 604.

[50] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 606.

Table 3-1: Arizona state – 13 requirements for use of greywater

1.	Human contact with gray water and soil irrigated by gray water is avoided
2.	Gray water originating from the residence is used and contained within the property boundary for household gardening, composting, lawn watering, or landscape irrigation
3.	Surface application of gray water is not used for irrigation of food plants, except for citrus and nut trees
4.	The gray water does not contain hazardous chemicals derived from activities such as cleaning car parts, washing greasy or oily rags, or disposing of waste solutions from home photo labs or similar hobbyist or home occupational activities
5.	The application of gray water is managed to minimize standing water on the surface.
6.	The gray water system is constructed so that if blockage, plugging, or backup of the system occurs, gray water can be directed into the sewage collection system or on-site wastewater treatment and disposal system, as applicable. The gray water system may include a means of filtration to reduce plugging and extend system lifetime.
7.	Any gray water storage tank is covered to restrict access and to eliminate habitat for mosquitoes or other vectors.
8.	The gray water system is sited outside of a floodway.
9.	The gray water system is operated to maintain a minimum vertical separation distance of at least five feet from the point of gray water application to the top of the seasonally high groundwater table.
10.	For residences using an on-site wastewater treatment facility for black water treatment and disposal, the use of a gray water system does not change the design, capacity, or reserve area requirements for the on-site wastewater treatment facility at the residence, and ensures that the facility can handle the combined black water and gray water flow if the gray water system fails or is not fully used.
11.	Any pressure piping used in a gray water system that may be susceptible to cross connection with a potable water system clearly indicates that the piping does not carry potable water.
12.	Gray water applied by surface irrigation does not contain water used to wash diapers or similarly soiled or infectious garments unless the gray water is disinfected before irrigation.
13.	Surface irrigation by gray water is only by flood or drip irrigation.

3.5.3 Israel

The Israeli Ministry of Health has published regulations on the requirements for the quality of greywater that is permitted to be re-used for the watering of gardens and flushing of toilets.[51] Use of greywater is subject to permission being obtained from the Ministry of Health, and small-scale domestic users do not qualify for such approval; permission is only extended to local authorities or businesses.[52] This has resulted in the installation of greywater systems in domestic households, unbeknownst to the Ministry of Health (*ibid*).

3.5.4 Japan

It is common practice for water used for hand washing to be re-used to flush toilets.[53] In Tokyo, the use of greywater is mandatory in respect of buildings over 30,000 square meters, and the usage of greywater by other users is incentivised.[54]

3.6 PROVISIONAL RECOMMENDATIONS REGARDING LEGISLATION

Whilst existing legislation does not specifically exclude use of greywater for irrigation and/or other purposes, there are inconsistencies which arise from the absence of a clear definition of greywater as a subset of domestic wastewater, which differs in character and hazards from blackwater (wastewater including toilet waste). These need to be resolved to clarify the legal position of use and management of greywater – particularly in respect of any personal liability which may arise for individual home-owners. There needs to be consistency between national Departments in terms of the understanding and use and/or management of greywater, particularly the Department of Water and Sanitation, Department of Health, and the Department of Environmental Affairs. Haphazard regulations do not contribute to a consistent understanding of the intention and requirements of the law.

[51] A Gross, A Maimon, Y Alfiya, E Friedlander *Greywater Reuse* (2015) CRC Press 230.
[52] A Gross, A Maimon, Y Alfiya, E Friedlander *Greywater Reuse* (2015) CRC Press 231.
[53] R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 616.
[54] L Allen, C Christian-Smith & M Palaniappan *Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management* Pacific Institute (2010) 18; R F Snodgrass "Greywater - The Reuse of Household Water: A Small Step Toward Sustainable Living and Adaptation to Climate Change" 22 *Geo. Int'l Envtl. L. Rev.* 591 2009-2010 616.

The following provisional recommendations regarding legislation are suggested:

- A universal definition of greywater is to be included in national legislation, regulations and local bylaws.
- A distinction should be drawn between greywater and black water, as well as between greywater and other treated wastewater, such as treated sewage effluent.
- The definition of greywater should distinguish between the re-use of greywater for outdoor and indoor uses.
- The requirements for the usage of greywater should be clearly stipulated.
- Specific guidelines are needed regarding the installation and management of greywater systems in terms of building regulations, so that installations meet certain standards and are certified as such.
- Should a permit be required for the usage of greywater, the procedural requirements for obtaining such a permit should be clearly stated.
- Various tiers of permission will be required depending on the nature of the use of the greywater.
- A distinction must be drawn between small-scale use and wider reuse categories (single-family, multi-family, commercial, industrial, institutional).
- Greywater may not be sold or given to people / institutions outside of the property upon which it is generated.
- Any regulations must consider the potential for actual implementation and compliance, as well as the required oversight function of the relevant authority.
- Worldwide, the greatest challenge posed in the context of the regulation of greywater, is the implementation and enforcement of the requirements.[55] It is envisaged that this will be a significant problem in the South African context as well, given the difficulty of monitoring the usage of such water.

[55] A Gross, A Maimon, Y Alfiya, E Friedlander *Greywater Reuse* (2015) CRC Press 164.

CHAPTER 4: HEALTH RISKS ASSOCIATED WITH GREYWATER HARVESTING

4.1 INTRODUCTION

According to most accepted definitions drawn up with reuse or recycling in mind, the term 'greywater' refers to untreated household wastewater which has not been contaminated by toilet waste or other sources of faeces. It includes the water from bathtubs, showers, hand basins, laundry tubs and washing machines. It does not include waste from kitchen sinks, garbage disposal units or dishwashers. It is called greywater because if stored for even short periods of time, the water will become turbid (cloudy) and grey in colour. It is usually defined in terms of the *sources* of the used water, as testing for the *quality* of used water in the domestic setting is not feasible, even in well-resourced countries. *This leaves a certain measure of uncertainty regarding the quality of the used water, since that will depend critically on the sanitation hardware, domestic arrangements and hygiene practices in a household.* The inclusion or exclusion of sources of greywater varies according to countries and organizations.

4.2 COMPOSITION OF GREYWATER

Greywater contaminants will vary from house to house, with the contents depending amongst other factors on the number of persons living in the house, their lifestyles and their ages. Households with babies or small children produce greywater with higher faecal counts. So, do households with pet animals (especially if the pets are bathed or washed on the premises). Households with inhabitants suffering from acute diseases such as gastroenteritis, eye or ear infections or waterborne hepatitis (jaundice) can produce greywater with considerable loads of bacteria or viruses during the course of the illness. Households with persons living with a chronic infectious condition (e.g. HIV/AIDS, tuberculosis) will produce greywater with increased infection risks over the long-term.

Even greywater from which water from the kitchen sink has been excluded contains appreciable amounts of soaps and detergents, fabric softener, detergents, shampoo, soap, hair conditioner, toothpaste, medicines, disinfectants, food particles, pesticides, dyes, cosmetics (make-up), lint and other fibres. Human waste products such as saliva, sweat, body oils, hair, blood, and some urine and faecal matter are additional sources of contamination.

A comprehensive description of the likely microbiological and chemical composition of greywater is discussed in Section 4.3, and examples of pathogens (microbial organisms able to cause disease) that could typically be present in greywater are listed in Table 4-1. The diseases caused by such pathogens are mainly gastroenteritic diseases, skin infections and eye and ear infections. Among the viral pathogens, hepatitis (jaundice) also features prominently. In endemic areas, diseases such as cholera and schistosomiasis (bilharzia) can also pose a serious risk. It must be kept in mind that once a communicable infection has taken hold in a few individuals from a contaminated water source, it can spread by means of person to person contact or as airborne or foodborne infection (depending on the pathogen).

After the initial contact, water does not have to be the only vector. If greywater is used on a wide scale by thousands of homes, incidents of accidental ingestion and contamination will inevitably occur, especially if supervision of the adherence to safety precautions is not conscientiously carried out (Mitakakis, Sinclair & Leder, 2004). Thus, the potential for waterborne diseases will inevitably rise under such circumstances. Public health authorities should be aware of this. One of the points in a well-planned greywater policy should be a decision on what frequency of contamination incidents and/or water-related diseases constitute a sufficient level to sound the alarm for the re-assessment of the continued use of greywater in that community.

Whilst some research has been undertaken on other countries around the world, the ranges of contaminants and their potential health impacts under South African conditions are relatively unknown. This is an area of research that needs urgent attention before any evidence-based advice can be provided or scientifically grounded regulations and policies constructed.

4.3 RISKS TO HUMAN HEALTH

4.3.1 Overview

Greywater composition varies widely from household to household, depending on the health conditions prevailing in the home, the personal habits of the residents and the products used in the home (Findlay, 2008). It is fair to say that the composition of pollutants in greywater produced in any home will reflect the health and sanitation situation prevailing during both the actual period that the greywater was produced as well as - in the case of some pollutants - the long-term usages and conditions in the home. A growing body of evidence indicates that the greatest risk of infection for enteric pathogens is borne by persons less than 19 years of age (Nwachuku & Gerba, 2004). Children are more likely to become ill from consumption of contaminated water and from exposure via recreational activities. This may be because their immunological, neurological and digestive systems are still developing and/or because they are environmentally more exposed.

Persons with compromised immune systems or those who suffer from other health conditions are also at increased risk. Old people, pregnant women, patients suffering from HIV/AIDS, TB, malnutrition and other chronic diseases also fall into this category. In South Africa, this collection of people comprises a sizeable proportion of the population. The following sections summarise information provided in many authoritative reviews about the pollutants in greywater that are associated risks for human health. They all provide standard information and thus the statements are not referenced individually (Benami *et al.*, 2016; Toze, 2004; Toze, 2006; Po, 2004; Findlay, 2008).

4.3.2 Microbial pathogens causing contamination of greywater

The most common human microbial pathogens found in water are enteric in origin. Enteric pathogens originate from the faeces of infected hosts and can enter water either directly through defecation into water, contamination with sewage effluent or from run-off from soil and other surfaces. The types of enteric pathogens that can be found in water include viruses, bacteria, protozoa and helminths (Table 4-1). The risk of acquiring water-borne infection from pathogens in greywater is dependent on a similar range of factors including pathogen numbers and dispersion in water, the infective dose required and the susceptibility of an exposed population, the chance of faecal contamination of the water and amount of treatment undertaken before potential exposure to the water. Most waterborne diseases are caused by pathogens typically transmitted by the faecal-oral route. However, pathogens released into water from skin or hair, wounds, pustules, urine, mucus, saliva and sputum and blood can also be transmitted. Some pathogens can also be excreted by healthy carriers who show no disease symptoms themselves. Infections are generally contracted by drinking contaminated water, recreational exposure to contaminated water, inhaling contaminated aerosols, ingesting shellfish from contaminated estuaries, or the consumption of raw food irrigated by contaminated water or organisms transmitted in the process of preparing food.

The faecal-oral route that is mentioned numerous times in relation to the risk of transmitting infection when greywater sources are applied to the environment is a pathway of infection that is implicated in many outbreaks of disease. The faecal-oral route involves transmission of infectious particles from surfaces contaminated with faecal matter or the organisms that came from excreta to the mouth via contaminated hands. It can readily be seen that the faecal-oral route is a major concern where contamination of surfaces such as lawns, plants and paved areas with faecal matter spread along with the greywater through touching. This is the reason why it is imperative that all persons living on premises where greywater is reused wash their hands in clean water regularly and always before eating, handling food or caring for babies.

Table 4-1: Common microorganisms in untreated domestic wastewater **(adapted from U.S. Environmental Protection Agency, 2004 Guidelines for Water Reuse, EPA/625/R-04/108)**

Examples of pathogen	Examples of diseases caused
Bacteria	
*Escherichia coli (*enterohaemorrhagic (EHEC), enterotoxigenic (ETEC), enteroinvasive (EIEC), enteropathogenic (EPEC), enteroaggregative (EAEC) and diffuse adherent (DAEC)	Gastroenteritis, septicaemia, haemolytic uremic syndrome, eye, ear, skin infections. Human excreta are the principal source of all pathogenic *E. coli*.
Shigella spp.	Shigellosis (bacillary dysentery)
Salmonella typhi	Typhoid fever
Salmonella other (1700 serotypes)	Salmonellosis
Vibrio cholerae	Cholera
Campelobacter jejuni	Gastroenteritis, reactive arthritis
Pseudomonas aeruginosa	Gastroenteritis, eye, ear infections, dermatitis
Aeromonas spp.	Gastroenteritis, wound infections
Viruses	
Enteroviruses (polio, echo, coxsackie, new enteroviruses, serotypes 68 to 71)	Gastroenteritis, heart anomalies, meningitis, others
Adenoviruses	Respiratory disease, eye infections, gastroenteritis (serotype 40 and 41)
Hepatitis A, enterically transmitted Non-A, non-B hepatitis viruses, hepatitis E	Infectious hepatitis
Norwalk virus	Gastroenteritis
Rotavirus	Gastroenteritis
Small round viruses (as calici viruses)	Gastroenteritis, food poisoning
Protozoa	
Entamoeba histolytica	Amoebiasis (amoebic dysentery)
Giardia intestinalis (formerly known as Giardia lamblia or **Giardia duodenalis***)*	Giardiasis (gastroenteritis)
Cryptosporidium parvum	Cryptosporidiosis, diarrhoea, fever
Microsporidia	Diarrhoea
Helminths	
Ascaris lumbricoides	Ascariasis (roundworm infection)
Ancylostoma spp.	Ancylostomiasis (hookworm infection)
Necator americanus	Necatoriasis (roundworm infection)
Ancylostoma spp.	Cutaneous larva migrans (hookworm infection)
Trichuris trichiura	Trichuriasis (whipworm infection)

4.3.2.1 Bacteria

Bacteria are the most common and numerous of the microbial pathogens found in recycled waters. There is a wide range of bacterial and other opportunistic pathogens which can be detected in wastewaters (see Table 4-1 for examples). Many of the bacterial pathogens are enteric in origin; however, bacterial pathogens which cause non-enteric illnesses (e.g. *Legionella* spp., *Mycobacterium* spp., and *Leptospira*) have also been detected in wastewaters. Enteric pathogenic bacteria can often infect both humans and animals, e.g., *Salmonella,* and thus animals can be another contamination source for recycled water as well as being at risk from contact with poorly treated recycled water. Most pathogenic enteric bacteria require ingestion of a high dose of cells to cause infection (up to $>10^6$ cells), although *Shigella dysenteriae* and *Campylobacter jejuni* have been observed to only require the ingestion of as few as 100 cells to cause infection in susceptible hosts. There are numerous individuals in South Africa with impaired immune systems arising from such causes as HIV positivity, tuberculosis, malnutrition and lifestyle factors such as smoking and overuse of substances e.g. alcohol. In addition, the persons at the two extremes of the age spectrum (the very young and the very old) are also especially susceptible to serious waterborne infections. High numbers of vulnerable individuals live in lower-income areas and dense settlements where many suffer from more than one of the risk factors named.

Survival and multiplication or regrowth of bacteria in greywater or in biofilms formed by greywater depend mainly on the type of organism, the chemical and biological environmental conditions, the presence of competing microorganisms and the available nutrients. Thus, what may under one set of circumstances, be a 'safe' use of certain greywater can change into a risk when the circumstances change. At the domestic level, the greywater user cannot keep track of the changes that can cause the proliferation of dangerous organisms or previously low levels of organisms that unexpectedly rose to the dangerous levels.

4.3.2.2 Viruses

Viruses do not replicate in the environment (outside their hosts) but they can persist for as long as 6 months. That makes them a class of pathogens that carry an increased risk when household greywater is applied to the immediate environment without any treatment. Most human enteric viruses have a narrow host range, meaning that only human faecal contamination of water need be considered as a risk for viral infection of humans. Enteric viruses are highly infectious and commonly require the ingestion of only a few viral particles in total to cause infection. These infectious doses can be as few as 10 viral particles or fewer. It is to be expected that these viruses would have a greater potential to cause infection in susceptible sections of the population such as the elderly, very young and the immunocompromised. As can be seen in Table 4-1, there are also other serious infections that can be transmitted by contaminated water and surfaces, namely eye, ear and skin infections, hepatitis (jaundice) and meningitis. All these are just examples of the vast array of possible infections and the actual risk is extremely varied as it depends on the prevailing diseases in the community, the state of the sanitation systems, the consistent and meticulous care with which the reuse systems are operated and the insight and knowledge of the inhabitants.

