Advancing Perth's Eastern Region

Reuse of Greywater for Local Governments in Western Australia

Discussion Paper
Revised May 2014
(original paper July 2011)

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1. Introduction

1.1. Scope

The purpose of this discussion paper is to provide local government staff and councillors with general information on greywater reuse, including types of systems, approvals, benefits, risks and potential applications. It is intended to give an indication of whether a particular project may be feasible and whether a detailed scoping study and cost benefit analysis should be undertaken.

This discussion paper is a review and update of the ‘Reuse of Greywater in Western Australia’ produced by EMRC in July 2011. There has been minimal change in this area in Western Australia since 2011 due to Department of Health regulations, however the revised paper contains some new guidelines (Guidelines for the Non-potable Uses of Recycled Water in Western Australia August 2011, and Water Forever Plan 2012), additional examples of greywater reuse (Bold Park Aquatic Centre Feasibility Study 2011) and updated cost ranges for greywater systems where available. For clarity, it only contains information relevant at the local government scale, unless it provides context.

1.2. Background

Being the driest inhabited continent, Australia has always had a limited supply of fresh water. Recently this problem has been receiving more attention due to a number of reasons, including Australia’s population growth and changes in climatic conditions, in particular declining rainfall in some areas, including the south-west of Western Australia.

The south-west of WA has experienced a decrease in annual rainfall of 15% since the mid 1970s, which has resulted in a greater reduction in stream flow into dams. From 1911 to 1974 the average annual stream flow into Perth dams was 338 GL. From 1975 to 2000 the average annual stream flow declined by 50% to 177 GL. From 2001 to 2010 the average annual stream flow declined by another 50% to 75 GL per year (Department of Water, 2013).

Australia’s population has increased rapidly in recent years with higher population growth predicted for the future. All states and territories experienced increased population growth over the 12 months ended 30 September 2013, with Western Australia recording the highest growth of 3.1% (Australian Bureau of Statistics, 2014). Western Australia’s population could reach 3.2 million people by 2026, representing an annual growth rate of 2.2%. At this growth rate, water use is anticipated to increase by 2.4% per year (Department of Water, 2013).

Factors such as decreasing rainfall and water supply combined with an increasing population and water demand means that efforts to conserve water are needed more now than ever before. Greywater reuse and wastewater recycling are some of the actions that can aid in improving water efficiency and water conservation. Local governments can provide an example to the community with the installation of greywater systems at council buildings.

1.3. What is Greywater?

Greywater is the wastewater from the laundry, kitchen and bathroom (shower, bath and bathroom basins) arising from daily activities such as washing clothes, washing dishes showering, brushing teeth, washing hands and other activities that result in water going down the ‘drain’. It does not contain blackwater (wastewater from toilets) or nitrogen and phosphorus rich yellowwater (water collected from urinals or urine diversion toilets).

Greywater may contain small amounts of bacteria, suspended matter, organic matter, oils, fats, lint, food, hair, body cells, traces of faeces, urine, blood and a range of chemicals including nutrients and salts coming from soaps, shampoos, toothpaste, mouthwash, dyes, bleaches and disinfectants (Department of Health, 2010). Greywater generated in the kitchen contains a higher concentration of fats and oils.

Greywater is most commonly used for sub-surface irrigation of lawns and gardens. Sub-surface irrigation delivers water at least 10cm below the surface of the soil or mulch, minimising the risk of direct contact with pathogens or contaminants in the greywater. All irrigation pipes must be colour coded purple, the international colour for wastewater identification (Department of Health, 2010). If treated and disinfected, greywater may potentially be used for surface irrigation, toilet flushing and cold water laundry washing machine use. Potential uses for greywater for local governments include irrigation of garden beds and public open space, road making, dust suppression, street cleaning, vehicle washing and water features, subject to appropriate treatment and compliance with the WA guidelines.

1.4. Types of Greywater Systems

The three greywater reuse options are bucketing, Greywater Diversion Device and Greywater Treatment System.

The level of treatment required and the type of greywater system that can be used depends on:

- The property that the greywater is being collected and used at (greywater from public facilities, commercial premises and multi-dwelling properties require more advanced treatment than single residences);
- The source of the greywater (for instance, greywater from kitchens has a high fat and oil content, so requires more advanced treatment); and
- The intended end use (greywater for surface irrigation, toilet flushing and cold water laundry washing machine use requires treatment and disinfection).

1.4.1. Bucketing

Bucketing is the simplest method of greywater reuse for households. The greywater can be collected directly from the bathroom and laundry, and applied to garden or lawn areas, so does not require modification to the plumbing or installation of greywater system.

