Draft for Public Comment

Form 36
Version 8.0

DPC: 08/30171875 DC

British Standards

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Date: 30 June 2008

Origin: National

Latest date for receipt of comments: 31 AUGUST 2008

Project no.: 2007/02552

Responsible committee: CB/506

Interested committees: B/505, B/505/21, B/505/22, B/503, B/504, B/533, CB/-, CB/50, PSE/4, PRI/88

Title: Draft BS 8515, Code of practice for the installation of rainwater harvesting systems

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Introduction
Your comments on this draft are invited and will assist in the preparation of the resulting British Standard. If no comments are received to the contrary, this draft may be implemented unchanged as a British Standard.

Please note that this is a draft and not a typeset document. Editorial comments are welcomed, but you are advised not to comment on detailed matters of typography and layout.

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BS 8515 – Code of practice for the installation of rainwater harvesting systems

Contents

Foreword

Publishing information

This British Standard is published by BSI and came into effect on XX Month 200X. It was prepared by Technical Committee CB/506, *Water reuse*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

The following standards, relating to water reuse, are currently in development:

BS 8525-1, *Greywater treatment systems – Part 1: Code of practice for installation*

BS 8525-2, *Greywater treatment systems – Part 2: Type tests for treatment equipment*

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Attention is drawn to the following regulations:

- The Confined Spaces Regulations 1997;
- The Private Water Supplies Regulations 1991;
- The Work at Height Regulations 2005;
- The Workplace (Health, Safety and Welfare) Regulations 1992.

In this document, the following national regulations, which apply to plumbing systems in premises to which a supply from the public mains has been provided, are referred to as the "Water Fittings Regulations [1]":

- The Water Supply (Water Fittings) Regulations 1999, in England & Wales;
- Water Byelaws 2000 (Scotland), in Scotland;
- Water Regulations (Northern Ireland) 1991, in Northern Ireland.

0 Introduction

0.1 General

On-site collection and use of rainwater is an alternative to public mains supply for a variety of non-potable water uses in the home, workplace and garden. It can also provide benefits for the attenuation of surface water run-off.

As the marginal cost of centralized water supply inevitably increases, there is increasing financial incentive for the installation of decentralized supply infrastructure in both new build and retrofit situations. Furthermore, the government is driving a sustainable buildings agenda, which will encourage the inclusion of rainwater harvesting and on-site stormwater control at the higher levels of specification. Consequently, rainwater harvesting is a rapidly expanding sector where there is a need for standardization to protect the public and to ensure that reliable systems are designed, made, installed and maintained.

0.2 Types of rainwater harvesting

There are seven basic types of rainwater harvesting systems (see Figure 1):

a) water butts (not covered by this British Standard);

b) water stored in below ground tanks and directly pumped to the points of use;

c) water stored in below ground tanks and pumped to elevated tanks for supply by gravity to uses;

d) water stored in below ground tanks, primed by a pump and pumped directly to uses;

e) water stored in above ground tanks and directly pumped to uses;

f) water stored in above ground tanks and pumped to elevated tanks for supply by gravity to uses;

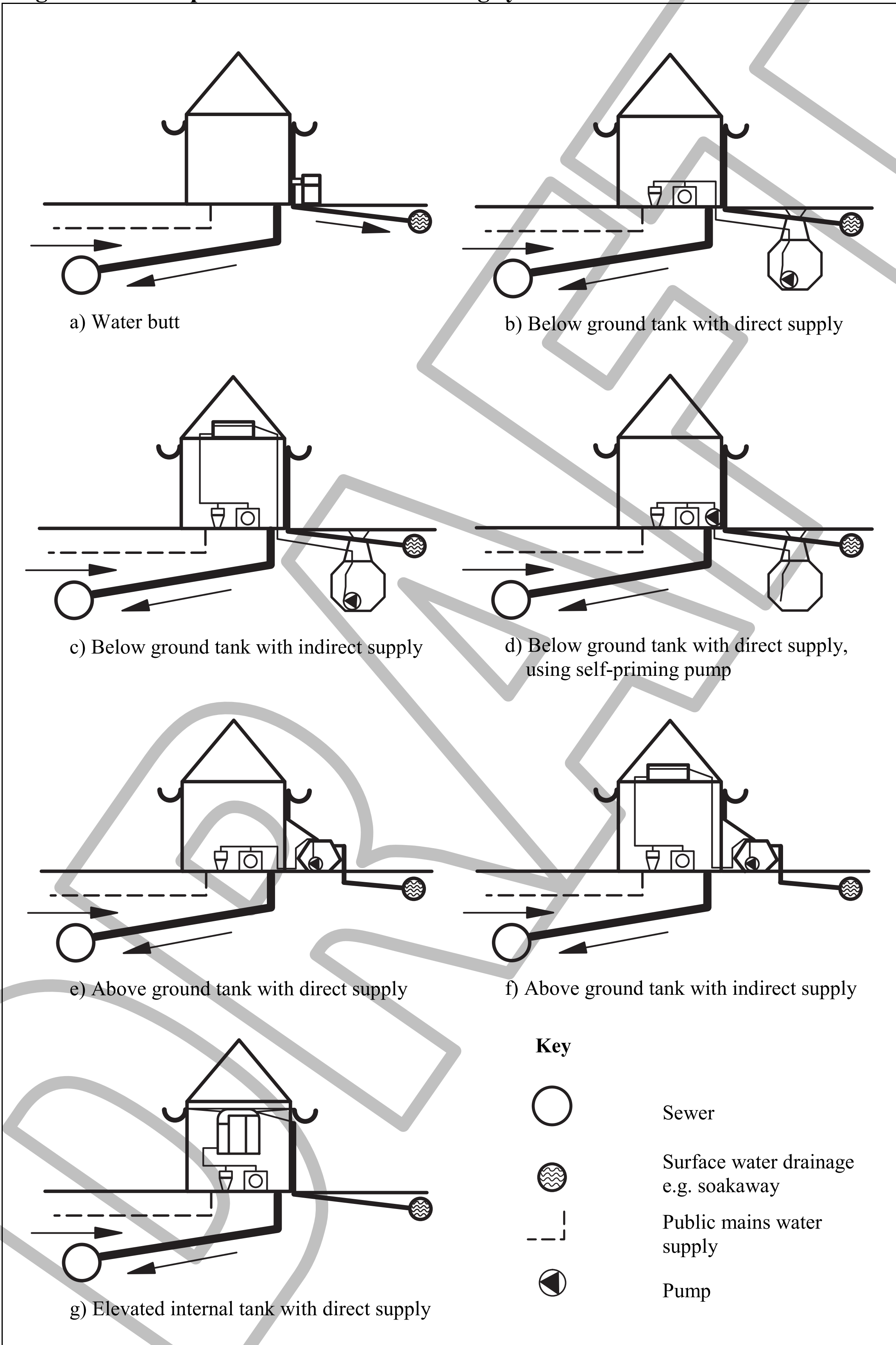
g) water stored in elevated tanks and directly supplying uses.

Within the seven basic types there are variations such as:

- internal or external locations for tanks;
- single or multiple linked tanks;
- freestanding or fully or partially buried tanks;
- communal tanks supplying multiple properties;
- packaged systems or components.

There are also systems for supplementing or replacing potable water supplies, as well as systems that contribute to stormwater control and supply fire suppression systems.

Figure 1 – Examples of rainwater harvesting systems



1 Scope

This British Standard gives recommendations on the design, installation, alteration, testing and maintenance of rainwater harvesting systems supplying non-potable water in the UK.

It covers systems supplying water for domestic water uses that do not require potable water quality such as laundry, toilet and urinal flushing and garden watering. It does not cover systems supplying water for drinking, food preparation and cooking, dishwashing and personal hygiene.

It covers individual and communal systems, and those providing stormwater control. It does not cover water butts.

It applies to retrofitting and new build.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 1710, *Specification for identification of pipelines and services*

BS 4800, *Schedule of paint colours for building purposes*

BS 6700:2006, *Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages*

BS 7291-2, *Thermoplastics pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings – Specification for polybutylene (PB) pipes and associated fittings*

BS 7291-3, *Thermoplastics pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings – Specification for cross-linked polyethylene (PE-X) pipes and associated fittings*

BS 7671, *Requirements for electrical installations – IEE Wiring Regulations – Seventeenth edition*

BS EN 1057, *Copper and copper alloys – Seamless, round copper tubes for water and gas in sanitary and heating applications*

BS EN 10216-5, *Seamless steel tubes for pressure purposes – Technical delivery conditions – Stainless steel tubes*

BS EN 10217-7, *Welded steel tubes for pressure purposes – Technical delivery conditions – Stainless steel tubes*

BS EN 12056-4, *Gravity drainage systems inside buildings – Part 4: Wastewater lifting plants – Layout and calculation*

BS EN 13564 (all parts), *Anti-flooding devices for buildings*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 air gap

physical break between the lowest level of the water inlet and the maximum fault level or critical level of an appliance or installation, a feed pipe, or an air inlet orifice incorporated into a hydraulic circuit

[BS EN 1717]

3.2 backflow

movement of the fluid from downstream to upstream within an installation

[BS EN 1717]

3.3 backflow prevention device

device which is intended to prevent contamination of potable water by backflow

[BS EN 1717]

3.4 back-up supply

supply of potable water, e.g. from the public mains water supply, that can supplement the non-potable supply in times of drought and/or heavy demand

3.5 break cistern

cistern used to separate two plumbing systems of different pressures, water qualities or flow rates, where the water from one system flows through an air gap and into the storage cistern feeding the second system

3.6 calmed inlet

fitting on the end of the drainage pipe feeding the storage tank that is minimizes turbulence and slows the water flow into the tank in order to prevent disturbance of any sediments near the base of the tank and to help release oxygen into the tank's water

3.7 cistern

fixed container for holding water at atmospheric pressure for subsequent reuse as part of a plumbing system

3.8 control unit

unit which automatically controls and monitors the function of the rainwater harvesting system to facilitate effective operation

3.9 cross-connection

physical hydraulic link or a removable link between two separate systems

3.10 domestic use

use related to residential or similar dwellings

NOTE Potable domestic use includes water for the kitchen sink, wash and hand basins, bath, shower and dishwasher. Non-potable domestic use includes water for WC flushing, domestic washing machines and garden watering.

In commercial, industrial or public premises, "domestic use" is limited to water used for those applications/appliances described above and excludes, for example, water used for fire fighting, central heating or irrigation systems.

[BS EN 1717]

3.11 infiltration

⟨into the ground⟩ the movement of surface water or treated effluent into the ground

[BS EN 1085]

3.12 nominal capacity

dimensional volume of the maximum capacity of water that can be retained within the tank, e.g. up to the overflow

3.13 non-potable water

water of insufficient quality to serve as drinking water

NOTE Non-potable water can also be referred to as "unwholesome" water.

3.14 overall capacity

dimensional volume of the tank, used to determine the space requirement for the installation

3.15 overflow

device that relieves the system of excess flow

3.16 point of use

point where water is drawn by the user either directly or by connecting an apparatus

[BS EN 1717]

3.17 potable water

water of sufficient quality to serve as drinking water, whether it is to be used as such or not

NOTE Potable water can also be referred to as "wholesome" water.

3.18 public mains water

wholesome water supplied by a water undertaker, licensed water supplier or the undertaker as specified in the Water Industry Act 1991 in England & Wales, the Water (Scotland) Act 1994 in Scotland, or The Water and Sewage Services (Northern Ireland) Order 2006 in Northern Ireland.

3.19 rainwater

water arising from atmospheric precipitation, which has not yet collected matter from the surface

[BS EN 1085]

3.20 soakaway

pit or other drainage arrangement prepared in permeable ground to which surplus surface water is fed and from which it soaks into the ground

[BS EN 1085]

3.21 spillover level

level at which water will start to flow over the receiving vessel with all outlets closed

3.22 stormwater control

measures to control the quantity, quality and/or velocity of surface water run-off

3.23 surface water

water from precipitation, which has not seeped into the ground and which is discharged to the drain or sewer system directly from the ground or from exterior building surfaces

[BS EN 1085]

3.24 tank

closed, watertight container for rainwater, which forms part of a drainage system

3.25 working capacity

maximum capacity of water that may be extracted from a tank in normal use, e.g. from the overflow to the lowest extraction point

4 Design

4.1 Sizing

4.1.1 General

As the optimum storage capacity for a rainwater harvesting system is a function of the rainwater availability and the non-potable water demand, the following factors should be identified in order to calculate the size of the system (see **4.1.2**):

- the amount and intensity of rainfall;
- the size and type of the collection surface (see Commentary on **4.2.1** regarding run-off characteristics);
- the number and type of intended applications.

