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Harvesting rainwater for domestic uses: an information guide

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Foreword

This document provides information on rainwater harvesting systems in the UK. It covers the supply of non-potable water for domestic uses such as flushing the toilet, watering the garden and washing clothes using a washing machine. It does not cover systems supplying water for drinking, food preparation or personal hygiene.

This publication does not recommend specific rainwater harvesting systems. It does provide guidance on the:

- benefits of these systems;
- savings that can be achieved;
- alternatives to be considered;
- cost of installation;
- suitability of a rainwater harvesting system;
- maintenance requirements;
- water quality issues; and
- regulations and guidance that should be referred to.

This publication also includes examples of where rainwater harvesting systems are already in use discussing associated costs, savings and experiences.

Throughout the document there is reference to a number of different sources where further details and guidance can be found on the installation of a rainwater harvesting system.

Contents

1 Introduction

This publication examines rainwater harvesting systems for non-potable domestic uses (those that do not require water suitable for human consumption) in houses and gardens. Many of the concepts can also be applied to industrial and commercial premises. This guidance is for homeowners, house builders, planners, plumbers, architects and building managers. It contains information on the benefits of rainwater harvesting systems, their design, installation, maintenance requirements and cost. It also contains examples of systems that have been installed and are in use.

This guide does not cover recycling of water, for example, from sources like the bath and shower (greywater). This is examined in a separate publication[1].

1.1 What is rainwater harvesting (RWH)?

Rainwater harvesting is the collection of rainwater directly from the surface(s) it falls on. This water would otherwise have gone directly into the drainage system or been lost through evaporation and transpiration. Once collected and stored it can be used for non-potable purposes. These include toilet flushing, garden watering and clothes washing using a washing machine. You should note that where used for washing machines, if the quality of the collected water is poor, there can be issues with both colour and odour.

1.2 Why consider a RWH system?

Despite the common perception that it rains a lot in England and Wales, our water resources are under pressure. A high volume of water is taken from the environment for human use. Demand for water is rising because the population is increasing, lifestyles are changing and the impacts of a changing climate are becoming more clear. In the South East of England, where large numbers of people live and work, water is scarcer than anywhere else in England and Wales. In fact, there is less water available per person in this region than in many Mediterranean countries.

We need to plan carefully for the future to ensure reliable water supplies are available for everyone whilst protecting the natural environment.

The Environment Agency advocates the 'twin track' approach of developing resources and managing demand. Exploring ways to reduce demand for mains water is essential to ensure a sustainable future for water resources. One of the options is to install RWH systems to substitute mains water use for purposes where drinking water quality is not required.

1.3 What savings can be achieved?

Any RWH system will reduce the dependence on the mains water supply.

Potential savings need to be assessed on an individual basis before any system is implemented. Factors which will influence this are; the demand for non-potable water, the amount of rainwater that can be collected and supplied and whether the property is charged by volume of water used (is metered).

[1] Greywater: an information guide: http://publications.environment-agency.gov.uk/pdf/GEHO0408BNWQ-e-e.pdf

Savings, both financial and environmental, will be higher in commercial/industrial buildings and schools. This is because they generally have larger roof areas and a greater demand for non-potable water than private dwellings.

Only customers with water meters will benefit financially from using a RWH system. At the time of writing (2010) this applies to approximately 37% of domestic properties and almost all industrial and commercial customers. Therefore, in England and Wales, for the majority of domestic customers, there is no financial incentive to install a RWH system.

Financial savings are usually higher when a system is installed during construction as retrofitting can be expensive and disruptive.

1.4 What are the benefits?

RWH systems can reduce demand for mains water and relieve pressure on available supplies. For customers with meters, water bills will be reduced.

Reducing the volume of mains water supplied means less water is taken from lakes, rivers and aquifers and more is left to benefit ecosystems and help sustain the water environment.

RWH systems can also reduce the risk of flooding and pollution as less rainwater is discharged to drains and sewers and, ultimately, to rivers. They can contribute to slowing down the flow of water and reduce the pressure on drainage systems in times of high flow.

Sustainable drainage systems (SUDS) often incorporate rainwater harvesting. SUDS reduce the risk of flooding by increasing the retention and control of surface/storm-water. In England, Planning Policy Statement 25 'Development and Flood Risk' (PPS25)[2] requires flood risk to be considered at all stages of the planning process to reduce future loss of life and damage to property from flooding.

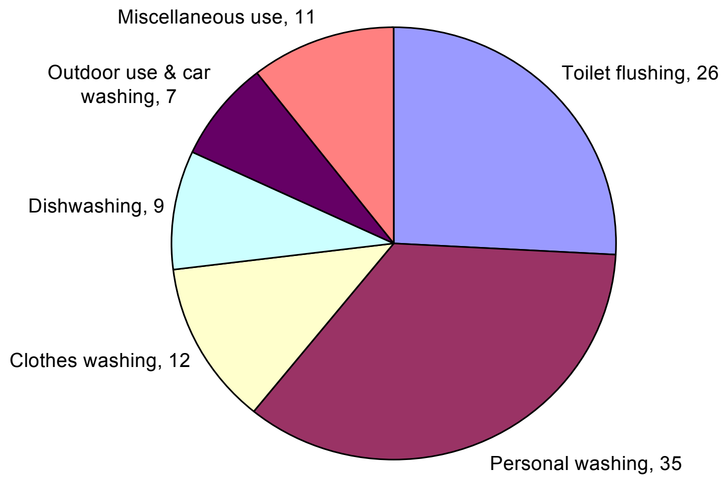
2 Water use in the home

This section looks at the way we use water in the home and examines which of those uses can be substituted by harvested rainwater.

[2] http://www.communities.gov.uk/documents/planningandbuilding/pdf/planningpolicystatement25.pdf

On average, every person in England and Wales uses around 150 litres of water per day (l/p/d). Figure 1[3] shows the elements (micro components) of the average demand for water in measured households.

Figure 1: Measured total England and Wales microcomponent use 2009-10 (%)



Toilet flushing uses the second highest percentage of water per person per day. Substituting mains supply for rainwater when flushing the toilet could potentially reduce pressure on mains supply by approximately 39/l/p/d (26%), reducing the average daily use of mains water to 111l/p/d.

If rainwater was also used to supply the washing machine and water to the garden, then the demand on mains water could be reduced further. The volume will depend on a number of factors and the suitability of a RWH system to meet your needs.

3 Suitability of a RWH system

It's important to make sure that a RWH system is suitable for your needs. This section looks at some of the factors you need to consider before deciding whether a RWH system is appropriate. They include:

- How much water can you collect;
- How much water you need to store;
- The costs; and
- Other/alternative water efficient measures to consider.