1.4.2. Greywater Diversion Device

A Greywater Diversion Device (GDD) diverts untreated greywater from entering the sewage system, and applies it to the garden. Two types of GDDs exist: the Gravity GDD and the Pump GDD. The Gravity GDD as the name suggests relies on gravity and has a manual switch or a valve fitted to the outlet of the waste pipe, such as laundry sink, and the greywater is directly diverted to a sub-surface garden irrigation system. The Pump GDD incorporates a surge tank to accommodate sudden surges of greywater and a pump to distribute the collected greywater to the sub-surface garden irrigation system. The surge tank does not act as a storage tank, as storage of greywater may cause it to turn septic (Department of Health, 2013). For a simplified schematic of greywater reuse through a diversion valve including a surge tank see Figure 1 below. Due to the high content of oils, fats and detergents in wastewater coming from the kitchen sink or dishwasher, this water needs to be treated before use on the garden and therefore cannot be reused through a GDD (Department of Health, 2010). As greywater from commercial premises and multi-dwelling properties requires treatment prior to use (Department of Health 2010), a GDD system is generally used only for domestic or single household purposes.

N.B. Commercial premises include public buildings, recreation and aquatic centres, libraries, and administration buildings (C. Rodriges, Department of Health, 2014, pers. comm).

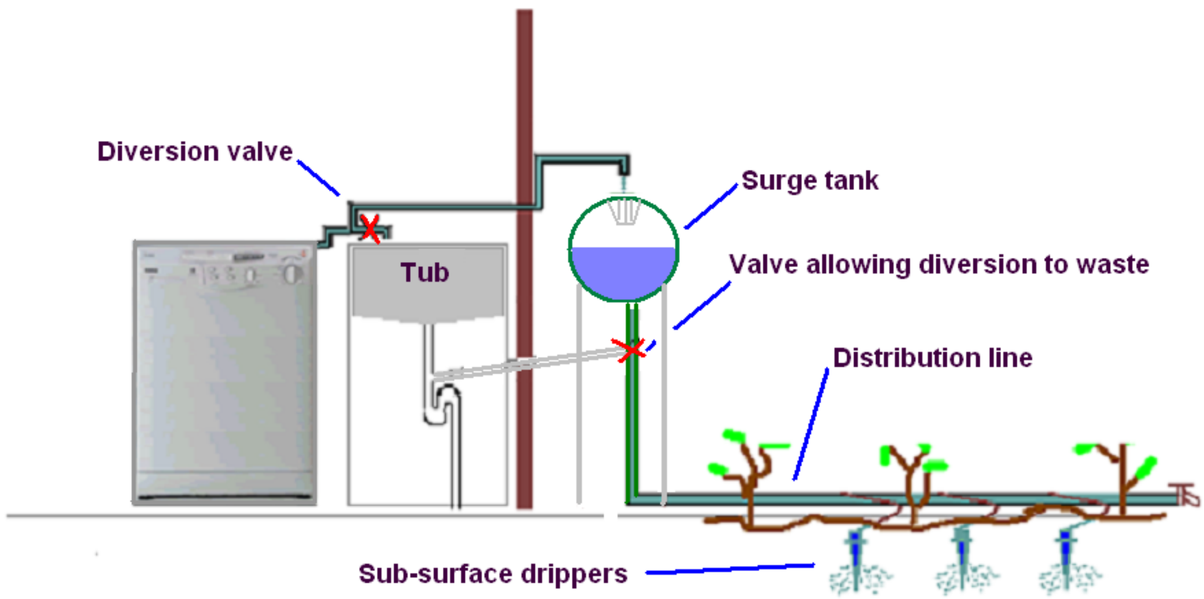

Figure 1: Simplified schematic of greywater reuse through a diversion valve including a surge tank
Source: www.sydneywater.com.au

1.4.3. Greywater Treatment System

A Greywater Treatment System (GTS) collects and treats greywater to a higher quality. If the GTS incorporates the disinfection of greywater, it may be used for surface irrigation, toilet flushing and possibly for cold-water in washing machines. For a schematic of GTS see Figure 2 below.

A GTS is the simplest method of greywater reuse for multi dwelling and commercial premises (including aquatic centres and public facilities) as these premises are required by the Code of Practice (Department of Health, 2010) to treat the greywater prior to discharge. In order to reuse the greywater for sub-surface irrigation or surface drip irrigation, the GTS needs to include disinfection. For toilet flushing and washing machine use the greywater requires a higher level of treatment (advanced secondary treatment and disinfection).