4.1.2 Calculation methods

4.1.2.1 General

The storage capacity of the rainwater harvesting system should be determined using one of the following methods:

a) a simplified approach for residential properties, where there is consistent daily demand, for which no calculations have to be carried out (see **4.1.2.2**);

b) an intermediate approach which uses simple formulae to calculate a more accurate estimation of storage capacity than the simplified approach (see **4.1.2.3**);

c) a detailed approach for non-standard systems, where there is variable demand through the year, or for large systems (see **4.1.2.4**).

NOTE 1 The simplified approach is not suitable for commercial buildings as the assumptions relating to demand are not applicable.

NOTE 2 For large rainwater harvesting systems, the size of the system needs to be analysed using a detailed approach to ensure a cost-effective solution is developed, as seasonal variations in rainfall can affect sizing requirements even where demand is relatively predictable and consistent.

Once the storage capacity has been determined, storage tanks should be selected on the basis of working capacity, rather than the total capacity of the container.

The size of the tank should allow for daily rainfall variation, but construction above a certain size, based on rainfall for that area, provides very limited additional benefit.

4.1.2.2 The simplified approach

To apply the simplified approach to sizing the rainwater harvesting system for non-potable domestic use, storage capacity should be estimated using the following method.

First, the roof area draining to the storage tank should be established, and the annual average rainfall depth for the location of the site should be determined from Figure 2.

In most cases, the storage capacity should then be read from the Y axis of Figure 3, using the appropriate diagonal line for the rainfall depth. However, where the site has a large roof area and/or is in a region with high annual rainfall, the storage capacity should be determined in relation to the population in the house.

Where the system is to provide both non-potable water for domestic use and stormwater control, the integrated sizing method given in **A.1** should be used to estimate the additional storage capacity needed.

*COMMENTARY ON **4.1.2.2***

The simplified approach is based on the following assumptions:

- *relatively constant daily domestic use through the year of 50 litres per day per person for toilet flushing and clothes washing;*
- *annual average rainfall depth for the site location;*
- *standard tiled pitched roofs are used for the collection surface.*

The storage is based on the rule of thumb of 18 days of average rainfall, which caters for the variability of rainfall that occurs in the UK. Provision of greater storage capacity provides very little additional benefit. Around 80% of all the effective run-off from the collection surface in the year will be utilized. Where the storage capacity is dictated by the number of users and not the roof area/rainfall, the storage capacity can be reduced by up to 30% due to the supply being significantly greater than the demand.

Readers might wish to note that sizing for non-potable supply alone provides a small beneficial element for stormwater control. However this volume is relatively small and is normally ignored when designing for stormwater control.

The integrated option may only be applied in situations where the average run-off yield is less than the average non-potable demand. This is because the likelihood of significant spare storage in the tank occurring at the time of a large storm is small.

Figure 2 – Hydrological regions of UK for the sizing of rainwater harvesting systems

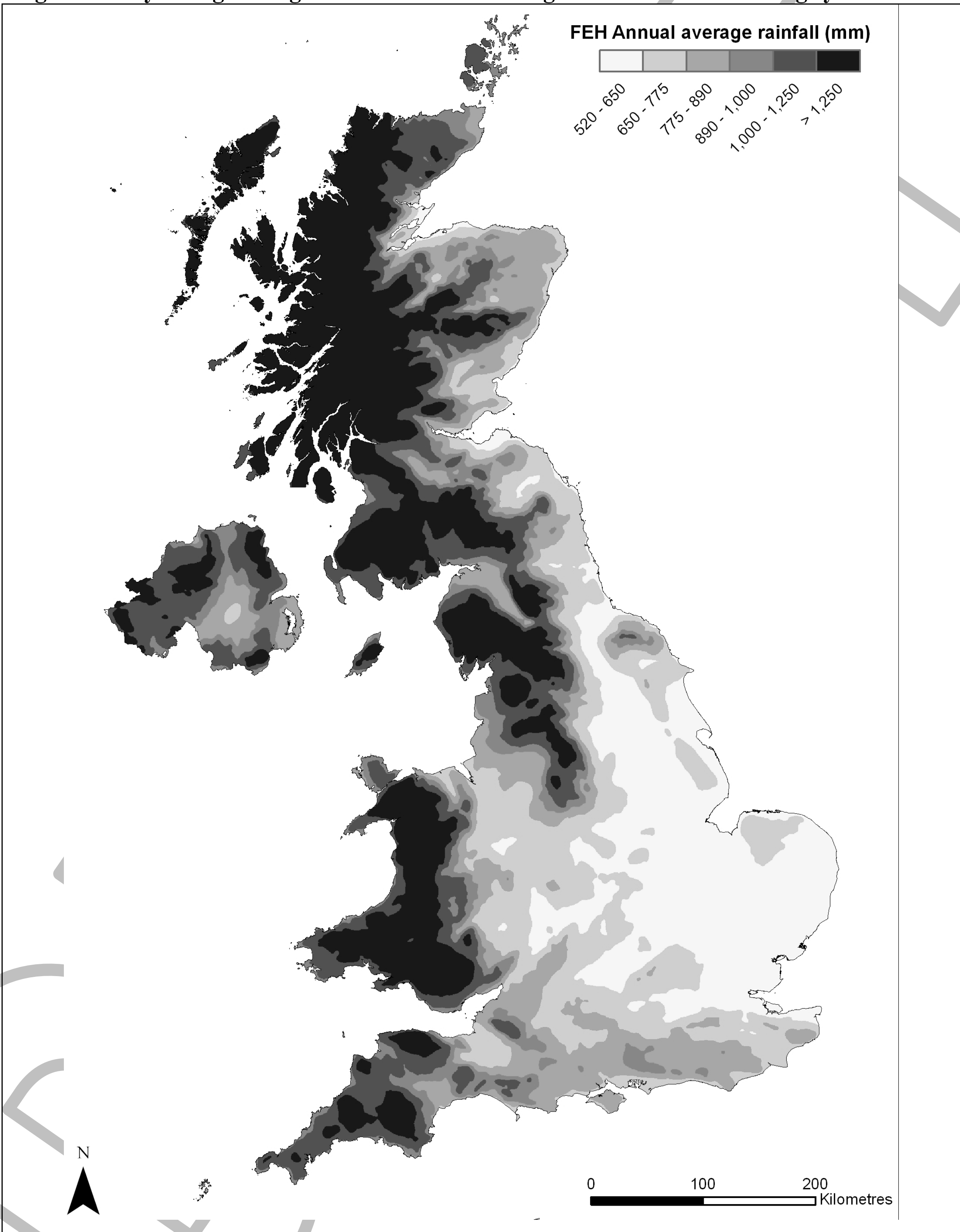
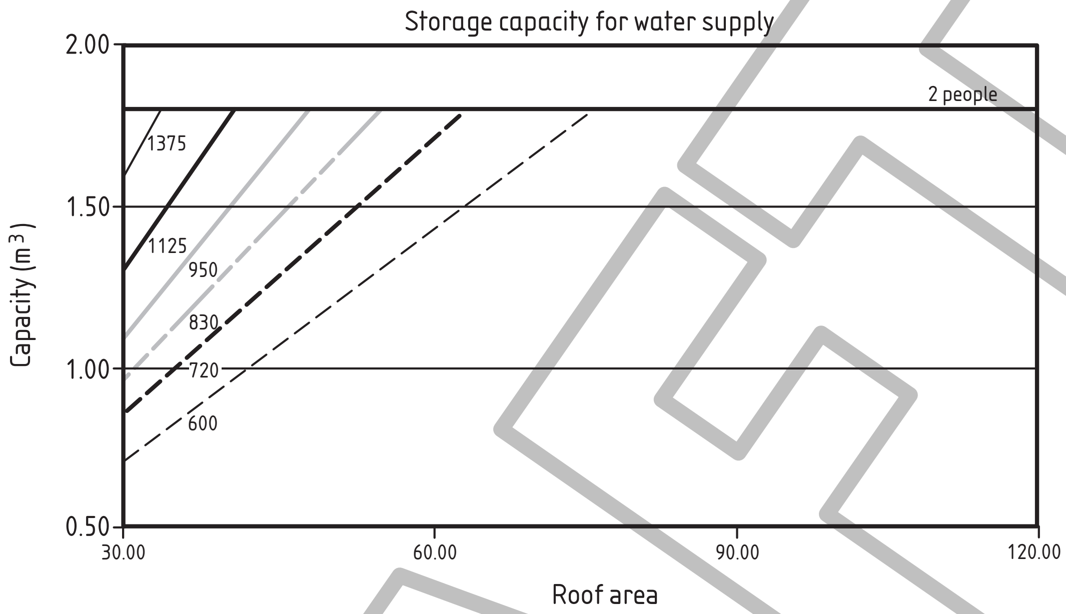
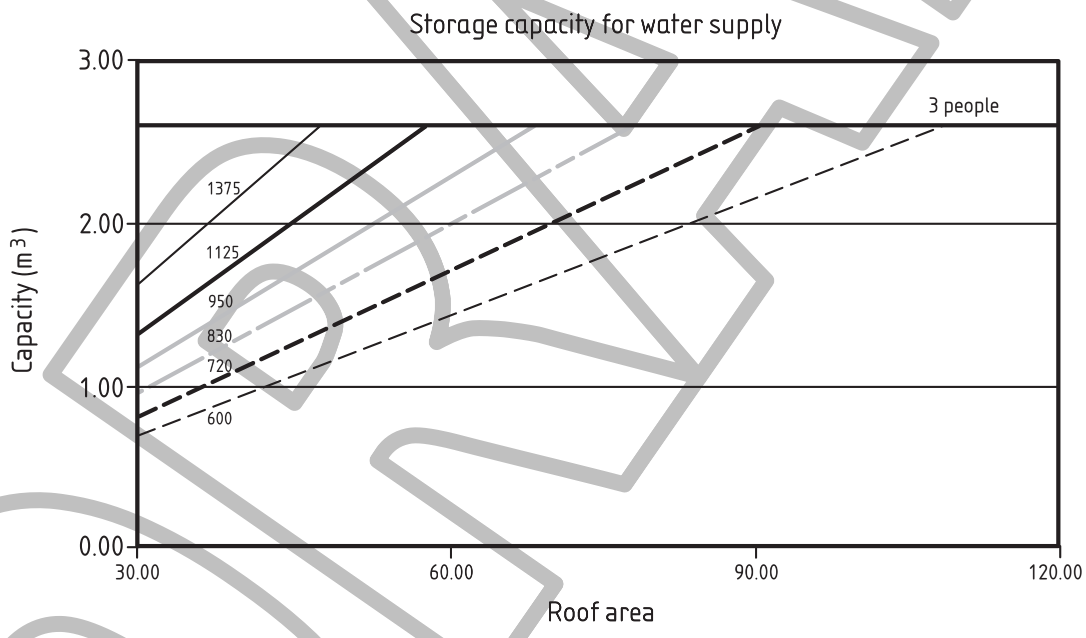


Figure 3 – Storage capacities for domestic water supply based on annual rainfall and roof size (simplified approach)

