Reclaimed water

CIBSE Knowledge Series: KS1

Principal author
Chris Parsloe

Editors
Gay Lawrence Race
Ken Butcher

Registered charity number 278104

ISBN 1 903287 54 5

Typeset by CIBSE Publications

Printed in Great Britain by Latimer Trend & Co. Ltd., Plymouth PL6 7PY

The Institution gratefully acknowledges contributions to this publication from John Armstrong, Cath Hassell (Construction Resources), Brian Hirst (Freewater UK Ltd.), Chris Shirley-Smith (Water Works UK Ltd.), Professor John Swaffield (Heriot-Watt University) and Steve Vaughan (FaberMaunsell)

Frequency	Action
Monthly	Check and clean collection filters
	Top-up disinfectant chemical levels
Annual	Service pump
	Check and clean rainwater collection areas, guttering etc.
	Clean low and high level storage tanks
	Check control system operation, e.g. level switches, disinfectant dosing, draining facilities
	Checking back-flow prevention device on low level storage tank overflow
	Check that reclaimed water complies with the target water quality values indicated in Table 3 (or as specified for the particular application)

Table 4:
Typical maintenance requirements for water reclamation systems

The installer or manufacturer of the system should provide an operating and maintenance manual detailing the operation of the system, and any routine maintenance operations required.

It is recommended that even the smallest household systems have regular checks to ensure that the system is operating correctly.

The normal maintenance activities and typical intervals are indicated in Table 4. A maintenance log book should be kept recording the dates of maintenance checks and the activities undertaken.

References

1 *Water reclamation standard* BSRIA TN 7/2002 (Bracknell: Building Services Research and Information Association) (2002)

2 *Public health engineering* CIBSE Guide G (Chartered Institution of Building Services Engineers) (2004).

3 *Plumbing engineering services design guide* (Hornchurch: Institute of Plumbing and Heating Engineering) (2002)

4 *Sustainable urban drainage systems — design manual for England and Wales* (London: Construction Industry Research and Information Association) (2000)

5 *Marking and identification of pipework for reclaimed (grey water) systems* WRAS Information and Guidance Note 9-02-05 (issue 1) (Oakdale, Gwent: Water Regulations Advisory Scheme) (1999)

6 BS 1710: 1984: *Specification for identification of pipelines and services* (London: British Standards Institution) (1984)

7 BS EN 124: 1994: *Gully tops and manhole tops for vehicular and pedestrian area* (London: British Standards Institution) (1994)

8 BS 7903: 1997: *Guide to selection and use of gully tops and manhole covers for installation within the highway* (London: British Standards Institution) (1997)

9 BS 4213: 2004: *Cisterns for domestic use. Cold water storage and combined feed and expansion (thermoplastic) cisterns up to 500 l. Specification* (London: British Standards Institution) (2004)

10 BS EN 13280: 2001: *Specification for glass fibre reinforced cisterns of one-piece and sectional construction, for the storage, above ground, of cold water* (London: British Standards Institution) (2001)

11 Rainwater and grey water use in buildings — best practice guidance CIRIA C539 (London: Construction Industry Research and Information Association) (2001)

12 Water fittings and materials directory (Oakdale, Gwent: Water Regulations Advisory Scheme) (published half-yearly).

13 BS 6920-1: 2000: *Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water. Specification* (London: British Standards Institution) (2000)

14 BS 6700: 1997: *Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages* (London: British Standards Institution) (1997)

15 *Information about installing, modifying or maintaining reclaimed water systems* WRAS Information and Guidance Note 9-02-04 (issue 1) (Oakdale, Gwent: Water Regulations Advisory Scheme) (1999)

Additional sources

Water reclamation guidance BSRIA TN 6/2002 (Bracknell: Building Services Research and Information Association) (2002)

Water Regulations Guide (Oakdale, Gwent: Water Regulations Advisory Scheme) (2000)

Contents

Note from the publisher

This publication is primarily intended to provide guidance to those responsible for the design, installation, commissioning, operation and maintenance of building services. It is not intended to be exhaustive or definitive and it will be necessary for users of the guidance given to exercise their own professional judgement when deciding whether to abide by or depart from it.

Introduction

Overview of reclaimed water sources and end uses

This guidance provides an overview of rainwater and grey water reclamation systems, covering legal requirements, system types, design considerations and system operation requirements.

The term 'grey water' is sometimes applied to water from a variety of sources including all forms of household waste water, industrial processes and water drawn from rivers or lakes.

However, in the context of this publication, grey water is defined as water that was previously supplied by a water undertaker as 'wholesome water', but which has already been used in washbasins, baths or showers. Wholesome water is defined as water supplied by a Water Supplier and complying with the requirements of Regulations made under Section 67 of the Water Industry Act 1991.

This publication does not cover treatments for contaminated water from toilets, dish washing, clothes washing or any other source. These sources are considered unsuitable for reclamation because they are likely to be contaminated with sewage, grease, food wastes or detergents.

Furthermore, this publication does not deal with reclamation systems intended to produce water fit for drinking or for the irrigation of edible crops. The main end uses intended are toilet flushing, garden watering, car washing and laundry. These uses typically account for 40–60% of total consumption in UK buildings.

Table 1 indicates the range of rain water and grey water sources and end uses covered by this publication.

Legal requirements

Grey water and rainwater reclamation systems must be designed and installed in compliance with the Water Supply (Water Fittings) Regulations 1999 for England and Wales, or their equivalents for Scotland and Northern Ireland, and the Building Regulations 2000 for England and Wales, or their equivalents for Scotland and Northern Ireland.

These state that, before any system is installed, system designs must be inspected and approved by the local water undertaker, the local sewerage undertaker and the local building control officer. The locating of large tanks requiring external structures may also require planning permission.