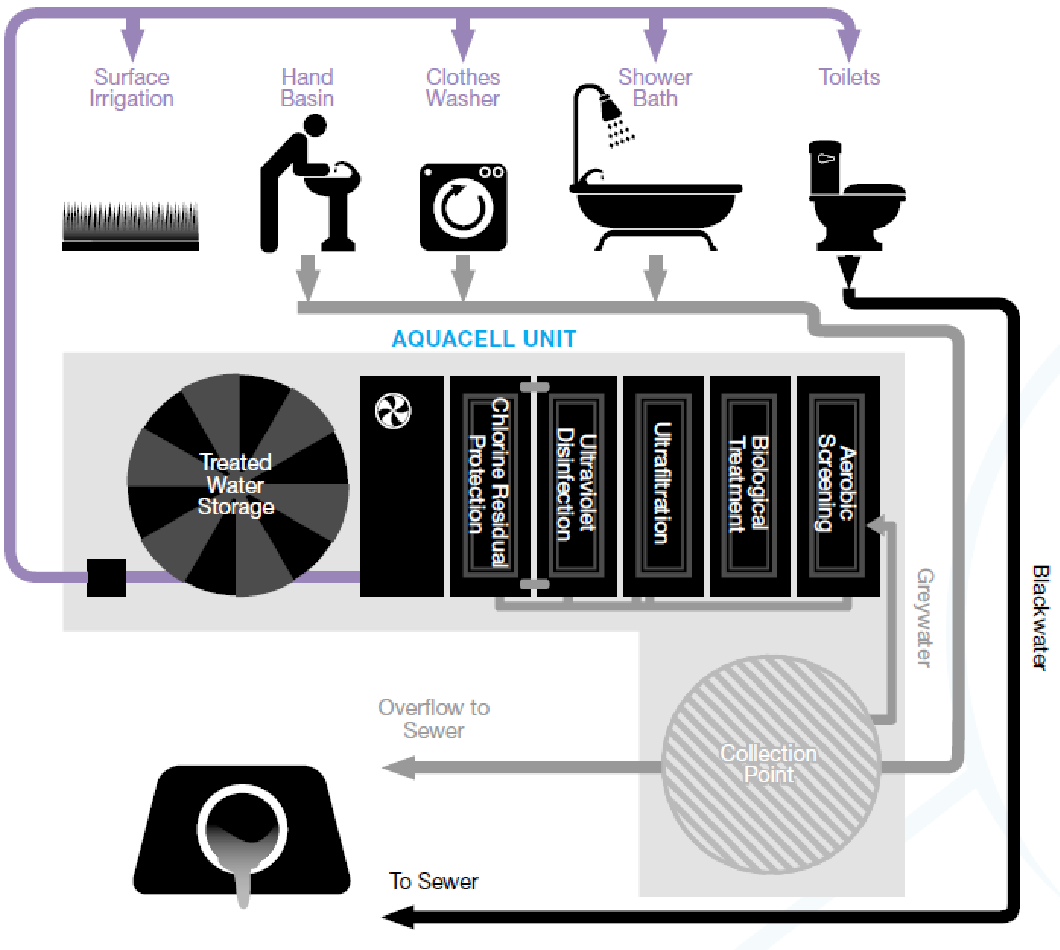

Figure 2: Simplified schematic of a comprehensive greywater treatment system
Source: www.aquacell.com.au
NB: The ability of reusing treated greywater for shower or bath depends on each State's health and environmental regulations. Western Australian guidelines do not currently permit greywater to be used for showering or bathing

1.5. Approvals

Both GDDs and GTSs must be approved prior to installation. The relevant Local Government Authority can approve greywater systems for:

- single dwellings; and
- commercial premises or multi dwelling properties producing less than 5,000L/day of greywater for sub-surface irrigation use (Department of Health, 2010).

This also applies to greywater systems proposed by local governments (C. Rodriges, Department of Health, 2014, pers. comm). Systems on commercial premises or multi dwelling properties producing more than 5,000L/day and using greywater for surface irrigation, or for indoor uses (e.g. toilet flushing) are required to be approved by the Department of Health, and are assessed under the Guidelines for the Non-Potable Uses of Recycled Water in Western Australia (Department of Health, 2011). Additionally, manufacturers of greywater systems must have product approval and a WaterMark License from the Executive Director of Public Health, allowing them to display the WaterMark logo (see Figure 3 below). The Department of Health provides a list of greywater systems approved for use in WA, including the brand, model, date approved, WaterMark Licence number and the manufacturer. See Section 2.5 below.

Figure 3: Department of Health WaterMark logo

2. Guidelines, Legislation and Practice

In order to help alleviate the unsustainable demands for potable water, recycling of water is increasingly being incorporated into Australian policy framework and guidelines development.

2.1. Code of Practice for Reuse of Greywater in Western Australia 2010

(The “Code of Practice for the Use of Greywater in WA 2010”, has been endorsed by the Executive Director Public Health in accordance with Section 344A (2) of the Health Act 1911).

The Code applies to the reuse of greywater in sewered areas of Western Australia for:

- Single residential domestic premises; and
- Multiple dwellings and commercial premises producing up to 5,000 L/day of greywater.

The Code provides information about greywater composition, health risks and environmental risks of using greywater. It sets out the minimum requirements for each of the greywater reuse options. The Code also provides details on greywater volume calculations, land application, installation requirements, and approval process (Department of Health, 2010).