3.1 How much water can you collect?

You can work out the amount of rainwater you can collect by calculating the amount of rain that falls in your region and whether you have a sufficient collection area to meet your demand. To estimate use the following calculation:

[3] Environment Agency 2010

Calculation to determine appropriate storage tank size

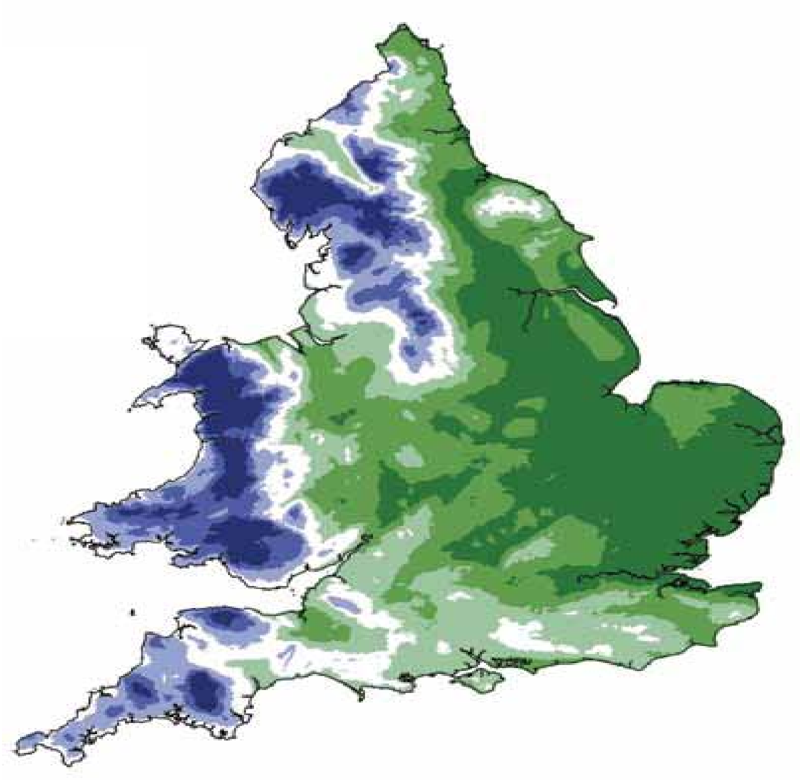
Annual rainfall (mm) **x** effective collection area (m^2) **x** drainage coefficient (%)**x** filter efficiency (%) **x** 0.05

The variables in the calculation are discussed below:

3.1.1 Annual rainfall

Your average rainfall figure will depend on where you live. Figure 2[4] below shows how the South East in particular has low rainfall, with most falling in the North West and Wales.

Figure 2



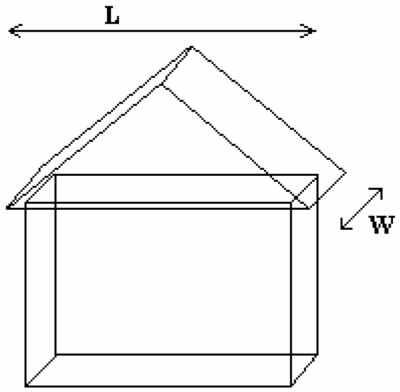
Rainfall
■ 500 - 640 ■ 641 - 740 ■ 741 - 870 871 - 1060
■ 1061 - 1290 ■ 1291 - 1590 ■ 1591 - 6000

3.1.2 Collection area

The larger the collection area the more rainwater can be collected. The effective collection area is equal to the area of roof or hard-standing that can be reasonably used to collect rainfall (see Figure 3). This may not be the entire roof area as the arrangement of down pipes may mean that not all the rainwater is collectable.

[4] Average annual rainfall in the UK (Environment Agency)

Figure 3. Roof catchment area



The roof area is the length in metres (L) multiplied by the width in metres (W). Figure 3 shows the measurements you need to calculate the roof collection area in metres squared (m^2).

3.1.3 Collection losses

Not all the rainfall that falls on the collection area will be caught. For example, during heavy rainfall, rainwater will overflow from the gutters and so will not be collected. Similarly, when rainfall is light, increased evaporation means less can be captured.

You need to include a drainage coefficient or 'run-off factor' in the calculation. This is to take account of the influences the above examples have on collection and drainage. Table 1 shows some typical drainage coefficients to apply depending on the roof type.

Table 1 Drainage coefficient figures

Roof type	Drainage coefficient
Pitched roof	0.9
Pitched roof with tiles	0.8
Flat roof with gravel layer	0.8

3.1.4 Filter efficiency

The efficiency of the filter also affects the amount of water that can be captured. Of the water that is collected in the gutters not all will reach the holding tank. Manufacturers usually advise that 90% of the water flowing into the filter is retained so, in the absence of a specific value, a filter coefficient of 0.9 can be used in the calculation.

3.1.5 Tank sizing for demand

Now you have an idea of how much water you can collect, the next step is to estimate what size tank you require in practice. The general rule is that the tank size should be around 5% of the annual rainwater supply, or of the annual demand. Therefore a coefficient of 0.05 is applied to calculate 5%[5] of the annual rainwater supply. This final step in the equation gives you an estimate of the tank size required.

[5] This represents 5% of the year (18 days)

3.1.6 Example calculation of how much water you can collect

This example shows a property with an effective collection area of $50m^2$ with a pitched tiled roof, so the assumed drainage coefficient is 0.8. The manufacturer assumed filter coefficient of 90% gives the figure of 0.9. Met Office annual average rainfall for the area is 850 mm/yr.

Effective collection area (m^2)	50
Drainage coefficient	0.8
Filter efficiency coefficient	0.9
Average rainfall (mm/yr)	850

Tank size = 50 x 0.8 x 0.9 x 850 x 0.05 = 1530 litres or 1.5 cubic metres (m^3)

This equation is appropriate for medium sized, domestic systems. You may want to use a more detailed approach for a larger RWH system, where demand is irregular or where the yield is uncertain. Further information is available in British Standard 8515:2009 *Rainwater Harvesting Systems – Code of Practice* (**BS 8515**)[6].

3.2 How much water do you need to store?

The tank is often the most expensive part of the system and choosing the right size is key to minimising costs. The tank size needs to be a balance of cost and storage capacity. It should also overflow at least twice a year to flush out floating debris.

3.3 What are the costs?

All costs and payback periods should be carefully calculated. The total cost of installing a RWH system is the sum of the cost of the components plus installation. Systems can cost from around £2,500 up to £6,000 depending on the size of the tank.

Installing a system during construction generally costs less than retrofitting a system into an existing building because of excavation required for installation of the tank and changes required to the existing plumbing arrangement.

The cost effectiveness of the rainwater system is site-specific. You should also consider:

- Current water charges – the higher the cost of water the higher the benefits of a RWH system; and
- Maintenance costs – the level of maintenance required by the system during its life.

[6] BS 8515:2009 Rainwater harvesting systems – Code of practice, www.standardsuk.com

4 Are there other/alternative water efficiency measures to consider?

A RWH system should not be viewed as a substitute for water efficiency. Simple water saving measures can provide significant benefits at a much lower cost. We recommend that a **reduce, reuse, recycle** hierarchy should be followed:

Reduce – for example, install a low flush or dual flush toilet (below the regulatory 6 l/flush), fit low flow taps, fit a low flow aerated shower; adopt efficient behaviour like turning the tap off when brushing your teeth;
Reuse – use water from a water butt to water the garden or wash the car;
Recycle - install a RWH system.

The cost usually increases with the hierarchy, while the benefits decrease.