Definitions

Within the context of this publications the following definitions apply:

- *Rainwater*: water which falls from the sky
- *Grey water*: water that was originally supplied as wholesome water, but has already been used for some other application such as bathing or laundry (but not water from WCs or from dish washing)

Table 1:
Grey water and rainwater sources and end uses

Grey water	
Sources	**End use**
Wash basins Baths Showers	Toilet flushing Industrial processes e.g. car washing

Rainwater	
Sources	**End use**
Roof guttering Permeable paving	Toilet flushing Industrial processes e.g. car washing Plant watering Clothes washing machines

Key legislation

- Water Supply (Water Fittings) Regulations 1999
- Building Regulations 2000
- Health and Safety at Work etc. Act 1974
- Control of Substances Hazardous to Health Regulations 1992

The inspections will involve checking the design for potential hazards to occupants and possible contamination of drinking water supplies. Schemes are more likely to be passed if it can be shown that the system proposed complies with some recognised standard, including applicable European standards. The water undertaker or building control officer may also wish to visit the site during installation to check that the system being installed complies with the approved design.

The installation of the system must be carried out in compliance with all relevant health and safety legislation including the Health and Safety at Work etc. Act 1974 and any subsidiary regulations. Due to the potential risks associated with handling reclaimed water, and the disinfectant chemicals that may be required, the works must comply with the Control of Substances Hazardous to Health Regulations 1992 (COSHH). Hence, any works involving potential contact with reclaimed water or chemicals will be subject to a risk assessment in compliance with the COSHH Regulations.

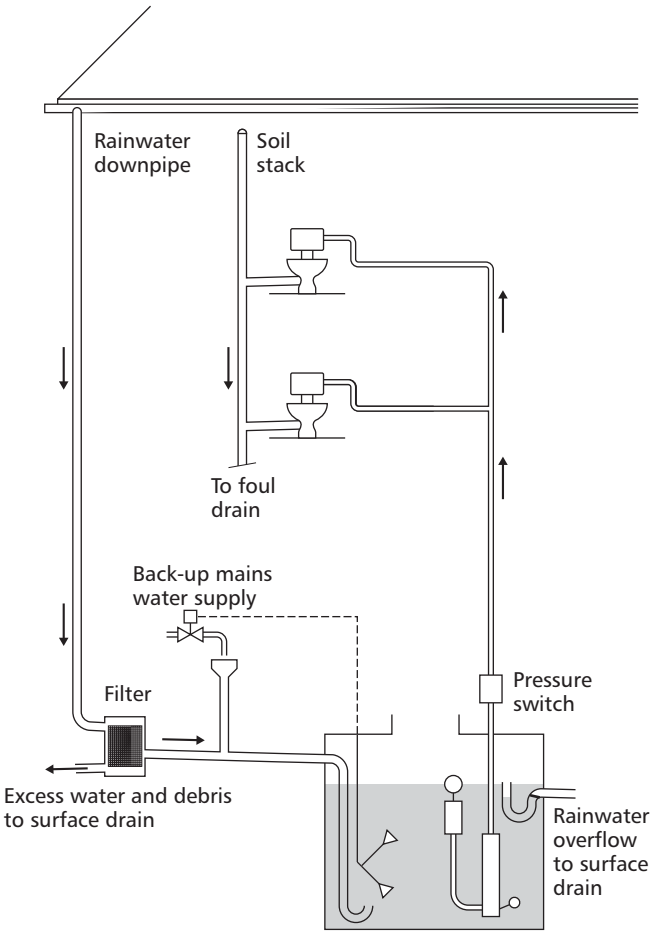
Reclaimed water systems

Overview

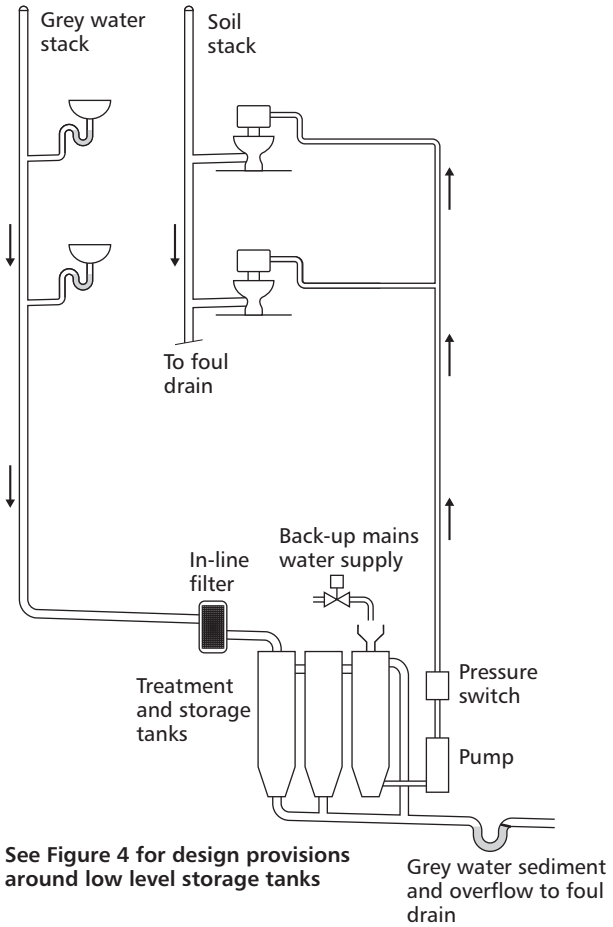
If it is possible to collect and treat water at a high point in the building, then the same collection tank can be used to feed water by gravity to outlets on lower levels. However, since it is often impractical to position collection and storage facilities at high level, the reclamation system will usually comprise some form of collection and treatment facility at low level.