Local government is responsible for the approval of all greywater reuse systems used in single dwellings. For multi-dwelling and commercial premises, this code defines the responsible agency (i.e. local government or the Department of Health, Western Australia) that will approve the greywater reuse system based on treatment method, proposed end use and estimation of volumes of greywater produced (Department of Health, 2010).

The Code of Practice is available on the Department of Health website: www.public.health.wa.gov.au/cproot/1340/2/COP%20Greywater%20Reuse%202010_v2_130103.pdf

2.2. Guidelines for the Non-potable Uses of Recycled Water in Western Australia August 2011

These guidelines are designed to cover the non-potable uses of recycled water including treated greywater, industrial wastewater and sewage in Western Australia. The guidelines apply to systems for multiple dwellings and commercial premises that produce between 5kL to 20kL of greywater per day (Department of Health, 2011), so can be applied to greywater systems for local government facilities (for example, recreation centres and administration buildings).

These guidelines are in line with the Australian Guidelines for Water Recycling. They cover feasibility of greywater projects, the risk management framework, the development of a management plan and the Department of Health approval process.

The guidelines are available on the Department of Health website: http://www.public.health.wa.gov.au/cproot/2280/2/Guidelines%20for%20the%20Non-potable%20Uses%20of%20Recycled%20Water%20in%20WA_121019.pdf

2.3. Australian Guidelines for Water Recycling: Managing Health and Environmental Risks

These guidelines describe a broad range of recycling options and provide the scientific basis for implementation of water recycling. Phase 1 of the guidelines covers management and monitoring of risks for the use of greywater and treated sewage for garden irrigation, public open space irrigation, agriculture and horticulture, and industrial uses. Three additional documents (Phase 2) cover the use of recycled water to augment drinking water supplies, the uses of stormwater and roof water for irrigation, and managed aquifer recharge. These guidelines have been designed to “provide an authoritative reference that can be used to support beneficial and sustainable recycling of waters generated from sewage, greywater and stormwater, which represent an under-used resource” (NRMMC, EPHC, & NHMRC, 2009). Recycling greywater at multi-dwelling and commercial premises for indoor use must demonstrate compliance with the Australian Guidelines for Water Recycling (Department of Health, 2010).

Phase 1 of the guidelines is available on the Department of Environment website: www.environment.gov.au/resource/national-water-quality-management-strategy-australian-guidelines-water-recycling-managing-0

2.4. State Water Recycling Strategy

The State Water Recycling Strategy has been designed to outline initiatives that would help increase recycling of wastewater and has set a target of recycling 30% of WA wastewater by 2030. Achieving this goal has to be both sustainable and accepted by the community (Department of Water, 2008).

The State Water Recycling Strategy is available from the Department of Water website: www.water.wa.gov.au/PublicationStore/first/80011.pdf

2.5. Water Forever Plan

Water Corporation's Water Forever Plan has also developed targets, initiatives and options to manage WA water demand and supply. The following targets are to be reached by 2030, and they include:

- Work with the community to reduce their water use by 15%;
- Increasing wastewater recycling to 30%; and
- Developing new sources (Water Corporation, 2012).

The Water Forever Plan is available through the Water Corporation website: www.watercorporation.com.au/~/media/files/about%20us/planning%20for%20the%20future/water-forever-50-year-plan.pdf

2.6. Approved Greywater Systems

A list of greywater systems approved for use in WA is provided by the Department of Health. The list includes the brand, model, date approved, WaterMark Licence number and the manufacturer (Department of Health, 2013).

The list of approved systems can be found on the Department of Health WA website: www.public.health.wa.gov.au/cproot/1342/2/ApprovedGreywaterSystems.pdf

3. Benefits, Risks and Other Considerations for Greywater Reuse

3.1. Benefits

There are a number of benefits to greywater systems including:

3.1.1. Financial savings

- Switching garden irrigation from scheme to greywater, or complementing scheme water irrigation with greywater, will reduce scheme water consumption and therefore reduce water bills.

3.1.2. Environmental benefits

- Reducing the pressure on existing freshwater sources;
- Reducing the amount of sewage discharged to the ocean or rivers;
- Reducing the impacts associated with development of new water sources such as desalination plants, and associated running impacts; and
- Increasing groundwater recharge.

3.1.3. Social benefits

- Reducing demand on potable water;
- Providing an example of sustainability-in-action to the community; and
- Providing a means for local governments to engage with the community and encourage water savings.

3.2. Risks

There are a number of risks associated with greywater systems that need to be taken into account. Many consider greywater to be relatively clean as it does not contain any blackwater. However there are environmental and health risks associated with reuse of greywater due to possible high levels of substances such as disease causing organisms including bacteria, suspended matter, organic matter, oils, fats, lint, food, hair, body cells, traces of faeces, urine, blood and a range of chemicals including nutrients and salts coming from soaps, shampoos, toothpaste, mouthwash, dyes, bleaches and disinfectants (Department of Health, 2010).