4.3.2.3 Protozoa

There are several protozoan pathogens that have been isolated from wastewater and recycled water sources. Outside of an infected host, protozoa persist as dormant stages known as cysts or oocysts. The most commonly detected protozoa are *Entamoeba histolytica, Giardia lamblia (intestinalis)* and *Cryptosporidium parvum.* These three parasites are of major concern to operators involved in the recycling of water, particularly water which has been in contact with human and animal faecal matter. Infection from all three these protozoan pathogens can occur after consumption of food or water contaminated with the cysts or oocysts or through person to person contact. Humans are the main reservoir for *C. parvum* and *G. intestinalis*, but several domestic and wild animals have been shown to be potential reservoirs for these parasites. Animals can for instance become infected with *C parvum* and then cause infection in humans due to contact with infected faeces. Like the enteric viruses, all human protozoan pathogens are significantly more infectious than most enteric bacterial pathogens. *Cryptosporidium*, *Giardia*, and *Entamoeba* have all been observed to have the potential to cause infection after ingestion of fewer than 10 (oo)cysts.

4.3.2.4 Helminths

Helminths mainly consist of nematodes and tape worms and are common intestinal parasites which can be transmitted by the faecal–oral route. Some of these parasites require an intermediate host for development prior to becoming infectious for humans. The helminths that have complex life cycles are not considered in this review as they are very rarely an infection concern in recycled water. Helminth parasites that are a significant health risk in reused water include the round worm (*Ascaris lumbricoides*), the hook worm (*Ancylostoma duodenale* or *Necator americanus*), and the whip worm (*Trichuris trichiura*) (see Table 4-1). These helminths have a simple life-cycle with no intermediate hosts and are usually transmitted via the faecal-oral route. The World Health Organization lists intestinal nematodes as the greatest health risk involving agriculture and aquaculture uses of untreated excreta and wastewater. It is important to note that the reuse of greywater has the potential to cause contamination of environmental waters and therefore the prevention of such cross-contamination should be strictly prevented. Helminth infections are particularly endemic where human faecal matter contaminates water used for growing vegetables. Infestation with nematodes leads to anaemia and malnutrition. Such infestations in children can also cause stunting and failure to thrive. In cases of serious infestation, it can predispose such affected individuals to other potentially fatal infections.

4.3.2.5 *Aspects of microbial contaminants of greywater that may be problematic*

Since the microbial composition of greywater can vary in a very large range, the risk distribution is difficult to determine. Household composition, housing infrastructure (particularly the sanitation arrangements), the health status of the inhabitants, the lifestyles and products used and not least of all the willingness to meticulously adhere to the prescribed treatment and other regulations regarding greywater reuse all determine the safety profile of such use. These factors are bound to vary enormously across local communities since it is often quoted that South Africa has one of the most unequal income distributions in the world. Therefore, a considerable amount of research still needs to be done before effective and safe regulations and infrastructure to enforce such regulations can be developed.

The species composition for different types of households and varying climatic conditions, antibiotic resistance patterns, effective treatment options in different communities are all examples of research still outstanding. Another aspect that needs a lot more attention from the scientific community is the accurate assessment of exposure for the various pathogen classes described above. There is no simple association between pathogen concentrations and disease prevalence. The origins of observed outbreaks of suspected water-related illnesses are notoriously difficult to pinpoint and hence the causes of many cases of waterborne disease go undetected. This leads to serious underestimation of the impact of water-related disease and can sometimes create a false sense of security.

4.3.3 **Chemicals of concern causing contamination of greywater**

Endocrine disrupting compounds and pharmaceutically active compounds are the classes of trace chemical contaminants causing the most concern in the reuse of greywater. They can originate from industrial or domestic sources and therefore occur in a wide range of recycled waters. Overall, these chemicals tend to occur at very low concentrations in treated recycled water (usually in the range of nanograms per litre). They also require the ingestion of large doses over long time periods to produce any clinical effect. There is a lack of research information on environmental persistence or on possible concentrations in recycled water. Without such reliable scientific information health regulations to protect the public are lagging.

4.3.3.1 *Endocrine disruptors (EDCs)*

EDCs are compounds not formed inside the body and which can have an impact on the structure and function of an organism’s endocrine system. These compounds can also cause health effects on the organism's progeny. There are a large number of compounds that are known or suspected endocrine disruptors. One of the most pervasive are the estradiol compounds commonly found in the contraceptive pill. There are also phytoestrogens, pesticides, industrial chemicals such as bisphenol A and nonyl phenol, and heavy metals.

Untreated sewage can be a source of all these compounds. This has created concern that these known and suspected EDCs may create health risks from potential contact with recycled waters.

The risk varies depending on the estrogenic potency of each compound. For example, the principal human oestrogen, 17β estradiol, has an oestrogen equivalent (EEQ) of 1, while nonyl phenol has an EEQ of 3×10^{-6} and DDT has an EEQ of 1×10^{-6}. Thus, a person would have to consume 1,000,000 parts of DDT to get the equivalent estrogenic response as 1 part of 17β estradiol. In addition, the concentrations of these chemicals in domestic wastewater are very low compared to the concentration in other sources. The concentration of 17β estradiol in raw sewage has been found to be as little as 19 ng/L whereas the modern oral contraceptive pill contains between 20 and 35 µg of oestrogen. The estimated daily dose for females from the contraceptive pill is 16,675 EEQ, while the equivalent daily EEQ dose from environmental organochlorides is 0.0000025. One has to keep in mind however, that humans can be exposed to these compounds over very long times. The cumulative effects are not well understood yet.

4.3.3.2 Pharmaceuticals

Pharmaceutically active compounds are an emerging area of concern for potential water reuse. Most of these chemicals are pharmaceutical drugs used for a variety of therapeutic purposes for both humans and animals. Examples include analgesics, antiretrovirals, anti-tuberculosis drugs, caffeine, anti-epileptics, cholesterol-reducing drugs, antibiotics and antidepressants. These drugs and other chemicals can enter the environment from a range of sources, but one of the main will be using recycled household greywater. Some of these compounds can possibly be degraded or removed by environmental processes but little is known on their fate in the environment. Like endocrine disruptors, the concentrations of pharmaceutically active compounds found in treated wastewaters and in environmental waters are significantly lower than the concentration found in medication used for therapeutic purposes. Thus, the exact health risk of these compounds in reclaimed water (particularly where minimal human or animal contact occurs) remains to be determined.

4.3.3.3 Disinfection additives - a special case

Domestic greywater is notable for the high concentration of soaps, detergents, and oils it contains. In addition, greywater contains pharmaceuticals and personal care products that include including antimicrobial agents such as triclosan. Triclosan (TCS; 5-chloro-2-(2, 4-dichlorophenoxy) phenol; CAS no. 9012-63-9) is the most commonly used antibacterial agent in the United States. Current estimates are that the discharge of this compound into the US environment is in the range of 300,000–500,000 kg yr^{-1} and use is increasing rapidly. (Harrow *et al*. 2011).

Triclosan is found in numerous products including clothing, toys, toothbrushes, rubber, hand soaps, toothpaste, deodorants, and laundry detergents. A concentration of 0.1% to 0.3% of triclosan can typically be found in consumer products. Triclosan is active against a wide range of both Gram-positive and Gram-negative bacteria. Several recent studies have proposed a link between triclosan resistance in bacteria and resistance to common antibiotics (Harrow *et al*, 2011), although other studies have questioned the existence of such a linkage. Triclosan and triclocarban are among 19 active ingredients banned by the US Food and Drug Administration in September 2016. Australia is planning to follow suit within 12 months. If past performance is anything to go by, it will take the South African authorities a long time before such a ban is instituted here.

Harrow *et al.* (2011) showed that under constant exposure, the community structure of organisms in the soil changed, showing two very distinct heterotrophic populations between those that were treated with triclosan and those that were not. It was also seen that due to the exposure to triclosan, resistance to four tested antibiotics (ampicillin, chloramphenicol, streptomycin and tetracycline) increased. Their results indicated that triclosan in greywater can have significant impacts on soil microbes. While the antibacterial products may be present in very minute concentrations, their constant presence may be selecting for bacteria that are resistant to all types of antibiotics, thus making it harder to treat. They conclude this is avoidable by treating the greywater before using it or by removing antibacterial products. They stated that there is a need for further investigation.

Baker *et al*. (2010) also found that irrigation of soil with triclosan-containing greywater resulted in both an increase in resistant bacteria and a concomitant decrease in overall microbial community diversity in the soil. They felt that these changes in the soil microbiota raise public health and environmental concerns about the release of untreated household waste streams into terrestrial ecosystems. Before irrigation with greywater can become a useful water reuse alternative, additional research focusing on the long-term impacts of triclosan and other pharmaceuticals and personal care products is needed.

4.3.3.4 Aspects of chemical contaminants of greywater that may be problematic

The concentration and distribution in of chemical contaminants in greywater tend to be more evenly distributed in water than microbial contaminants. This means that ingestion of an organic chemical in a volume of recycled water is easier to predict than for microbial pathogens. If their concentration in water is above the technical detection limits, the detection of chemicals-of-concern tends to be more straightforward than for the randomly distributed pathogens, especially those pathogens that tend to clump around silt or other particles. Pathogens normally affect the invaded host in a relatively short time. In contrast, toxic chemicals tend to have an effect only after constant, long-term exposure over a period of months or years. For endocrine disruptors and pharmaceutically active compounds this would require the ingestion of fairly large amounts of water over a long period of time before a significant health impact was observed. It has-been stated that, even if this very large exposure did occur, the actual concentration of compounds consumed would have minimal, if any, impact on a person or their offspring. This is however a pronouncement that needs careful research. One of the problems with assessing the health risks associated with chemicals of concern is the long latency period that usually occurs before symptoms develop. It is very difficult to pinpoint the exact contributions of the multiple exposures that any individual face over such a long time. This complex relationship may exert a contrasting influence - it may cause either over- or underestimation of the risks involved.

4.4 RISKS TO EDIBLE CROPS

4.4.1 Overview

Using greywater to irrigate edible crops, especially vegetables and fruits eaten raw or after minimal processing, is unsafe. Edible crops should only be irrigated with greywater in time of such severe food shortage that the risk of disease becomes less than the risk attached to compromised food supplies (a rare occurrence). There is a large body of evidence showing bacterial transmission from greywater or other wastewater to food crops and livestock kept for slaughter (Petterson & Ashbolt, 2001; Fasciolo *et al*., 2002; Sadovski *et al*., 1978). Clumping of viruses on lettuce and carrots irrigated by wastewater has been shown to occur (Petterson & Ashbolt 2001). Subpopulations of viruses showing high persistence also occur under these circumstances. These factors caused the risks associated with such contamination to be under-estimated.

Experiments in Mendoza, Argentina were carried out to assess the sanitary acceptability of crops irrigated with treated wastewater (Fasciolo *et al*. 2002). Garlic irrigated with wastewater only reached sanitary acceptability 90 days after harvest once the roots and soil were removed. Onions cleaned immediately after harvest reached sanitary acceptability 55 days after harvest. None of the irrigated crops were fit to consume raw at harvest. In some greywater advisory documents (some of those that are written from an engineering perspective), the user is only advised to withhold irrigation with greywater for one week before harvesting root crops (e.g. Marshall, 1997). This is not scientifically justifiable advice.

Sadovski *et al*. (1978) investigated the levels of microbial contamination of vegetables irrigated with wastewater by the drip method. They could show that irrigation carried out under plastic sheeting or buried under the soil surface significantly reduced crop contamination. Unfortunately, they also found that microbial contamination persisted in the irrigation pipes for at least 8 days and in the soil for at least 18 days. Abdul-Raouf *et al*. (1993) investigated the ability of *Escherichia coli* O157:H7 (a serious pathogen with a high associated mortality rate) to survive or grow on raw salad vegetables. This was done to study the fate of such organisms should the crops become accidentally contaminated before harvest and consumption. Populations of viable *E. coli*

O157:H7 declined on raw salad vegetables stored at 5°C, but increased on vegetables stored at 12°C and 21°C (conditions such as would occur in ordinary shelf storage).

4.4.2 Survival of pathogens in the environment

The ability of pathogenic organisms to survive in soil, in water and on surfaces has important implications to produce safe food and the health of humans and animals. Maule (2000) investigated the survival of *E. coli* O157:H7 in various settings such as river water, different soil cores and stainless steel and plastic surfaces. Survival of the organisms was greatest in soil cores under rooted grass. Under these conditions, a moderate decline occurred only after 130 days. The organism survived less readily in river water, where it fell to undetectable levels after 27 days. Air-dried deposits of the organism survived on stainless steel surfaces for periods more than 60 days. It was most stable at chill temperatures (4°C) and viability was only partially reduced at 18°C. The organism was also shown to survive for extended periods on plastic domestic food cutting boards at both chill and room temperatures. This data indicates the ability of some serious pathogens to persist in the environment beyond the expectations of some engineers and other advisors on greywater re-use projects.

Malkawi & Mohammad (2003) looked at the survival and accumulation of micro-organisms in soils with secondary treated wastewater as their source of pathogens. They irrigated soil samples with an amount of water equivalent to 100% of the Class A Pan evaporation reading, and some samples to 125% of the Class A Pan reading. The bacteriological analyses showed that the total coliform count was highest on the soil surfaces. They stated that the results "*strongly suggest the necessity to treat wastewater effluents to an extent to which no or very few residual bacterial contaminants will be detected*". In practice, these results could be obtained with contaminated greywater as well and therefore their recommendation should be borne in mind by proponents of unrestricted application of greywater in home gardens.

4.5 HEALTH RELATED RESTRICTIONS WHEN USING GREYWATER

In the light of the lack of any uniform code of practice for the use of greywater in South Africa, it is important to follow internationally accepted guidance. Some general considerations are discussed below.

4.5.1 What is the intended use of the reclaimed water?

Consideration should be given to the expected degree of human contact with the reclaimed water. It is reasonable to assume that reclaimed water used for the irrigation of non-food crops on a restricted agricultural site may be of lesser quality than water used for landscape irrigation at a public park or school, which in turn may be of a lesser quality than reclaimed water intended to augment potable supplies.

4.5.2 Given the intended use of reclaimed water, what concentrations of microbiological organisms and chemicals of concern are acceptable?

Reclaimed water quality standards have evolved over a long period of time, based on both scientific studies and practical experience. Whilst requirements might be similar in different areas, allowable concentrations and the constituents monitored are area-specific, as well as being dependent on the use to which the greywater is put.

4.5.3 Which treatment processes are needed to achieve the required reclaimed water quality?

While it must be acknowledged that raw wastewater may pose a significant risk to public health, it is equally important to point out that current treatment technologies allow water to be treated to almost any quality desired. For many uses of reclaimed water, appropriate water quality can be achieved through conventional, widely practiced treatment processes. Advanced treatment beyond secondary treatment may be required as the level of human contact increases. Different treatment systems do however have different levels of effectiveness and also carry a wide range of associated running costs, as well as a wide variation in time and effort needed to maintain them.

4.5.4 Which sampling / monitoring protocols are required to ensure that water quality objectives are being met?

As with any process, wastewater reuse programs must be monitored to confirm that they are operating as expected. Once a process is selected, there are typically standard Quality Assurance/Quality Control (QA/QC) practices to assure that the system is functioning as designed. Reuse projects will often require additional monitoring to prevent the discharge of substandard water to the reclamation system. On-line, real-time water quality monitoring is typically used for this purpose.

4.6 MANAGING RISKS AND UNCERTAINTY

4.6.1 Overview

As outlined in previous sections, greywater harvesting has many health and environmental risks associated with it. It is therefore not surprising that all the identified reports between 2001 and 2013 highlight the need for a multi-barrier[56] approach to manage these risks – especially those related to managing the additional risks and challenges associated with health issues (e.g. Rodda *et al.,* 2010b; Ilemobade *et al.,* 2013). While the use for which greywater is being harvested was different in these two studies – Rodda *et al.* (2010b) largely focused on greywater use for agricultural and garden irrigation; and Ilemobade *et al.* (2013) focused on greywater harvesting to flush toilets – the principles for managing risks are equally applicable. It is clear, however, that these management approaches are very often not being followed, and greywater harvesting continues to take place in the absence of regulations, guidelines and management capacity (Ilemobade *et al.,* 2013).