From the low level collection point, reclaimed water can be pumped either directly to outlets or to a high level tank from which it can be fed by gravity to outlets. Figure 1 shows typical schematic diagrams for direct fed systems; Figure 2 shows typical schematic diagrams for gravity fed systems.
A direct pumped solution can generate more pressure at the outlets than a gravity fed system. This may be essential for some applications such as washing machines or pressure hoses. However, where feasible, it is good

Figure 1:
Direct fed reclamation system for (a) rainwater, (b) grey water



(a)



(b)

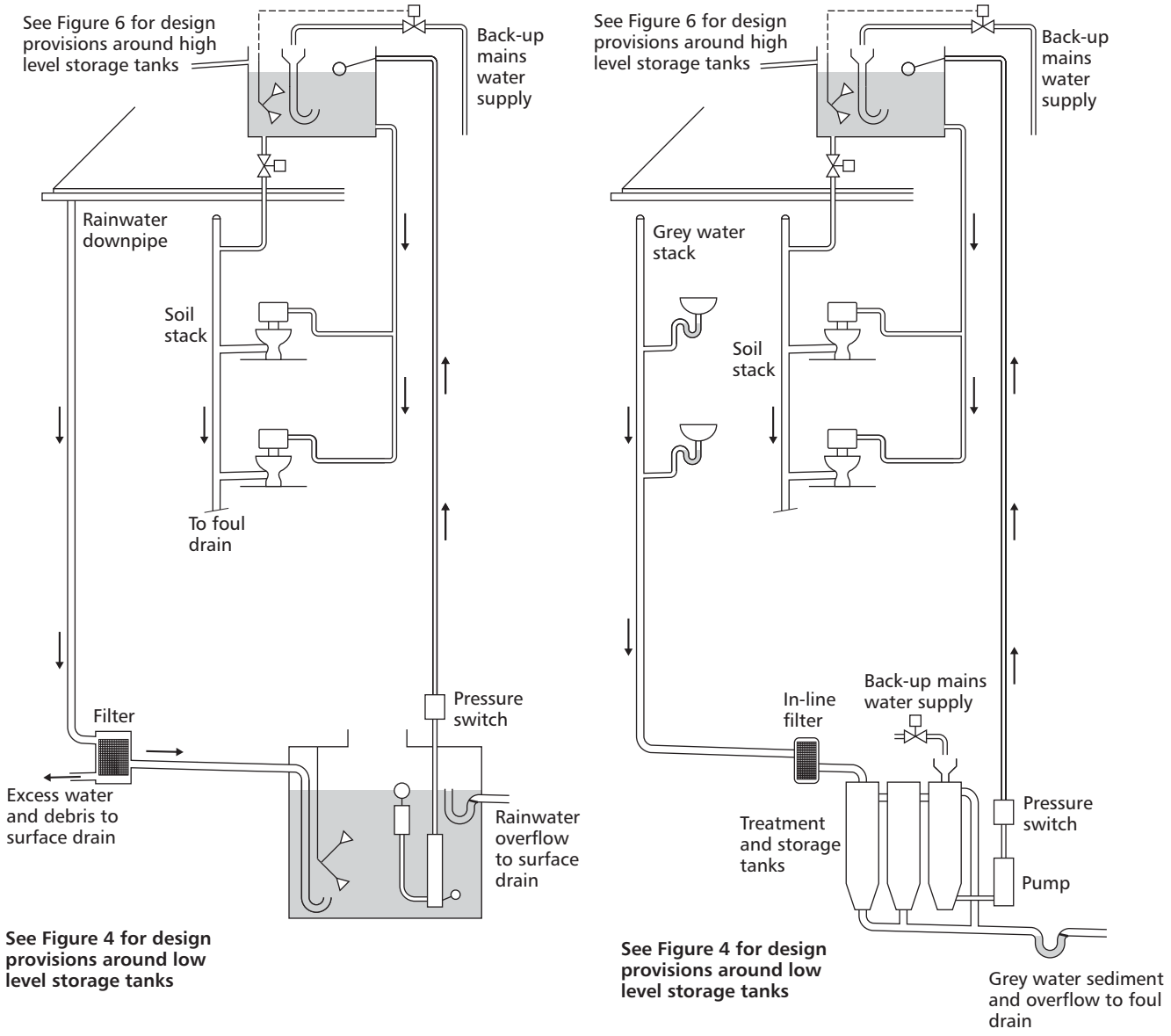


Figure 2:
Indirect fed reclamation system for (a) rainwater, (b) grey water

practice to operate the reclaimed water system at a lower pressure than the mains fed supply. This helps to avoid contamination of mains water in the event of accidental cross connections between the two systems.

Packaged systems

Packaged rainwater or grey water reclamation systems can be purchased as complete systems or as individual parts from specialist suppliers. Packaged system suppliers are usually able to offer specific design advice to suit individual circumstances.

BSRIA Technical Note TN 7/2002: Water reclamation standard — laboratory testing of systems using grey water[1] identifies a method by which systems can be categorised in terms of the intended water source and its end uses.

Manufacturers of packaged grey water systems can have their systems tested against this standard and given a classification indicating its suitability for different applications.

Water collection

Sources of grey water must be routed through a vented grey water waste stack rather than sharing the soil stack into which toilets discharge.

The grey water drainage system should be designed in compliance with section 3 of CIBSE Guide G: *Public health engineering*[2], the Institute of Plumbing and Heating Engineering's *Plumbing engineering services design guide*[3] and relevant British Standards. It should be constructed from standard plastic drainage pipes and fittings in high density PE, PVC or ABS plastic. Corrosive materials, which could discolour or contaminate collected water, should generally be avoided although ductile iron may be considered for buried pipes if ground conditions do not suit the use of plastics.