With use of greywater friendly products, regular and thorough monitoring and compliance with the Code of Practice (Department of Health, 2010), these risks can be minimised.

3.2.1. Health risks

Greywater is capable of transmitting disease and illness through direct and indirect contact.

To minimise the risk to public health, the Code of Practice (Department of Health, 2010) sets out a number of requirements, including:

- Only permitting untreated greywater to be used via sub-surface irrigation;
- Defining minimum setback distance from buildings and other infrastructure for irrigation areas;
- Ensuring that the greywater does not runoff onto neighbouring properties; and
- Ensuring that the edible parts of plants do not come into contact with greywater.

3.2.2. Environmental risks

Key potential environmental risks from using greywater include build up of chemicals in soils and vegetation over time, and eventually reaching and contaminating groundwater. Chemicals such as bleaches and disinfectants in greywater can potentially kill beneficial micro-organisms in the soil. The high phosphorous content of some detergents can be toxic to some plants, particularly native plants of the Proteaceae family (such as hakea, grevillea and banksia), and the alkalinity of greywater can be detrimental to shade and acid loving plants. The build up of fats and oils which cannot be broken down can over time make soils water repellent (Department of Health, 2010).

Consideration needs to be given to the salt and nutrient content of the cleaning products and detergents used to minimise the environmental risk. Low phosphorus and low salt products should be used. Paints, turpentine, bleach, automotive oils and greases, pesticides and pharmaceuticals should not enter the greywater system (Department of Health, 2010). Community engagement, including an awareness and education program promoting the use of appropriate products for patrons and staff, may be required to ensure acceptance, and proper use of the greywater system.

The volume of greywater generation will vary according to the water usage practices of the council facility and the use of water efficiency devices. The volume of greywater generated may be affected by seasonal changes in the usage of the facility. If the greywater is being used to irrigate, supplementary irrigation may be required.

3.2.3. Financial Risks

Besides the associated health and environmental risks, there are also the risks or disadvantages associated with long payback periods and medium to high capital costs due to the concept and technology being relatively new. There are also the costs associated with regular testing and maintenance of the systems, as well as with the testing of the soil to make sure the system is functioning properly and not contaminating the soil and eventually groundwater. These costs are usually overlooked or not considered in the initial planning of the project and may later be seen as an additional cost. In some instances because of this, systems are not maintained properly, or the soil testing is not performed to avoid the perceived 'additional' cost resulting in contamination of the ground and or making the system inefficient. Another risk is associated with decreased wastewater flows in the sewer pipelines and the cost of services to unblock them. This risk is relatively high especially in WA due to low gradients and the nature of landscape. An adequate volume of water needs to be discharged to flush sewer pipes and prevent blockages.

3.3. Viability

According to the Department of Water (2011), the viability of a wastewater reuse scheme will depend on factors including:

- availability and intended uses, estimated demand and back-up (contingency) water source;
- required level of treatment for intended uses;
- management of health and environmental risks;
- site limitations, including proximity to public drinking water source areas or to conservation category wetlands;

- infrastructure requirements;
- cost of implementation and ongoing management of the scheme; and
- governance issues surrounding long-term ownership, operation and management.

4. Cost-benefit Analysis

Due to greywater systems being relatively new and technology constantly improving and changing it is not possible to develop an accurate cost-benefit analysis for a local government building that can be applied at a generic level. Another factor that also influences development of a cost-benefit analysis is the fact that every single building or facility is different and factors including size of the building, design, number of people working or visiting the building, and size of the irrigation area all affect the cost-benefit analysis. Therefore an accurate cost-benefit analysis can only be developed based on the detailed project specific plan that incorporates all of the variables associated with a particular project.

The financial savings of GTSs for local governments are based on the ongoing reduction of scheme water consumption, after considering maintenance and soil and water testing costs. There is no financial benefit to local government for the reduction of water being discharged to the sewer, as local government facilities are exempt from discharge to sewer charges.

The greywater feasibility study for Bold Park Aquatic Centre calculated an approximate payback period of 16 to 19 years based on the reduction of scheme water consumption (Josh Byrne & Associates, 2011).

In another study, Wiltshire (2005) calculated that the payback period for a GTS was between 6 and 15 years, based on a measure of the true cost of potable water supply of $2.50 per kL. The study identified that the least complex systems (GDDs) with lowest capital costs appeared to be most cost effective (however, GDDs are not suitable for public or commercial facilities). This study did not include soil testing and installation of sub-surface irrigation in the cost-benefit analysis.

Payback periods will decrease as the cost of scheme water increases.

5. Related Installation Costs and Examples

5.1. Estimated cost of supply and installation of Greywater Reuse systems

The cost of a system and related installation costs depend on the type of system and size of the dispersal area. The costs of individual systems for household use can range from approximately $300 for a simple GDD to $7,000 for a GTS, plus the additional costs associated with the approval process, installation, and irrigation modification. Detailed information and costs for household systems has not been provided here, as they are not appropriate for public facilities.