For example, it has become increasingly evident that greywater is gaining in popularity as a source of water to irrigate edible crops such as lettuce at the household scale – and that there is no standardised guidance for this practice. This should be of concern as authors such as Franz *et al.* (2007) have shown that microbial contaminates in irrigation water are able to migrate from the soil surrounding the root system to the edible portion of lettuce plants through the root conducting tissues – although Jackson *et al*. (2006) note that the risk is different for varying edible crop types and whether the vegetable is eaten cooked or raw, and peeled or un-peeled.

Jackson *et al.* (2006); Rodda *et al.* (2010b); and Winter *et al.* (2011) have all shown that greywater often exceeds the microbiological standards for water. Rodda *et al.* (2010b) highlighted that the quality of greywater is dependent on its source; e.g. washing machine / laundry or bathroom. Certain sources pose a significantly higher health risk, and would therefore require additional barriers. While this is often highlighted, tools are not readily available to assess the risk. Until recently, risks within the water sector have been managed using end-use standards – water quality standards based on what the water is used for. The South African Water Quality Guidelines (DWAF, 1996a, 1996b, 1996c) reflect this approach. These guidelines are no longer based on the latest or most appropriate science and practice, however, and do not take account of site specificity in what are largely generic guidelines (Boyd *et al.*, 2015).

4.6.2 Greywater use risk assessment

There is already a move worldwide towards the use of risk assessment as a more effective approach (Howard *et al.*, 2006; WHO, 2008), as endorsed by the World Health Organisation (WHO) – through the use of the concept of Disability Adjusted Life Years (DALYs) which calculate both the number of years of potential life lost due to death (YLL) and the years lived with disability (YLD) in order to determine the health of a society and thus assess maximum tolerable risks (Maimon *et al*., 2010). Boyd *et al.* (2015) appear to indicate that South

[56] Risk-management interventions which minimise the exposure of human users, plants or soil to a given hazard – examples are washing hands, peeling and cooking vegetables etc. (Rodda *et al*., 2010b), or pre-treatment using chlorination and filtration prior to use for toilet flushing (Ilemobade *et al*., 2013)

Africa is also moving towards a risk based approach to water quality management in the current review of the SA Water Quality Guidelines.

The best way to mitigate risk is to form a multi-barrier approach, such as those which have been implemented in the management of drinking water quality, and recommended in the management of recycled water (NRMMC, 2006). This approach comprises the formation of multiple barriers that collectively reduce human risk exposure and is designed so that when one barrier fails to provide control, the remaining barrier(s) will continue to provide control Furthermore, by having multiple barriers, there is less variability in performance (risk reduction) in comparison to the use of just one barrier (NRMMC, 2006). The first barrier is designed to limit the number of pollutants in the greywater that will be reused for irrigation purposes, and is done by performing a Quantitative Microbial Risk Assessment (QMRA).

Howard *et al.* (2006) note that quantitative microbial risk assessment (QMRA) – an approach that makes use of the dose-response relationship of a pathogen to assess the risk of exposure – is considered by "*the WHO as a valuable tool for setting health-based targets and for validation of water safety plans". NRMMC* et al. *(2006, 2008, 2009)* adopted *the QMRA approach used by the WHO for use in Australia when assessing the risk of using recycled water and storm water for a range of purposes.*

The second barrier involves risk reduction methods that can be performed during or post irrigation to reduce the health risks – an example of some of the more common suggested barriers in this regard is shown in Table 4-2.

4.6.3 Quantitative microbial risk assessment (QMRA)

The World Health Organisation (WHO, 2006c) recommends that a four-step process be followed for a QMRA:

- Hazard identification
- Hazard characterisation
- Exposure assessment
- Risk characterisation

The problem with the use of the QMRA approach in the South Africa is that the selected pathogens (e.g. *Cryptosporidium, Campylobacter, Rotavirus*) on which the QMRA in Australia is based are not commonly tested for in water sources in South Africa. On the other hand, *E. coli* is regularly tested for as an indicator organism, and could potentially be used as a proxy (Howard et al., 2006). However, the relationship between *E. coli* counts and the presence or counts of other disease pathogens is complex and variable. There is no single indicator of disease risk that will be able to forecast the levels of many of the other potential pathogens that may also be present in greywater. Another complicating factor for the use of QMRA in South Africa is whether it can be easily understood both by installers and users; and whether the concepts of ‘disease burden’ and DALYs will have any significance also needs to be considered.

The management of waterborne risks in South Africa is currently transitioning from a relatively simplistic, generic approach to a more site-specific, risk-based analysis approach. It is envisaged that the updated SA Water Quality Guidelines will incorporate a ‘tiered’ guideline approach, with either an assessment or objective setting mode of use – to account for different levels of sophistication of users, and levels of risk. Further research is however required to determine how to incorporate the management of risk and build these concepts into the greywater resource guidelines.

Table 4-2: Greywater exposure scenarios and related barriers (Maimon *et al.*, 2010)

<table>
<tr><th>Exposure type</th><th>Exposure scenario</th><th>Suggested barriers</th></tr>
<tr><td rowspan="5">Direct</td><td>Accidental ingestion of greywater</td><td rowspan="5">• Wear protection when maintaining the system
• Mark the pipes as non-potable water
• Avoid human contact
• Restrict spray irrigation
• No ponding of water
• Use sub-surface irrigation
• Overflow to sewage
• Restrict food crops irrigation</td></tr>
<tr><td>Ingestion of greywater from irrigation system</td></tr>
<tr><td>Ingestion of soil contaminated with greywater</td></tr>
<tr><td>Inhalation of aerosols from spray irrigation</td></tr>
<tr><td>Eating fresh vegetables irrigated with greywater</td></tr>
<tr><td rowspan="3">Indirect</td><td>Groundwater pollution</td><td rowspan="3">• Apply setback distance from groundwater level
• Water should not flow outside property boundaries
• Locate outside drainage or flood zones
• Greywater should not get into open water bodies
• Overflow to sewage
• No ponding of water</td></tr>
<tr><td>Surface water pollution</td></tr>
<tr><td>Pathogen transmission through vectors such as mosquitoes</td></tr>
</table>

4.7 CONCLUDING REMARKS ON HEALTH RISKS

The benefits of harvesting greywater need to be carefully balanced with the risks associated with its use and unintentional misuse. Critics of overly restrictive policies for greywater re-use feel that rigid rules discourage home owners, and especially the urban poor, from utilising greywater as a resource. Unfortunately, making the use of greywater unrestricted (especially if there is no education about risks and no supervision) will increase the disease burden on those who can least afford it.

According to the latest HIV estimates by Statistics South Africa (2013) there are 5.25 million South Africans who are HIV positive while 17.4% of women between the ages of 15 and 49 years are HIV-positive. These women are in their peak childbearing years. They are also in the age and gender categories most likely to be involved in child care, as well as cooking and cleaning, where most of the household greywater is generated. In impoverished areas, they are also often involved in subsistence gardening, thereby coming into contact with polluted water (grey or otherwise). HIV infection damages the immune system and environmentally acquired infections can shorten the life expectancy of such persons. Added to the HIV burden in especially poor communities are those who suffer from TB, diabetes, smoking- and alcohol-related diseases and other chronic conditions. Greywater poses a much greater risk to those people than to the generally healthy, well-fed population of a First World country where much of our experience of greywater re-use originates.

In South Africa, the advantages brought by extra food supplies generated using greywater in impoverished areas should be balanced against the risks of infection in vulnerable groups, such as malnourished children and HIV positive persons. Achieving a balance in these special circumstances will be no easy task and the regulatory agencies should consult widely and debate wisely before they officially sanction the use of greywater. Key aspects of this would of necessity be the education that is crucial for the safe use of greywater and the supervision of adherence to essential safety precautions.

South Africa faces the conflicting demands of improving access to water for a large proportion of its inhabitants, while at the same time trying to improve the health of the population by reducing the risk disease from dirty, polluted environments. This conflict needs to be very carefully weighed by many stakeholders and affected public services before a decision on widespread re-use of greywater in an unrestricted and unsupervised way is encouraged publicly. Okun (2000) stated that re-use may be feasible, but *"it imposes added public health risks that need to be accepted only as a last resort."* It should be a subject for careful consideration of actual risks and wide consultation of affected persons before a decision is made on when that point of last resort is.

CHAPTER 5: USEFUL RESOURCES AND RECOMMENDATIONS FOR FUTURE STUDIES

5.1 GREYWATER HARVESTING PUBLICATIONS

A timeline of greywater-related research in South Africa undertaken over the last fifteen years (mainly funded by the Water Research Commission) is presented in Figure 5-1.

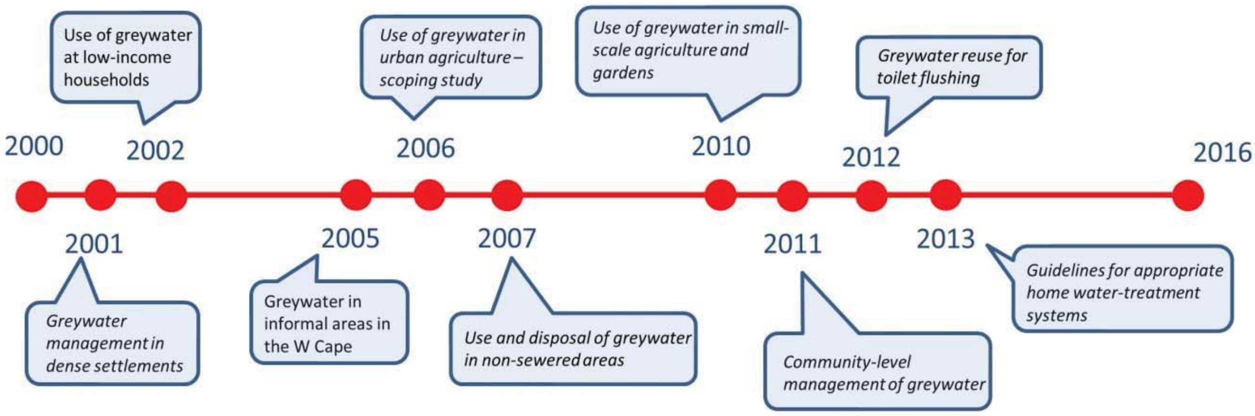

Figure 5-1: Timeline of greywater-related research in South Africa

Links to some of the existing South African guidelines relating to greywater harvesting are provided in Table 5-1, while Table 5-2 provides links to selected appropriate international guidelines and manuals.

Table 5-1: South African guidelines for greywater harvesting

Resource	Download
City of Cape Town's Alternative Water Resources Pamphlet 3 of 4: Greywater re-use	Download
eThekwini's Water Conservation Guideline	Download

Table 5-2: International guidelines for greywater harvesting

Resource	Download
Code of Practice for the Reuse of Greywater in Western Australia	Download
Overview of Greywater Reuse: The Potential of Greywater Systems to Aid Sustainable Water Management	Download

Table 5-3 provides links to all the greywater harvesting-related research studies published between 2006 and 2013. The reports from these studies provide useful and detailed resources in respect of greywater harvesting, and have provided much of the material used in the development of these guidelines.

Table 5-3: Greywater harvesting studies in South Africa

Year	Report Title	Download
2001	Greywater management in dense, informal settlements in South Africa. WRC Report no. 767/1/01 (Wood *et al*., 2001).	Hard copy only
2002	The possible use of greywater at low-income households for agricultural and non-agricultural purposes: a South African overview (Alcock, 2002).	Hard copy only
2005	Greywater in informal areas in the Western Cape: a management framework drawn from lessons learnt by three municipalities. Department of Water Affairs and Forestry Masibambane Project No. 271/2004 (Bergstan, 2005).	Hard copy only
2006	A scoping study to evaluate the fitness-for-use of greywater in urban and peri-urban agriculture. WRC Report no. 1479/1/06 (Murphy, 2006).	Download
2007	Understanding the use and disposal of greywater in the non-sewered areas in South Africa. WRC Report no. 1524/1/07 (Carden *et al*., 2007).	Download
2010	Sustainable use of greywater in small-scale agriculture and gardens in South Africa – Technical Report. WRC Report no. 1639/1/10 (Rodda *et al*., 2010a).	Download
2010	Sustainable use of greywater in small-scale agriculture and gardens in South Africa – Guidance Report. WRC Report no. TT 469/1/10 (Rodda *et al*., 2010b).	Download
2011	Sustainable options for community-level management of greywater in settlements without on-site waterborne sanitation. WRC Report no. 1654/1/11 (Winter *et al*., 2011).	Download
2012	Greywater reuse for toilet flushing in high-density urban buildings in South Africa: A pilot study. WRC Report no. 1821/1/11 (Ilemobade *et al.,* 2012).	Download
2013	South African guidelines for the selection and use of appropriate home water-treatment systems by rural households. WRC Report no. TT 580/13 (Momba *et al*., 2013).	Download

5.2 RECOMMENDATIONS FOR FUTURE STUDIES

This study has identified several areas of further research regarding the harvesting and use of greywater as a resource, as follows:

- Investigate the long-term health and environmental impacts of greywater use for irrigation purposes – including monitoring (e.g. through the implementation of strategic boreholes) and understanding the movement of salts and other pollutants in the soil and in groundwater resources.
- Conduct a thorough investigation of the composition of greywater – products, soaps and liquids; including those that claim to be eco-friendly, natural, biodegradable and biocompatible (products may be capable of being slowly destroyed and broken down by natural processes – but they may

still be toxic to plants; using biocompatible (as opposed to biodegradable) products ensures that no salt or other toxic residues are present in the greywater).

- Investigate different possibilities for greywater sanitising systems – i.e. how do we sanitise greywater without chemicals (perhaps through the use of green infrastructure (e.g. biomimicry) so that it can be safely used for irrigation purposes and edible cropping?
- Consider the use of greywater for groundwater recharge – using appropriate pre-treatment systems, for example bioretention cells.
- Conduct household surveys of domestic water usage, and the associated uptake of greywater reuse systems – formal (installed systems) or informal ('bucketing') – in different settlement types around the country. Develop an understanding of greywater management best practices under local conditions – to provide an incentive for using the resource safely.
- Develop greywater reuse policy and/or specific guidelines – for different user groups, and intended purposes. Develop appropriate local-level codes of practice for greywater reuse (particularly with respect to nuisance and smell issues in residential areas), with the required administrative processes in place to ensure the safe utilisation of greywater.
- Determine how to incorporate the management of risk and build these concepts into the greywater resource guidelines. Consider the development of a software product that could account for different tiers of guidelines, depending on the level of sophistication of the greywater user, and an assessment of risk where necessary. This process should tie in with complementary processes as part of the review of the South African Water Quality Guidelines.
- Consider the use of greywater for non-domestic purposes; e.g. industrial or commercial use.
- Develop specific guidelines for use by NGOs who work with community groups on projects such as household food gardening.

PART B

GUIDELINES FOR GREYWATER USE AND MANAGEMENT

CHAPTER 6: GUIDELINES FOR GREYWATER USE AND MANAGEMENT

6.1 WHAT IS GREYWATER?

Greywater is untreated household wastewater from all domestic processes other than toilet flushing; i.e. baths, showers, kitchen and hand wash basins, and laundry. It can be further classified into 'light' (Class I and Class II) and 'dark' (Class III) greywater, as follows:

- Class Ia: Bathroom greywater – greywater sourced from showers.
- Class Ib: Bathroom greywater – greywater sourced from basins and baths.
- Class II: Laundry greywater – greywater sourced from: laundry basins and washing machines.
- Class III: Kitchen greywater – greywater sourced from: kitchen sinks and dish washing machines.

Note:

Class III has been excluded as a potential resource for the purposes of these guidelines for the reasons discussed below.

Classifying greywater according to its source (bathrooms, kitchens, etc.) is only *one* way of determining the potential level of contamination of that greywater and affords no guarantee that such water will automatically fall into the above classes. The level of risk associated with greywater in any household is heavily dependent on many factors – number and ages of inhabitants, their health status, sanitation / personal hygiene habits and needs, plumbing 'hardware' and washing facilities, and quality of original potable water source.