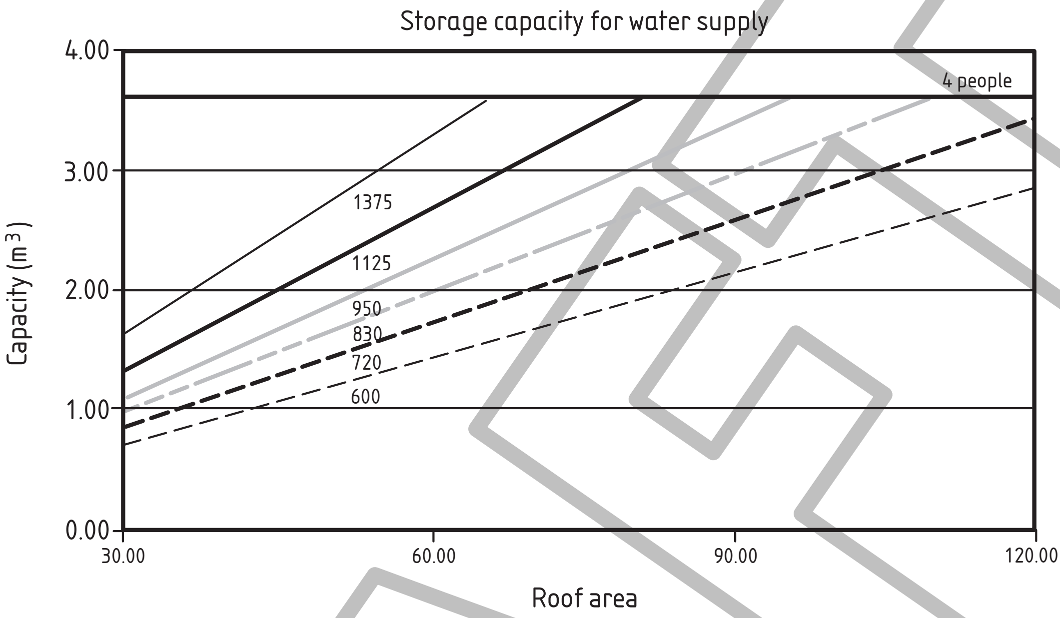


a) Storage capacity for a 2-person household

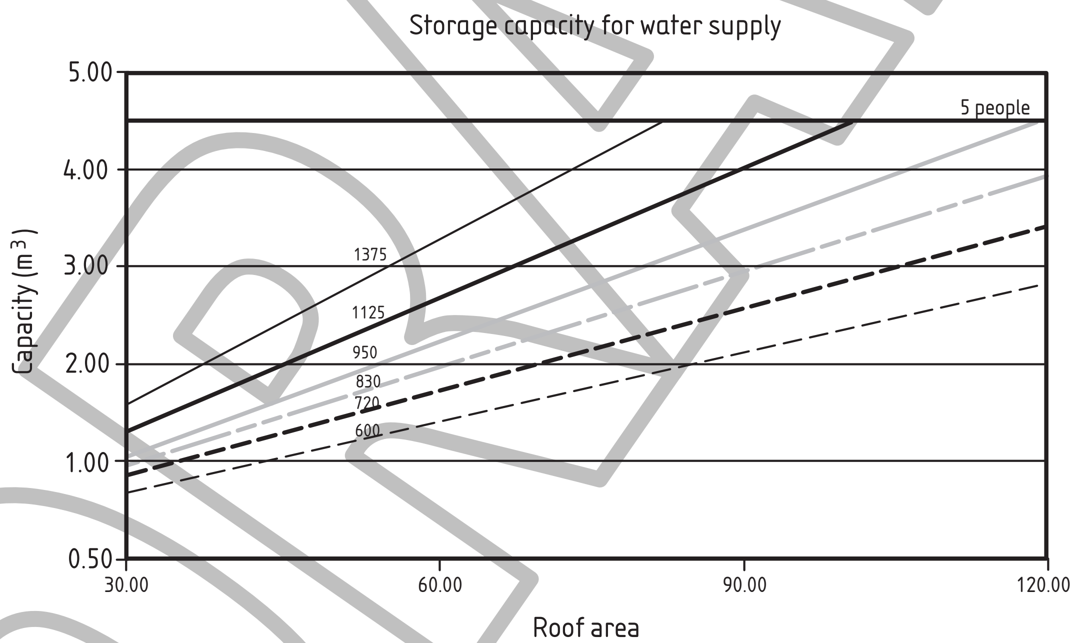


b) Storage capacity for a 3-person household

Figure 3 – Storage capacities for domestic water supply based on annual rainfall and roof size (simplified approach)



c) Storage capacity for a 4-person household



d) Storage capacity of a 5-person household

EXAMPLE
If a house has four residents, the maximum storage that might be useful is 3.6m^3. However, if the house is in London, where the rainfall is around 600 mm according to Figure 2 and the roof plan area draining to the tank is 90m^2, the storage capacity ought to be reduced to around 2.1m^3 in line with Figure 3c. It is not necessary to provide a 3.6m^3 tank as the tank will rarely store more than 2.1m^3 and thus very little extra water will be provided over the year.

4.1.2.3 The intermediate approach

*NOTE The intermediate approach is similar to the method described in **4.1.2.2** and thus the results obtained are likely to be similar. Equations are provided to allow a more flexible and accurate facility for calculating the storage needed. The advantage of this approach is that certain variables can be selected and modified to reflect the situation being considered.*

To apply the intermediate approach to sizing the rainwater harvesting system for non-potable domestic use, storage capacity should be calculated from the following equations and should be the lesser of 5% of the annual rainwater yield and 5% of the annual non-potable water demand.

Five percent of the annual rainwater amount should be calculated using the equation:

$$Y_R = A_A \times e \times h \times \eta \times 0.05 \tag{1}$$

where:

Y_R is the rainwater storage (l);

A_A is the collecting area (m^2);

e is the yield coefficient (%);

h is the depth of precipitation (mm);

η is the hydraulic filter efficiency.

Five percent of the annual non-potable water demand should be calculated using the equation:

$$D_N = P_d \times n \times 365 \times 0.05 \tag{2}$$

where:

D_N is the non-potable water demand (l);

P_d is the daily per-person requirements (l);

n is the number of persons.

Where the system is to provide both non-potable water for domestic use and stormwater control, the integrated sizing method given in **A.2** should be used to estimate the additional storage capacity needed.

*COMMENTARY ON **4.1.2.3***

The values normally used for each of the parameters in these equations are:

a) 5% of annual demand or supply

This equates to 18 days a year and is needed to take account of daily rainfall variability. In practice there are diminishing returns for tank sizes designed using 7 or 8 days. The use of a longer period is more important for areas with greater rainfall variability and where demand is significantly greater than supply.

b) Collection area

This is the plan area of the roof or other collection surface which is to be drained to the rainwater harvesting system. Modification of this value to allow for pitch and alignment to the prevailing wind is not usually made.

c) Yield coefficient & hydraulic filter efficiency

*Uncertainty in the yield from a catchment surface is fairly small for a standard pitched roof. The loss of volume from rainfall through to stored run-off comprises both losses in terms of wetting of the surface and also the filtering process. In general the combination of these two coefficients results in a value of 0.7 to 0.8 being assumed. Where flat roofs, green roofs or paved surfaces are used for collection, it is advised that the more detailed approach given in **4.1.2.4** is used.*

The filter efficiency in the region of 0.9 is commonly quoted and used. However where storage systems are designed for stormwater control, the filter performance during extreme events is important and information on this aspect needs to be explicitly obtained.

d) Non-potable demand

*This is usually set at around 50l per person per day and comprises the demand for toilet flushing and clothes washing. Where car washing and garden watering is included, demand can be much greater. In this case, supply is normally much less than the demand and the daily variability of demand in allowing for external use of rainwater is such that it is advisable to use the detailed approach to analyse the storage requirements (see **4.1.2.4**).*

4.1.2.4 The detailed approach

The detailed approach should be used to calculate storage size for all situations where:

- the demand is irregular (for example, external use, non-residential use, tourism, etc.);
- the yield is uncertain (for example, due to the use of green roofs, permeable pavements etc.);
- the use of average annual rainfall is inappropriate;
- costly, large or complex rainwater harvesting systems are proposed.

NOTE 1 Computer models may be used to simulate the performance of the rainwater harvesting system as accurately as possible. The uncertainty associated with both the demand and the supply needs to be considered using appropriate uncertainty methods.

To apply the detailed approach to sizing the rainwater harvesting system for non-potable domestic use, storage capacity should be estimated by building a model of yield and demand, which is based on a continuous rainfall time series for a minimum of 3 years and preferably 5 years. This time series should use daily rainfall data for assessing non-potable system storage.

From an analysis of the results of the storage capacity, the value which is exceeded twice a year should be used for sizing the system.

NOTE 2 The analysis also enables an assessment of how much water might be saved annually and the number of days that no rainwater is available, which is particularly useful if there is no back-up facility.

Where the system is to provide both non-potable water for domestic use and stormwater control, the integrated sizing methods detailed in **A.3** should be used to estimate the additional storage capacity needed.

4.2 Collection

4.2.1 Surface

*COMMENTARY ON **4.2.1***

Hard roof surfaces are considered the most suitable for rainwater collection, although many common roofing materials may also be used. It is important to note that different collection surface materials have different drainage characteristics, e.g. only around 30 to 50% of the annual precipitation runs off green roofs.

It is also important to note that the water from green roofs is likely to be affected by a brownish discolouration, while the water from bitumen covered roofs is very likely to be yellow. The water from newly built, large-surface, uncoated copper and zinc coated roofs might have some increased concentrations of heavy metals.

When selecting a collection surface, consideration should be given to the surface's materials as these can affect the quality and quantity of the collected water.

Surfaces subject to as little pollution as possible should be used.

Ground level or trafficked surfaces can provide large areas for collection and may be used in areas where there is a high demand for non-potable water (e.g. commercial, industrial or public premises). As these surfaces carry a larger risk of pollutants entering the system, they should only be used once a specific risk assessment has been completed (see Clause **8**).

NOTE Run-off from these areas is likely to be contaminated by animal and bird faeces, soil, grit, sand, hydrocarbons, weedkiller and various chemicals.

4.2.2 Guttering and collection pipework

Roof outlets, guttering and pipework should function as an integral part of the whole system, with access for routine maintenance and cleaning.

Collection pipework should allow the rainwater to flow from the catchment to the tank (or an intermediate pumped sump) by gravity or syphonic action. Pipework should be free draining to avoid stagnation and should prevent the ingress of contaminated water from other sources.

NOTE Conventional rainwater goods and drainage pipes may be used.

Sealed gullies should be used at ground level to minimize the risk of pollutants entering the system.

4.3 Filtration and treatment

To ensure that rainwater is free from debris before entering the tank, a filter system should be incorporated in the drainage pipework, upstream of the tank.

The filter system should include a filter which:

- is water and weather resistant;
- is removable and readily accessible for maintenance purposes;
- has an efficiency of at least 90%;
- passes a maximum particle size of <1.25 mm.

Additionally, to prevent any other floating debris from entering the distribution system, the tank should be fitted with a calmed inlet.

Where feasible, a floating extraction point from the tank should be used, which is approximately 10–15 cm below the surface of the water. If floating extraction is not practicable, a fixed extraction point may be used but should be positioned approximately 15 cm above the base of the tank.

NOTE An additional filter may also be fitted at the extraction point.

*COMMENTARY ON **4.3***

*A rainwater harvesting system with filtration conforming to **4.3** provides water of a suitable quality for laundry, WC flushing and garden watering in most residential, commercial and industrial situations. However, readers might wish to note that some situations, e.g. where higher exposure to the water is* *anticipated or where the water is to be used in public premises, could require higher water quality. In such cases, the system may incorporate treatment processes such as ultraviolet (UV) or chemical disinfection.*

UV disinfection is effective against bacteria in rainwater but needs to be applied near to the point of use as it has no residual effect. If UV disinfection is used, filtration prior to the disinfection cell is necessary to ensure that water entering the cell is free from particles that could obscure the UV light.

Conventional chemical disinfectants (oxidizing biocides such as chlorine, bromine and chlorine dioxide) may be used, but with close control of chemical dosing.

The use of disinfection equipment is site specific depending on the user's requirements and therefore expert advice is to be taken if such treatment is deemed appropriate. Consideration also needs to be given to the environmental impact of disinfection treatments.

4.4 Storage

4.4.1 General

The rainwater harvesting system should, as a minimum, include a tank for primary storage, which may be positioned either above or below ground. All tanks should be ventilated and appropriate to the site (see Clause **5**).

NOTE 1 Tanks are normally prefabricated off site.

The tank(s) used in the system should be constructed from materials that create watertight structures without encouraging microbial growth.

NOTE 2 Suitable materials include concrete, glass reinforced plastic (GRP), polyethylene or polypropylene (including geo-cell structures) and steel coated with non-corrodible materials, e.g. steel conforming to BS EN 10143.

NOTE 3 Storage may be accommodated in porous pavement constructions.

All tanks and cisterns, whether used separately or connected to each other in order to create greater capacity, should avoid stagnation by ensuring that pipework connections allow the through-flow of water.