A commercial GTS, suitable for a local government facility, may cost between $20,000 to $500,000 depending on the size of the system, volume of greywater treated, and level of treatment (M. Baker, Perth Grey Water, 2014, pers. comm.) For example, Earth & Water (2014) quoted $44,800 for a greywater system at Coogee Beach Surf Lifesaving Club in 2012, plus additional costs related to installation including landscaping requirements (N. Thompson, Earth and Water, 2014, pers. comm.).

Aquacell quoted between $130,000 and $160,000 for a 5kL/day commercial greywater reuse system would be suitable for a local government building (similar to the EMRC Administration Building in Belmont) in 2011. The quoted cost includes obtaining the necessary regulatory approvals, all process equipment and installation and commissioning. There are also the operational costs of approximately $40,000 to $50,000 per year to cover regulatory compliance costs, sample analysis, remote monitoring, monthly servicing and calibration of instruments, consumables, annual full technical servicing, power, and asset replacement (I. Kikkert, Aquacell, 2011, pers.comm.)

Maintenance of GTSs must be performed by a qualified person under the agreement of installation with the manufacturer or installer, according to the Greywater Industry Group (2013). Maintenance includes regular cleaning of filters, removal of solids from sediment tanks, servicing of pumps, and flushing of irrigation pipes and drippers (Greywater Industry Group, 2013). Water quality testing may also be required to ensure public health safety. Josh Byrne and Associates (2011) estimated maintenance and water quality testing costs to be $500-1000 per year for a greywater system at Bold Park Aquatic Centre.

5.2. Grants and Subsidies

Currently there are no grants or subsidies available for greywater reuse or wastewater recycling for local governments, households or businesses in Western Australia.

Under the National Rainwater and Greywater Initiative rebates up to $500 were available for householders for the purchase of new rainwater tanks and greywater reuse systems from 1 March 2009 to 10 May 2011. A total of 14,625 rebates worth $7,017,200 were paid across Australia (Department of the Environment, 2014). Additionally the Western Australian State Government provided rebates of up to $500 to householders for the purchase or installation costs for approved waterwise products including greywater reuse systems. This rebate scheme ended on 30 June 2011.

Future funding for stormwater harvesting could potentially be made available through the Australian Government’s Plan for a Cleaner Environment (Department of the Environment, 2013). Water Security for Clean Water is one of the focus areas of the plan, including measures to harness stormwater. To date, no funding opportunities have been announced.

5.3. Examples of Integrated Water Management Systems in Local Government

5.3.1. ‘The Grove’

‘The Grove’, is initiative of the Town of Cottesloe, the Shire of Peppermint Grove and the Town of Mosman Park, supported by funding from the Australian Government under the Green Precincts Program. It houses the Shire of Peppermint Grove council offices, a library and community centre. The building, completed in December 2010, incorporates several environmentally sustainable design features, including an on-site wastewater treatment and reuse system installed.

The system incorporates a source-separation approach, and uses recycled water for irrigation. By using recycled water for irrigation the library is expected to reduce the groundwater use by 700,000L each year (The Grove, 2010). The system also incorporates treatment of blackwater. The greywater coming from showers and hand basins, including the kitchen wastewater, and blackwater from toilets and urinals is being separated at the point of generation and plumbed to respective treatment and storage tanks for effective reuse. The system incorporates an overflow and diversion capacity in case of a malfunction or overloading (The Grove, 2010). The schematic design of the integrated wastewater treatment and recycling is shown in Figure 4 below. A photograph taken during the installation of the treatment and storage tanks can be seen in Figure 5.

Benefits of this type of system include a tailored treatment for each wastewater stream, and in case of urine diversion, it allows for efficient capture and storage of nutrients for later application as fertiliser through a controlled irrigation system.

The total cost of the integrated on-site wastewater treatment and reuse system installed at ‘The Grove’ was $550,000, according to Yew Han Goh of PS Structures Pty Ltd, the main builder on the project.