Rainwater will usually be captured in roof guttering and directed via the downpipe, straight to the collection tank. To avoid dragging leaves and other debris into the tank with the rainwater, purpose made downpipe filters, or ground level filters must be fitted. Good filtration of rainwater at this point will minimise the amount of bacteria promoting nutrients in the tank thereby avoiding the need for disinfection in most cases.

Rainwater may also be collected via permeable paving. Methods for constructing permeable paving collectors are described in *Sustainable Urban Drainage Systems — Design Manual for England and Wales*[4].

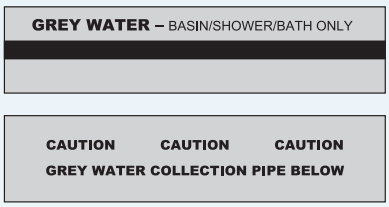
Collection pipes for rainwater are usually easy to identify. However, collection pipes for grey water could be confused with the main soil waste pipes and should therefore be labelled.

Water Regulations Advisory Scheme (WRAS) Guidance Note 9-02-05[5] recommends following the principles laid out in BS 1710: *Identification of pipelines and services*[6] but using black writing on a grey background to denote grey water collection pipes. Figure 3 shows the recommended labelling for grey water collection pipes and marker tape to be laid directly above buried pipes. The labelling for collection pipes should be applied along the length of the pipe and be repeated at 90 degree angles so that it is visible from all sides. If possible, these markings should be applied during manufacture. It is also important to label pipes and collection tanks with their intended waste water sources. This will minimise the risk of future accidental connections from unwanted waste outlets, e.g. toilets, dishwashers or washing machines.

System pressure

To avoid accidental cross contamination, it is good practice to operate the reclaimed water system at a lower pressure than the mains-fed supply.

Figure 3:
Grey water collection pipe label and marker tape for buried pipes



Demand assessment

- Assess actual volume of reclaimed water available
- Assess likely demand for its use

Overview of design approach

System capacity

The sizing of rainwater and grey water collection and storage tanks requires some assessment of the actual water volume of water available, and the likely demand for its use within the building.

Rainwater

The maximum amount of rainwater retrievable each year can be calculated from the following equation:

$$Y_r = A_c \times R_m \times C_r \times \eta_f \qquad (3.1)$$

where:

Y_r is the annual rainwater yield (litre/year)
A_c is the collection area (m^2)
R_m is the average annual rainfall (mm)
C_r is the run-off coefficient
η_f is the fractional collector efficiency

These parameters are described as follows:

— *Collection area*: the plan area available for rainwater collection, i.e. for roofs, the plan area (rather than the slope area) of the roof surface feeding into the downpipe.

— *Annual rainfall*: the average annual rainfall for the particular location. Average rainfall figures are available from the Met Office (www.meto.gov.uk).

— *Run-off coefficient*: the percentage of water actually coming off the roof or paved area after allowing for evaporation, and absorption by the construction materials. Typical values are shown in Table 2.

— *Filter efficiency*: the percentage of water captured by rainwater collection filters. This value is typically 80–90% but should be checked with the manufacturer.

Table 2:
Run-off coefficients for different types of catchment area

Rainwater catchment area	Run-off coefficient
Guttering around pitched roof:	
— slate tiles	0.8–0.9
— concrete tiles	0.75–0.8
Guttering around flat roof	0.4–0.5
Permeable paving:	
— concrete blocks with wide joints	0.5–0.7
— gravel covered	0.15–0.3

Grey water

In the absence of specific water consumption data, the amount of grey water retrievable can be estimated from a knowledge of the use of the building, assisted by typical water consumption data such as those given in section 2 of CIBSE Guide G: Public health engineering[2]. However, it should be remembered that CIBSE consumption figures are maximum figures intended for peak design purposes (i.e. a worst case scenario). Therefore, it may be more realistic to apply a usage factor to these figures (say 60–70%) in recognition that not all of the possible consumption will actually take place.

The same sources can be used to estimate the likely demand for reclaimed water. Estimates for garden watering and car washing may need to be determined based on specific knowledge of the application. Again, section 2 of CIBSE Guide G: Public health engineering provides some indication of maximum storage requirements for toilet flushing.

Matching supply with demand

In order to ensure maximum efficiency (and hence use as little mains water as possible) the annual yield of reclaimed water should, as near as possible, match the estimated annual demand. To allow for periods when the yield is insufficient to meet the demand, the storage tank must be sized to provide a certain number of days' back-up supply.

For grey water in particular, storage capacity should be kept as small as possible to ensure a fast turnaround of the water so that there is less time for bacteria to multiply. The appropriate storage duration is dependent on the source of the water and any treatment methods applied to the water.

Since rainwater generally carries less contaminated material than grey water, it can generally be stored for longer periods than grey water. Depending on the cleanliness of the rainwater and any treatments applied, storage for 20 days or more is feasible. This is helpful to ensure sufficient collection of water during wet periods to cover for drier periods. For the UK, estimated efficiencies of up to 90% are feasible with 10 days' storage, rising close to 100% with 20 days' storage.

For grey water systems, the advised storage capacity is likely to be much shorter. Treatment manufacturers may recommend as little as 3 days' storage capacity for grey water. However, unlike rainwater, the supply of grey water is likely to be more uniform throughout the year so that a 3-day supply should still achieve good efficiency.

Storage

- Storage tanks for reclaimed water need to be sized to provide several days' back-up supply
- Depending on water quality, rain water can be stored for 10–20 days; grey water for 3 days or less after treatment

Rainfall data

Data on average rainfall for particular locations is available from the Met Office.

An approach to sizing a rainwater collection system for toilet flushing is given in the following example.