All tanks and cisterns should have close-fitting lids to exclude light, debris, insects etc. Air vents should be screened and raised above the surface flood level.

The primary tank should be positioned such that extremes of temperatures are avoided.

Where tanks are positioned above habitable or vulnerable areas, the risk of water leakage should be considered, e.g. bunding, additional drainage, sump pump.

NOTE 4 In principle, rainwater harvesting storage may form part of the surface water drainage attenuation strategy and/or fire sprinkler tanks, subject to approval from the relevant authorities.

4.4.2 Above ground tanks or cisterns

NOTE Above ground tanks are particularly cost effective for retrofit applications.

Where they are used, above ground tanks and cisterns should be insulated and opaque to minimize the potential problems of freezing, warming and algal blooms.

The loading of the structure should be taken into account when locating internal tanks.

4.4.3 Below ground tanks

NOTE 1 Below ground tanks can provide frost protection, are cooler in the summer months and restrict algal growth due to the lack of sunlight.

Below ground tanks (and their covers) should be sufficiently rigid to resist likely ground and traffic loadings, and flotation.

NOTE 2 This might require the use of concrete for back filling.

4.5 Materials and fittings

The materials selected for the tank and other components should be suitable for the location and temperature ranges anticipated.

Consideration should be given to the environmental impact of materials used and materials with lower environmental impact should be preferentially specified. Existing resources on site should be utilized, where appropriate, and materials re-used where possible to limit the environmental impacts of the system.

4.6 Power supply

The power supply of the rainwater harvesting system should be readily accessible but also guarded to ensure against the inadvertent isolation or disconnection of electricity.

Where feasible, the electricity used to power the system should be from renewable sources, either on site or off site.

4.7 Back-up water supply and backflow prevention

NOTE Attention is drawn to the Water Fittings Regulations which require adequate backflow prevention to be provided so that water supplied from the public mains for domestic uses does not become contaminated.

4.7.1 Back-up water supply

The rainwater harvesting system should incorporate a back-up water supply, which may be introduced into:

- a purpose-designed module, incorporating a break cistern prior to its pump, for delivery to the distribution pipework;
- an intermediate storage cistern, usually located at high level; or
- the main collection tank, via a direct connection or discharging into the collection pipework, but not before filtration.

NOTE For examples of typical systems with different back-up supply arrangements, see Annex B.

The back-up supply should be fitted with a control mechanism which ensures that the amount of water supplied is minimized to that needed for immediate use. It is recommended this is provided from a make-up module or an intermediate storage cistern.

The back-up supply should be sized to allow it to meet the full demand requirements in dry periods.

If the back-up supply is to be fed into the main collection tank, careful consideration should be given to tank selection in order to minimize the amount of water needed for continued normal operation before the next rainfall event, e.g. it might be beneficial to use a tank with a small sump area.

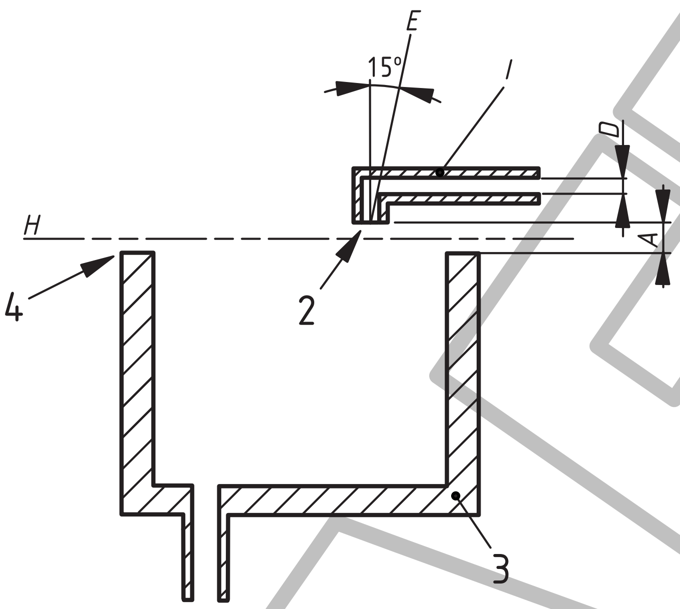
4.7.2 Backflow prevention

To prevent non-potable water entering the potable or mains supply, the back-up supply should be fitted with a backflow prevention device that is capable of providing category 5 protection (an air gap), such as:

- a Type AA air gap conforming to BS EN 13076 (see Figure 4); or
- a Type AB air gap conforming to BS EN 13077 (see Figure 5).

Flow rates, head loss and installation requirements should be taken into account when selecting the backflow prevention device.

Figure 4 – Unrestricted Type AA air gap (BS EN 13076)

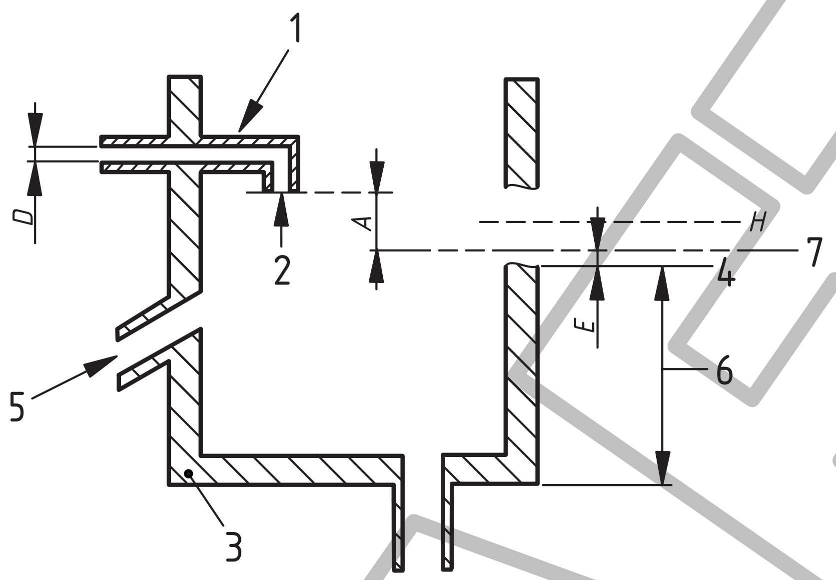


Key

1	Feed pipe	A	Air gap
2	Feed orifice	H	Maximum level
3	Receiving vessel	D	Internal diameter of feed pipe (bore)
4	Spillover level		
5	15° maximum from the vertical		

NOTE This arrangement may be used where the discharge point from the public mains can be placed above the spillover level of the rim of the storage cistern.

Figure 5 – Unrestricted Type AB air gap with non-circular overflow (BS EN 13077)



Key

1	Feed pipe	6	$Uw \geq 2h$
2	Feed orifice	7	Critical water level
3	Receiving vessel	A	Air gap
4	Spillover level	H	Maximum level
5	Optional warning pipe	D	Internal diameter of feed pipe (bore)

NOTE This arrangement may be used where the discharge point from the public mains is to be enclosed within the storage cistern. The slot that provides the spillover level is provided within the side of the cistern body and below the outlet of the inlet device. The size of the spill slot needs to conform to BS EN 13077 within critical limits. A free-to-access online Type AB Air Gap Calculator is available from the Water Regulations Advisory Scheme (WRAS) website at www.wras.co.uk/publications_default.htm

The backflow prevention device should be located upstream of, or at, the point of delivery where the two supplies come into contact with each other.

The impact that a sudden demand from the back-up mechanism might create in operation on the water supply, particularly in large communal systems, should be considered and it is important that infrastructure is capable of meeting this increase. The design of the system should ensure that there are no dead legs and suitable turnover of water is achieved, reducing the opportunity for water to become stagnant when not required.

Where this is unavoidable, additional backflow prevention in the form of a single check valve should be provided at the branch of the pipework supplying the back-up mechanism to protect the potable water supply.

4.8 Pumping

4.8.1 General

For most systems, other than those which distribute the collected rainwater by gravity, a pump(s) should be used to ensure its continual availability.

NOTE The operational safety and hydraulic demand will dictate whether a single pump or multiple-pump systems are needed.

The flow rate and the required pressure head of the pump should be determined in accordance with BS EN 12056-4.

The pump should be selected and arranged such that:

- energy use and noise are minimized;
- cavitation is prevented;
- air is not introduced into the system.

The pump should be equipped with dry-run protection.

Surges from the pump should be absorbed and prevented from causing undue high pressures, for example, by the incorporation of expansion vessels or pressure controls, in order to prevent bursting and excessive draw off.

4.8.2 Pumps outside the tank

If the pump is installed outside the tank, a pump with its own self-priming mechanism should be used. The suction line to the pump should be laid with a steady gradient upwards towards the pump.

The pump should be placed in a frost-free, well-ventilated location with sound- and vibration-free mountings.

A non-return valve should be provided in the suction line to the pump in order to prevent the water column from draining down. The pressure line of the pump should be supplied with an isolating valve for maintenance of the non-return valve.

4.8.3 Pumps inside the tank

NOTE A minimum level of water needs to be maintained above the pump inlet in order to prevent damage by sucking in air, sediment or debris.

The immersion depth recommended by the pump manufacturer should be observed.

The pump should be capable of being removed, e.g. for maintenance.

A non-return valve should be provided in the pumping main, with an isolating valve for maintaining the non-return valve.

4.8.4 Multiple pump systems

Multiple pump systems should conform to BS EN 12056-4, with a standby pump as necessary.

4.8.5 Pump control unit

The pump control unit should operate the pump(s) to match demand.

Water hammer, surge and hunting should be avoided by using suitable measures (e.g. in the case of multiple pump systems, a diaphragm expansion vessel).

The pump control unit should protect the pumps from running dry and the motor from thermal and electric overload.

The pump control unit should permit manual override.

4.9 Overflow and drainage

An overflow should be fitted to the tank to allow excess water to be discharged during extreme rainfall events. The overflow should be such that any backflow is prevented and vermin are unable to enter the tank.

The capacity of outlet pipe on the overflow should be equal to or greater than the capacity of the inlet pipe.

Where appropriate, the overflow should be fitted with an anti-surcharge valve conforming to BS EN 13564 (all parts).

For the majority of systems, it is recommended that the overflow is connected to a soakaway.

NOTE 1 For some systems, it might be more appropriate to either pass the flow back into the surface water drainage system or allow it to flood. The choice of drainage is dependent on factors such as ground conditions and the consequences of the performance being exceeded. For example, in locations where soils have very low permeability, a soakaway might overfill as a result of large rainfall events although this will result in minimal consequences like infrequent temporary local wet areas and run-off in most instances.

NOTE 2 Where the tank is likely to be full on a regular basis, due to high regional rainfall, the overflow may be located at a lower level and designed to throttle and attenuate the flow. However, as throttles are small orifices, they are liable to blockage from floating material.

The overflow is likely to contain a small amount of floating material such as leaves washed from filters so, if the water is to be passed to a soakaway, appropriate trapping of the material should be provided.

NOTE 3 Additional information on soakaways and infiltration drainage systems is given in Annex C.

4.10 Controls and metering

4.10.1 Control unit

A control unit should be incorporated in the rainwater harvesting system to ensure, as a minimum, that users are aware of whether the system is operating effectively.

The control unit should:

- control pumps and minimize operational wear and energy use;
- activate the mains water back-up automatically when the minimum water volume in the tank is reached;
- provide a volt-free output to enable the system to be linked to a building management system (BMS), where appropriate.

NOTE Guidance on the design of a suitable control unit can be found in BS 6739.

4.10.2 System status monitoring

In addition, status monitoring may be incorporated that can inform the user of:

- whether rainwater or back-up supply water is being used;
- the volume of rainwater used and the volume of mains water used. This can be logged and displayed;

- how full the tank is;
- any malfunctions. These should relate to the specific fault, e.g. pump failure, back-up supply failure.

NOTE Additional monitoring of the overflow, water quality, tank temperature and other parameters may be included.

4.11 Distribution

*COMMENTARY ON **4.11***

Readers might wish to note that the requirements specified for potable water systems in BS 6700 and BS EN 806 are considered good plumbing practice for all systems, regardless of the source of water.

Attention is also drawn to the Water Fittings Regulations. These apply to pipes and fittings that are supplied, or are to be supplied, with water from the public supply.