More information on how to save water through a variety of different water efficiency measures is available in *Conserving Water in Buildings*[7] including a section on RWH. For water efficient fittings please refer to www.water-efficiencylabel.org.uk.

5 Types of rainwater harvesting systems

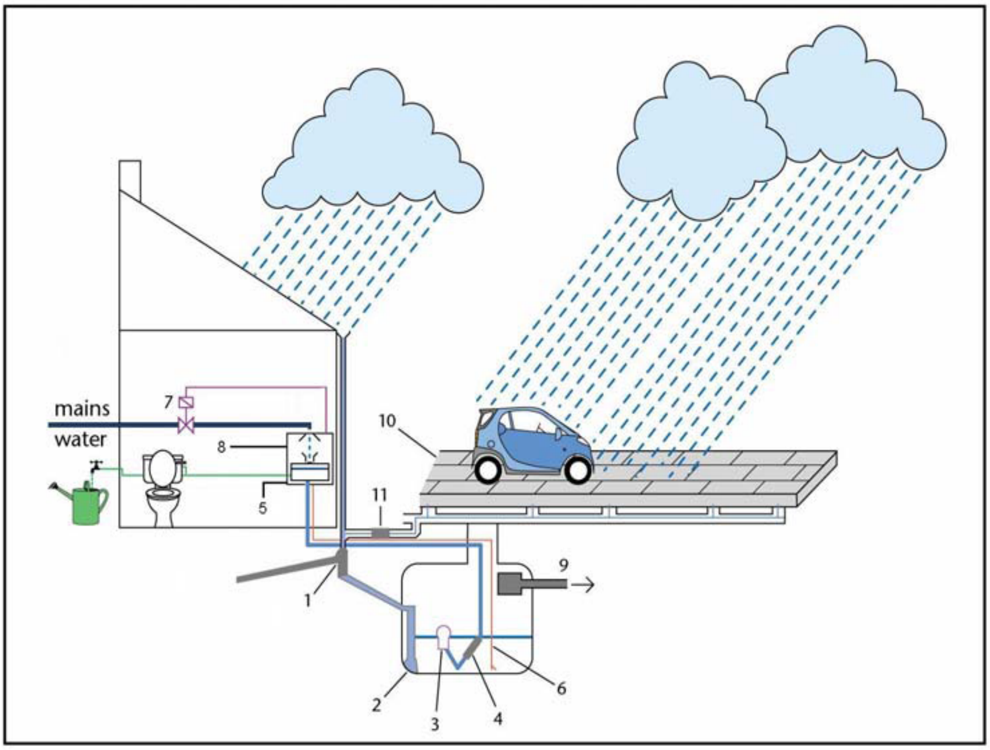
If you decide a RWH system is appropriate, the next step is to identify which type of system to install. There are a number of different systems available with a range of features. BS 8515 gives guidance on the design, installation and maintenance of RWH systems for the supply of non-potable water in the UK, and applies to both retrofitting and new builds. The code of practice covers three basic types of RWH systems:

- water collected in storage tank(s) and pumped directly to points of use;
- water collected in storage tank(s) and fed by gravity to points of use; and
- water collected in storage tank(s), pumped to an elevated cistern and fed by gravity to the points of use.

Figure 4 shows an example of a system that pumps directly to points of use. Many of the concepts are broadly applicable to the other systems mentioned.

[7] Conserving Water in Buildings; http://publications.environment-agency.gov.uk/pdf/geho1107bnjr-e-e.pdf

Figure 4 Schematic of a typical rainwater harvesting system



1 Filter
2 Smoothing inlet
3 Suction filter
4 Pump
5 Control unit with intermediate storage
6 Water level monitor
7 Automatic change over
8 Type AA air gap
9 Overflow trap
10 Permeable pavement
11 Oil trap

Rainwater is collected from the roof area or hard standing. A filter (1) prevents leaves and other large solids from getting into the holding tank. Water enters the tank through a smoothing inlet (2), which stops sediment at the bottom of the tank from being disturbed by rainwater entering the tank.

A suction filter (3) prevents the uptake of floating matter when the water is drawn up for use. As the water is non-potable, it travels through a separate set of pipes, as specified in the Water Supply (Water Fittings) Regulations 1999[8]. A pump (4) pressurises the water. In the example shown the pump is submerged, although other systems may use suction pumps which are located outside of the tank.

The control unit (5) monitors the water level in the tank and you can see information on whether the system is operating properly on the water level monitor (6). If the water level in the tank drops too low, the control unit will trigger an automatic change over to mains water supply (7). The system must have a type AA air gap (8) installed in order to prevent back flow of rainwater into the mains.

When the water in the tank reaches a certain level, an overflow trap (9) allows floating material to be skimmed off into the storm drain. A non-return valve needs to be fitted to prevent contamination of the tank by backflow, together with a rodent barrier.

Water soaking through a permeable pavement (10) can also be collected, and in addition to a filter, an oil trap (11) should also be fitted. Collecting water from this source increases the potential for oil and animal faeces contamination of the rainwater stored in the tank. To overcome this, additional filtration and disinfection may be necessary. The choice of collection surfaces should be considered on a site by site basis. It is usually simplest to collect water exclusively from the roof of a property, however, collecting from additional hard surfaces increases the yield and may be beneficial in some cases.

[8] http://www.defra.gov.uk/environment/quality/water/industry/wsregs99/

This is a typical example of a RWH system. There are other models and combinations but all systems have components to:

- collect, filter and store rainwater;
- distribute water to points of use;
- provide a supply of mains water for back up to ensure a continuous supply of water when the level of rainwater runs low; and
- control the mains backup and monitor levels.

Although the principles and components are common, the approach differs in some key areas:

5.1 Distributing rainwater

Appliances can be supplied with rainwater in two ways:

- Direct pumped systems - rainwater is collected and held in a storage tank/reservoir and then pumped directly to the point of use as and when required; or
- Gravity fed (header tank) systems – this involves rainwater being collected and piped to a header storage tank, usually in the loft, which then delivers the rainwater to appliances using gravity.

Table 2 shows the main advantages and associated issues with each system:

Table 2 Advantages and issues of direct feed and gravity fed systems

Direct feed systems		Gravity fed (header tank) systems	
Advantages	**Issues**	**Advantages**	**Issues**
No header tank required	More energy intensive	Less pump maintenance	Location (height) is important
Adequately pressurised supply	Costly/regular pump maintenance	Greater energy efficiency	Difficult to install tank

5.2 Locating the mains backup supply

Figure 4 (page 11) shows a direct feed system that pipes water via a small intermediate tank with a control unit. When rainwater is not available, the mains water supply can top up this tank. Having an intermediate storage tank means the water pumped from it has less distance to travel.

Alternatively you can use a direct feed system which can supply mains water into the large storage tank usually located underground. This is a cheaper option than using an intermediate storage tank.

5.3 Locating the main pump

The rainwater supply pump can either be a submerged unit in the main storage tank, or a suction pump on the outside of it.

Suction pumps are usually located within the control unit and must be positioned relatively close to the tank, in frost-free conditions. These pumps are easier to inspect, service and maintain and an electricity supply to the underground tank isn't needed.