Example 1

For a school building, the daily cold water demand for toilet flushing is approximately 12 litres per pupil (2 flushes per pupil). Assuming 200 pupils in the building, the estimated total demand is therefore 2400 litres per day. The school is in use for an average of 230 days per year indicating an annual demand of 552 000 litres.

From Met Office data, the average annual rainfall for the particular location is 1125 mm. Assuming a run-off coefficient of 0.85 and a filter efficiency of 0.9, the collection area required for this application can be found by rearranging equation 3.1, as follows:

$$A_c = \frac{Y_r}{R_m C_r \eta_f} \qquad (3.2)$$

Storage location

Consider storage tank location — high level tanks in loft spaces will get hot in summer and will therefore need rapid water turnover.

Therefore:

$$A_c = \frac{552\,000}{1125 \times 0.85 \times 0.9} = 641 \text{ m}^2$$

To allow for periods of dry weather, the storage tank is sized to provide for 12 days' supply (i.e. 5% of the annual demand) achieving an estimated usage efficiency of at least 90%:

$$12 \times 2400 = 28\,800 \text{ litres}$$

In gravity fed systems, water will be pumped from the main storage tank at low level to a high level storage tank on the roof or in the loft. High level tanks can be much smaller than the main low-level tank since they only need to store water for daily use. Indeed, it is desirable to keep tanks located in loft space as small as possible since loft temperatures can be high during summer months accelerating bacterial growth.

Hence, for the school described in the example, a high level tank providing a one-day supply is appropriate, i.e. 2400 litres.

Storage, treatment and distribution of reclaimed water

Storage of reclaimed water

Low level tanks

Figure 4 shows a typical arrangement of facilities around a low level rainwater or grey water storage tank. The diagram should be considered in conjunction with Figures 1 and 2.

Referring to the numbered features in Figure 4:

(1) Low level tanks may be located at ground level or beneath ground level but must be fully accessible for cleaning and servicing of internal plant and pumps. The tank must be vented to prevent the build-up of gases. The cover should be strong and secure to minimise the risk of accidents. It should also be slightly raised above ground level to prevent the ingress of surrounding dirt or vegetation. External manhole covers must comply with BS EN 124[7] or BS 7903[8]. In most cases tanks should be constructed from glass reinforced plastic or high density polyethylene. Rainwater tanks should maintain total darkness so as not to stimulate the growth of algae. Depending on the location of the tank, precautions against freezing may need to be implemented.

(2) To help avoid stagnation and consequent bad smells in tanks where there is no disinfection, it helps to keep the water aerated. One way of achieving this is to introduce rainwater at low level within the tank. This solution forces air bubbles through the water helping to keep it aerated. The pipe outlet should be upturned (or be fitted with a 'flow smoother') to minimise the risk of disturbing any sediment at the bottom of the tank.

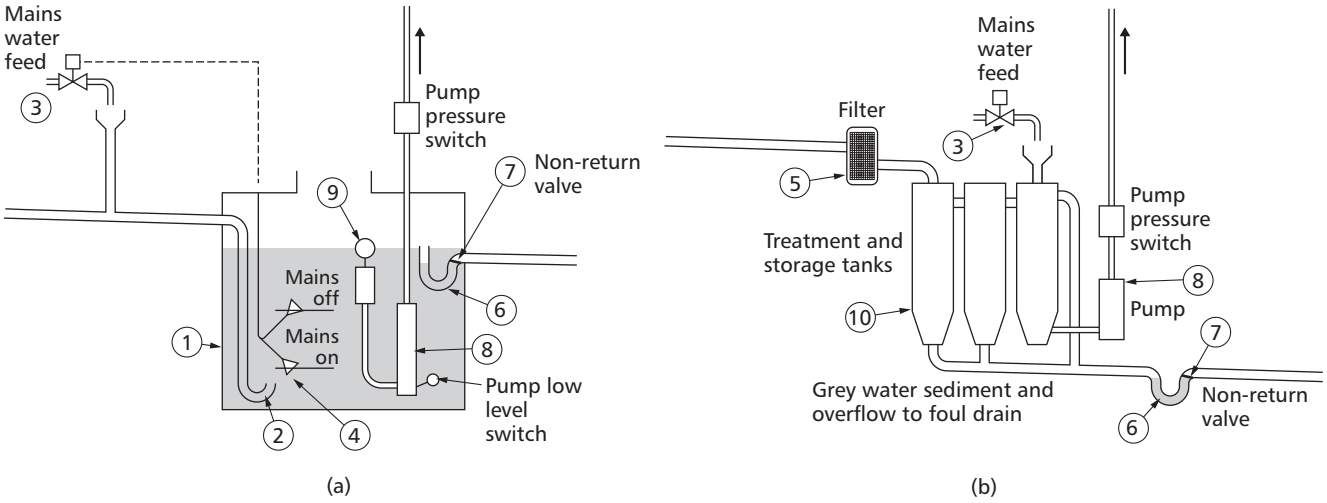


Figure 4:
Low level collection tanks for (a) rainwater, (b) grey water

(3) Where mains top-up is via a feed at low level into the main collection tank, a type AA or AB air gap needs to be established as defined in the Water Supply (Water Fittings) Regulations 1999. The main feature of these types of air gap is that the mains supply is positioned above the spill-over level of the inlet. This can be achieved by allowing the mains water to feed into a funnel or tundish arrangement where there is a clear gap between the mains outlet and the spill-over level.

(4) A float switch located inside the tank can be used to open the mains supply when the water level in the tank reaches a low level. The float switch must also turn off the mains at a level which leaves space for incoming reclaimed water.

(5) Rainwater should be filtered at its collection point. A filter should also be located before the inlet to a grey water tank to remove larger particles such as hair and soap. The filter must be easily accessible for inspection and cleaning purposes.