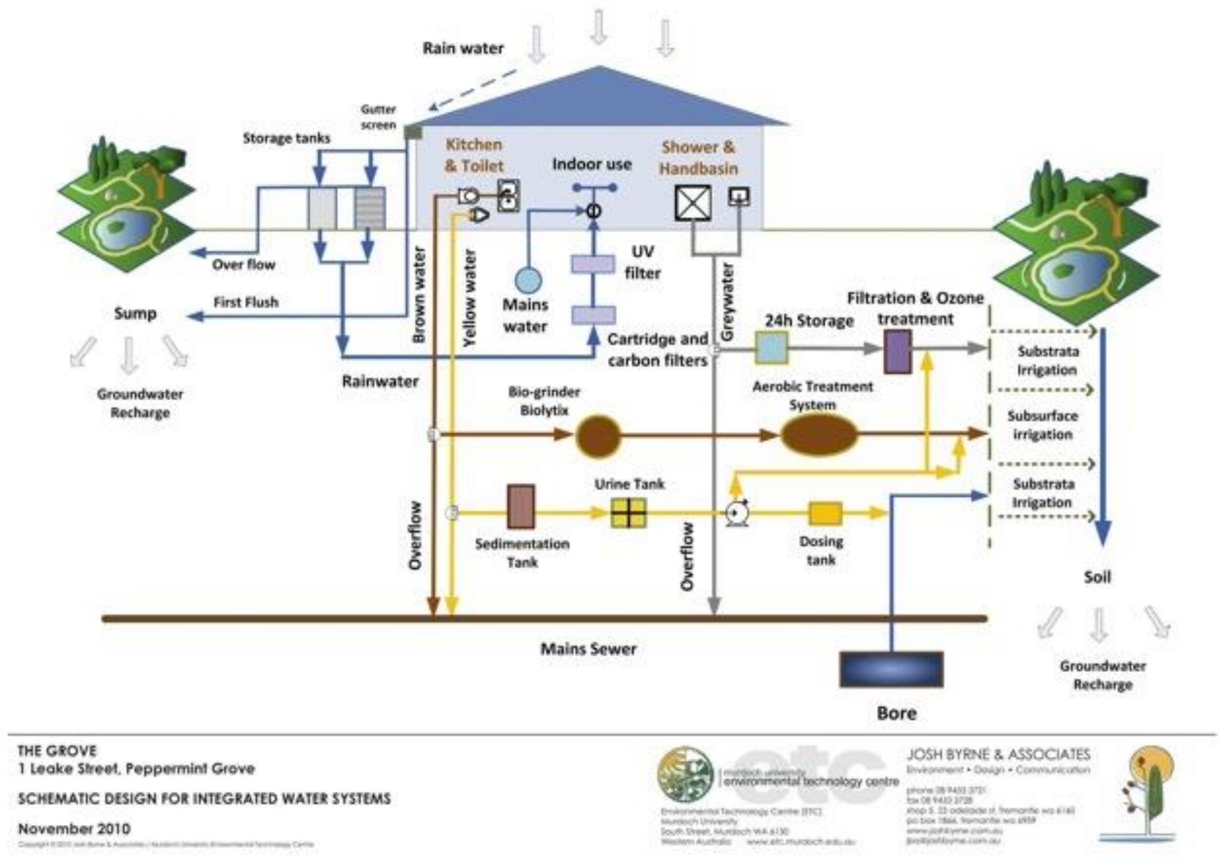

Figure 4: Schematic Design for Integrated Wastewater system at Cottesloe - Peppermint Grove - Mosman Park Combined Library
Source: http://thegroveprecinct.com/the-building/water-systems/#wastewater

Figure 5: Photo of installation of wastewater recycling system at the Cottesloe - Peppermint Grove - Mosman Park Combined Library
Source: http://thegroveprecinct.com/the-building/water-systems/#wastewater

5.3.2. Bold Park Aquatic Centre Feasibility Study

A feasibility study into greywater reuse, rainwater harvesting and landscape efficiency at Bold Park Aquatic Centre was undertaken by Josh Byrne & Associates in 2011. The study was initiated by the Water Corporation and the Town of Cambridge as an example of how similar projects may be undertaken.

The study investigated the diversion of water from the showers to displace scheme water for irrigation of the centre's lawn areas and native garden beds. It was determined that the lawn areas could accept up to 43 kL per week of greywater and the native garden beds could accept up to 44 kL per week of greywater. Water use in the showers accounted for approximately 62.6kL per week in the high season (summer). If water efficiency measures were to permanently reduce greywater volumes in excess of 20kL/week then measures such as a reduction in the area of turf or supplementary irrigation in summer may be required.

The study estimated a cost of $74,000 for the supply and installation of a GTS capable of treating 10,000L/day and sub-surface drip irrigation. Installation at the time of new construction or major renovations as opposed to retrofitting would save approximately $9,000 or 10-15%. Maintenance of the system was estimated at $250-500 per year, and soil and water testing was estimated at $250-500 per year.

The study calculated an annual saving of approximately $4,000, or an approximate payback period of 16 to 19 years, based on the reduction of scheme water consumption of 2675kL per year at $2 per kL. This does not include sewer charges, as local government facilities are exempt from discharge to sewer charges.

The scope of the study did not include advanced greywater treatment for uses such as toilet flushing (Josh Byrne & Associates, 2011).

6. Conclusion

In conclusion, greywater reuse systems offer an opportunity for creating an alternative water source for non-potable uses, such as garden irrigation, reducing the pressure and demand on the potable water sources.

A greywater system for a local government facility (considered to be commercial premises) must include treatment and disinfection. Depending on type of facility, volume of greywater treated, size of the irrigation area and other factors, the cost of a greywater treatment system may vary from $20,000 to $500,000.