There are two advantages to submerging the pump in the tank. Firstly, it won't be heard within the building. Secondly, a submersible pump can be more powerful then a suction pump.

6 Common components

6.1 This section discusses some of the components common to all systems in more detail.

6.1.1 Tank

The size of the tank can vary from a small tank on the side of a house to large underground tanks that can contain thousands of litres of water. In the UK, larger tanks are generally constructed from glass reinforced plastic, polyethylene or concrete. You should seek advice from a reputable rainwater harvesting supplier on which material is most appropriate for your requirements. Visit the United Kingdom Rainwater Harvesting Association website (UKRHA)[9], for further advice as different tank materials suit different installations.

The tank needs to be located in a place that will moderate the water temperature, helping to reduce bacterial growth in summer and frost damage in winter. It needs to be shielded from direct sunlight to avoid overheating and growth of algae. Underground tanks solve these issues.

Table 3 shows the advantages and issues associated with locating a tank above or below ground:

Table 3 Advantages and issues of above and underground tanks

Above ground tank		Underground tank	
Advantages	**Issues**	**Advantages**	**Issues**
Easy access for repair or inspection	Increased risk of algae growth	Reduced daylight to prohibit algal growth	Installation is more expensive (excavation costs)
Less expensive to install	Risk of frost damage to pipes	Protected from weather conditions	Less accessible for maintenance and inspection
No groundwater issues (water table)	Needs space	Saves space onsite	Requires suitable location

6.1.2 Pump

Most available systems use automatic pressure and flow-activated pumps. When a toilet is flushed the pump switches on and refills the cistern. Alternatively, rainwater can be pumped to a header tank where it feeds the WC. The differences in suction pumps and submersible pumps are discussed in section 5.

6.1.3 Control unit

During dry periods, there may be insufficient rainwater to meet demand. A display in the control unit should indicate when water levels are low and that mains water is supplying the tank. In addition, further system status monitoring can show volumes of rainwater and mains back-up used, how full the tank is and whether there are any malfunctions.

6.1.4 Back-up water supply

All RWH systems need to have a back-up mains water supply. A control mechanism ensures that the minimum amount of required water is supplied by directing mains water back up only for immediate use. Back up storage needs to be sized to allow for full demand to be met during dry periods.

[9] www.ukrha.org

6.1.5 Overflow and drainage

An overflow needs to be fitted to the tank to allow excess water to be released, and ideally should be connected to a soakaway.

6.1.6 Backflow prevention

The Water Supply (Water Fittings) Regulations 1999 require that sufficient backflow prevention is provided to prevent contamination of the public mains water supply. This is usually in the form of an air gap that prevents non-potable water entering the mains water supply.

Backflow prevention for specific appliances should be discussed with the manufacturer to ensure suitable category 5 (air gap) backflow prevention has been incorporated into the appliance. For more information on backflow prevention and types of air gap see the WRAS[10] website.

6.2 Treatment

A filter is the first step to treating rainwater. This will prevent solid debris and leaves from entering the storage tank. This is the only line of treatment required if the RWH system is to be used for toilet flushing and garden watering.

Whist no further treatment is actually required, there are a number of 'good practice' measures that can be taken to maintain the quality of the water:

- overflow siphons which allow floating material to be removed;
- rodent barrier - a device on the holding tank overflow pipe to prevent rodents entering the holding tank; and
- a floating extraction with additional filter that allows rainwater to be taken from just below the surface where the water is cleanest.

Bird and animal faeces and leaf litter on roofs or guttering can pose a health risk if they are washed into the RWH system. Gutters should be cleared regularly.

6.3 Labelling

Figure 5 shows an example of a label that should be visible to clearly signal to users that the appliance is using a non-potable water supply.

[10] http://www.wras.co.uk/

Figure 5 – Label for use at points of use supplied by non-potable water[11].

It is recommended that any external taps fed by untreated rainwater should have their handles removed and be clearly labelled to prevent this water from being used for drinking.

Where possible, different coloured pipework must be used to distinguish between rainwater and potable pipework. This is to make sure there is no accidental cross connection. Suppliers can provide marking tape and warning labels.

7 Water quality, contamination and maintenance

7.1 Water quality

There are currently no regulatory water quality standards for rainwater use in England and Wales. Harvested rainwater should not be used as drinking water unless treated to a potable quality. There are strict regulations concerning the quality of water for drinking. Please refer to the Drinking Water Inspectorate[12] for further information. Guidance and further information on rainwater harvesting is available in BSI 8515.

It's not necessary to test harvested rainwater frequently because it is used for purposes that do not present significant risk. However, water quality observations should be carried out during maintenance visits to identify any problems early.

[11] www.mysafetysign.com
[12] www.dwi.gov.uk

A guide to rainwater harvesting technologies is available through the Market Transformation Programme (MTP)[13]. The MTP have investigated both rainwater and greywater systems and has produced a set of recommended quality guidelines and monitoring arrangements. The report '*Rainwater and Greywater: review of water quality standards and recommendations for the UK*'[14], identifies that the main hazard from rainwater use is exposure to pathogenic micro-organisms derived from faecal contamination. The report recommends basing monitoring on the EU Bathing Water Directives (1975 and 2006)[15]. It identifies different guidelines for different end uses and these recommendations have been adapted by BS 8515. The tables below have been taken directly from BS 8515[16].

Table 4 gives guidelines to use when monitoring the bacteriological water quality of harvested rainwater. It should be used with the traffic light system shown in Table 5.

Table 4 – Guideline values for bacteriological monitoring

Parameter	Guideline values by use		System type
	Pressure washers and garden sprinklers	Garden watering and WC flushing	
Escherichia coli number/100mL	1	250	Single site and communal domestic systems
Intestinal enterococci number/ 100mL	1	100	Single site and communal domestic systems
Legionella number/litre	100	-	Where analysis is necessary as indicated by risk assessment
Total coliforms number per 100mL	10	1000 for garden watering and WC flushing	Single site and communal domestic systems

Table 5 – Interpretation of results from bacteriological monitoring.

Sample result [A)]	Status	Interpretation
<G	Green	System under control
G to 10G	Amber	Re-sample to confirm result and investigate system operation
> 10G [B)]	Red	Suspend use of rainwater until problem is resolved

[A)] G = guideline value (see Table 4).
[B)] In the absence of *E.coli*, *Intestinal enterococci* and *Legionella*, where relevant, there is no need to suspend use of the system if levels of coliforms exceed 100 times the guideline value.

In addition to health risk, Table 6 shows the parameters relating to general system monitoring and should be viewed alongside Table 7 that uses a similar traffic light system to interpret the results.