(6) Tanks collecting rainwater must have an overflow connection into the surface water drain. Tanks collecting grey water must have an overflow connection into the foul water drain.

(7) If the low level collection tank forms the lowest connection to the drain, there is a risk that, if the drains block or flood, a surcharge of contaminated water could back-up from the drains and enter the tank. To prevent this risk, it is necessary to install a non-return valve incorporating a visible indicator that can only be manually re-set.

(8) A submersible pump situated in the low level collection tank, or external self-priming pumps are the most common choices. When there is demand, the pump is triggered by a pressure switch in the main supply pipe. A low level switch disconnects the pump when the tank is nearly empty.

(9) A floating filter inlet to the pump means that pumped water can be filtered before entry to the pump. Also in its position of floating just below surface level, the cleanest possible water is drawn from the tank.

(10) Sediment removal and disinfection tanks may be installed to suit the particular application. Treatment processes should be provided with a failsafe feature such that if the treatment fails or is interrupted, the system will shut down to avoid pumping dirty water around the building.

High level tanks

Figure 5 shows a typical arrangement of facilities around a high level rainwater or grey water tank for a gravity fed system. The diagram should be considered in conjunction with Figure 2.

Referring to the numbered features in Figure 5:

(1) Tanks should be constructed to BS 4213[9] or BS EN 13280[10]. Tanks should be located in well ventilated spaces away from occupants to avoid any risk of build-up of disinfectant gases which may be released during hot weather.

(2) A float switch located in the tank can be used to open the mains supply when the water level in the tank is low. Where a mains supply is connected, a type AA or AB air gap needs to be established as defined in the Water Supply (Water Fittings) Regulations 1999. The main feature of these types of air gap is that the mains supply is positioned above the spill-over level of the tank. Hence, even under a fault condition where the overflow is blocked, reclaimed water still will not make contact with the mains supply pipe.

(3) An overflow pipe from the tank will give warning of a fault to ball float valves.

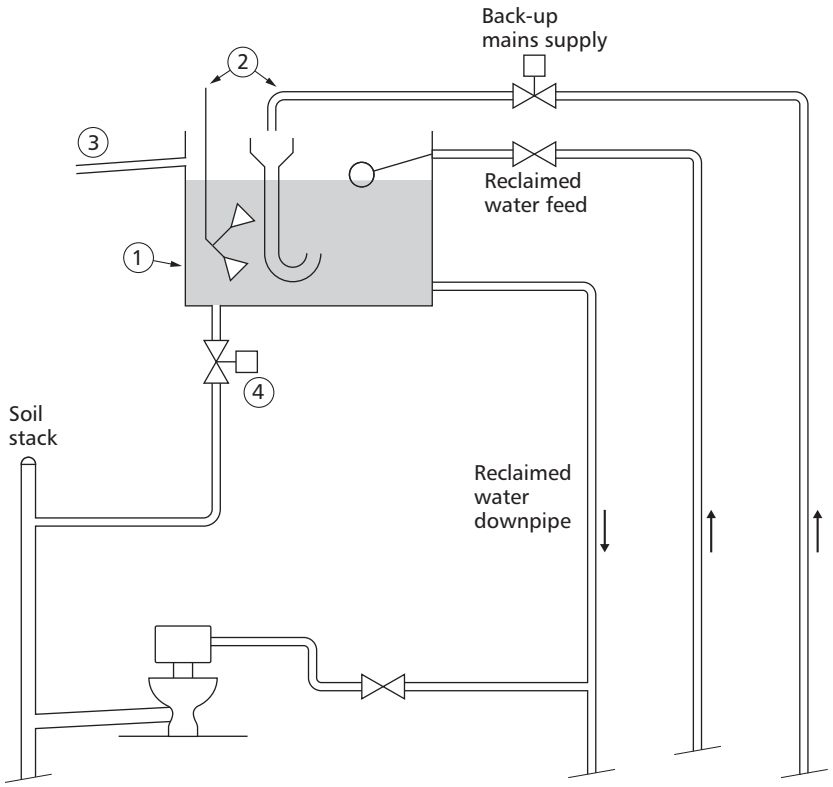


Figure 5:
High level storage tanks for rainwater/grey water

Water treatment

Water treatment can involve:

- filtration
- disinfection
- biological treatment

Grey water will always require disinfection.

Rainwater will need filtration and may require disinfection if it is to be stored and used in a spray application (e.g. car washing hoses or garden sprinklers) — assess the cleanliness and maintenance standards of the collection area.

(4) For grey water systems, a connection to the soil stack will enable the entire tank contents to be dumped to drain in the event of an operating problem, or a prolonged delay in usage. It is prudent to operate the system on a timer basis such that if there has been no draw-off from the tank within the preceding 3 days, the entire contents are dumped to drain and refilled. This will prevent the possibility of deteriorating water quality during a period when the building is unoccupied. Make-up water supplies to the tank will also need to be disabled whilst the tank empties.

Treatment of reclaimed water

All reclaimed water systems require adequate and continuing maintenance as part of a formal maintenance regime (see *System maintenance*, page 16), including suitable water treatment.

The lowest levels of decontamination treatment would be required in systems where the source water is relatively low in harmful bacteria, the storage duration is short and the end use involves minimal contact with humans, e.g. toilet flushing, clothes washing. The highest level of decontamination treatment would be required where the source water could contain harmful bacteria or viruses, and the end use involves potential contact with humans, e.g. high pressure sprays for vehicle washing.

Grey water is categorised as 'fluid category 5' under section 6.1 of the Water Supply (Water Fittings) Regulations 1999. This is water which potentially contains pathogenic organisms capable of causing illness in humans. These are present from human body fluids or faecal matter introduced during bathing. As such, it is usually essential that some form of disinfection treatment of the water is undertaken.