6.2 GREYWATER LEGISLATION / INSTITUTIONAL ISSUES

The following provisional recommendations regarding legislation (policy, bylaws, regulations) with respect to the harvesting of greywater for reuse purposes are suggested:

- A universal definition of greywater is to be included in national legislation, regulations and local bylaws.
- A distinction should be drawn between greywater and black water, as well as between greywater and other treated wastewater, such as treated sewage effluent.
- The definition of greywater should distinguish between the reuse of greywater for outdoor and indoor uses.
- The requirements for the usage of greywater should be clearly stipulated.
- Specific guidelines are needed regarding the installation and management of greywater systems in terms of building regulations, so that installations meet certain standards and are certified as such.

- Should a permit be required for the usage of greywater, the procedural requirements for obtaining such a permit should be clearly stated.
- Various tiers of permission will be required depending on the nature of the use of the greywater.
- A distinction must be drawn between small-scale use and wider reuse categories (single-family, multi-family, commercial, industrial, institutional).
- Greywater may not be sold or given to people / institutions outside of the property upon which it is generated.
- Any regulations must consider the potential for actual implementation and compliance, as well as the required oversight function of the relevant authority.
- Worldwide, the greatest challenge posed in the context of the regulation of greywater, is the implementation and enforcement of the requirements.[57] It is envisaged that this will be a significant problem in the South African context as well, given the difficulty of monitoring the usage of such water.

6.3 BEST PRACTICE RULES AND REGULATIONS FOR GREYWATER SYSTEMS

6.3.1 Greywater Diversion Devices (GDDs)

- Use diverted, untreated greywater from GDDs for sub-surface irrigation only (at least 10 cm below the surface of soil or mulch).
- Ensure the greywater diversion device is switched back after irrigation periods so that greywater is diverted to sewer.
- Make use of a filter to screen solids when using a diversion device.
- Ensure that regular maintenance is undertaken, including cleaning out the GDD filter weekly and maintaining the sub-surface irrigation system. Regularly clean the whole irrigation system as greywater causes bio slimes to build up in the filter and pipes, leading to blockages. Take care to use gloves and avoid splashing as there may be considerable numbers of disease-causing organisms that have built up in the bio-slimes over time.

6.3.2 Greywater Treatment Systems (GTSs)

- The storage tank should be classified as a septic tank and all the regulations for septic tanks should apply to such a system. Tanks should be clearly marked to indicate greywater storage.
- Label pipes carrying greywater under pressure to eliminate confusion between greywater and potable (drinking) water pipes.
- Ensure that the GTS is installed by a registered GTS installer / plumber and maintained regularly by a trained service agent.
- Adhere to the water quality guidelines for specified end uses.

[57] A Gross, A Maimon, Y Alfiya, E Friedlander *Greywater Reuse* (2015) CRC Press 164.

- Ensure that the GTS has a device that allows greywater to be diverted to the formal municipal sewer. Should the GTS be supplying greywater for toilet flushing, there needs to be a back-up in the form of municipal supply into the cistern for situations when the greywater system fails.
- Only greywater that has been treated AND disinfected may be used for another non-potable uses such as toilet flushing, car washing etc.

6.4 GUIDANCE ON APPROPRIATE USES FOR GREYWATER

6.4.1 Overview

Figure 6-1 provides a simple overview of typical on-site greywater harvesting systems and potential uses for the greywater harvested in these ways. Importantly, under certain circumstances, especially where other services are not available, greywater harvesting may not be appropriate – see Section 2.5.3 and Section 2.6. Greywater is most appropriate for activities such as garden watering / irrigation (untreated) and toilet flushing (treated and disinfected), where human contact is limited – although it should be noted that the long-term impacts on the environment of irrigating with greywater have not yet been determined. As a rule, untreated greywater should never be used in any manner where it may easily come into contact with susceptible individuals and/or ingested. It is **inappropriate** for use in the following situations:

- Drinking or cooking.
- Irrigating of any produce eaten raw or minimally processed, such as leafy produce or root vegetables (e.g. carrots and beetroot) growing in soil frequently irrigated with greywater.
- Washing / cleaning pavements – especially those draining to storm water systems.
- Irrigating gardens during or immediately subsequent to rainfall.
- Irrigating areas in gardens such as lawns where children play.

Greywater use in informal and/or unserviced settlements is also generally not recommended; rather, efforts should be focused on its effective management. In other words, greywater management in these areas should be directed at disposal or off-site treatment, rather than considering it as a resource that could be used productively (refer to Carden *et al*., 2007 for specific guidelines in this regard).

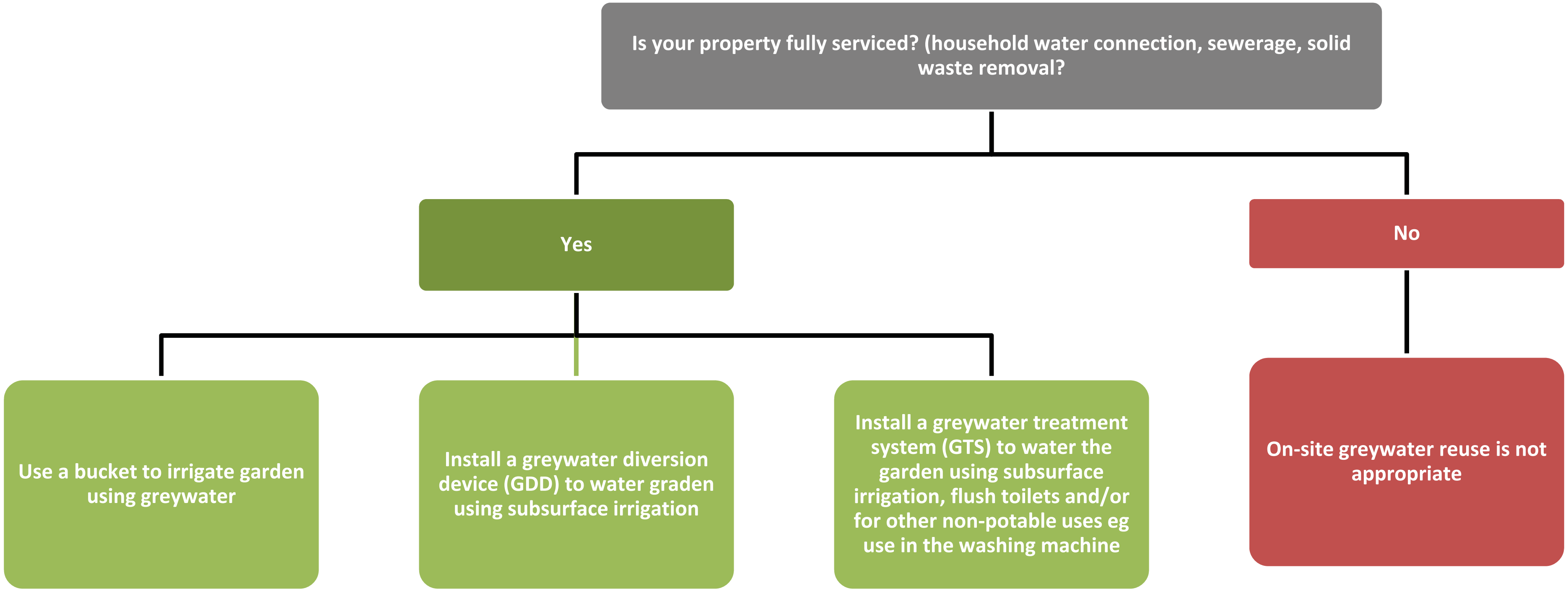

Figure 6-1: Appropriate on-site uses for greywater

6.4.2 General rules to be adhered to always:

- Avoid direct human contact with greywater, or soil irrigated with greywater. Children and pets should be kept away from areas that are irrigated with greywater.
- Water that comes into contact with a toilet, urinal or a toilet fixture such as a bidet should never be used as greywater.
- Water that has been used to wash nappies or other clothing soiled by faeces and/or urine should not be used; nor should that generated by cleaning in the laundry or bathroom, or when using hair dyes or other chemicals.
- Water from the kitchen sink or used in the kitchen to wash dishes or food should not be used (it is too highly contaminated with grease, bacteria, blood and chemicals). Also, do not use greywater that is generated by washing cloths / brushes used for painting or for maintaining machinery and vehicles.
- Greywater should not be used if anybody living on the premises is suffering from diarrhoea, ear or skin infections.
- Water used to wash animals, such as domestic pets, should not be used. It typically has high concentrations of organisms able to cause disease.
- Preferably use only 'low risk' greywater – e.g. warm-up water from hot taps, rinse water, bath or shower water.
- Do not store untreated greywater for periods longer than 24 hours. Water stored for longer than 24 hours should be treated before use, especially if applied to garden areas where humans and animals can come into contact with such water.
- Mark / label all pipes and use signs to indicate greywater reuse.
- Ensure that hands are properly washed, without fail, after contact with any form of greywater harvesting and reuse system.

6.4.3 General rules for irrigating with greywater

- Greywater should be used with extreme caution in irrigating edible crops– care should be taken to ensure greywater never comes in contact with these types of produce. This may be achieved through drip irrigation, subsurface irrigation, or irrigation under a heavy mulch cover.
- Never use hosing, spraying or misting methods when irrigating with greywater.
- Greywater should never be applied to uncooked edible crops – such as vegetables eaten raw or lightly cooked, e.g. salads. It should also be avoided for root crops such as carrots, since the pathogens can accumulate in the topsoil.
- Greywater should not be allowed to leave the boundaries of the property and should under no circumstances be allowed to enter the storm water system. Therefore, excess greywater should

be disposed of into the sewerage system during rain periods or when too much greywater is produced for the garden to absorb.

- Surface accumulation of greywater must be kept to a minimum. Care should be taken to ensure greywater does not run off irrigated surfaces into water courses, storm water drains, swimming pools or dams.
- Greywater should never be allowed to pond or pool where mosquitoes and other insect vectors of disease can breed.
- Make use of garden-friendly detergents low in phosphorus, sodium, boron and chloride.
- Spread the greywater around different areas in the garden to prevent pooling.
- Monitor plant and soil response to greywater irrigation – if your plants show signs of yellowing, wilting or mottled colour, consider the above points or stop applying greywater altogether. For example, alternate irrigation with freshwater to leach out salts if plants show symptoms of stress; apply agricultural gypsum and compost to ameliorate soils if infiltration rate decreases as a result of high salt content.
- Consider applying a soil wetting agent every sixth month to assist in the absorption of greywater by the soil (soils can become hydrophobic or water repellent when they are dry for extended periods).

6.5 GUIDANCE FOR THE SUSTAINABLE USE OF GREYWATER IN SMALL-SCALE AGRICULTURE AND GARDENS - RODDA ET AL. (2010B)

6.5.1 Overview

The following section presents guidance for the use of greywater for irrigating gardens or for small-scale crop cultivation in South Africa. It should be noted that it is assumed that ***guidance provided here will be used in the context of existing guidelines and best practice for irrigation, both nationally and locally***. Thus, the intention of this document is not to provide a catch-all manual for general irrigation water quality, treatment processes, irrigation methods, plant water requirements, soil selection, *etc*. Although reference is made to many of these issues, it is assumed that suitable source water quality (*i.e.* before use in the home which renders the water 'grey') and suitable plants, cultivation and irrigation practices are already available or known for successfully irrigated plants in each Agro-climatic zone, or that this knowledge will be developed using existing procedures. This Guidance Document has been developed specifically to provide guidance for managing the ***additional*** risks and uncertainty associated with using greywater in place of conventional irrigation water sources.

6.5.2 Guidance on greywater quality constituents

6.5.2.1 Rationale underlying choice of constituents

The constituents included here for quality of greywater to be used for small-scale irrigation reflect the aims and scope of the overall Guidance Document, *viz*.

- Protection of human health.
- Protection of irrigated plants.
- Protection of the environment, specifically the irrigated soil.

Thus, the constituents included are related to human health, plant growth and yield, and soil quality. Distinction is made between ***minimum analysis*** and ***full analysis***. Water users who wish to use greywater productively but do not have the resources to support full analysis, can still take advantage of better evaluation of potential risks and hence less restrictive greywater uses than those for whom no analysis is performed, by performing a defined minimum set of analyses, termed ***minimum analysis*** here. For larger greywater irrigation implementations, the number of potentially exposed users, and hence the risk, increases. In these situations, or where users can afford a wider analysis and wish to manage risks primarily through control of the quality of the greywater used for irrigation, a wider analysis, termed ***full analysis*** here, is recommended.

6.5.2.2 Greywater constituents and greywater quality guidance ranges

In keeping with the South African Water Quality Guidelines (DWAF, 1996), the properties of greywater included in the Guidance Document are referred to as ***constituents***. Based on a review of available greywater quality studies in South Africa and comparison to the South African Water Quality Guidelines (SAWQG), and on peer review of the resultant list of greywater constituents, the following physical constituents, chemical constituents and microbiological constituent were chosen for inclusion in this Guidance Document:

Minimum analysis

- Electrical Conductivity (EC)
- Sodium Adsorption Ratio (SAR)
- *E. coli*
- pH

Full analysis

Minimum analysis

- Electrical Conductivity (EC)
- Sodium Adsorption Ratio (SAR)

- *E. coli*
- pH

In addition

- Boron
- Chemical Oxygen Demand (COD)
- Oil and grease
- Suspended solids
- Total inorganic nitrogen
- Total phosphorus

Greywater quality guidance ranges for the indicator greywater constituents were derived wherever possible from the SAWQG for irrigation. The precautionary principle implemented in a qualitative manner in the SAWQG for irrigation for many irrigation-related endpoints, and in a quantitative manner in the WHO guidelines for human health risks, was also applied to the present guidance for the use of greywater in small-scale irrigation. This includes a graded series of greywater quality ranges, indicating preferred quality (***target range*** in Table 6-1**Error! Reference source not found.**), tolerable quality (***maximum range*** in Table 6-1), quality which can be used on a site-specific basis for a limited time and with special precautions (***short-term use on site-specific basis only*** in **Error! Reference source not found.**), or quality which is not suitable for irrigation use unless treated (***not recommended for irrigation use*** in Table 6-1). These ranges correspond to minimal excess risks to human health, plants and soil associated with the target range, followed by increasing risks, up to excessive and hence unacceptable risks associated with the range which is not recommended for irrigation use.

Note:
Water quality should preferably comply with the target quality guidance range, but certainly be within the maximum guidance range.

It should be considered that where extensive or high technology treatment would be required to make greywater suitable for irrigation use of any kind, then off-site disposal is likely to be a safer and cheaper option.

<u>*Special consideration with respect to guidance for microbiological quality for short-term use*</u>

Studies on the microbiological quality of vegetable crops irrigated below the soil surface with domestic greywater originating from an informal settlement showed that although microbial levels in greywater were high, many simple precautions reduced risk of infection associated with greywater irrigation to within acceptable levels.

Table 6-1: Water quality guidance for greywater use for irrigation and toilet flushing (adapted from Rodda *et al*., 2010b)

Greywater constituent	**Target water quality range**	**Max water quality range (applicable only to well-drained, chemically stable soils)**	**Water quality suitable only for short-term use on site-specific basis.[1]**	**Water quality not recommende d for irrigation use**
	Suitable for unrestricted use with minimal risk to human health, plants or soil	**Increasing risk to human health, plants or soil – not suitable for flushing**	**Significant risk to human health, plants or soil; tolerable for short-term use only; not for toilet flushing**	**Excessive risk to human health, plants or soil – not for toilet flushing**
Physical constituents				
Electrical conductivity (mS/m)	< 40	40 – 200	200 – 540	> 540
Oil and grease (mg/ℓ)	< 2.5	2.5 – 10	10 – 20	> 20
pH	6.5 – 8.4	6 – 9	6 – 9	< 6 > 9
Suspended solids (mg/ℓ)	< 50	50 – 100	> 100	> 100
Chemical constituents				
Boron (mg/ℓ)	< 0.5	0.5 – 4.0	4.0 – 6.0	> 6.0
Chemical oxygen demand (COD, mg/ℓ)	< 400	400 – 5 000	> 5 000	> 5 000
Sodium adsorption ratio[2] (SAR)	< 2.0	2.0 – 5.0	5.0 – 15.0	> 15.0
Total inorganic nitrogen (mg/ℓ)	< 10	10 – 20	20 – 60	> 60
Total phosphorus (mg/ℓ)	<10	10 – 15	15 – 50	> 50
Microbiological constituent				
E. coli (colony-forming units, CFU/100 mℓ)	< 1	$1 – 10^3$ (1 – 1 000)	$10^3 – 10^5$ (1 000 – 100 000) Note: Only with appropriate exposure restrictions – see text.	$> 10^6$ (> 1 000 000)

[1.] Treatment to maximum range (at minimum) is the preferred option. If this is not sustainable in the long term, then disposal to a sewer should be considered.