[13] *Rainwater and Grey Water: A Guide for Specifiers, MTP (2007)*
[14] Market Transformation Programme (MTP), *Rainwater and Grey Water: Review of water quality standards and recommendations for the UK*
[15] Bathing Water Directive (76/160/EEC) http://ec.europa.eu/water/water-bathing/directiv.html
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Table 6 – Guideline values for general system monitoring

Parameter	Guideline values	System type
Dissolved oxygen in stored rainwater	>10% saturation or > 1 mg/ litre oxygen (whichever is least) for all uses	All systems
Suspended solids	Visually clear and free from floating debris for all uses	All systems
Colour	Not objectionable for all uses	All systems
Turbidity	< 10 NTU for all uses (< NTU if UV disinfection is used)	
pH	5-9 for all uses	Single site and communal domestic systems
Residual chlorine	<0.5 mg/L for garden watering <2 mg/L for all other uses	All systems, where use
Residual bromine	<2 mg/L for all uses	All systems, where used

Table 7 – Interpretation of results from general system monitoring [A)]

Sample result [B)]	Status	Interpretation
<G	Green	System under control
>G	Amber	Re-sample to confirm result and investigate system operation

A) When monitoring pH, the system is considered to be under control (green status) when levels are within the range recommended in Table 6. If levels are outside this range, the system status becomes amber and re-sampling is necessary. Where colour or suspended solids are present at levels which are questionable, it is necessary to investigate the system operation to resolve the problem.
B) G = guideline value (see Table 6).

The tables provide an indication of the water quality that a well designed and maintained system is expected to achieve for the majority of operating conditions.

7.2 Contamination

Simply filtering harvested rainwater is generally good enough when rainwater is collected from a roof, but there is always a risk of contamination.

Where rainwater is collected from a driveway the risk of contamination from oil or faecal material is higher. Oil traps can be installed but don't remove all of the oil. As a result, some suppliers advise against using driveways to collect water, although a suitable permeable pavement with appropriate substrate below can provide a reasonable level of treatment.

There are some types of roof cover that are less suitable for rainwater collection because they are more likely to affect the water quality:

- asbestos-cement roofs can cause filters to block, reducing the amount of water collected and potentially posing a health risk;
- metal roofs (except stainless steel) can release small amounts of leachates, which can stain water fixtures, for example, copper roofs may colour water green;
- bitumen felt or coated roofs can lead to discolouration and odour problems;

- grass (and other vegetation) covered roofs reduce the amount and speed of run-off water. Extra treatment might be needed to deal with the discolouration caused by soil.

7.3 Maintenance

It is essential that humans don't enter tanks unless absolutely necessary. This should only be attempted by a trained professional who has the appropriate equipment and training to work in confined spaces. In addition to the manufacturer's maintenance guidance, we recommend that you should:

- clean filters approximately three times a year, depending on tree cover over the collection area;
- keep gutters free of debris to prevent blocking the system;
- visually inspect the tank at least once a year;
- check the mains water top-up once a year.

BS 8515 provides useful recommendations on maintenance schedules.

Maintenance and repair of communal RWH systems is an ambiguous area and has been considered by the Construction Industry Research & Information Association (CIRIA) [17]. *Rainwater and Greywater Use in Buildings: Project Results From The Buildings That Save Water Project; Best Practice Guidance (C539), CIRIA (2001)*, provides advice on the use and development of model operation and maintenance arrangements for both rainwater and greywater systems. It also includes simple guidance on how to incorporate these systems in developments.

8 Energy and carbon

This section explores the energy requirements and resulting greenhouse gas emissions from RWH systems. There are a large number of RWH systems available and the energy requirements and carbon implications will vary depending on system type, installation arrangements and the amount of rainfall harvested and used.

8.1 Carbon emissions

The carbon emissions that result from using a typical RWH system are, on average, around 40%[18] greater than emissions from using mains water.

The carbon emissions resulting from installation and use of a RWH system can be divided into embodied and operational carbon.

8.1.1 Embodied carbon

Embodied carbon is defined as the 'cradle to site' carbon footprint and includes sourcing the materials, manufacturing and distribution.

The highest embodied carbon is in storage tanks. However as they tend to be long lasting (if undamaged, a rainwater tank should last significantly longer than the typical 15 year manufacturer's warranty), the relative importance of embodied carbon emissions from the tank decreases over time. This is in contrast to pumps, which are usually the second

[17] www.ciria.org.uk
[18] Environment Agency 2010

largest contributor to embodied carbon. They will need replacing from time to time so their proportional contribution to embodied carbon increases over time.

8.1.2 Operational carbon

Most rainwater harvesting systems require energy to operate; generation of this energy emits greenhouse gases. Pumping water is the greatest contributor. Estimates of in-use carbon will depend on assumptions made about electricity use. See further reading for more information:

- *Energy and Carbon Implications of Rainwater Harvesting & Greywater Recycling – Final Report* **(AECOM Report)**; and
- *The Water-Energy Nexus: Investigation into the energy implications of household rainwater systems, [prepared for CSIRO], Institute for Sustainable Futures, University of Technology, Sydney.*

8.1.3 Carbon implications

Due to economies of scale, it generally takes more energy to treat and supply a litre of harvested rainwater than a litre of mains water. RWH is also more carbon intensive than mains water. The scale of carbon emissions will depend on the design of the system and components used.

Over a 30 year lifetime the net emissions split of operational and embodied energy varies considerably. Research shows that for an average 90m^2 semi-detached house with 3 occupants the split is 52% operational to 48% embodied emissions, excluding emissions from excavation and transport. This highlights that the carbon contribution from embodied and operational emissions of a RWH system are both significant parts of a system's total emissions.

The evidence shows that collecting, storing and pumping rainwater for domestic uses is not an energy saving technology. Whilst substituting mains water with rainwater for toilet flushing will inevitably reduce mains water use, it will not reduce total water use and will have other trade-offs which should be considered on an individual basis. One of these trade offs is greenhouse gas emissions.

However, it's important to put these emissions in context. The amount of energy used by even the most complex RWH systems is small compared with the energy used to heat water in the home. Heating water for domestic uses, such as showering and bathing currently contributes about 5 per cent[19] of the UK's annual greenhouse gas emissions.

Reducing use of hot water is the easiest way to reduce the energy associated with your water use. Many water efficiency measures such as aerated shower heads (which use less water but give the illusion of 'high flow') are simple and cheap to install and use. However you don't even need to change your shower head to reduce energy and water use: just spending one less minute in the shower will also save a significant amount of water and energy over a year.

For more information on the energy implication of RWH systems please read the **AECOM Report**, whose conclusions confirm that:

- RWH systems are generally more carbon intensive than mains water;
- the storage tank accounts for a large proportion of the footprint of the RWH system; and
- the pump and pumping also accounts for a large proportion of the carbon footprint.

[19] http://www.energysavingtrust.org.uk/Water/Water-and-carbon-the-facts

8.2 Energy used in RWH components

Most RWH systems consume electricity to operate pumps, and control systems. Some of the main RWH system components and the associated energy use or carbon emissions are described below:

8.2.1 Storage tanks

The location of the storage tank will have a direct impact on the energy used. For example, an underground storage tank in the garden may require greater effort from the pump than if located underground in the cellar of the house.

8.2.2 Header tanks

Pumping rainwater to a header tank allows water to be stored at an elevated level, where gravity is used to feed the end uses. This allows the main pump to be used more efficiently, reducing energy use.

8.2.3 Pump

The energy consumption of the pump will be determined by how much work the pump has to do and how efficient it is. This will vary depending on the number of end uses and the type of storage tank (underground or above ground). To reduce energy use you can make the pump more efficient or design the system to use the pump less. A broad range of pumps are available and it's important to select a pump designed to suit the individual system.