Rainwater is not as clearly categorised and therefore its treatment will depend on an assessment of the rainwater source and its intended use. Rainwater collected from clean surfaces and filtered to remove nutrients is likely to be low in harmful bacteria and, if only used for toilet flushing or garden watering, no disinfection will be necessary. However, regular cleaning of the collection area is important to prevent rainwater contamination from animal droppings or rotting vegetation.

Rainwater which is to be reused in a spray application, e.g. garden sprinklers or high pressure hoses for car washing, may require some form of disinfection.

Reclaimed water that has been treated is occasionally referred to as 'green water' or 'service water'.

The main options for treatment of reclaimed water are as follows.

Filtration

All reclamation systems will involve some form of filtration of the water prior to re-use. Filters can be located before the water enters the low level collection tank, or could be downstream of the tank.

If installed before the tank, this has the advantage that particles and nutrients for bacteria will be removed before they enter the tank, resulting in better water quality and longer potential storage time. However, in this location the filter itself will trap more material and will require more frequent inspection and cleaning. Automatic back-flushing of filters in grey water systems is desirable for this reason.

If installed downstream of the tank i.e. such that the pump has to pump through the filter, this will result in a higher build up of debris in the tank thus necessitating more frequent cleaning of the tank. Furthermore, the filter would need to be carefully monitored to ensure that it did not become fully blocked thereby causing the pump to operate against a closed system.

Whatever the location, the filter should be easily accessible for cleaning purposes.

Chemical disinfection

Chemical disinfection is generally inappropriate for rainwater — UV treatment is acceptable

Disinfection

Chemical disinfection is generally inappropriate for rainwater since there is a risk that chemicals will overflow to surface water drains. The use of ultra-violet light treatment can be considered for rainwater provided that the water has previously passed through an appropriate filter medium. Ultra-violet light can also be applied to grey water provided there is a pre-treatment which removes all sediment from the water so that it is clear.

Alternatively, the low level grey water storage tank can be dosed with liquid disinfectants, or solid tablets, to kill bacteria. Chlorine or bromine based disinfectants are most common for grey water systems. Disinfectants may be coloured to provide users with an indication that the water has been treated. The system installed must be provided with some failsafe system to ensure that all water supplied has been dosed. Some form of interlock which disables the system if the disinfectant supply runs out is also essential.

Biological treatment

Generally used for larger grey water systems, this type of treatment operates by introducing bio-cultures to the water. These bacteria consume any

biologically degradable waste particles present in the water. A biological sludge then forms at the bottom of the tank which can be flushed away to drain. Having removed the particulate matter, the water is then transferred to a separate tank where it is treated with ultra-violet light to kill any remaining bacteria.

Further advice on filtration and water treatment options is provided in section 6 of CIBSE Guide G: *Public health engineering*[2] and CIRIA C539: *Rainwater and grey water use in buildings best practice guidance*[11].

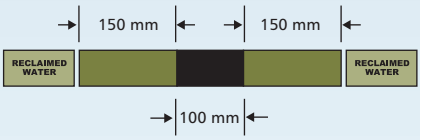
Distribution of reclaimed water

Distribution

Mains water supplies and reclaimed water systems must NOT cross-connect at any point.

Reclaimed grey water may have unexpected corrosive properties due to dissolved salts retained from its original usage, or residual treatment chemicals. For this reason, plastic distribution pipes are recommended, ideally cross linked polyethylene (PEX) or polybutylene (PB). If pipes are to be located outside, they must be resistant to ultra-violet light. To discourage bacterial growth on internal pipe surfaces, appropriate materials for reclaimed water must be selected from the *Water Fittings and Materials Directory*[12] and BS 6920[13].

Figure 6:
Recommended labelling for reclaimed water pipes located inside buildings



Furthermore, reclaimed water pipework should be designed such that dead-leg lengths are minimised. If it is likely that water is to remain stationary in pipes for long periods (i.e. longer than 3 days), consideration should be given to establishing some form of recirculation, preferably back to the treatment facility. Dead-leg lengths should comply with the requirements of BS 6700[14], and any other relevant guidance for the particular application.

Extreme care must be taken not to cross-connect between mains water supplies and reclaimed water. Maintaining the reclaimed water at lower pressure than the mains water will help to mitigate the effects in the event of accidental cross-connection.

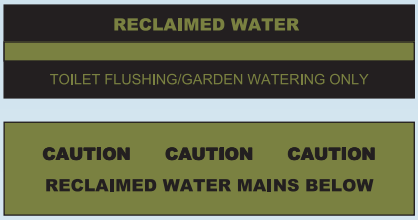
To help avoid accidents, the Water Supply (Water Fittings) Regulations 1999 require that pipe distribution systems conveying reclaimed rainwater are properly identified as such. The guidance recommends that pipes are colour coded in accordance with BS 1710[6].

BS 1710 requires that the basic identification colour for reclaimed water pipes inside buildings should be green, with a black code indication colour, as shown in Figure 6. As an added protection, the Water Regulations Advisory Scheme (WRAS) has also issued a guidance note[5] recommending that the words 'RECLAIMED WATER' should appear on either side of the banding in black text on a green background for the benefit of those coming across such a system for the first time. These labels should appear approximately every 0.5 m along the length of the pipe.

Pipes located outside buildings or below ground should be labelled along their length with marker tape directly above, as shown in Figure 7. Pipe labelling should be applied along the length of the pipe and repeated at 90 degree angles so that is visible from all sides. If possible, these markings should be applied during manufacture.

In addition, any outlets supplying reclaimed water must also be clearly labelled as not suitable for drinking and identifying the permissible uses (i.e. suitable for WC flushing or garden watering only etc).