[2.] Sodium adsorption ratio: SAR = [sodium]/√([calcium]+[magnesium])/2……………………..Equation 1

All concentrations measured in mmol/ℓ, SAR is reported without units

For this reason, the water quality guidance table (Table 6-1) allows for short-term use of greywater with microbial levels up to the mean concentrations detected in that study. However, exposure precautions ***must*** be implemented. In brief:

- Handlers of greywater, must wear gloves and boots, and wash face, hands, arms, feet and legs with water and soap after greywater use;
- Handlers of greywater-irrigated produce must wash thoroughly with water and soap after handling produce; and
- Greywater-irrigated produce must be washed, peeled and cooked prior to consumption.

6.5.3 Managing risks and uncertainty

Using a categorisation of risk and uncertainty based on data gained from existing South African studies, South African water quality guidelines and South African climatic and agricultural data, Rodda et al. (2010b) developed flowcharts to guide users through decision associated with the various risk-management categories for greywater irrigation – and consequently a table of restrictions on use for each category. Categories were classified according to the level of certainty around the quality of the greywater – determined by the level of analysis. Excerpts from this report is provided in the sections that follow, showing the various flowcharts and tables of restrictions that can be applied in instances where the use of greywater for irrigation is envisaged.

Risk, whether expressed qualitatively or quantitatively, indicates the probability of a defined adverse effect occurring in an exposed population. Within the context of this Guidance Document, the adverse effects and exposed ‘populations’ are as follows:

- Illness in human handlers of greywater and greywater-irrigated produce, or human consumers of greywater-irrigated produce.
- Reduction in plant growth or yield in plants / crops irrigated with greywater.
- Environmental degradation, specifically reduction in ability of the soil irrigated with greywater to support plant growth in the long term.

Uncertainty refers to the degree of confidence associated with the estimate of risk. In the context of greywater quality, this relates largely to the degree of confidence associated with knowledge of water quality, as once the quality of the greywater is known, suitable steps can be taken to address the risks described above. It should however be noted that the baseline of uncertainty associated with greywater use is inherently higher than that associated with, *e.g.* domestic water use or recreational water use, since:

- Greywater is inherently highly variable in quality, further complicated by the fact that the quality of various greywater sources in a household vary considerably.

- Greywater irrigation implementations are most likely to occur on a small scale, where frequent monitoring of greywater quality is likely to be both economically and logistically difficult.

Within this context, three risk and uncertainty categories can be identified among potential users of greywater for irrigation:

- Users unable / unwilling to conduct any analyses to characterise greywater quality prior to planning irrigation use and during its implementation.
- Users willing and able to conduct limited analyses (minimum analysis) to characterise greywater quality prior to planning irrigation use and during its implementation.
- Users willing and able to conduct more extensive analyses (full analysis) to characterise greywater quality prior to planning irrigation use and during its implementation.

The reason for identifying these risk and uncertainty categories is that risk can only be said to exist where human users, plants or soil are exposed to a potential hazard. Where there is no exposure, there is no risk. Thus, risk can be managed by managing either the magnitude of the hazard (the quality of greywater) or the extent of exposure to the hazard. The higher the magnitude of the hazard (*i.e*. the poorer the quality of the greywater), the more stringent the required risk management interventions to protect human health, plants and soil. Risk management interventions related to exposure take the form of barriers which minimise the exposure of human users, plants or soil to a given hazard. As the extent of analysis increases from Category 1 to Category 3 – and, by implication, as greywater quality improves as it complies with the quality guidance associated with the analysis – so the magnitude of the hazard decreases, and hence so do the risk management requirements. Figure 6-1 depicts identification of the three categories of irrigation use, as determined by risks and uncertainty concerning greywater quality.

Risk for Category 1 is unknown and uncertainty is high. Thus, this category of use faces the greatest restrictions in the anticipated greywater irrigation implementation. These restrictions are necessary to manage the potentially high risks associated with irrigation use of greywater of unknown quality.

Risk for Category 2 is moderate (assuming compliance with guidance for greywater quality subject to minimum analysis), as is uncertainty. Analytical results for broad indicators of risk to human health, plants and soil are available. Thus, restrictions for this category are less than for Category 1, being aimed at providing barriers to specific classes of risk and thereby managing those risks.

Risk for Category 3 carries the lowest risk (assuming compliance with guidance for greywater quality subject to full analysis) and the lowest uncertainty. The quality of greywater with respect to human health, plants and soil is relatively well characterised and necessary barriers to risks can be identified with relatively little uncertainty. Risks in this category are therefore the easiest to manage.

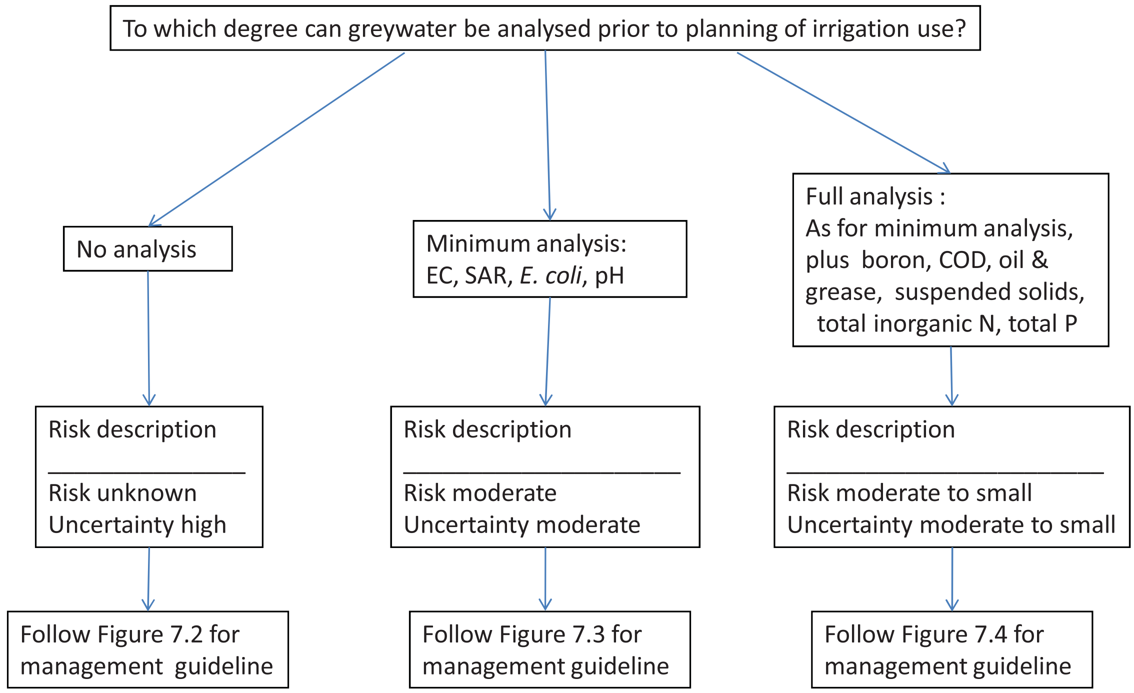

Figure 6-1: Division of potential greywater use into three categories according to risk and risk management options.

6.5.3.1 Category 1: No greywater analysis

This is the simplest use scenario, but perhaps the most complex to manage because users (both human and environmental) must be protected from essentially unknown risks (Figure 6-2). There is no quantitative assessment of greywater quality and no treatment of greywater prior to use. Greywater use without any prior assessment of the quality of the greywater should be considered for household level use only, where users are exposed only to wastes generated on the property. The reason for this is that, within a household, other routes of exposure to potential pathogens are likely to be more significant as exposure routes than those associated with greywater. When greywater is used by someone not from the household of origin, exposure to greywater increases in significance as an exposure route. Thus, no communal gardening initiative should be undertaken in this category. Kitchen greywater should not be considered for use because it typically carries the highest loads of micro-organisms, COD, oil and grease, and suspended solids. Laundry wash water should also not be used because of potentially high pH and high salt levels. Only laundry rinse water and bath greywater can be used in accordance with restrictions R1 in Table 6-2.

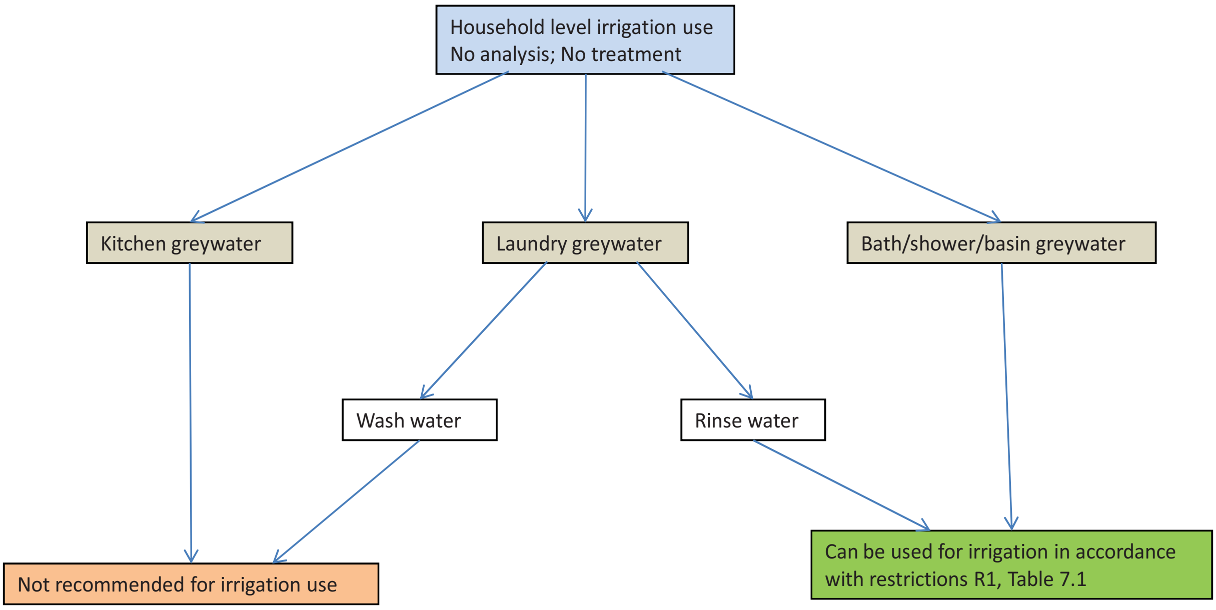

Figure 6-2: Decision flow chart for management of risks associated with greywater use in Category 1 (no analysis).

This set of restrictions is the most stringent of those presented. All restrictions in Table 7-2 are intended to minimise: (1) risks to human health, (2) risks to plant growth and yield, and (3) risks to the environment, specifically to the ability of soil to support plant growth. Note that cognisance must be taken of the volume of greywater which can be applied to land.

Table 6-2: Risk management restrictions for use of greywater for irrigation without analysis of greywater.

Restrictions R1, applicable to greywater use in Category 1
Restrictions relating to health impact **Do:** Wash hands and arms well with soap after handling greywater. Use bathwater water and laundry rinse water only. Use all greywater within 24 hours of collection. Grow only non-food plants or food plants with crops that will be cooked before consumption. Use irrigation methods that minimise contact of greywater with above-ground plant parts. If using on lawns, avoid direct human contact for 8 hours after irrigation. If using on crops, stop irrigating with greywater 2 weeks before harvesting. Reduce volume of greywater per application if ponding occurs on surface of irrigated ground, or if water runs off the surface. Wash all crops well in soapy water after harvest and dry in sunlight. Peel and cook crops prior to consumption.

Restrictions R1, applicable to greywater use in Category 1
Do not: Do not use greywater falling in this category of use restrictions for any form of communal gardening. Do not use greywater if someone in the household has an infectious disease. **Restrictions relating to impacts on plant growth and yield** **Do:** Use irrigation methods that minimise contact of greywater with above-ground plant parts. Switch to salt-tolerant plants, if plants show symptoms of salt stress. **Do not:** Do not plant or irrigate plants prone to boron toxicity. **Restrictions relating to soil and environmental deterioration** **Do:** Use bathwater water and laundry rinse water only. Increase greywater application or alternate with freshwater, in order to leach out salts, if plants show symptoms of salt stress. Apply agricultural gypsum and compost to ameliorate soils if infiltration rate decreases and it is suspected that this is related to high sodium content of greywater. **Do not:** Do not irrigate with kitchen greywater or with laundry greywater except rinse water. Do not use greywater falling in this category of restrictions if the soil is very clayey, if the ground has a steep slope, or if the irrigation site is close to a river or borehole. Do not use greywater if the irrigated land is close to sensitive environments which may be adversely affected by greywater runoff or infiltration, *e.g.* high-water table, wetlands.

6.5.3.2 Category 2: Minimum greywater analysis

This is the first category in which a quantitative assessment of greywater quality is made, and thus the first in which greywater use can be considered at either household or communal level (Figure 6-3).

Special considerations for communal use of greywater for irrigation

If greywater use is at a communal level, *i.e.* either for a communal garden or for a number of households situated in close proximity to each other all wishing to practice greywater use on their own properties, then cognisance must be taken of the capacity of the available land to absorb the volume of greywater generated. This may be estimated by calculating the ***greywater generation rate*** (Carden *et al*., 2007). The greywater generation rate is particularly important in planning greywater irrigation implementations in unsewered settlements. In sewered settlements it is unlikely that the total fraction of greywater will be considered for irrigation and any water in excess of the estimated volume required for irrigation can be easily disposed of to the sewer.

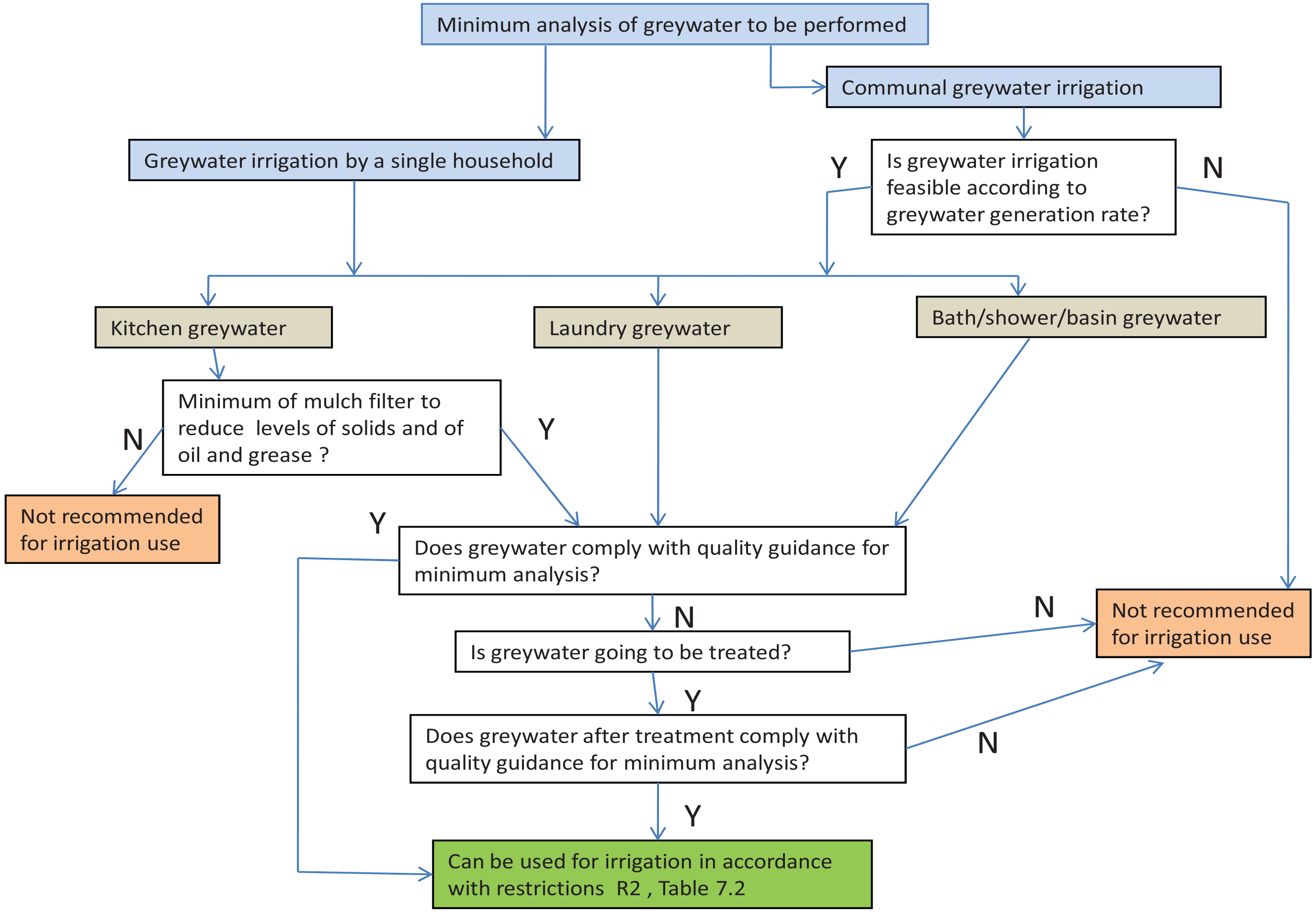

Figure 6-3: Decision flow chart for management of risks associated with greywater use in Category 2 (minimum analysis).