8.2.4 Ultra violet treatment

RWH systems do not normally require energy intensive treatment. However, UV may sometimes be installed where water quality is seen as a particular priority. This involves the passing of treated water through an ultraviolet (UV) filter to kill any remaining bacteria. The use of UV lamps as part of a treatment process will increase the energy consumption of a RWH system. RWH systems have been identified as having a typical operational energy use of between 0.6 – 5 kWh/m^3. Where UV disinfection is included, this increases the upper band of reported energy intensity to 7.1 kWh/m^3.[20]

9 Regulation and guidance

You need to:

- install the RWH system in accordance with the manufacturer's / supplier's instructions; and
- consult national building regulations and Water Supply (Water Fittings) Regulations 1999.

You can get advice and guidance on the Water Fittings Regulations from local suppliers, the Water Regulations Advisory Scheme[21] (WRAS) or the UK Rainwater Harvesting Association (UKRHA[22]).

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[20] AECOM Report - (http://publications.environment-agency.gov.uk/pdf/SCHO0610BSMQ-E-E.pdf)
[21] www.wras.co.uk
[22] www.ukrha.org

9.1 WRAS

Information and Guidance Note 9-02-05[23] states that:

- before installing pipework it needs to be tested to make sure the operating pressure and electricity standards meet the required levels; and
- all pipework must be labelled.

9.2 UKRHA

The UKRHA lists recommended/accredited suppliers and installers of RWH equipment. Their website contains a list of members and provides a good introduction to rainwater harvesting systems.

The Water Technology List[24] is another useful resource. It is an online database of products that qualify for the Enhanced Capital Allowance scheme (ECA)[25]. The ECA scheme enables businesses to claim 100% first year capital allowances on investments in technologies and products that encourage sustainable water use. It is also a useful resource for other users as the products it lists guarantee a certain level of water efficiency.

9.3 Non-compliance with regulations

A drinking water quality incident at Upton[26] eco-housing development in Northampton has highlighted the risks associated with RWH systems. What started with Anglian Water receiving some complaints of 'sewage' odours in tap water from a house on the development, resulted in a small number of E.Coli contamination cases being identified.

A detailed report from the Drinking Water Inspectorate (DWI)[27] concluded that non-compliance with Water Regulation Fitting Regulations resulted in cross-connections between a RWH system and potable water supply at this development. The following issues were highlighted as contributing to the contamination:

- Labelling – There were a number of visits by water company staff to the site of the first complaint before the cause of the odour was established. It was not until the fourth visit that it was discovered that a RWH system was present at the property. Only once this was discovered was a full water fittings inspection arranged.

  There was further delay as the pipe work for the RWH system was hidden behind fitted kitchen units. During the inspections of other properties, Anglian Water found there were labelling infringements in most of the properties inspected.

- Air gap - The Water Supply (Water Fittings) Regulations 1999 require an air gap to exist between non-potable and drinking water supplies to prevent cross contamination or backflow. This rule had clearly not been followed in the property's plumbing.

Sampling highlighted a reading of greater than 100/100ml *E.coli* and also the identification of an open cross connection between the RWH system and the drinking water supply. As a result, all houses with the same RWH system installed were investigated. In total three open cross connections were identified at the Upton eco-housing development. Cross

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[23] Guidance Note 9-02-05: Marking and Identification of Pipework for Reclaimed Water: www.wras.co.uk/PDF_Files/IGN%209-02-05%20Marking.pdf

[24] www.eca-water.gov.uk

[25] www.businesslink.gov.uk/bdotg/action/layer?topicId=1084216413

[26] http://www.homesandcommunities.co.uk/upton-northampton.htm

[27] http://www.dwi.gov.uk/upton-eal.pdf

connections were found at 87 properties, but fortunately the isolation valve was in the closed position, preventing contamination of the main water.

This incident should be a lesson to the water and construction industries over the dangers of incorrectly installed water-saving systems. The DWI has recommended that water companies:

- send guidance to their approved plumbers to ensure wider knowledge of the risks; and
- include the risks of cross contamination from water-saving systems in their water supply risk assessments, designed to protect against quality failures.

As a result of this incident, Anglian Water have given specific instruction to check for both RWH and greywater reuse systems during all investigations at customer properties. The company have also briefed relevant staff on the circumstance of the event and also plan to familiarise staff with *BS 8515* and *BS 8525-1:2010 Greywater Part 1 – a code of practice*.

Anglian Water has written to the UK Rainwater Harvesting Association to ensure its members are aware of the water supply regulations.

9.4 Initiatives and further regulations

With the popularity of RWH and greywater reuse increasing in the UK, so does its recognition in regulation and building codes.

The Code for Sustainable Homes (CSH) provides an environmental assessment method for rating and certifying the performance of new homes, aimed at encouraging continuous improvement in sustainable home building. To achieve higher levels of the code (**levels 5 and 6**) RWH systems generally have to be installed alongside water efficient appliances.

View the CLG *Code for Sustainable Homes Technical Guide May 2009 Version 2*[28] for more information.

Part G of the updated Building Regulations[29] introduces a new requirement that, for any new dwelling, the potential wholesome water consumption should not exceed 125 litres per person per day. To help achieve this the Regulations have been amended to allow the option of reusing rainwater for toilet flushing. See *G1 Cold Water Supply* that covers the quality of water required for sanitaryware fixtures and fittings.

10 Use of rainwater harvesting in other countries

RWH systems are not a new concept in the UK. Traditionally, people have collected and stored rainwater for household use. Until mains supply became the norm, rainwater was used for laundry, washing up and other cleaning operations. However, modern RWH systems have only been introduced in the UK relatively recently.

[28] www.communities.gov.uk/publications/planningandbuilding/codeguidesummarymay09
[29] www.communities.gov.uk/documents/planningandbuilding/pdf/1235290.pdf

Other countries have been quicker to introduce RWH; Germany is the renowned leader in this technology, 35% of new buildings built in Germany are equipped with a rainwater collection system. The German RWH industry is worth 340 million Euros and creates a large number of jobs[30].

10.1 What are the drivers?

10.1.1 Price of water

RWH development in Austria, Switzerland, Belgium and Denmark is also increasing. The popularity of installing RWH systems can be linked to the water price. The higher the price, the greater the incentive to save water. In Germany for example, water is an expensive commodity. With almost complete water metering and the fact that RWH systems are grant aided, Germany is in the forefront of RWH in Europe.

10.1.2 Reducing other costs

Bangalore[31] was the first city in India to implement a RWH policy. Driven by a need to reduce pumping costs and energy use associated with supplying water to the elevated city, innovative approaches for RWH are being incorporated into byelaws for all new construction. This will utilise the average annual rainfall of 900 – 970mm and reduce the need to pump water from lower levels.

10.1.3 Legislation

In Australia, where there is a high demand for lawn and garden watering, new government legislation has been introduced to increase the number of RWH systems. In response to private households consuming over 70% of water supply in Sydney, the government of New South Wales introduced the Building Sustainability Index (BASIX)[32]. The programme will ensure that homes are designed to use less potable water and produce fewer greenhouse gases.