The most appropriate facilities to be considered for the installation of greywater systems would be those facilities where a relatively high volume of greywater is produced, such as aquatic centres and recreation centres (from showers), and where there are gardens and turf capable of receiving the greywater, resulting in a reduction in scheme water or groundwater consumption.

Benefits associated with greywater reuse include reducing scheme water consumption, reducing water bills, reducing the amount of sewage discharged to the ocean, reducing the pressure on existing freshwater sources, and reducing the impacts associated with development of new water sources such as desalination plants. The use of greywater by local government is seen to be innovative and leading by example.

Risks associated with greywater reuse include potential risk to human health through the transmission of disease and illness through direct and indirect contact, and environmental risks through contamination of soil and groundwater through accumulation of chemicals, which in turn could affect the health of vegetation and useful micro-organisms in the soil. These risks can be avoided and or minimised by following Department of Health guidelines and Code of Practice, and by using greywater friendly products.

Due to the concept of greywater reuse being relatively new with technology constantly improving and due to great variability in the system components and depending factors, it is not possible to develop an accurate cost benefit analysis for a local government facility that could be used as a generic model across all local governments.

Another factor that influences development of a cost-benefit analysis is the fact that every single facility is different and the size of the building, design, number of people working or visiting the building and size of the irrigation area all affect the outcome. Therefore an accurate cost-benefit analysis can only be developed based on a detailed project-specific plan that incorporates all of the variables associated with the particular project. Similarly, the payback period for a particular project would need to be determined through a detailed scoping study, however, payback periods for other greywater projects have been estimated at between 16 to 19 years.

7. References

Australian Bureau of Statistics (2014), *Australian Demographic Statistics*, viewed 2 April 2014, <http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0 >

Australian Bureau of Statistics (2013), *Population Projections, Australia, 2012 (base) to 2101*, viewed 2 April 2014, <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/3222.0main+features52012%20(base)%20to%202101 >

Department of the Environment (2014), *National Rainwater and Greywater Initiative*, Commonwealth of Australia, viewed 9 May 2014, <www.environment.gov.au/topics/water/water-cities-and-towns/national-rainwater-and-greywater-initiative >

Department of the Environment (2013), *A Plan for a Cleaner Environment*, Commonwealth of Australia, available: http://www.environment.gov.au/system/files/resources/d25d512f-fd38-49f4-8434-bf6a9edd6d5d/files/cleaner-environment.pdf

Department of Health (2013), *Approved Greywater Systems.* Department of Health. Government of Western Australia, viewed 25 March 2014, <http://www.public.health.wa.gov.au/cproot/1342/2/ApprovedGreywaterSystems.pdf >

Department of Health (2011), *Guidelines for the Non-potable Uses of Recycled Water in Western Australia*, August 2011. Department of Health. Government of Western Australia.

Department of Health (2010), *Code of Practice for Reuse of Greywater in Western Australia 2010*. Department of Health. Government of Western Australia.

Department of Water (2013), *Securing Western Australia's Water Future: Position paper – reforming water resource management September 2013*, Department of Health, Government of Western Australia, viewed 17 April 2014, <http://www.water.wa.gov.au/PublicationStore/first/106021.pdf >

Department of Water (2011), *Wastewater: General Considerations*, Department of Water. Government of Western Australia, viewed 2 April 2014, <http://www.water.wa.gov.au/Managing+water/Recycling/Waterwise+community+toolkit/Non-drinking+water+sources/Wastewater/General+considerations/default.aspx >

Department of Water (2008), *State Water Recycling Strategy, An Overview June 2008.* Department of Water. Department of the Premier and Cabinet.

Greywater Industry Group (2013), *Learning Centre*, viewed 9 April 2014, <http://www.gwig.org/learning-centre.html#myAnchor4 >

The Grove Precinct (2011), *The Grove Environmentally Sustainable Design (ESD) Factsheet 6: Wastewater Treatment and Reuse*. The Grove Precinct, viewed 2 April 2014, <http://thegroveprecinct.com/wp-content/uploads/2011/03/ESD-Sheet-6-Wastewater-Reuse.pdf >

Josh Byrne and Associates (2011), Bold Park Aquatic Centre: Greywater Reuse, Rainwater Harvesting and Landscape Water Efficiency, Josh Byrne and Associates, Fremantle WA

NRMMC, EPHC, & NHMRC (2009), *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks,* Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, and the National Health and Medical Research Council.

Water Corporation (2014), *Groundwater Replenishment,* Water Corporation, Western Australia, viewed 2 April 2014, <http://www.watercorporation.com.au/water-supply-and-services/solutions-to-perths-water-supply/groundwater-replenishment >

Water Corporation (2012), Water Forever: Whatever the Weather. A 10 year plan for Western Australia. June 2012. Water Corporation, Western Australia.

Wiltshire, M. (2005), *Greywater Reuse in Urban Areas*. University of Southern Queensland, Faculty of Engineering and Surveying.