However, in unsewered settlements careful planning is required to ensure responsible disposal of greywater which is more than irrigation requirements (as also of greywater which is of a quality not suitable for irrigation). The greywater generation rate is calculated as follows:

$$G_G = Q \times D \quad \text{...Equation 2}$$

G_G is the greywater generation rate, ℓ/ha.day
Q is the approximate volume of greywater produced per household (water consumption x 75%), ℓ/dwelling unit (du). day
D is the density of households per hectare, du/ha (Carden *et al*., 2007).

If this value is below 500 ℓ/ha.day, then irrigation use of greywater is not constrained by the availability of land to absorb the volume of greywater generated. If it is between 500 and 2 500 ℓ/ha.day, then careful attention needs to be paid to site-specific factors (*e.g.* nearby surface water bodies, slope of the land, type of soil, rainfall, depth to the water table) before a decision is taken to use greywater for irrigation.

If this value is above 2 500 ℓ/ha.day, then greywater use should preferably be avoided unless adequate provision for disposal of excess greywater is available.

If greywater use is to be undertaken despite a high greywater generation rate, then all users of greywater must understand clearly that it is likely that only a fraction of the total volume of greywater generated can be used for irrigation and that the remainder of available greywater cannot be disposed of to land. The fraction which could potentially be used would need to be evaluated on a site-specific basis, taking into account the area to be irrigated and the estimated water use. In such instances, it is advisable that the best quality greywater is reserved for irrigation use.

Considerations applicable to both household level and communal use of greywater for irrigation
Kitchen greywater should be treated with a minimum of a mulch filter prior to irrigation use. If this is not possible, then use of this greywater fraction should be avoided. All greywater to be used for irrigation under this category is analysed for the greywater constituents specified as per **minimum analysis**, viz. electrical conductivity (EC), sodium adsorption ratio (SAR), pH and Escherichia coli. These constitute the minimum indicators of risk to human health (E. coli), plant growth and yield (EC, SAR, pH) and soil structure (EC, SAR). A distinction is drawn between **minimum analysis** and **full analysis** so that water consumers who wish to use greywater productively but do not have the resources to support full analysis, can still take advantage of better evaluation of potential risks and hence less restrictive greywater uses than those for whom no analysis is performed.

If greywater complies with at least the maximum range for the specified greywater constituents, then irrigation with greywater can be performed in accordance with restrictions R2 in Table 6.3.

If greywater does not meet these greywater quality ranges, then some form of treatment must be considered. Where a treatment option is chosen for which it is possible to monitor the treated greywater, this should again be tested to determine whether the greywater quality after treatment falls within the target range (preferably) or the maximum range. Integrated treatment and irrigation options, and mitigation, treatments should not be applied if greywater quality before treatment / mitigation falls beyond the ranges for short-term use. Note that cognisance must be taken of the volume of greywater which can be applied to land.

Table 6-3: Risk management restrictions for irrigation use of greywater after minimum analysis of greywater (as defined), and assuming compliance with quality guidance for minimum analysis.

Restrictions R2, applicable to greywater use in Category 2
Restrictions relating to health impact **Do:** Wash hands and arms well with soap after handling greywater. Use all greywater within 24 hours of collection. Use irrigation methods that minimise contact of greywater with above-ground plant parts. If using on lawns, avoid direct human contact for 8 hours after irrigation. If using on crops, stop irrigating with greywater 2 weeks before harvesting. Reduce volume of greywater per application if ponding occurs on surface of irrigated ground, or if water runs off the surface. Wash all crops well in soapy water after harvest and dry in sunlight. Preferably, peel and cook crops prior to consumption. **Do not:** Do not use kitchen greywater unless treated with minimum of a mulch filter. Do not use greywater if someone in the contributing household(s) has an infectious disease. **Restrictions relating to impacts on plant growth and yield** **Do:** Use irrigation methods that minimise contact of greywater with above-ground plant parts. Switch to salt-tolerant plants, if plants show symptoms of salt stress. **Do not:** Do not plant or irrigate plants prone to boron toxicity. **Restrictions relating to soil and environmental deterioration** **Do:** Increase greywater application or alternate with freshwater, in order to leach out salts, if plants show symptoms of salt stress. Apply agricultural gypsum and compost to ameliorate soils if infiltration rate decreases and it is suspected that this is related to high sodium content of greywater. **Do not:** Do not use kitchen greywater unless treated with minimum of a mulch filter.

Restrictions R2, applicable to greywater use in Category 2
Do not use greywater falling in this category of restrictions if the soil is very clayey, if the ground has a steep slope, or if the irrigation site is close to a river or borehole. Do not use greywater if the irrigated land is close to sensitive environments which may be adversely affected by greywater runoff or infiltration.

6.5.3.3 Category 3: Full greywater analysis

The decision-making process for greywater use in this category follows essentially the same flow as described for Category 2, except that greywater is subjected to full analysis in place of minimum analysis (Figure 6-4:). ***If greywater falls within the target range (preferably) or the maximum range for all constituents in the full analysis, either before or after treatment, then it can be used in accordance with restrictions R3 in Table 6-4.*** If this cannot be achieved, but greywater quality can be improved so that constituents for minimum analysis fall within the desired ranges, then greywater can be used in accordance with restrictions R2 in Table 6-3.

It is important to note that there are few differences between the recommendations listed in Table 6-3 and those in Table 6-4. The main difference in irrigating with greywater complying with the quality guidance associated with full analysis, *vs.* that associated with minimum analysis, is that remedial interventions, *e.g.* to manage salt or boron toxicity or to counteract biological growth, are less likely to be necessary if greywater complies with the quality guidance recommended for full analysis. Note that cognisance must be taken of the volume of greywater which can be applied to land.

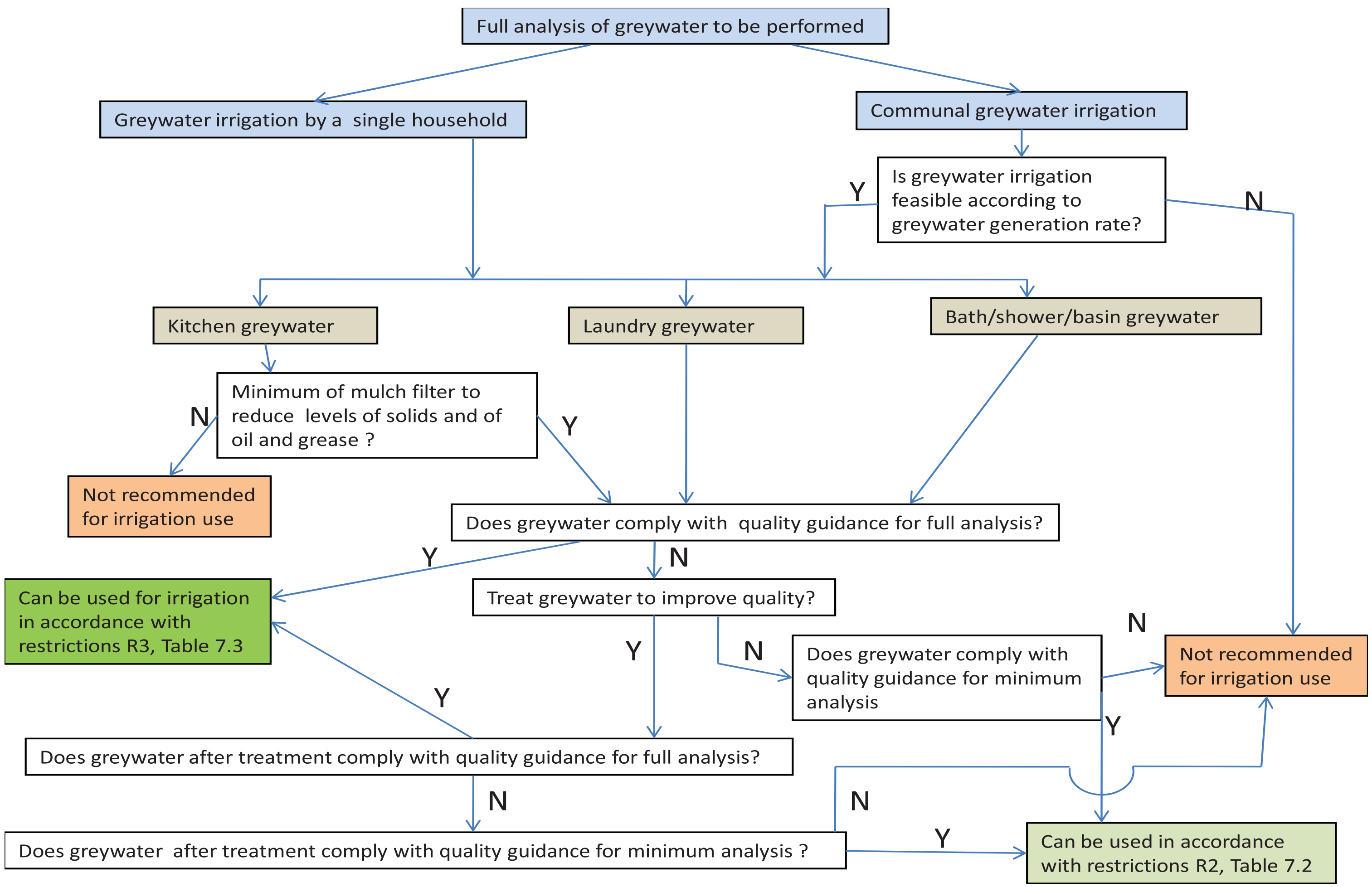

Figure 6-4: Decision flow chart for management of risks associated with greywater use in Category 3 (full analysis).

Table 6-4:Risk management restrictions for irrigation use of greywater after full analysis of greywater (as defined), assuming compliance with quality guidance for full

Restrictions R3, applicable to greywater use in Category 3
Restrictions relating to health impact **Do:** Use all greywater within 24 hours of collection. Use irrigation methods that minimise contact of greywater with above-ground plant parts. If using on lawns, avoid direct human contact for 8 hours after irrigation If using on crops, stop irrigating with greywater 1 week before harvesting. Reduce volume of greywater per application if ponding occurs on surface of irrigated ground, or if water runs off the surface. Wash all crops well in soapy water after harvest and dry in sunlight. Preferably cook crops prior to consumption. Wash hands and arms well with soap after handling greywater. **Do not:** Do not use kitchen greywater unless treated with minimum of a mulch filter. Do not use greywater if someone in the contributing household(s) has an infectious disease. **Restrictions relating to impacts on plant growth and yield** **Do:** Use irrigation methods that minimise contact of greywater with above-ground plant parts. Be aware of possible need to switch to boron or salt tolerant plants, although this should not be necessary if guidance present here is used as indicated. **Restrictions relating to soil and environmental deterioration** **Do:** Be aware of possible need to flush soils to prevent accumulation of salts, especially in hot and/or dry areas where evaporation is high. Apply agricultural gypsum and compost to ameliorate soils if infiltration rate decreases and it is suspected that this is related to high sodium content of greywater. Be sensitive to the proximity of sensitive environments which may be adversely affected by greywater runoff or infiltration. **Do not:** Do not use kitchen greywater unless treated with minimum of a mulch filter.

6.6 MANAGEMENT GUIDELINES FOR DISPOSAL OF GREYWATER IN NON-SEWERED AREAS - CARDEN ET AL. (2007)

6.6.1 Overview

There are no definitive health regulations or guidelines for the disposal and / or use of greywater in the non-sewered areas of SA, although the City of Cape Town has published draft Greywater Guidelines (City of Cape Town, 2005) specifically for the disposal of greywater in high-density, informal settlements, and eThekwini Municipality have included greywater disposal and drainage issues in their business plan for the delivery of basic sanitation services in the eThekwini Municipal area (eThekwini, 2003). A summary is given here of these guidelines as well as the relevant risk management measures from around the world that are being applied to ensure human health and environmental protection.

6.6.2 Planning considerations and guidelines for greywater disposal in non-sewered areas

As previously noted, it is essential to address the potential for greywater generation when planning and developing settlements, and the integration of suitable long-term service provision is necessary to alleviate the problems of greywater management (Wood *et al*, 2001). This is particularly relevant in densely-settled areas where the options for the use of greywater are limited and the focus is on safe disposal only. The following guidelines are suggested when planning for greywater disposal in high-density settlements:

6.6.2.1 Settlement planning

- Avoid establishing settlements on steep slopes to prevent erosion and runoff of greywater and storm water (Wood *et al*., 2001).
- No development should occur within the 1:50 year flood line (Wood *et al*., 2001).
- Open spaces should be maintained within the settlements in order to inter alia assist in pollution control, absorb rainfall and reduce flooding (Wood *et al*., 2001).

6.6.2.2 Service provision

- Water standpipes should be provided within 100m of each household (Wood *et al.*, 2001). Reduce water wastage (and concomitant increased volumes of greywater) at standpipes through the use of fittings such as automatic shut-off taps.
- Provision must be made for the collection of greywater and leakage from water standpipes; preferably infiltration beds and soakaways should be provided at the standpipes (or drainage to gravitate the greywater to sewer or an appropriate site for handling and disposal) so that ponding of contaminated water is minimised (Wood *et al.*, 2001).

- In addition to providing a greywater disposal facility at each water supply point, additional disposal points should be installed so as to reduce the walking distance from dwellings to disposal point to a maximum distance of 25m (City of Cape Town, 2005).
- For new standpipes, greywater disposal points with galvanised gratings should be provided (City of Cape Town, 2005).
- Where communal washing facilities are provided, sediment and fat traps are required before disposal of greywater (City of Cape Town, 2005).
- Communal sanitation facilities should be conveniently located (Wood *et al.*, 2001) and must include washing facilities with provision for the disposal of greywater.

6.6.2.3 Greywater disposal

- The preferred option for greywater disposal is by gravity to sewer – the collection and treatment of greywater in ponds or wetlands is not a viable option for many high-density settlements owing to the lack of large open spaces, the health risks and safety considerations (Wood *et al*., 2001). Alternatives to disposal to sewer can include modified septic tanks (with enzymes) and centralised collection of greywater, e.g. tankers.
- Purpose-built greywater disposal soakaways should be provided for plots that are <350m2 (eThekwini, 2003), but can only be provided in areas where the soil is permeable and the water table is low (City of Cape Town, 2005).
- Should discharge into the storm water system be considered, further treatment of the greywater is required (City of Cape Town, 2005).

6.6.2.4 Operation and maintenance

- Communities provided with greywater disposal systems should be educated in terms of their purpose and correct use, i.e. greywater systems may not be used for the disposal of blackwater or night soil (City of Cape Town, 2005 & eThekwini, 2003).
- The maintenance of gratings and sediment and fat traps should be programmed to take place on a regular cycle, depending on capacity and usage of system (City of Cape Town, 2005).