BASIX sets water reduction targets for houses and implies that RWH systems are essential to realise these targets.

Belgium[33] has national legislation that supports RWH systems and requires that all new constructions have a system that can be used for toilet flushing and external water uses. This legislation has been devised for two main purposes:

I. to help reduce demand for mains supply water; and
II. to collect and use rainwater as part of SUDS systems.

11 Case studies

According to data from UKRHA, there are approximately 400 RWH systems installed in the UK each year, ranging in scale from individual domestic installations to large scale commercial schemes. This section sets out some examples of water efficiency projects and details their experiences when installing a range of RWH systems.

[30] Taken from a CIWEM Rainwater Information guide; http://www.ciwem.org/resources/water/rainwater/index.asp)
[31] Rainwater Harvesting and Grey Water Reuse; www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/03-100-e.htm
[32] http://www.basix.nsw.gov.au/information/index.jsp
[33] www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/03-100-e.htm

11.1 Berkeley Homes

Winners of the Gold award for the 'Solve' category at the 2009 Environment Agency Water Efficiency Awards, Berkeley Homes[34], build houses and apartments in London and the South East.

The Forest Hill Central development has an EcoHomes 2006 'very good' rating. This was achieved by installing technologies such as; solar panels on the roof, energy efficient appliances and lighting, low water consumption showers and toilets and RWH collection systems.

This project examined all the water efficiency factors carefully to maximise water conservation. Berkeley Homes used roof top rainwater only to reduce the risk of contaminants associated with using hard standing; oil spillages for example.
The tank was selected to include an in-line washable filter at ground level to minimise entry of silt and a full capacity ultraviolet filter was added to kill water-borne bacteria prior to use. The average daily rainwater capture was calculated to be approximately 1.36m^3 per day based on a roof area of 440m^2, which means it takes around 4.5 days of average rainfall to fill the 6000 litre tank.

The water is used for irrigating the landscape and watering trees and plants.

11.2 Radian Homes – Water Efficiency Project

A two year project in partnership between the Environment Agency and Radian Homes explored the methods of tackling water efficiency and demand in South Hampshire.

The water consumption of a range of new homes was compared to Defra's vision of each person consuming an average of 130l/p/d by 2030. Where homes were built to CSH levels, actual water consumption was compared to estimated consumption via the water efficiency calculator. They were also compared to CSH targets of 105 l/p/d for levels 3 and 4 and 80 l/p/d for levels 5 and 6.

In part one of the project Radian trialled RWH by installing a system as well as other water efficient devices in one house and comparing it to a house which did not have a RWH system but did have the same devices. Data was collected over a year and the costs together with the water consumption savings are included in Table 8.

Table 8 – Cost and water savings from the different activities

Water activity	Cost to install (£s)	Average household consumption (l/p/d)
Range of water efficient devices [A)]	500	86
RWH system [B)]	3,600	58

[A)] Including; tap aerators, aerated showerheads, low flush toilets and water butts
[B)] In addition to the range of water efficient devices

The study results show an average water consumption of 58 l/p/d for the house that had a RWH system and water efficient devices and an average of 86 l/p/d for the house without a RWH system.

A further trial involved installing RWH systems in two terraced houses to supply downstairs and upstairs toilets. In this very small sample of homes with a RWH system the estimated water use was 55 l/p/d.

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[34] http://www.berkeleygroup.co.uk/berkeley

In both studies RWH systems have achieved between 40 and 50 per cent reductions in mains water consumption compared to homes without a RWH system. Other findings include:

- RWH should only be considered after the cheaper and more effective water saving options which reduce demand at point of use.
- The decision to install a RWH system should be made at the start of a project to allow enough space for internal pumps and a back-up gravity fed system.
- Installing a RWH system can significantly reduce demand on mains water supply.

The study also highlighted a number of issues and challenges to consider before installing a RWH system:

- The size of the roof and amount of rainfall has an impact on the volume of water harvested. During times when rainfall harvested is insufficient to effectively service the toilets, the system will revert to the mains water.
- If there is a power cut, a separate gravity feed will supply the toilets.
- In the extreme cold weather, the external pump system could freeze and stop working. Appropriate insulation of external stores is important to address this.

For more information about this project you should visit the Radian Homes website[35]

11.3 Old Rectory Barn[36]

In 2007 a 16th century barn was renovated and converted into self-catering cottages with an emphasis on providing environmentally sustainable tourism accommodation. A number of water saving measures were installed including dual flush toilets and a RWH system. The system collects rainfall from the roof area and supplies all non-potable water to the cottages for:

- the outside tap for garden uses and all outdoor use;
- filling the dual flush cisterns; and
- supplying the washing machine used for all of the Barn’s laundry.

The Old Rectory Barn is a 5 star establishment and is required to provide the highest of standards. This extends to the washing and presentation of all bed linen and towels. There have been no issues with adverse odour or discolouration effects from using rainwater to feed the washing machine.

11.4 Sutton & East Surrey Water - Preston water efficiency initiative[37]

This project looked at reducing water demand in social housing using a range of water saving schemes and an educational programme. The project was divided into the following four areas:

1 – rainwater harvesting trial (12 flats);
2 – bathroom refurbishments (160 homes);
3 – demand management retrofit programme (340 homes); and
4 – school programme to include refurbishing water fittings and educating children.

Retrofitting the block of twelve flats with a RWH system was found to be a massive undertaking. A number of different contractors were both individually and collectively responsible for correct installation of the rain collection pipework, groundworks, tank installation, electrics and secondary pipework to the toilets.

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[35] http://www.radian.co.uk/200907092005/water-conservation.html
[36] www.oldrectorybarn.co.uk
[37] Final report – March 2009 **Preston Water Efficiency Initiative** www.waterwise.org.uk

The project report concluded that savings associated with RWH were lower than from the refurbishment and retrofit measures, such as replacing taps, showers and toilets with more efficient ones. In this case, RWH represented *'poor value for money'* due to significant technical issues in installation and maintenance.

11.5 Gusto Homes - Millennium Green

Millennium Green is a development of resource efficient housing that was built by Gusto Homes. The houses each incorporate the individual 'Freerain' RWH system, along with a number of other environmental features. The RWH systems collect water from all available roof areas, filter it and store it underground in individual 3300 litre tanks. The harvested rainwater is then used to flush toilets, feed washing machines and supply outside taps.

Severn Trent Water and the Environment Agency monitored the Freerain systems to see how effective they are at reducing demand for water. The performance was monitored for one year in:

- a four bedroom detached house occupied by a middle aged couple; and
- a six bedroom detached house which was occupied by a family of five.

This project showed that during the trial period, the smaller property was able to meet approximately 43% of its demand from rainwater and the larger property was able to meet about 37% of its total demand from rainwater.

The year the systems were monitored was exceptionally wet, receiving 862mm of rainfall, well above the average rainfall of 581mm between 1995 and 2001. This led to larger water savings than would be expected in a typical year. Both of the properties were sizable with larger than average roof areas, allowing more rain than average to be collected. The combination of the large roof areas and high rainfall in this trial mean that these savings are not directly transferrable to other schemes or representative of other years.