In premises where a public mains supply exists, or is to be provided, notification needs to be given to the local water supplier prior to work commencing, with a plan, schematic diagram and details of what is proposed.

4.11.1 General

The system should distribute the collected rainwater by:

- pumping it from the collection tank directly to the point of use (pressurized system);
- pumping it from the collection tank to intermediate storage cisterns near the point of use;
- using a gravity distribution tank, where practicable; or
- using a full gravity system, without pumps.

Consideration should be given to minimizing the energy used to distribute rainwater.

4.11.2 Distribution pipework and fittings

Although a variety of materials may be used, it is recommended that distribution pipework is manufactured from one of the following:

- polybutylene conforming to BS 7291-2;
- cross-linked polyethylene (PE-X) conforming to BS 7291-3;
- copper conforming to BS EN 1057; or
- stainless steel containing molybdenum (Mo) and conforming to either BS EN 10216-5 for seamless pipes or BS EN 10217-7 for welded pipes.

NOTE Where polybutylene or cross-linked polyethylene pipes are to be installed below ground, ducting is required.

Where practicable, to differentiate rainwater pipework from potable water pipework, a contrasting type of pipe material should be used. In addition, all pipework and fittings should be marked and/or labelled in accordance with **5.4.2**.

Pipework should be sized to provide adequate flow and pressure, e.g. oversized pipes can cause water quality issues from low flows and excessive pressures can cause undue consumption or leakage.

Pipework and fittings should be arranged in such a way as to:

- be sufficiently strong to resist bursting from the pressure they are to be subjected to in operation (see **6.1** for hydraulic testing);
- prevent cross-connections with any public mains or potable supply;
- prevent the trapping of air during filling, and the formation of air locks during operation, that would cause water to be unduly drawn off to clear the system.

5 Installation

5.1 General

NOTE Attention is drawn to local planning and building regulations, including the Water Fittings Regulations. Full guidance on these is available from either the UKRHA (the UK Rainwater Harvesting Association) or WRAS.

Prior to installation, any site specific factors that might affect the installation process should be taken into account. Such factors include:

- groundwater levels;
- ground strength and stability;
- land contamination;
- proximity to trees;
- proximity to utilities and foundations;
- access routes.

Installation should be carried out in accordance with instructions given by the manufacturer or supplier.

Installation should ensure that all components, including tanks, are accessible for future maintenance and/or replacement of consumable parts. In particular, consideration should be given to the following points:

- access to underground tanks;
- access for personnel to above ground tanks e.g. those located in lofts and roofs;
- the location of access covers and filters (avoiding the need for access equipment wherever possible);
- vehicular access to the site.

5.2 Tank installation

5.2.1 General

All tanks should be fitted with lids that protect the water from contamination and prevent human entry.

Any holes that have been cut in a tank, other than those provided by the manufacturer, should be round, so as to not cause any additional stress on the tank that might result in a split. Where non-circular apertures are unavoidable, stress relief should be applied to the aperture to minimize any risk of splitting.

5.2.2 Above ground tanks

Above ground tanks should be securely mounted on a stable base.

Tanks that are to be installed within a building should be able to withstand any temporary deformation that is required during installation (e.g. when being squeezed through a doorway or loft-hatch). Tanks, when installed and correctly supported, should not deform as the water level in the tank changes.

Tanks should be well supported on close boarding.

Tanks should not be supported by pipework.

5.2.3 Below ground tanks

Below ground or partially buried tanks should be installed so that they are not deformed or damaged.

Measures, such as concrete surrounds or backfilling and/or controlled filling with water, should be taken to ensure the structural stability of these tanks.

NOTE Issues relating to structural stability include avoiding flotation, resisting ground pressures (structural deformation), resisting vehicle loadings and accommodating differential movement.

The area around the access covers of any below ground tank should be impervious and free draining away from the covers to avoid contamination during maintenance and inspection.

5.3 Cistern installation

Where rainwater storage cisterns are needed within buildings, these should be installed as for any cold water cistern with appropriate support, insulation and means to prevent contamination. The cistern should be supported on a firm level base capable of withstanding the weight of the cistern when filled with water to the rim. Plastic cisterns should be supported on a flat rigid platform fully supporting the bottom of the cistern over the whole of its area.

Overflows fitted to rainwater storage cisterns should be capable of discharging all inflows into the tank. In addition, an automatic supply cut-off device activated by an overflow may be installed to minimize the waste of water.

5.4 Pipework installation

5.4.1 General

The pipework connecting the collection surface to the tank should be installed so that water losses are minimized. Pipes should not discharge into open gullies where splashing or additional contamination could occur.

5.4.2 Labelling and identification

Where two or more water systems, i.e. potable and non-potable, supply one property, all pipework, fittings and points of use for the rainwater harvesting system should be marked and/or labelled in accordance with Annex D, in order to facilitate identification, to prevent inadvertent consumption or cross-connection between the systems, and to avoid operating errors.

5.5 Testing and commissioning

The system should be flushed and tested prior to handover to ensure that pipework and containers are watertight and that there are no cross-connections in accordance with BS 6700 and the manufacturer's recommendations.

NOTE Running coloured dye through the system and carrying out a visual inspection is regarded as a suitable test.

The system should also be tested in accordance with BS 7671 to ensure that wiring is electrically safe and that there is no interference to or from other electrical or electronic equipment, or wiring in the vicinity.

A certificate of commissioning should be provided.

6 Performance

6.1 Hydraulic performance of pipework and fittings

All pipework and fittings should be tested in accordance with, and meet the requirements of, BS 6700:2006, **6.1.12.3**, at a minimum of 1½ times normal operating pressure.

6.2 Water quality performance

NOTE 1 It is essential that rainwater harvesting systems are designed in a way that ensures the water produced is fit for purpose and presents no undue risk to health, although there are currently no specific regulatory requirements for water quality that apply to systems which re-use rainwater for non-potable water use.

NOTE 2 The Market Transformation Programme (MTP) has undertaken a review of rainwater and greywater systems and made recommendations for quality guidelines and monitoring arrangements.[1] The recommendations and tables given here have been adapted from this MTP report.

Observations for water quality should be made during maintenance visits to check the performance of the system. Tests should then be undertaken to investigate the cause of any system that is not operating satisfactorily and any complaints of illness associated with water use from the system.

Routine testing of water quality is not recommended. Similarly, testing following the commissioning of systems is not recommended as systems are generally filled with water from the public supply in order to facilitate the testing of components, and water quality is therefore not representative of the normal rainfall collection.

Water quality should be measured in relation to the guideline values given in Table 1 for parameters relating to health risk, and Table 2 for parameters relating to system operation, which provide an indication of the water quality that a well-designed and maintained system is expected to achieve for the majority of operating conditions.

NOTE 3 Water quality will fluctuate particularly following rainfall events when there might be a short-term deterioration.

[1] Market Transformation Programme (MTP), *Rainwater and Grey Water – Review of water quality standards and recommendations for the UK,* www.mtprog.com [2].

Table 1 – Guideline values (G) for bacteriological monitoring

Parameter	Use		System type
	Pressure washers and garden sprinklers	**Garden watering and WC flushing**	
Escherichia coli number/100 ml	1	250	Single site and communal domestic systems
Intestinal enterococci number/100 ml	1	100	Single site and communal domestic systems
Legionella number/litre	100	—	Where analysis is indicated by risk assessment (see Clause **8**)

Table 2 – Guideline values for general system monitoring

Parameter	Use	System type
Total coliforms	10/100ml for pressure washers and garden sprinklers 1 000/100ml for garden watering and WC flushing	Single site and communal domestic systems
Dissolved oxygen in stored rainwater	>10% saturation or >1 mg/L O_2 (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 (<1 NTU if UV disinfection is used)	
pH	6–8 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 used
Residual bromine	<2 mg/l for all uses	All systems, where used

The results of bacteriological monitoring should be interpreted with reference to Table 3. The results of general system monitoring should be interpreted with reference to Table 4.

Table 3 – Interpretation of results from bacteriological monitoring

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

NOTE It might be necessary to include some type of UV or chemical disinfection to attain the more stringent bacteriological standards suggested, in situations where higher exposure might occur or for systems within public premises.

Table 4 – Interpretation of results from system monitoring

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

7 Maintenance

Tanks should only be entered by trained personnel with personal protection equipment suitable for confined spaces.

Maintenance procedures should be in accordance with manufacturer's maintenance recommendations.

In the absence of any manufacturer's recommendations, the maintenance schedule given in Table 5 should be followed. The maintenance intervals listed here are for initial guidance but the frequency should be modified in the light of operational experience.

A log should be kept of inspections and maintenance.

Table 5 – Maintenance schedule

System component	Operation	Notes	Frequency [A]
Gutters/downpipes	Inspection/ Maintenance	Check that there are no leaks or blockages due to build up of debris; clean the gutters if necessary	Annually
Filter	Inspection/ Maintenance	Check the condition of the filter and clean, if necessary	Annually
Storage tank	Inspection	Check that there are no leaks, that there has been no build up of debris and that the tank is stable	Annually
	Maintenance	Drain down and clean the tank	Every 10 years
Pumps and pump control	Inspection/ Maintenance	Check that there are no leaks and that there has been no corrosion; carry out a test run; check the gas charge within the expansion vessel or shock arrestors	Annually
Back-up water supply	Inspection	Check that there are no leaks and that the air gaps are maintained	Annually
Control unit	Inspection/ Maintenance	Check that the unit is operating appropriately, including the alarm function where applicable	Annually
Water level gauge	Inspection	Check that the gauge indication responds correctly to the water level in the tank	Annually
Wiring	Inspection	Check that the wiring is electrically safe	Annually
Pipework	Inspection	Check that there are no leaks and that the pipes are watertight	Annually
Markings	Inspection	Check that warning notices and pipework identification are correct and in place	Annually
Support and fixings	Inspection/ Maintenance	Adjust and tighten, where applicable	Annually
UV lamps	Inspection/ Maintenance	Clean and replace, if necessary	Every 6 months

[A] These frequencies are recommended if no information is given by the manufacturer.

8 Risk management

8.1 General

A risk assessment should be carried out to determine whether the system is safe and fit for purpose. This should take place when the system is being designed.

The risk assessment should follow a recognized process, such as that described in BS 31100[2)].

NOTE 1 Additional guidance and examples are provided in the WRAS Information and Guidance Note No. 9-02-04 on Reclaimed Water Systems [3].

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2) In preparation.

The risk assessment should consider the design, installation, testing and commissioning, operation and maintenance of the system, including water quality (see also **8.2**), structural stability, electrical safety and access provision.

The risk assessment should consider the effects of exposure to, and the potential impacts of, the system on:

- people, including operators, installers, maintainers, and water users, particularly those who might be more susceptible to poor water quality (e.g. children or the elderly);
- the environment, including domestic and feral animals, birds and fish, plants, water courses and groundwater;
- physical assets, including buildings, foundations, drains, paved areas and gardens.

The risk assessment should be used to identify additional actions, process improvements or enhanced controls that can reduce risks in a cost-effective manner.

NOTE 2 The use of rainwater for WC flushing and general garden watering is considered to be a low-risk application due to the low level of human exposure. However, there are some factors, such as the use of pressure washers and garden sprinklers, that increase the extent of exposure through aerosols, thus making risk assessment necessary.

8.2 Water quality

NOTE The World Health Organization endorses the "water safety plan" approach to protect the safety of water supplies. This involves a system of risk assessment and risk management.

The risk assessment should consider potential sources of contamination of water entering or already in the system.

The risk assessment should be used to identify the need for any further water quality control measures, including additional monitoring, for systems where a ground-level and/or highly trafficked collection surface is to be used.