6.6.3 Risk management measures for handling greywater in non-sewered areas

There are basic handling rules with respect to health issues that should be followed when disposing or reusing greywater in areas where there is enough space for on-site disposal. These guidelines have been adapted from Murphy (2006) and include the following:

- Use natural cleaning products where possible, e.g. phosphate-free, low-sodium, and zero-content boron (Fane & Reardon, 2005; Centre for the Study of the Built Environment, CSBE, 2003)

- Do not store greywater for more than 24 hours (and preferably no more than a few hours) before use or disposal (Fane & Reardon, 2005; State of Victoria, 2003)
- Do not dispose of greywater to surface or storm water or into the groundwater system (State of Victoria, 2003)
- Ensure greywater does not contaminate drinking water sources (State of Victoria, 2003)
- Greywater should not be allowed to leave the boundaries of the property on which it is generated (CSBE, 2003; State of Victoria, 2003)
- Greywater should be withheld from areas where children play, such as lawns (CSBE, 2003; State of Victoria, 2003)
- Do not irrigate with greywater if the soil is already saturated and do not allow surface ponding of greywater (State of Victoria, 2003; Fane & Reardon, 2005)
- Do not use kitchen wash water or water that has been used to wash nappies or other clothing soiled by faeces and/or urine, for irrigation purposes (State of Victoria, 2003; Little, 2004)
- Do not use greywater if anyone on the premises is suffering from an infectious health condition (Little, 2004)
- Always use subsurface irrigation and never hose, spray or mist with greywater (State of Victoria, 2003)
- Avoid watering fruits and vegetables with greywater if they will be eaten raw or under-cooked and always wash and cook food that has been irrigated with greywater (CSBE, 2003; State of Victoria, 2003)
- Wash hands after contact with greywater (State of Victoria, 2003)

6.7 SIGNAGE & LABELLING BEST PRACTICES

6.7.1 Introduction

To avoid cross connections between greywater and potable water systems, it is critical to distinguish between the two. In the absence of a South African National Standard in this regard, the following Australian Standards are suggested: AS/NZS 3500, AS 1345, AS 2700 and AS1319. These standards cover three critical aspects, and these are covered in the sections below.

6.7.2 Piping

AS 2700 requires all pipes, pipe sleeves and identification tapes to be coloured purple (Figure 6-5) and marked with the following in accordance with AS 1345: **“WARNING RECYCLED WATER – DO NOT DRINK”** at intervals not exceeding 0.5m. In South Africa, the text should be translated into at least three of the country's official languages and alternated such that there is no more than 1m between the text in each language.

Figure 6-5: Purple piping used to reticulate greywater

6.8 POINT OF USE

Greywater outlets (connections, taps, appliances) should have signage that indicates **"WARNING DO NOT DRINK"** in accordance with AS 1319 (e.g. Figure 6-6).

Figure 6-6: Example of a warning sign

6.9 IRRIGATION

Irrigation areas must have multiple warning signs at the boundaries of the irrigation area – in-line with AS 1319. The signs must be clearly visible and **indicate "Recycled Water – Avoid Contact – DO NOT DRINK"**.

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APPENDIX A: THEMATIC MAPPING SESSION

Greywater resource guidelines inception workshop, 18 April 2016

Legislative issues

1. *What legislation is relevant?*
   - National legislation / regulations; city by-laws
   - National water re-use strategy?
   - Water Services Act
   - Local authority policies and supporting by-laws etc. to promote on a large scale

2. *How important is a legislative framework?*
   - Crucial due to potential health risks
   - Guidelines need to be as consumer-friendly as possible for scaled adoption
   - Control / Management / Regulation (norms and standards) – consider the health impacts
   - Important because of the health impacts
   - Needs to be appropriate to context and resources
   - It's time for a practical legislative framework
   - At this stage?
   - Does anyone know capacity of municipalities??
   - Non-issue

3. *Should legislation be developed?*
   - How can guidelines or assessment tools adapt or incorporate new / future technologies into them (i.e. not stay static?)
   - Can policy stimulate business opportunities for greywater?
   - Yes, DWS in consultation with Agriculture and Health Departments
   - Yes
   - Essential for health aspects but monitoring an issue – by whom? Lack of resources in local authorities.
   - No – let it happen; then see
   - Yes, many inappropriate systems have been installed by fly-by-night companies

4. *What about enforcement?*
   - How – we have so many laws that are not enforced
   - Who regulates?
   - Cost of implementation at a local level?
   - Enforcement tricky as depends on scale and user type
   - Licensed installers
   - Small-scale – through municipal by-laws
   - Enforcement is unlikely – existing point pollution enforcement is ineffective. Regulation of GWH manufacturers or installers more likely to be effective
   - None

5. *Are there any relevant building codes?*
   - 1040?

- Needs to be in planning permission process – Dept. BW&S sign these

6. *What about plumbing 'sign-off' on home-based systems?*
   - Good idea, albeit with risks
   - Yes, good idea but will need industry training and uptake by, e.g. estate agents
   - Enforceable? Up to the home-owner to investigate
   - Good idea
   - Yes
   - Stick or carrot approach?

Socio-cultural issues

1. *Are socio-cultural-religious considerations important?*
   - Yes, there is a need to be sensitive. Need to have people explain the issues – e.g. Hindus
   - Some activities need very clean water
   - Yes, the role of traditional and spiritual healers
   - Yes, these must be considered
   - No, education is!
   - Role of children in the water cycle must be taken into account

2. *What are the most important socio-cultural concerns?*
   - The removal of 'isinyama' – bad luck
   - Seen as '2nd class' form of water – not desirable
   - Maslow's hierarchy of needs?
   - Acknowledge those who are more water efficient
   - Time, motive, money, beliefs – place / person decides on priority

3. *What are the most important 'influencers' of social acceptance?*
   - Community leaders
   - Focus on community leaders and entrepreneurs or business people using water; e.g. car wash businesses
   - Organised community formations and active CBOs
   - Hotspots for champions to set examples; e.g. restaurants, hotels
   - Church, chiefs, traditional healers, NGOs

4. *Who are appropriate users?*
   - Those who demand it. Under water-stressed conditions, options could be provided for reducing demand; GWH could be an option
   - People who want it and are committed to the monitoring and lifestyle change.
   - Anyone who produces it and can install a safe system
   - Need to bring in citizen science to greywater use
   - 'Educated' people

5. *What are the likely behavioural impacts?*
   - Unserviced areas – no disposal
   - Education
   - Traditional healers?? Water cannot be reused (bad luck)
   - There will still be 'outsiders' who will not practice. Need to be sensitive to this

Appropriate applications / uses

1. *What are appropriate uses?*
   - Washing appliances, cars etc.
   - Garden, toilet, pool?
   - Toilet, grass, car wash
   - Reuse for flushing of toilets
   - Anything, especially toilet flush and garden
   - Garden, toilet
   - What are the drivers? Price of water; connections or supply assurance; environmental (not really?)

2. *What are inappropriate uses?*
   - Root and leaf vegetables
   - Definition of greywater important here – bath, shower, hand basin and laundry only. Treated effluent is NOT greywater; kitchen, bidet and toilet water is NOT greywater.
   - Long-term storage without treatment for whatever use
   - Drinking water
   - Certain vegetables, drinking, storage

3. *Is scale important when designing a greywater system?*
   - Yes, but not as important as risk
   - Yes, retention time is key
   - One must assume, yes. Really depends on the scale of inputs to the system

4. *How do you decide which risk preventative barriers to adopt?*
   - Currently – Google

5. *Is greywater harvesting appropriate in both serviced and un-serviced settlements?*
   - Yes, BUT….
   - Yes, different opportunities and drivers
   - Yes – formal; No – informal (other factors to be considered; e.g. dense communities)
   - It is likely more appropriate in serviced areas as risks can be better mitigated but if it is going to happen anyway in unserviced areas, then information must be provided on appropriate uses
   - Classify use of greywater: domestic – formal / informal, or industrial

Health aspects

1. *Is greywater a health risk?*
   - Yes, if not properly controlled or managed
   - Depends on contact and treatment
   - Untreated, then Yes
   - Depends on how it is used and where it was sourced.

2. *What are the pathways to infection?*
   - Ponds / pools (kids likely to use these for swimming
   - Edible crops (e.g. carrots)

3. *What preventative barriers are there?*
   - Filtration
   - Hands-on user exposure to practical solutions
   - Controlled installation of systems
   - Depends on where the system is being used BUT education alongside implementation is crucial; i.e. pathogen reduction through knowledge of the risks involved

4. *Is hygiene education important?*
   - Yes!
   - Yes, very. The risks involved should be known. Behavioural awareness / education is very important
   - Absolutely – inappropriate use is deadly
   - Need to have stats from nearby clinics to back up information
   - Very important to not fuel disease outbreaks
   - Yes – people mostly in informal settlements will need awareness campaigns
   - Regarding health – clinics should be more involved in helping communities to understand the causes of ill health

5. *What health risks are associated with greywater? To plants, animals, people?*
   - See Jo Barnes' report
   - Transfer of pharmaceuticals and heavy metals? Exposure to immune drugs
   - Plants – viruses and bacteria affect / reduce growth stages. People – infections, death

Key design considerations

1. *What are the key technical design considerations?*
   - Value for returning greywater to sewer when raining or for other reasons
   - Maintenance
   - Formal sewer system preferred
   - Ease of use; don't store water; overflow to sewer
   - Minimal O&M
   - Overflow to sewer from installed systems

2. *Centralised or decentralised systems; i.e. scale?*
   - Both
   - Both, depending on location
   - Both, but in the short-term likely to remain small-scale
   - Both; dependent on area, erf size and income distribution
   - Why either or? Is this not a context, scale and capacity issue?
   - Is the infrastructure around separating grey from black water in established suburbs possible for a centralised system?

3. *Are there specific considerations related to quantity and quality?*
   - This could possibly be unpacked with real numbers at different scales (household / village / town / city)

4. *Are there basic handling rules for greywater*?
   - Wash hands afterwards

- Subject to context-driven risks
- See Jo Barnes' report
- Use acceptably

5. *What are the operation and maintenance issues?*
    - Reduced flows in sewage system
    - Who is paid to manage the system? Where does the money come from to manage systems? What about sustainability of funds and resources to maintain?
    - Is maintenance centralised or decentralised?
    - The context of greywater in informal settlements
    - Ease of use
    - Long maintenance time scale; e.g. once monthly
    - Keep it simple (KISS), and low-cost / time

6. *Is economic viability important?*
    - No! You need to be prepared to put in money (pay) if necessary
    - Economic viability is a massive driver of greywater use. Disagree with comment re increased use of greywater having negative implications on phosphorous extraction at WWTW – seems too broad an area of concern for now
    - Yes, but it is also about making water available for fit-for-purpose uses during drought / water scarcity
    - Yes, but overly onerous regulation may kill economic viability. Should not be the focus of the guidelines
    - Decentralisation of services has an impact on municipal revenue – it is important to acknowledge disincentives to promoting GWH

7. Are there potential impacts on other water services?
    - Groundwater pumps / systems?
    - Yes – water supply, wastewater systems, budgets – maintenance and operational

Risk management / Quantification

1. *Why have previous guidelines not been widely adopted?*
    - What guidelines?
    - Too much text to read. Too vague
    - Probably not publicised enough. Greywater harvesting still very fragmented – needs to be promoted on a larger scale.
    - Reverse this question – what is it that this project needs to do differently?
    - The documents are not easily accessible (translation, language, technical words).
    - Do the relevant or eligible users even know about them?

2. *Are guidelines useful for managing risk?*
    - Yes
    - Somewhat
    - Maybe – depends if people use them and if they are able to use them (socio-economic pressures may not allow risk mitigation investment)

3. *Is the WHO approach to risk management useful?*

- Localise – agreed!

4. *What are the simplest ways to manage risk?*
    - Bottom-up (households want to save money and/or garden) and top-down (city wants to reduce demand / 'process' for income?)
    - City by-laws due to impacts on water supply and wastewater system and public health
    - Monitor who gets sick?
    - Information fliers
    - Polluter pays principle
    - By-laws and enforcement – but this means costs for local authority

5. *Is the "Greywater Harvesting Assessment tool" a good idea in principle?*
    - There seems to be an opportunity for guidelines or legislation to prevent greywater that has been reused from reaching storm water systems – in order to manage environmental risks. The greywater harvesting assessment tool could be used to guide household users on quantity, not just quality of water used for irrigation.
    - Looks good!
    - Yes – it should be as simple and user-friendly as possible, whilst being tailored for different users.
    - Yes, important to empower users. Should be online and updated with all latest data. Should have an 'over-ride' function if risks become too high – which could trigger a referral to expert / local authority.
    - No / Yes – a simple tool is needed
    - Keep it very simple
    - Yes, consider O&M
    - Yes, must be practical and tested
    - Yes – only as a basic assessment as each case should be assessed individually
    - Overall – demonstrate rather than debate
    - As a householder, proof is in the pudding. Must be simple to do, affordable, minimum O&M – assessment will show in water bill

APPENDIX B: OVERVIEW OF EXISTING LEGISLATIVE CONTEXT – MUNICIPAL / LOCAL REGULATIONS

C1 MUNICIPAL / LOCAL REGULATIONS

WESTERN CAPE
City of Cape Town Metropolitan Municipality (*Provincial Gazette* No. 6847: Local Authority Notice of 2011) In circumstances where an owner of land wishes to install a new water installation system, written permission must be obtained from the Director following the submission of plans.[58] Where this new installation includes a system for water management and conservation, including a greywater system, these details must also be furnished to the Director.[59]
Drakenstein Local Municipality (*Provincial Gazette Extraordinary* No. 6426: Local Authority Notice of 2007; *Provincial Gazette Extraordinary* No. 7291: Local Authority Notice No. 51385 of 2014) The use of greywater is restricted and may only be used by those who have obtained written permission from the Municipality are entitled to do so.[60] An owner of land is permitted to install a greywater system, though the definition provided for greywater expressly excludes kitchen water (due to its fat content).[61] This entitlement is restricted by the duty on owner to exercise proper control. Limited guidance is provided in this regard, as the by-law only states that the owner must ensure that the system does not cause a nuisance to others or emit bad odours. The Municipality is entitled to impose limitations or restrictions on the use of greywater in circumstances where it "suspects that the use thereof has a negative impact on the health of persons occupying such premises or the environment". In addition, the Municipality may inspect the use of greywater under such circumstances.[62]
Bitou Local Municipality (*Provincial Gazette Extraordinary* No. 6668: Local Authority Notice of 2009) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[63] The definition for greywater excludes any waste water obtained from a garbage grinder.
George Local Municipality (*Provincial Gazette* No. 6687: Local Authority Notice of 2010) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[64]

[58] Reg 42(1).
[59] Reg 42(5).
[60] By-law 47.
[61] By-law 49.
[62] By-law 49(2).
[63] Bylaw 47.
[64] Bylaw 47.

Hessequa Local Municipality (*Provincial Gazette Extraordinary No. 6588*: Local Authority Notice of 2008) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[65]
Knysna Local Municipality (*Provincial Gazette Extraordinary* No. 7487: Local Authority Notice of 2015) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[66]
Mossel Bay Local Municipality – Water Conservation Policy (*Provincial Gazette* No. 6788: Local Authority Notice of 2010; *Provincial Gazette* No. 6678: Local Authority Notice of 2009) The municipality, in accordance with its water demand management requirements, may require any owner or consumer to reuse greywater for purposes of gardening.[67] The by-laws provide that greywater usage is not permissible without the prior written approval of the Director, and subject to any conditions that they may impose.[68]
Overstrand Local Municipality (*Provincial Gazette* No. 6683: Local Authority Notice of 2009) An owner of land is permitted to install a greywater system.[69] This entitlement is restricted by the duty on owner to exercise proper control. The Municipality is entitled to impose limitations or restrictions on the use of greywater in circumstances where it "suspects that the use thereof has a negative impact on the health of persons occupying such premises or the environment".
Swellendam Local Municipality (P*rovincial Gazette* No. 7400: Local Authority Notice of 2015) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[70] No definition is provided for greywater.
Theewaterskloof Local Municipality (*Provincial Gazette Extraordinary* No. 7488: Local Authority Notice of 2015) No specific regulations provided for the use of greywater, though it is expressly excluded from the definition of "storm water".
West Coast District Municipality (*Provincial Gazette Extraordinary* No. 6777: Local Authority Notice of 2010) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[71]
Bergriver Local Municipality (*Provincial Gazette Extraordinary* No. 6777: Local Authority Notice of 2009)

[65] Bylaw 46.
[66] Bylaw 47.
[67] 5(1)(q).
[68] Bylaw 49.
[69] By-law 44.
[70] Bylaw 47.
[71] Bylaw 48.