The payback period was, excluding energy usage and maintenance, around 18 years. It is expected that this period would be longer in a house with a more typical roof area and in a year with average rainfall. Payback time would also increase with the inclusion of maintenance and operating costs.

The users felt positive towards the system both for reducing mains supply and with the quality for clothes washing.

12 Conclusions

This guidance provides information on what to consider when deciding whether to install a RWH system. Local rainfall, site specific requirements, maintenance, energy costs and carbon emissions are just some elements to think about.

This guidance concludes that:

- There are cheaper and more simple water conservation devices, such as low flow taps, aerated showers, rainwater butts and low flush toilets that can offer short payback periods and should be considered before RWH. A RWH system should only be considered in the later stages of the reduce, reuse and recycle hierarchy after savings have been made through water efficiency activities.
- RWH systems are an alternative source of supply and therefore have the potential to reduce demand for mains water, but not overall water consumption.
- Water saving technologies are encouraged by government sustainable initiatives/policies such as the CSH, where RWH systems are generally required to meet the highest level of the Code.
- Increasing awareness of the benefits of rainwater harvesting systems and the combination of these systems with SUDS should encourage wider uptake.
- Installation during construction or major refurbishment is less expensive and easier than retrofitting an existing building.
- Generally, the cost effectiveness improves with the scale of the project.
- Using harvested rainwater is more carbon and energy intensive than mains water.

As a guide, RWH systems will be most effective where:

- All feasible water efficiency measures are already in place;
- It is designed to ensure that energy use and carbon emissions are minimised; and
- It is installed, maintained and monitored appropriately.

Glossary of terms

Air gap	A physical break between the lowest level of the water inlet and the maximum fault level of an appliance, installation, feed pipe, or an inlet
Backflow	Fluid that moves from downstream to upstream within an installation
Back-up supply	Supply of potable water that can supplement the non-potable supply when required
Cistern	A fixed container for holding water to be used as part of a plumbing system
Coliform	Bacteria found in the intestines, faeces, nutrient-rich waters, soil and decaying plant matter
Cross-contamination	Contamination resulting from the connection of pipes carrying mains water to pipes carrying non-potable water
Down pipes	Pipes leading down from roof guttering to drains
Legionella	A bacterium named *Legionalle pneumophila* that can cause legionnaire's disease (lung infection)
Non-return valve	A pipe fitting that limits flow to one direction only
Permeable pavements	Pavements that allow water to drain through paved surfaces rather than running off into drains
Potable water	Water suitable for human consumption that meets the requirements of Section 67 of the Water Industry Act 1991 [7]
Public mains water	Wholesome water supplied by a water undertaker, licensed water supplier, Scottish Water or the undertaker as specified in the Water Industry Act 1991 in England and Wales, the Water (Scotland) Act 1980 [8] in Scotland, or the Water and Sewerage Services (Northern Ireland) Order 2006 [9] in Northern Ireland.
Rodent barrier	Device on the holding tap overflow pipe to prevent rodents entering into the holding tank
Rainwater	Water resulting from atmospheric precipitation
Rainwater butt	Small scale garden water storage container that collects rainwater from the roof via the drainpipe
Run-off	Water falling on a surface but flowing into a downpipe, drainage channel or surface water rather than permeating the ground
Soakaway	A drainage arrangement (i.e. a pit) in permeable ground to which surplus surfacewater is fed and from which it soaks into the ground
SuDS	Sustainable drainage measures which alleviate flood risks both at a development site and elsewhere in the catchment

Suggestions for further reading

• *British Standard 8515:2009 Rainwater Harvesting Systems – Code of Practice*
• *Building (Amendment) Regulations 2009: New Part G in Schedule 1 to the Building Regulations and new minimum water efficiency requirements*
Conserving Water in Buildings, Environment Agency (2001)
• *Code for Sustainable homes: Summary of changes to the Technical Guidance May 2009 (Version2)*
• *Energy and Carbon Implications of Rainwater Harvesting & Greywater Recycling – Final Report*
http://publications.environment-agency.gov.uk/pdf/SCHO0610BSMQ-E-E.pdf
• *Guidance on water cycle management for new developments* (WaND) CIRIA C690 2010
• *Greywater: an information guide: GEHO0408BNWQ-E-E*
Model agreements for sustainable water management systems. Model agreement for rainwater and greywater use systems (C626), CIRIA (2004)
• *Planning Policy Statement 25: Development and Flood Risk*
• *Preston Water Efficiency Initiative – Final Report (2009)*
• *Rainwater and Greywater: Review of water quality standards and recommendations for the UK, MTP (2007),* http://www.mtprog.com/referencelibrary/MTP_RWGW_guidelines.pdf
• *Rainwater and Greywater: Technical and Economic Feasibility, MTP (2007)*http://www.mtprog.com/referencelibrary/MTP_RWGW_feasibility.pdf
• *Rainwater and Greywater: A Guide for Specifiers, MTP (2007)*
http://www.mtprog.com/referencelibrary/MTP_RWGW_specification.pdf
• *Rainwater and Greywater Use in Buildings: Project Results From The Buildings That Save Water Project; Decision-Making for Water Conservation (PR80), CIRIA (2001)*
• *Rainwater and Greywater Use in Buildings: Project Results From The Buildings That Save Water Project; Best Practice Guidance (C539), CIRIA (2001)*
• *Rainwater and Greywater Use in Buildings: Project Report and Case Studies (TN7/2001),* CIRIA, (2001)
• *Saving Water on the Right Track 2*, Environment Agency (1999)
• *The Rainwater Technology Handbook; Rainharvesting in Building,* Klaus Kőnig, Wilo-Bran (2001)
• *The Water-Energy Nexus: Investigation into the energy implications of household rainwater systems, [prepared for CSIRO], Institute for Sustainable Futures, University of Technology, Sydney.*
• *Water Efficiency Awards 2007 and 2009: www.environment-agency.gov.uk/business/topics/water/32042.aspx*
• *Water Reclamation Standard and Guidance, TN 6/2002 and TN 7/2002*, BSRIA (2002)
• *Water Supply Regulations 1999*
• *Water Supply and Treatment Resource Guide*, Centre for Alternative Technology.
• WRAS *Information and Guidance Note Number 9-02-04 Issue 1, Reclaimed Water Systems (*1999)
• *WRAS Information and Guidance Note Number 9-02-05 Issue 1, Marking and Identification of Pipework for Reclaimed (Greywater) Systems* (1999)

Useful contacts and other example sites

Detail	Website
British Standard Institute	www.bsigroup.co.uk
BSRIA – Building Services Research and Information Association	www.bsria.co.uk
Building Sustainability Index (Australia)	www.basix.nsw.gov.au
CIRIA – RWH information and SuDS	www.ciria.org.uk
Communities and Local Government - Regs	www.communities.gov.uk
Enhanced Capital Allowance	www.eca-water.gov.uk
Environment Agency, Water Demand Management	www.environment-agency.gov.uk/savewater
Meteorological Office – for rainwater data	www.met-office.gov.uk
Market Transformation Program	www.mtprog.com
UK Rainwater Harvesting Association	www.ukrha.org
Waterwise	www.waterwise.org.uk
WRAS – Water Regulations Advisory Service	www.wras.co.uk

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