Annex A (normative)
Sizing for integrated stormwater control

A.1 The simplified approach

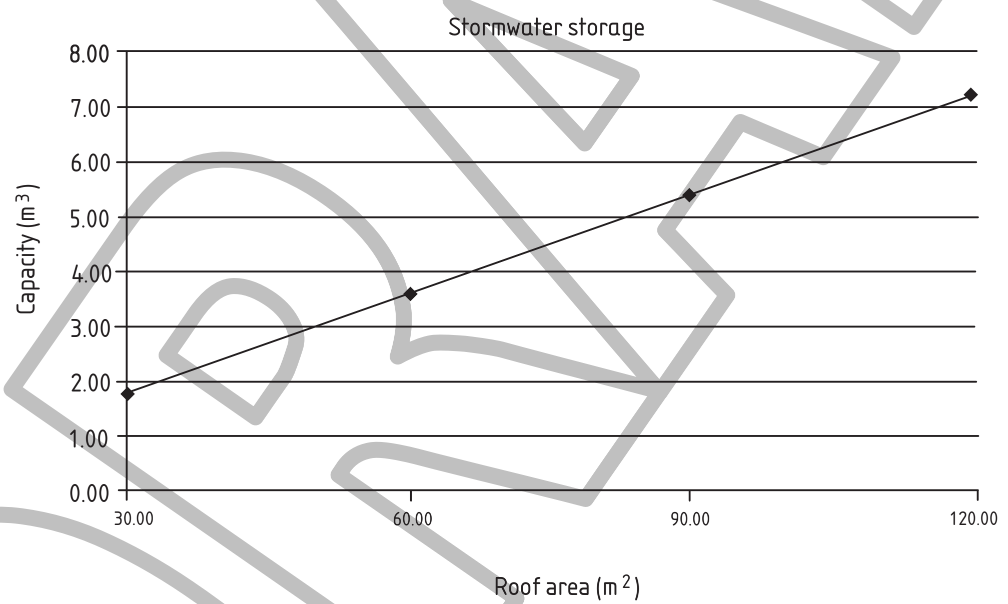
NOTE 1 Rainwater harvesting reduces the amount of run-off from a site and therefore reduces the impact of stormwater on the receiving drainage system. However, on sites where a reduction in run-off into the drainage system is to be taken into account in its design, sizing the storage capacity for water supply alone, as detailed in ***4.1.2.2****, does not provide sufficient spare stormwater control storage.*

Where stormwater control is to be integrated into the rainwater harvesting system, the storage capacity should be determined by adding the relevant value from Figure A.1 to that obtained from the base method given in **4.1.2.2**.

This simplified approach should only be applied where the demand is more than the supply of rainwater and therefore is not recommended for systems where the storage capacity is dictated by the household population (see Figure 2).

NOTE 2 Where storage is dictated by population, detailed analysis in accordance with ***A.3*** *is needed to demonstrate the benefits of stormwater control. However, it is noted that for most properties the roof area and annual rainfall is such that stormwater control is applicable.*

Figure A.1 – Additional storage capacity for non-potable domestic use and stormwater control (simplified approach)



NOTE Based on 100% run-off for 60 mm of rainfall, which represents a 100 year, 6 hour event.

A.2 The intermediate approach

NOTE Where demand for non-potable water is greater than the supply, it is likely that the tank will not be full for most of the time. What is difficult to estimate is how much storage is available at any instant. Thus an allowance for stormwater storage needs to be provided to ensure that the majority of run-off from large storm events is captured.

Where stormwater control is to be integrated into the rainwater harvesting system, the additional storage capacity needed should be determined using the following equations, which makes an allowance for some storage being available in the tank.

Where $D_{\mathrm{N}} > Y_{\mathrm{R}}$

$$StC = R\mathrm{d} \times A_{\mathrm{A}} - (D_{\mathrm{N}} - Y_{\mathrm{R}}) \times 0.5 \qquad (3)$$

However, where $\mathrm{D_N} < \mathrm{Y_R}$

$$StC = 0 \qquad (4)$$

where:

StC is the stormwater control capacity (l)

$R\mathrm{d}$ is the design storm event rainfall depth (mm)

A_{A} is the area of the collection surface (m^2)

*COMMENTARY ON **A.2***

The values normally used for each of the parameters in these equations are:

a) Stormwater control capacity

There is no coefficient of reduction used, which therefore means that 100% run-off is assumed. Wetting of the surface is of little relevance for big events, but filter efficiency still theoretically applies. However, as the formula selects relatively arbitrary rainfall depth values, this is seen as an unnecessary refinement.

b) Rainfall depth

A rainfall depth of 60 mm is approximately equal to a 100 year 6 hour event across the UK . For a longer duration event, the return period is more frequent. Although it is an arbitrary figure, it does tie in with other current best practice requirements for drainage design.

Design of drainage pipe systems downstream can assume that no run-off is contributed from the collection surfaces used for the rainwater harvesting sized on this basis. However design of storage ponds and attenuation structures should be made by making explicit allowance for this upstream storage in the system.

c) Allowance for spare storage

Where demand is more than supply, there is likely to be spare storage in the tank. As this capacity can be quite significant, an allowance has been made to this effect. An arbitrary use of 50% of this spare storage has been assumed to ensure a precautionary approach.

Where there is uncertainty over whether demand is significantly greater than supply, it might be more appropriate to not allow for this capacity component.

d) Systems where supply is greater than demand

In situations where stormwater control is desirable but demand is less than supply, such as in many commercial or industrial buildings, it is still possible to obtain some stormwater control benefits. Options include:

- *green roofs or flat roofs, which result in much lower yields from the rainfall, e.g. a green roof would result in a yield coefficient of 40% or less;*
- *the tank to attenuate flows with an outlet throttle to discharge excess flows (throttles can be as low as 0.05 l/s);*
- *a large tank which is sized for stormwater storage and automatically pumped out after the event;*
- *a standard-sized tank which is connected to an infiltration system for excess flows.*

As extreme events, which cause major drainage system problems, generally have a short duration and occur in the summer, spare storage is likely to exist anyway.

*However it is advised that the design of stormwater control for all these situations uses the detailed approach given in **A.3**.*

A.3 The detailed approach

A.3.1 General

Where stormwater control is to be integrated into the rainwater harvesting system, the additional storage capacity needed should be determined in accordance with one of the following methods:

- analysis of 20+ extreme events (see **A.3.3**);
- 100+ year extreme stochastic series (see **A.3.4**); or
- probability analysis with a five-year time series (see **A.3.5**).

Each of these methods should only be applied by experts in hydrology and drainage modelling.

NOTE The fundamental underlying principle is that analysis is needed using time series rainfall, which has embedded within it the seasonal and inter-event characteristics of the rainfall for any region.

A.3.2 Rainfall yield

Although uncertainty in the yield from a collection surface is fairly low for standard pitched roofs, even these surfaces have significant losses for small events and run-off models should therefore take account of antecedent conditions by using a depression storage or a soil moisture function, as well as a run-off factor.

Loss models for permeable pavements and green roofs are fairly uncertain; however, for the purpose of a time series rainfall approach, the run-off parameters given in Table A.1 are recommended.

NOTE In particular cases where rain-shadow is thought to exist (e.g. from vegetation, other buildings, orientation, strong prevailing winds etc.), a reduction in the coefficients may be appropriate.

Filter efficiencies should be explicitly applied. The manufacturer's information with regard to the usable rainwater volume flow should be taken into consideration for hydraulic-action filter systems that are used in the tank supply line.

Table A.1 – Yield coefficients

Type	Run-off	Depression
Pitched roof with profiled metal sheeting	0.9	0.1
Pitched roof with tiles	0.8	0.3
Flat roof without gravel	0.8	1.0
Flat roof with gravel	0.8	2.0
Green roof, intensive [A)]	0.5	5.0
Green roof, extensive [A)]	0.7	4.0
Permeable pavement [A)] – Granular media	0.7	4.0
Permeable pavement [A)] – Plastic crates	0.8	2.0

[A)] The run-off yield is uncertain for these surfaces and design needs to take account of the possibility of yields that are up to 20% higher or lower. In particular, the hydraulic run-off behaviour of green roofs depends on their design.

A.3.3 Method 1 – analysis of 20+ extreme events

Daily rainfall events that exceed 40 mm to 50 mm should be selected. More than one gauge may be used as long as they are independent of each other (best achieved by not selecting storms from the same day). This data should be hourly information, which enables the modelling to demonstrate the impact downstream if the storage system becomes full. Each event should have at least 3 months of antecedent rainfall and should be modelled with the initial storage depth preferably based on the average depth found from running the 5-year series.

An analysis of the 20+ observed rainfall events should be carried out to establish the return period of each of the events in the context of the site location.

As the tank provides a high level of protection (return period) against flooding for short intense storms, but much less for very long storms, subsequent analysis of the downstream drainage system, particularly storage units such as ponds, should cater for this aspect and take into account the level of service provided by the tank.

NOTE The observed events can be modelled for both the sizing of the tank itself and the assessment of the tank and the rest of the downstream system.

A.3.4 Method 2 – 100+ year extreme stochastic series

NOTE This method is effectively the same as Method 1, except that by having at least a 100-year series, an analysis of the events is not needed. Theoretically the performance of the proposed tank can be measured against all significant events of a 100-year series.

The stochastic series should be up to 4 times longer than the return period being investigated to allow an accurate assessment of the storage needed to meet a specific return-period criterion.

The series should be evaluated before use as it might only provide an approximate representation of rainfall through the year (numbers of events, dry periods, intensities etc.).

A.3.5 Method 3 – Probability analysis with a 5-year time series

NOTE 1 This method has the advantage of using real rainfall from a series which is long enough to provide enough information on the range of depths for various return frequencies. Assuming that extreme events are independent of ordinary rainfall, this information can be used by simply allowing an additional depth allowance, based on a return-period analysis for various durations. Thus the chance of an extreme event occurring when the water level in the tank is above the 80 percentile level (80% of the time it is less full) can be computed. This analysis can take into account seasons as well as different categories of storms.

A relevant 5-year time series for the area should be run through a simulation model and the maximum volume of water stored for 20% of the time should be assessed.

NOTE 2 This may be broken down into seasonal volumes if there are significant differences through the year.

The storage tank should be selected on the basis of this volume plus an additional rainfall depth, e.g. a 30-year, 30-minute event, which allows local drainage pipe and any attenuation storage in the downstream drainage system to be designed and sized on the assumption that run-off from these collection surfaces is likely to be minimal for rainfall depths up to the amount provided for.

NOTE 3 This method therefore is not prescriptive in the sizing of the tank. It is aimed at gaining a balance between the additional storage provided by the rainwater harvesting storage and the drainage system downstream.

Annex B (informative)
Examples of typical rainwater harvesting systems with different back-up supply arrangements