The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[72]
Saldhana Bay Local Municipality (*Provincial Gazette Extraordinary* No. 7077: Local Authority Notice of 2012) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[73]
Swartland Local Municipality (*Provincial Gazette Extraordinary* No. 7285: Local Authority Notice of 2014) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality. [74]
Cederberg Local Municipality (*Provincial Gazette Extraordinary* No. 6181: Local Authority Notice 21 of 2004) The by-laws provide that greywater usage is not permissible without prior written approval of the Municipality, and subject to any conditions they may impose.[75]
Breede Valley Local Municipality (*Provincial Gazette Extraordinary* No. 6650: Local Authority Notice of 2008) The by-laws provide that greywater usage is not permissible without the prior written approval of the Municipality, and subject to any conditions that they may impose.[76]

NORTH-WEST
Madibeng Local Municipality (*Provincial Gazette Extraordinary* No. 7602: Local Authority Notice No. 17 of 2016) The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or re-use of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges".[77] No definition of greywater is provided.
Moses Kotane Local Municipality (*Provincial Gazette Extraordinary* No. 6503: Local Authority Notice No. 249 of 2008) The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or re-use of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges".[78] No definition of greywater is provided.
Moretele Local Municipality (*Provincial Gazette Extraordinary* No. 6839: Local Authority Notice No. 264 of 2010)

[72] Bylaw 82.
[73] Bylaw 46.
[74] Bylaw 83.
[75] Bylaw 48.
[76] Bylaw 46.
[77]
[78]

The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or re-use of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges".[79] No definition of greywater is provided.
Ramotshere Moiloa Local Municipality (*Provincial Gazette Extraordinary* No. 551: Local Authority Notice No. 101 of 2015) Greywater is defined as "waste water resulting from the use of water for domestic purposes but does not include human excreta". The bylaws further provide that the Municipality may limit the use of greywater in circumstances where it negatively effects heath, the environment or other water resources.[80]

MPUMALANGA
Thaba Chweu Local Municipality (*Provincial Gazette Extraordinary* No. 1434: Local Authority Notice No. 196 of 2007) The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or reuse of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges for domestic or any other purposes which, in the opinion of the Council, may give rise a health hazard".[81] No definition of greywater is provided.

LIMPOPO
Vhembe District Municipality (*Provincial Gazette Extraordinary* No. 1550: Local Authority Notice No. 358 of 2008) A definition of greywater is provided as "waste water resulting from the use of water for domestic purposes, but does not include human excreta", though no further reference is made to greywater in the bylaw.
Mogalakwena Local Municipality (*Provincial Gazette Extraordinary* No. 1687: Local Authority Notice No. 306 of 2009) Greywater is defined as meaning "effluent resulting from wash basins, showers, baths, laundry washing machines", though no further reference is made to greywater in the bylaw.
Greater Sekhukhune District Municipality (*Provincial Gazette Extraordinary* No. 1844: Local Authority Notice No. of 2010) The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or reuse of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges".[82] No definition of greywater is provided.

[79]

[80] 77.

[81] 51

[82] 43.

KWA-ZULU NATAL
Umzimkhulu Local Municipality (*Provincial Gazette Extraordinary* No. 1134: General Notice of 2004) The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or reuse of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges".[83] No definition of greywater is provided.
Umhlathuze Local Municipality (*Provincial Gazette Extraordinary* No. 6430: General Notice of 2005; *Provincial Gazette Extraordinary* No. 1929: General Notice of 2015) The use of greywater is permissible, though it may not contain food particles.[84] The bylaw requires that any greywater, following its re-use, must be discharged to the sewer. In addition, it may not pose a health risk.[85] It is defined as "waste water resulting from the use of water for domestic purposes, but does not include human excreta". Additional bylaws also require that there is no cross connection between greywater systems and potable water supply, as part of a plumber's checklist.
uThungulu District Municipality (*Provincial Gazette Extraordinary* No. 1261: Local Authority Notice 142 of 2014) The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or reuse of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges".[86] No definition of greywater is provided.

GAUTENG
Kungwini Local Municipality (*Provincial Gazette Extraordinary* No. 105: Local Authority Notice 985 of 2008) A definition of greywater is provided as "waste water from residential use that does not include human waste", though no further reference is made to greywater in the bylaw.
Mogale City Local Municipality (*Provincial Gazette Extraordinary* No. 156: Local Authority Notice 754 of 2013; *Provincial Gazette Extraordinary* No. 4: Local Authority Notice 62 of 2007) Greywater is included within the definition of "sewage". In addition, the bylaws require the planning of low-cost housing to ensure that "households must be able to access greywater effluent for gardening purposes".

EASTERN CAPE
Buffalo City Local Municipality (*Provincial Gazette Extraordinary* No. 2532: Local Authority Notice 4 of 2011)

83 52.
84 59.
85 59.
86 71.

A number of references are made to greywater. The use of greywater is prohibited without written authority being obtained from the Municipality.[87] This permission is ostensibly only obtainable by the owner of the premises.[88] This permission must be sought by a written application, which sets out the reasons for the use and motivates that such use falls within the ambit of the by-law.[89] The Municipality is able to reverse any approval for any reason whatsoever, and will not attract any liability for doing so.[90] The use of greywater by an owner will not afford the owner any reduction in charges for the utilisation thereof.[91] Greywater is included within ambit of the disposal of liquid using a french drain. In addition, the irrigation of sports fields, golf courses, market gardens, nurseries, food lots, crop production, pasture and turf cultivation using greywater is permissible, subject to the requisite approval being obtained. Greywater is defined within the context of "sullage", meaning "non-industrial wastewater, generated from domestic processes such as dish washing, laundry or bathing, or sediment deposited from flowing water". The definition of "pollution" also envisages that the discharge of greywater may amount to pollution. As part of the process to obtain approval for a greywater system, a Municipality may require an owner to provide an Environmental Impact Assessment or Health Effect Assessment.[92] A separate receptacle must be provided for the storage of greywater, which may not be connected to a septic tank or municipal sewer.[93] Only an authorised officer or agent may carry out the removal of greywater, which must occur twice per week.[94]
Ntabankulu Local Municipality (*Provincial Gazette Extraordinary* No. 1596: Local Authority Notice 126 of 2006) The exact meaning of the regulations provided is unclear. The bylaw provides that "any device which entails the recycling or reuse of water shall not make use of water derived from any kitchen, excluding clothes washing machines, or from toilet discharges".[95] No definition of greywater is provided.

Nelson Mandela Metropolitan Municipality (*Provincial Gazette Extraordinary* No. 2361: Local Authority Notice 57 of 2010) Greywater is defined as "waste water resulting from the use of water for domestic purposes and does not include kitchen waste water or human excreta". Any use of greywater is required to meet the standards set out in SABS 0323.
Joe Gqabi District Municipality (*Provincial Gazette Extraordinary* No. 3488: Local Authority Notice 102 of 2015)

[87] 69(1).
[88] 69(1).
[89] 69(2).
[90] 69(4).
[91] 69(6).
[92] 70(9).
[93] 187.
[94] 187(6)-(7).
[95] 52.

The bylaws permit the use of a soak away for the disposal of greywater. No definition of greywater is provided.

No specific provision/reference to greywater in the following districts/municipalities:	
Western Cape	Cape Winelands District Municipality • Central Karoo District Municipality • Eden District Municipality • Overberg District Municipality Breede River/ Winelands Local Municipality Langeberg Local Municipality Stellenbosch Local Municipality Witzenberg Local Municipality Beaufort West Local Municipality Laingsburg Local Municipality Prince Albert Local Municipality Kannaland Local Municipality Oudtshoorn Local Municipality Cape Aghulas Local Municipality Cederberg Local Municipality Matzikama Local Municipality
North-West	Bonjanala District Municipality Dr Kenneth Kaunda District Municipality • Dr Ruth Segomotsi District Municipality • Ngaka Modiri Molema District Municipality Kgetlengrivier Local Municipality Rustenberg Local Municipality Maquassi Hills Local Municipality Matlosana Local Municipality Tlokwe Local Municipality Ventersdorp Local Municipality Greater Taung Local Municipality Kagisano-Molopo Local Municipality Lekwe-Teemane Local Municipality Mamusa Local Municipality Molopo Local Municipality Naledi Local Municipality Ditsobotla Local Municipality Mafikeng Local Municipality Ratlou Local Municipality Tswaing Local Municipality

Northern Cape* *(The only reference to greywater in the Northern Cape is in the context of charging for removal of greywater)	Frances Baard District Municipality • John Taolo Gaetsewe District Municipality • Namakwa District Municipality • Pixley ka Seme District Municipality • Siyanda District Municipality Dikgatlong Local Municipality Magareng Local Municipality Phokwane Local Municipality Sol Plaatje Local Municipality Gamagara Local Municipality Ga-Segonyana Local Municipality Joe Morolong Local Municipality Hantam Local Municipality Kamiesberg Local Municipality Karoo Hoogland Local Municipality Khai-Ma Local Municipality Nama-Khoi Local Municipality Richtersveld Local Municipality Emthanjeni Local Municipality Siyancuma Local Municipality Siyathema Local Municipality Thembelihle Local Municipality Ubuntu Local Municipality Umsobomvu Local Municipality Khara Hais Local Municipality Kgatelopele Local Municipality Tsantsabane Local Municipality Kai! Garib Local Municipality
Mpumalanga	Ehlanzeni District Municipality Gert Sibane District Municipality Nkangala District Municipality Bushbuckridge Local Municipality Mbombela Local Municipality Nkomazi Local Municipality Umjindi Local Municipality Albert Luthuli Local Municipality Dipaleseng Local Municipality Govan Mbeki Local Municipality Msukaligwa Local Municipality Pixley Ka Seme Local Municipality

	Dr JS Moroka Local Municipality Emakhazeni Local Municipality Emahaleni Local Municipality Steve Tshwete Local Municipality Thembisile Hani Local Municipality Victor Khanye Local Municipality
Limpopo	Bohlabela District Municipality Capricon District Municipality Mopani District Municipality Waterberg District Municipality Aganang Local Municipality Blouberg Local Municipality Lepelle-Nkumpi Local Municipality Molemole Local Municipality Polokwane Local Municipality Elias Motsoaledi Local Municipality Ephraim Mogale Local Municipality Fetakgomo Local Municipality Greater Tubatse Local Municipality Makhuduthmanga Local Municipality Ba-Phalaborwa Local Municipality Greater Giyani Local Municipality Greater Letaba Local Municipality Greater Tzaneen Local Municipality Maruleng Local Municipality Makhado Local Municipality Musina Local Municipality Mutale Local Municipality Thulamela Local Municipality Bela-Bela Local Municipality Lephalale Local Municipality Modimolle Local Municipality Mookgophong Local Municipality Thabazimbi Local Municipality
Kwa-Zulu Natal	eThekwini (The eThekwini Municipality published guidelines on the use of greywater, though this document is merely informative. They recommend the following: • "Avoid storage of greywater for any length of time as this can lead to the growth of pathogens and harmful bacteria.

	• Make use of biodegradable soaps and laundry detergents that are low in phosphorous when re-cycling water from clothes washing. • Do not use excessive amounts of soap and detergent. Install a filter to remove solid waste from the water. • Ensure that the filter is cleaned / replaced regularly. • Do not re-use kitchen water from dishwashing due to the high risk of growth of harmful bacteria.)[96] Amajuba District Municipality iLembe District Municipality Sisonke District Municipality Ugu District Municipality Umgungundlovu District Municipality Umkhanyakude District Municipality Umzinyathi District Municipality Uthukela District Municipality Zululand District Municipality eMadlangeni Local Municipality Dannhauser Local Municipality Newcastle Local Municipality KwaDakuza Local Municipality Mandeni Local Municipality Maphumolo Local Municipality Ndwedwe Local Municipality Greater Kokstad Local Municipality Ingwe Local Municipality Kwa Sani Local Municipality Ubuhlebezwe Local Municipality Ezinqoleni Local Municipality Hibiscus Local Municipality Umdoni Local Municipality uMuziwabantu Local Municipality Umzumbe Local Municipality Vulamehlo Local Municipality Imendle Local Municipality Mkhambathini Local Municipality Msunduzi Local Municipality Mpofana Local Municipality

[96] Environmental

	Richmond Local Municipality uMngeni Local Municipality uMshwati Local Municipality Big Five False Bay Local Municipality Hlabisa Local Municipality Jozini Local Municipality Mtubatuba Local Municipality Umhlabuyalinga Local Municipality Emdumeni Local Municipality Msinga Local Municipality Nquthu Local Municipality Emnambithi-Ladysmith Local Municipality Imbabazane Local Municipality Indaka Local Municipality Okhahlamba Local Municipality Umtshezi Local Municipality Mthonjaneni Local Municipality Nkandla Local Municipality Ntambanana Local Municipality Umfolozi Local Municipality Umlalazi Local Municipality Abaqulusi Local Municipality Ulundi Local Municipality uPhongolo Local Municipality eDumbe Local Municipality Nongoma Local Municipality eThekwini • Amanzimtoti • Assegay • Bothas Hill • Canelands • Cato Ridge • Clermont • Drummond • Durban • Everton • Gillits • Hammarsdale • Hillcrest • Inner West Substructure Council

	• Isipingo • Kingsburgh • Kloof • Lovu • Lower Illovo • Marianhill • Marrianridge • Mount Edgecombe • Multiple Municipalities • New Germany • North Central Substructure Council • North Substructure Council • Ottawa • Outer West Council • Pinetown • Port-Natal Ebhodwe • Queensburgh • Redcliffe • Saiccor • Shallcross • South Central Substructure Council • South Substructure Council • Tongaat • Ugu Regional Council • Umbogintwini • Umhlanga • Umkomaas • Verulam • Waterfall • Widenham • Westville • Western Transitional Metropolitan Substructure Council • Yellow Wood Park
Gauteng	City of Johannesburg Metropolitan Municipality City of Tshwane Metropolitan Municipality Ekurhuleni Metropolitan Municipality Metsweding District Municipality Sedibeng District Municipality West Rand District Municipality

	Emfuleni Local Municipality Lesedi Local Municipality Midvaal Local Municipality Merafong Local Municipality Randfontein Local Municipality Westonaria Local Municipality
Free State	Fezile Dabi District Municipality Lejweleputswa District Municipality Motheo District Municipality Thabo Mofutsanyane District Municipality Xhariep District Municipality Mafube Local Municipality Metsimaholo Local Municipality Moqhaka Local Municipality Ngwathe Local Municipality Masilonyana Local Municipality Matjhabeng Local Municipality Nala Local Municipality Tswelopele Local Municipality Mangaung Local Municipality Mantsopa Local Municipality Naledi Local Municipality Dihlabeng Local Municipality Maluti a Phofung Local Municipality Nketoana Local Municipality Phumelela Local Municipality Setsoto Local Municipality Kopanong Local Municipality Letsemeng Local Municipality Mohokare Local Municipality
Eastern Cape	Alfred Nzo District Municipality Amatole District Municipality Cacadu District Municipality Chris Hani District Municipality O.R Tambo District Municipality Alfred Nzo Local Municipality Matatiele Local Municipality Umzimvubu Local Municipality Amahlathi Local Municipality Great Kei Local Municipality

	Mbashe Local Municipality Mnquma Local Municipality Ngqushwa Local Municipality Nkonkobe Local Municipality Nxuba Local Municipality Baviaans Local Municipality Blue Crane Route Local Municipality Camdeboo Local Municipality Ikwezi Local Municipality Kouga Local Municipality Koukamma Local Municipality Makana Local Municipality Ndlambe Local Municipality Sunday's River Local Municipality Emalahleni Local Municipality Engcobo Local Municipality Lukanji Local Municipality Inkwanca Local Municipality Intsika Local Municipality Inxuba Yethemba Local Municipality Sakhisizwe Local Municipality Tsolwana Local Municipality Elundini Local Municipality Gariep Local Municipality Maletswai Local Municipality Senqu Local Municipality Ingquza Local Municipality King Sabata Dalindyebo Local Municipality Mbizana Local Municipality Mhlonto Local Municipality Nyandeni Local Municipality Port St Johns Local Municipality

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