Figure 7:
External reclaimed water pipe marking and warning tape for buried pipes



System operation

Control systems

Controls provide greater safety and security of operation but obviously add to the cost of the system. For grey water systems, depending on the design of the system and its application, the following safety features must be considered:

- automatic disinfectant dosing with automatic shut down and draining of the system if the disinfectant supply runs out
- automatic draining of the high level tank if there is no draw-off of water for a prolonged period (more than 3 days)
- automatic shut-down and drainage of the low level tank in the event of back-flow from the drains into the tank
- alarm indication in the event of pump failure, filter blockage, or back-flow from the drains.

In all situations, grey water systems must be configured such that in the event of a power failure, all systems are left in a safe condition.

Water quality

Installed systems should be checked to ensure that the quality of water they are producing meet minimum acceptable levels. The following criteria are normally used for assessing reclaimed water:

- *Appearance*: reclaimed water (particularly grey water) may be cloudy due to the retention of very fine particulate matter after filtration. Treatment chemicals may also give the water a slight colour or odour. Tests on water opacity can be undertaken to ensure that water is acceptable.

- *Bacteria*: to determine the effectiveness of bacterial disinfection, treated water should be tested for total coliform counts and faecal

Labelling of outlets

Outlets supplying reclaimed water must be clearly labelled as 'Not suitable for drinking' and must identify the permissible uses.

Pipes located outside buildings or below ground should be labelled along their length with marker tape directly above, as shown in Figure 7. Pipe labelling should be applied along the length of the pipe and repeated at 90 degree angles so that is visible from all sides. If possible, these markings should be applied during manufacture.

In addition, any outlets supplying reclaimed water must also be clearly labelled as not suitable for drinking and identifying the permissible uses (i.e. suitable for WC flushing or garden watering only etc).

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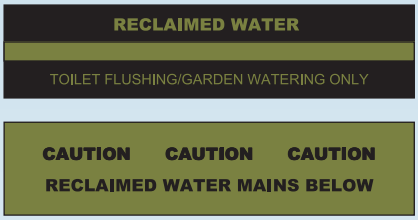
External reclaimed water pipe marking and warning tape for buried pipes



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coliform counts. Coliforms are a group of bacteria universally present in soil, river water and faecal material. They are therefore a good indicator of the success of the disinfection treatment. If water is found to be absent of coliforms then it can also be assumed that the water will be free from other potentially harmful bacteria such as *E. coli* or *Legionella*.

— *Residual chlorine*: where systems have been dosed with a chlorine based disinfectant, the levels of chlorine in the water must be tested to ensure acceptable levels are not being exceeded.

There are no specific legal requirements defining an acceptable standard for reclaimed water to be used for toilet flushing, garden watering or vehicle washing. Table 3 shows acceptable water quality properties for different applications based on previously published guides. These values should suffice for most applications, although the opinion of a water hygiene specialist may be required for specific applications. Obviously further standards for water quality in reclaimed water systems may be set in the future and it is important to check for current requirements as part of the design process.

Table 3:
Acceptable water quality for reclaimed water

Use	Requirements				Source
	Total coliforms / counts per 100 ml	Faecal enterocci / counts per 100 ml	Opacity / % at 254 nm	Chlorine / ppm	
Toilet flushing	< 10 000	< 100	60	2	WRAS Information and Guidance Note 9-02-04[15]; BSRIA *Water reclamation standard*[1]
Garden plant watering (non-edible plants)	1000	< 200	—	0.5	CIRIA C539: *Rainwater and grey water use in buildings*[11]; BSRIA *Water reclamation standard*[1]
Vehicle washing (where a spray might be generated)	10	—	—	0.5	BSRIA *Water reclamation standard*[1]

System maintenance

All reclaimed water systems require adequate and continuing maintenance as part of a formal maintenance regime to ensure correct system operation and acceptable water quality, and this is especially important for those using reclaimed grey water. This should be carefully considered when deciding if a reclaimed water system is a feasible option, particularly for smaller or domestic properties. Long term maintenance requirements must form part of the system selection criteria.

Frequency	Action
Monthly	Check and clean collection filters
	Top-up disinfectant chemical levels
Annual	Service pump
	Check and clean rainwater collection areas, guttering etc.
	Clean low and high level storage tanks
	Check control system operation, e.g. level switches, disinfectant dosing, draining facilities
	Checking back-flow prevention device on low level storage tank overflow
	Check that reclaimed water complies with the target water quality values indicated in Table 3 (or as specified for the particular application)

Table 4:
Typical maintenance requirements for water reclamation systems

The installer or manufacturer of the system should provide an operating and maintenance manual detailing the operation of the system, and any routine maintenance operations required.

It is recommended that even the smallest household systems have regular checks to ensure that the system is operating correctly.

The normal maintenance activities and typical intervals are indicated in Table 4. A maintenance log book should be kept recording the dates of maintenance checks and the activities undertaken.

References

1 *Water reclamation standard* BSRIA TN 7/2002 (Bracknell: Building Services Research and Information Association) (2002)

2 *Public health engineering* CIBSE Guide G (Chartered Institution of Building Services Engineers) (2004).

3 *Plumbing engineering services design guide* (Hornchurch: Institute of Plumbing and Heating Engineering) (2002)

4 *Sustainable urban drainage systems — design manual for England and Wales* (London: Construction Industry Research and Information Association) (2000)

5 *Marking and identification of pipework for reclaimed (grey water) systems* WRAS Information and Guidance Note 9-02-05 (issue 1) (Oakdale, Gwent: Water Regulations Advisory Scheme) (1999)

6 BS 1710: 1984: *Specification for identification of pipelines and services* (London: British Standards Institution) (1984)