Figure B.1 – Typical system with direct primary supply and Type AA air gap

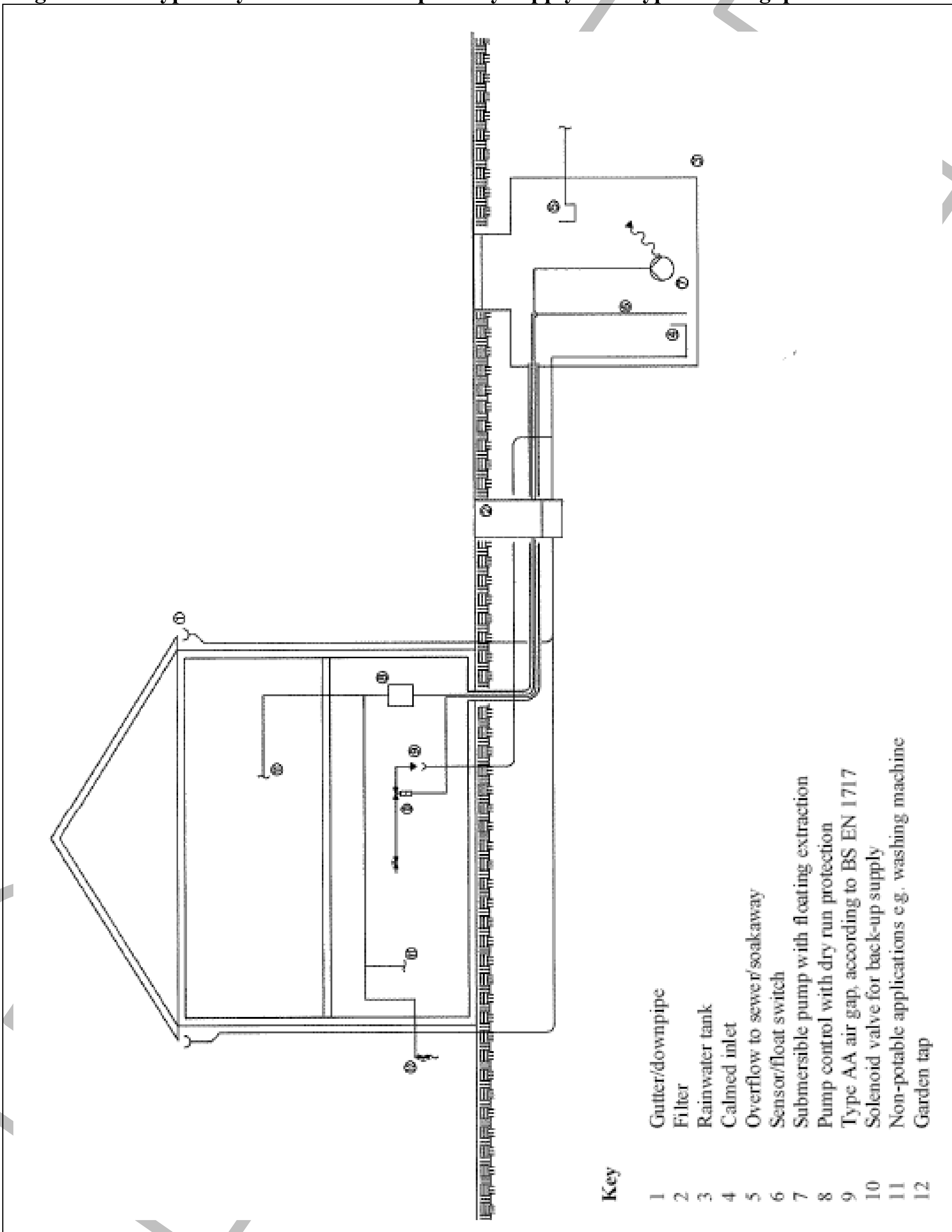
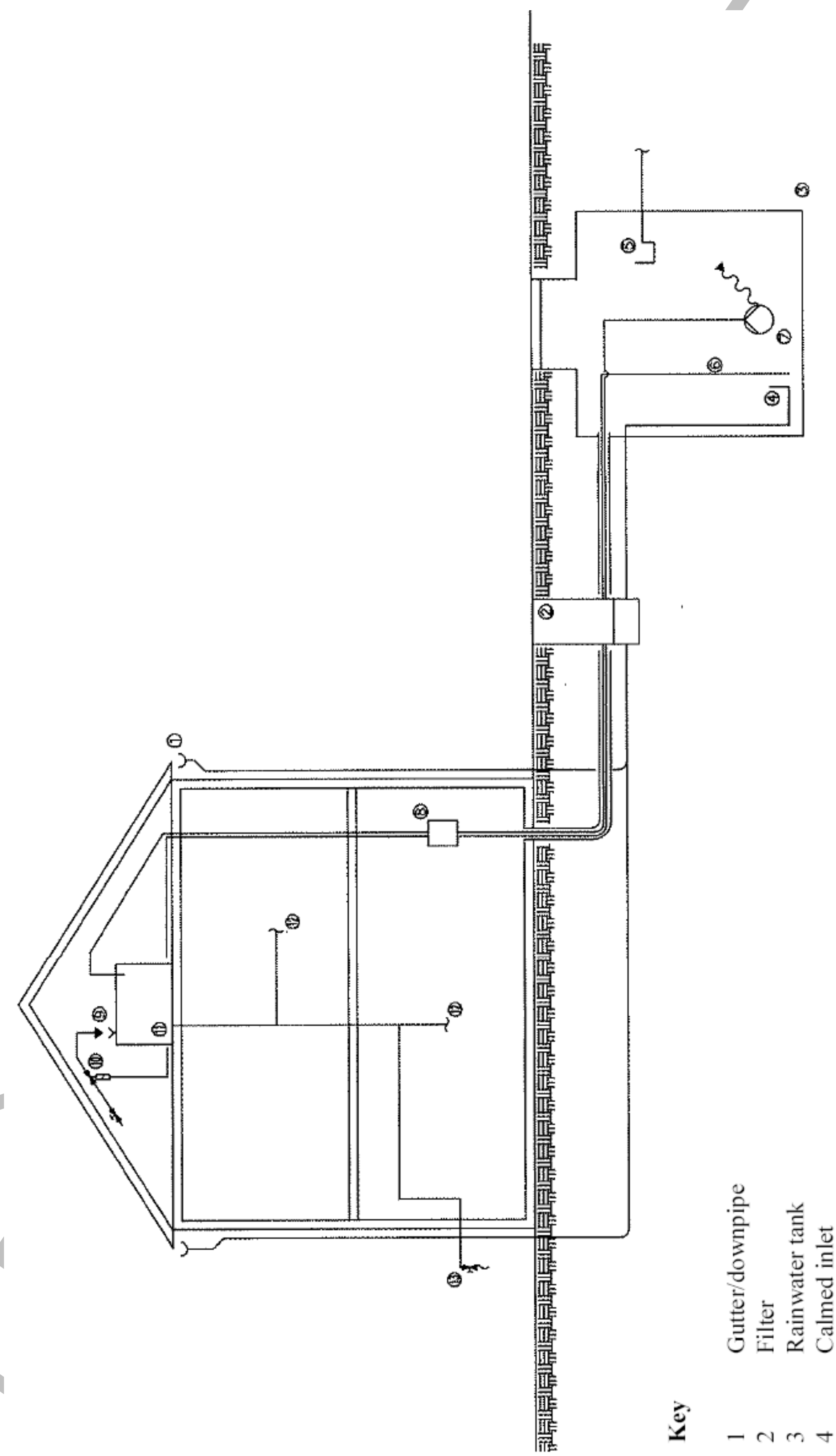


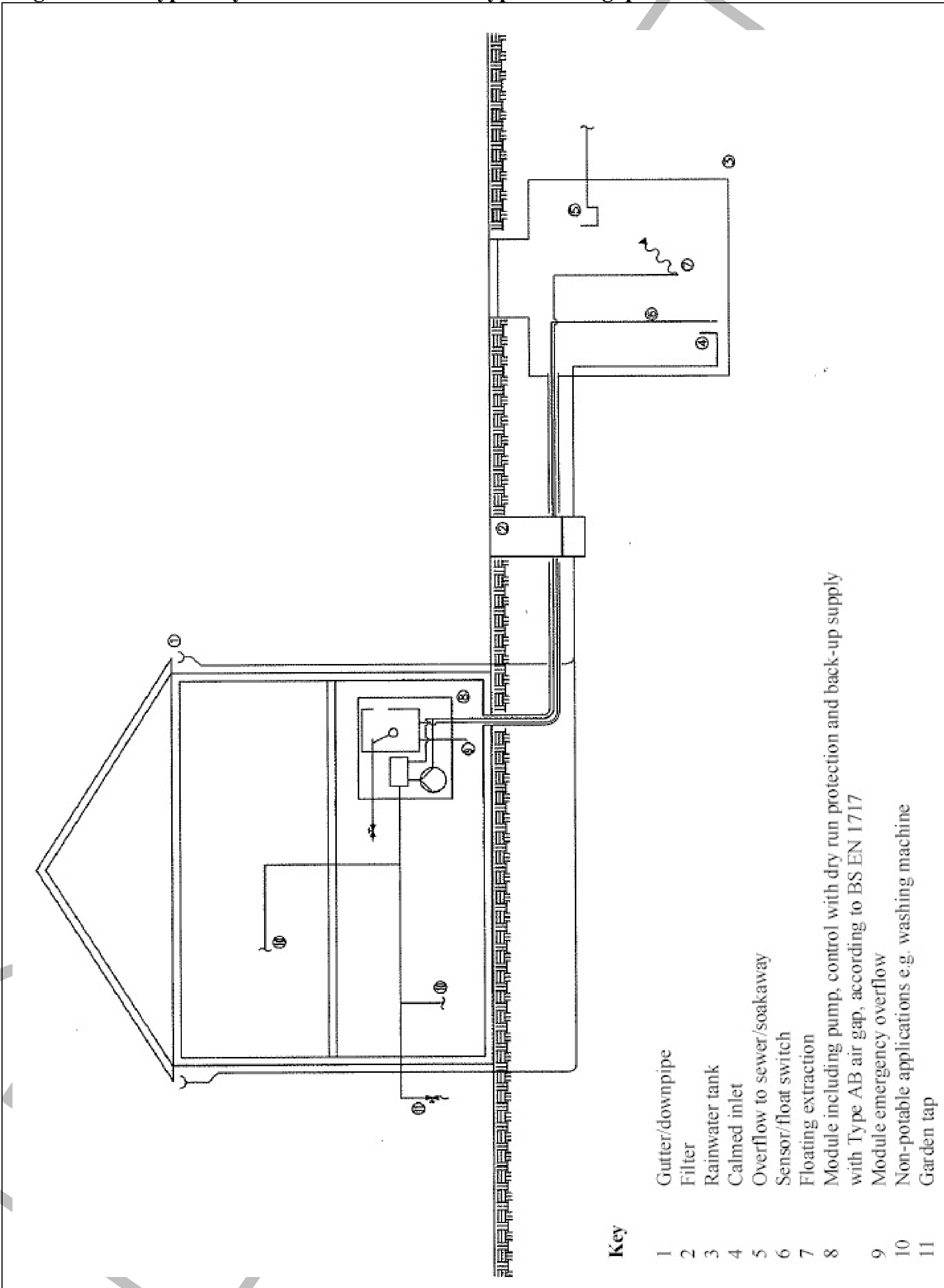
Figure B.2 – Typical system with indirect primary supply and Type AA air gap



Key

1 Gutter/downpipe
2 Filter
3 Rainwater tank
4 Calmed inlet
5 Overflow to sewer/soakaway
6 Sensor/float switch
7 Submersible pump with floating extraction
8 Pump control with dry run protection
9 Type AA air gap, according to BS EN 1717
10 Solenoid valve for back-up supply
11 Cistern in loft
12 Non-potable applications e.g. washing machine
13 Garden tap

Figure B.3 – Typical system with module and Type AB air gap



Annex C (informative)
Infiltration drainage

NOTE The following information can be found in the UK National Annex to BS EN 752:2008. Readers might wish to consult this document for further details on drainage systems.

EDITORIAL NOTE – It has been queried whether the inclusion of Annex C is appropriate for this document. The annex has been proposed for deletion. Comments on this issue are welcomed.

C.1 Introduction (see BS EN 752:2008, NA.4.4.3.1)

"Under certain circumstances infiltration drainage systems can be used to dispose of surface water. They can be sized to cope with an expected rainfall event with or without overflowing.

If surface water drainage is to be discharged to an infiltration drainage system, the subsoil and the general level of the groundwater should be investigated.

Infiltration drainage systems dispose of surface water by allowing the surface water to infiltrate into the soil over a period of time. The water pollution control authority (see NA.13.4) will usually require that any discharge is made to the unsaturated zone above the groundwater table and not directly to the groundwater table itself. Detention storage is provided to store the peak flows during heavy rainfall, allowing it to infiltrate into the ground when the flow has reduced. The volume of storage required therefore depends on the hydraulic properties of the soil, the area which the system is draining, the topography and the chosen design rainfall events.

In some cases, an overflow is provided from the infiltration drainage system either to a surface water sewer or direct to a surface receiving water.

In order to limit any possible alteration to the quality of groundwater, attention should be paid to the source of the run-off water that is to be collected. In particular, the water pollution control authority (see NA.13.4) is unlikely to permit infiltration drainage where:

— the site is close to a groundwater abstraction point (e.g. in groundwater source protection zone 1 (the inner zone). Information on the location of these zones in England is available from the water pollution control authority [14] (see NA.13.4));

— the risk of contaminated run-off is high (e.g. hard standing and car parking in industrial areas and lorry parking);

— there is a risk of groundwater contamination due to leaching of contaminants from the soil. If there is any doubt as to whether any of these conditions arise and for any major infiltration drainage (e.g. > 1 ha) scheme, advice should be sought from the water pollution control authority (see NA.13.4). However, in other cases where the risk of contamination is low (e.g. roof drainage and residential or retail car parking areas), infiltration drainage can usually be used."

C.2 Site investigation (see BS EN 752:2008, NA.4.4.3.2)

"Where any doubt exists as to the suitability of the ground, it can be necessary to obtain permeability figures by test."

"On some sites, the permeability is substantially reduced when the soil is saturated. If this applies, the testing should be carried out in saturated conditions. In other situations (e.g. chalk valleys), there is a high fluctuation in groundwater levels. In such cases the design should take into account the historical peak groundwater levels."

C.3 Design (see BS EN 752:2008, NA.4.4.3.3)

"Depending on the type of infiltration system being considered the design may be on the basis of:

— infiltration through the base of the system only;

— infiltration through the sides of the system only;

— infiltration through both the base and sides of the system."

C.4 Access (see BS EN 752:2008, NA.4.4.3.4)

"Below ground infiltration drainage systems should be designed with facilities for inspection and maintenance. The life of an infiltration drainage system will be reduced if its flow paths become clogged by silt or debris."

C.5 Proximity to buildings (see BS EN 752:2008, NA.4.4.3.5)

"Soils can be affected in various ways by the action of water. It is not desirable to site an infiltration drainage system in any position where the ground below foundations is likely to be adversely affected. In particular, a below ground infiltration system that concentrates significant volumes of water in a small area (e.g. soakaways) could damage vulnerable foundations by the:

— localized differential movement of shrinkable clay soils under the foundations;

— dissolution of certain rocks under foundations;

— collapse of certain open-textured, wind-blown soils in the presence of water leading to voids under foundations;

— reduced strength of certain types of soil in the presence of water.

If there is a risk of any of these conditions then specialist geotechnical advice should be obtained.

The infiltration of surface water into the ground over a large area at rates similar to those that existed when the land was in its undeveloped state do not normally cause problems unless there are specific geological hazards."

C.6 Pit soakaways (see BS EN 752:2008, NA.4.4.8)

"A pit soakaway consists of a pit from which water can infiltrate into the surrounding ground. Small pits can be unlined and filled with hard core, and larger pits can be unfilled but lined, e.g. with brickwork laid dry, jointed honeycomb brickwork, perforated precast concrete rings or segments laid dry, and the lining surrounded with suitable granular material. An unfilled pit should be safely roofed and provided with access for maintenance purposes. Although square or circular pits are compact, it is often easier, and cheaper, to excavate trench soakaways if excavating equipment is available.

Provision should be made to remove sediments from the incoming flow to prevent the flow paths in the surrounding soil from becoming clogged.

A soakaway can be used most effectively in pervious subsoils, such as gravel, sand, chalk or fissured rock, and where it is completely above the water table. Seasonal variations in the water table can necessitate an increase in the storage capacity.

In ground with low permeability where soakaways are a feasible solution, storage capacity should be provided to retain the flows during prolonged or heavy rainfall (e.g. a capacity equal to 20 mm of rainfall over the area being drained should be adopted). Its effective depth is measured below the invert of the lowest incoming drain. This can be achieved by the provision of one soakaway or by splitting flow to a number of soakaways linked at overflow level by piped seepage trenches. Similar trenches can be used to provide means of overflow from a soakaway.

Access points will enable the point of discharge of the drain to be viewed. For small filled soakaways, a 225 mm perforated pipe can be used as an inspection well."

C.7 Infiltration trenches (see BS EN 752:2008, NA.4.4.9)

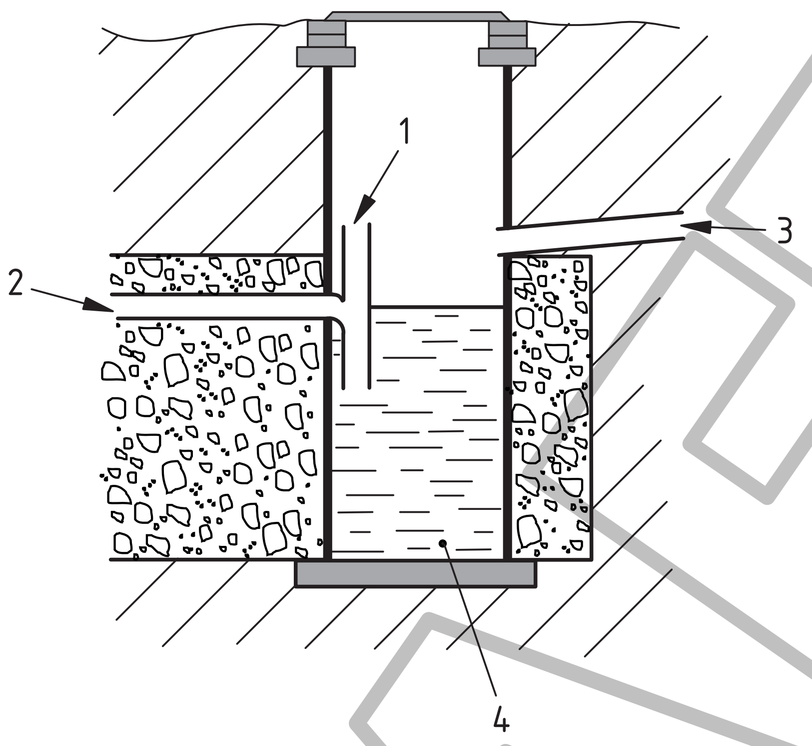
"An infiltration trench is usually filled with permeable granular material, designed to promote infiltration of surface water to the ground following convenient contours.

This type of soakaway provides better infiltration characteristics for a given excavation volume than traditional soakaways.

Infiltration trenches should have at least two inspection access points, one at each end of a straight trench. These should be linked, near the top of the granular fill, by a horizontal perforated or porous distributor pipe. Where more than one drain feeds an infiltration trench, each connection should be via a suitable access chamber.

With infiltration trenches, the use of catchpits at drain outlets and the use of T-piece inlets to the perforated or porous distributor pipes will improve performance by limiting the sediment that could otherwise block the distributor pipe."

Figure C.1 – Catchpit design



Key

1	T-piece inlet	3	Incoming flow
2	Porous or perforated distributor pipe	4	Catchpit

Annex D (normative)
Marking and labelling

NOTE Attention is drawn to the Water Fittings Regulations which require that any water fitting conveying rainwater to be clearly identified so as to be easily distinguished from any supply pipe or distributing pipe than that supplying wholesome water. This is to prevent inadvertent cross-connection between water of different qualities, particularly drinking water.

D.1 Pipework

All distribution pipework should be identified as supplying rainwater. For most systems, more than one form of identification should be used to ensure that identification is possible throughout the life of the installation. The following methods are recommended:

- permanent marking made at the time of manufacture; and/or
- labels attached during installation.

Insulated pipes should be labelled on the outer surface of the insulation, regardless of whether the pipe has been identified prior to insulation. Buried pipes should be clearly identifiable during any subsequent excavations.

Marking and labels should be located along the length of the pipework, at intervals of no more than 0.5 m and at key connection points.

The marking used for the identification of rainwater distribution pipes should differentiate between non-potable supplies of different pressures, qualities and designated uses.

The labels used for the identification of rainwater distribution pipes should:

- be either self-adhesive or mechanically secured to the pipe;
- be no less than 100 mm in length;
- be coloured green in accordance with BS 4800, 12 D 45;
- have “RAINWATER” in black lettering, no less than 5 mm in height.

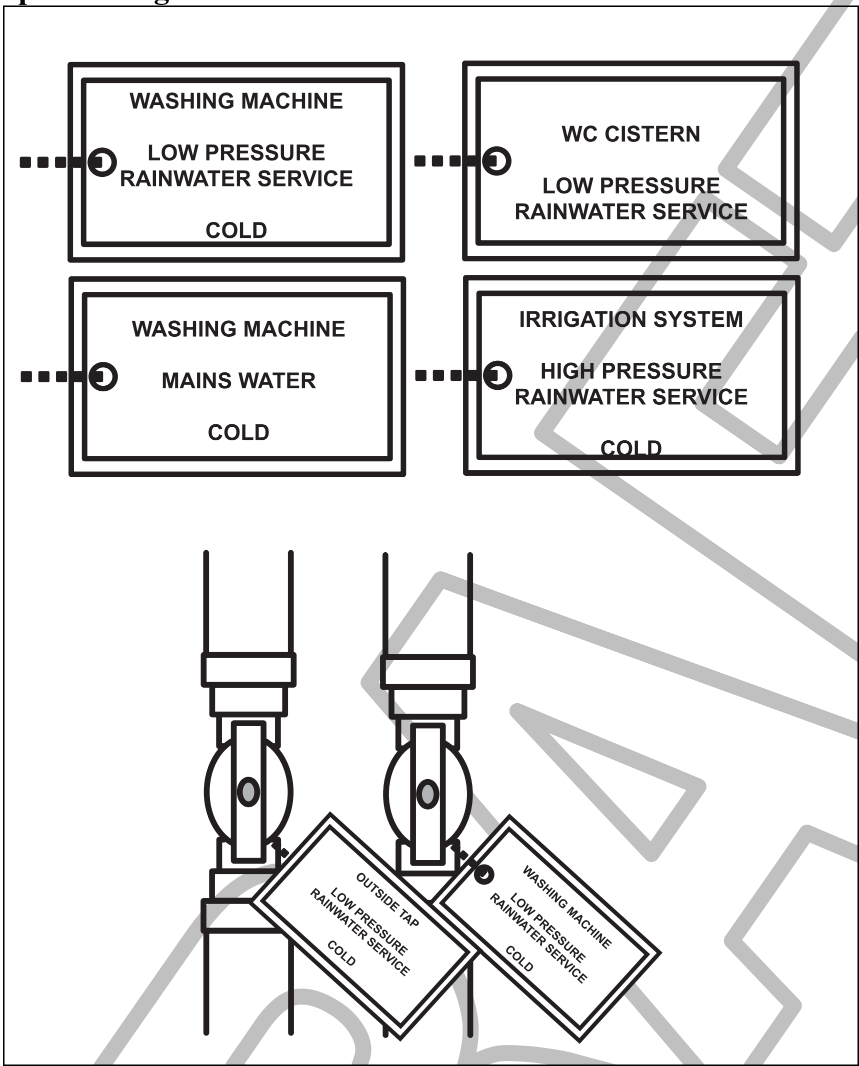
In addition, it is recommended that tags identifying each appliance and its water supply are secured to the pipework at key connection points using flexible fasteners. The lettering on these tags should be black or green, on a white background, and no less than 5 mm in height.

NOTE 1 Tags may be green or edged in green.

The wording on identification tags should be concise and unambiguous, and should enable the various supplies to be uniquely identified (see Figure D.1).

NOTE 2 Identification codes alone are not sufficient.

Figure D.1 – Examples of identification tags and their positioning



D.2 Points of use

Points of use for the rainwater harvesting system, including all appliances, should be clearly identified with the words "Non-potable water" or a prohibition sign (see Figure D.2) so that users and maintenance personnel are aware of the non-potable water supply. Where other non-potable systems are available, e.g. greywater, the words "Non-potable water: RAINWATER" should be used.

NOTE If the majority of points of use on industrial premises are for non-potable water, the points of use for potable water may be identified by the words "Potable water" or by the "Potable water" sign shown in Figure D.3, provided that notices are posted to draw attention to this deviation from normal practice.

Figure D.2 – Signage for points of use supplied by non-potable water

Figure D.3 – Signage for points of use supplied by potable water

Bibliography

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 6739, *Code of practice for instrumentation in process control systems: installation design and practice*

BS 31100, *Code of practice for risk management*

BS EN 752:2008, *Drain and sewer systems outside buildings*

BS EN 1085, *Wastewater treatment – Vocabulary*

BS EN 1717, *Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow*

BS EN 10143, *Continuously hot-dip coated steel sheet and strip – Tolerances on dimensions and shape*

BS EN 13076, *Devices to prevent pollution by backflow of potable water – Unrestricted air gap – Family A – Type A*

BS EN 13077, *Devices to prevent pollution by backflow of potable water – Air gap with non-circular overflow (unrestricted) – Family A, type B*

Other publications

[1] GREAT BRITAIN. The Water Supply (Water Fittings) Regulations 1999. http://www.hmso.gov.uk

SCOTLAND. Water Byelaws 2000 (Scotland). http://www.scottishwater.co.uk

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[2] MARKET TRANSFORMATION PROGRAMME. Rainwater and Grey Water – Review of water quality standards and recommendations for the UK. http://www.mtprog.com

[3] WATER REGULATIONS ADVISORY SCHEME. Information and Guidance Note No. 9-02-04: Reclaimed Water Systems. Newport, 1999. http://www/wras.co.uk