

BS 8515:2009+A1:2013



BSI Standards Publication

Rainwater harvesting systems – Code of practice

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Foreword

Publishing information

This British Standard is published by is published by BSI Standards Limited, under licence from The British Standards Institution and came into effect on 31 January 2009. 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.

Supersession information

BS 8515:2009+A1:2013 supersedes BS 8515:2009, which is withdrawn.

Text introduced or altered by Amendment No. 1 is indicated in the text by tags **A1** **A1**. Minor editorial changes are not tagged.

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.

In particular, attention is drawn to the following regulations:

- The Private Water Supplies Regulations 1991 [1];
- The Workplace (Health, Safety and Welfare) Regulations 1992 [2];
- The Confined Spaces Regulations 1997 [3];
- The Work at Height Regulations 2005 [4];
- The Private Water Supplies (Scotland) Regulations 2006 [5].

In this document, the following national regulations, which apply to plumbing systems in premises to which a supply of public mains water has been provided, are referred to as the "Water Fittings Regulations [6]":

- Water Supply (Water Fittings) Regulations 1999, in England & Wales;
- Water Byelaws 2004 (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 water 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 rainwater harvesting sector expands, there is a need for standardization to protect the public and to ensure that reliable systems are designed, installed and maintained.

0.2 Types of rainwater harvesting

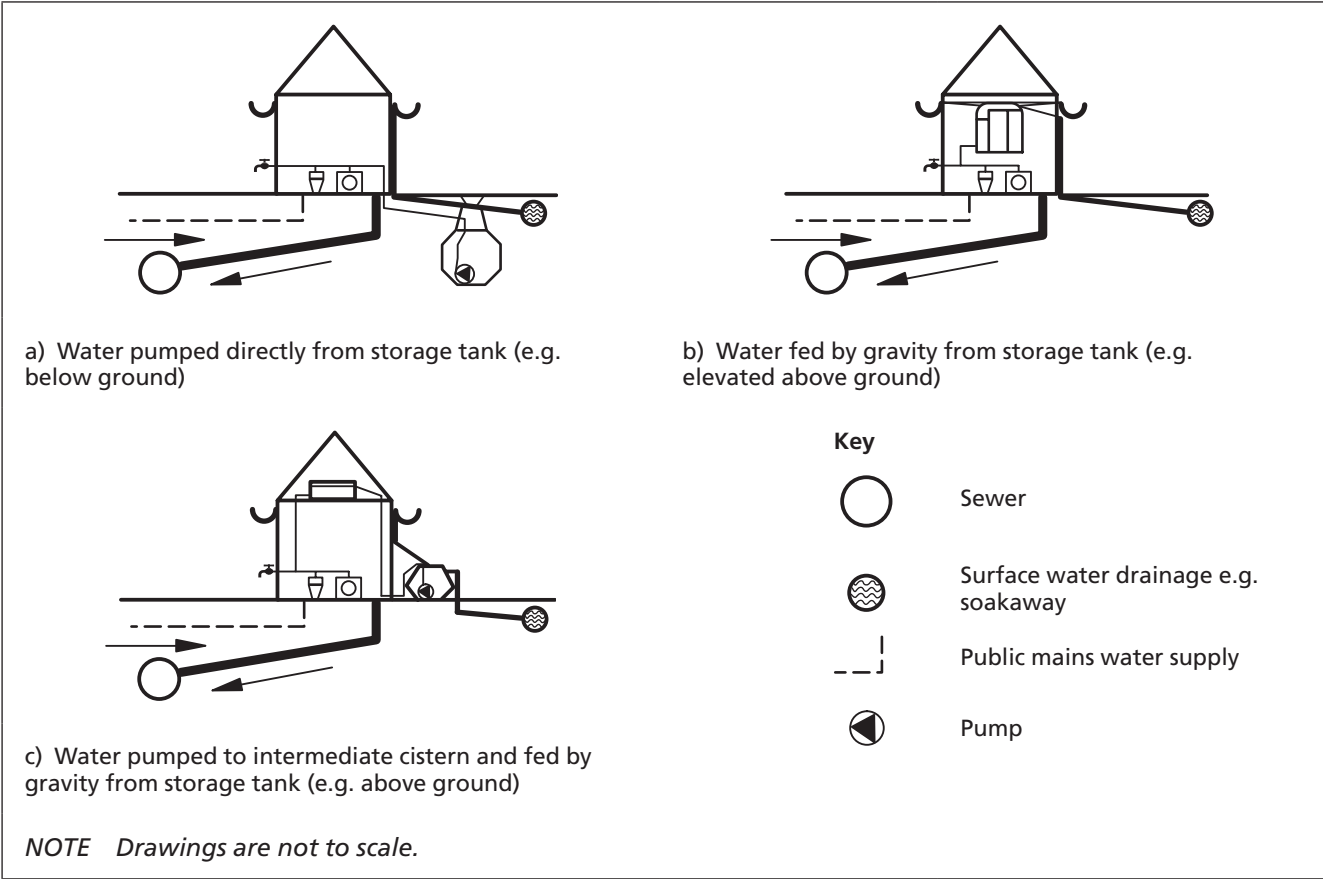
There are three basic types of rainwater harvesting systems (see Figure 1):

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

Within these basic types, there are variations such as:

- 1) internal or external locations for tanks;
- 2) single or multiple linked tanks;
- 3) freestanding or fully or partially buried tanks;
- 4) communal tanks supplying multiple properties;
- 5) packaged systems or components.

Figure 1 Outline examples of rainwater harvesting systems



1 Scope

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

It covers systems supplying water for domestic water uses (in residential, commercial, industrial or public premises) that do not require potable water quality such as laundry, WC flushing and garden watering. It does not cover systems supplying water for drinking, food preparation and cooking, dishwashing and personal hygiene.

NOTE Although this Standard does not give specific recommendations relating to the use of rainwater for fire suppression or commercial irrigation, these applications are not excluded.

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

It also does not cover product design for specific system components.

It applies to retrofitting and new build.

A1 This British Standard does not cover greywater recycling systems, for which see BS 8525-1. **A1**

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 4800:1989, *Schedule of paint colours for building purposes*

A1 Text deleted. **A1**

BS 7592, *Sampling for Legionella bacteria in water systems – Code of practice*

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

A1 BS 8558, *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806*

BS 8580, *Water quality – Risk assessments for Legionella control – Code of practice*

BS EN 805, *Water supply – Requirements for systems and components outside buildings*

BS EN 806, (all parts) – *Specifications for installations inside buildings conveying water for human consumption* **A1**

BS EN 12056-3, *Gravity drainage systems inside buildings – Part 3: Roof drainage, layout and calculation*

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 anti-surge valve

valved device, installed directly in the pipework of a drainage system intended to protect buildings from backflows and flooding from drains or sewers

3.3 backflow

movement of the fluid from downstream to upstream within an installation
[BS EN 1717]

3.4 backflow prevention device

device which is intended to prevent contamination of potable water by backflow in a water supply system
[BS EN 1717 (modified)]

3.5 back-up supply

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

3.6 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

3.7 calmed inlet

fitting on the end of the drainage pipe feeding the storage tank that minimizes turbulence and slows the water flow into the tank

NOTE The calmed inlet is used to prevent disturbance of any sediments near the base of the tank.

3.8 cistern

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

3.9 control unit

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

3.10 cross-connection

physical hydraulic link or a removable link between two separate systems, which can lead to cross-contamination

3.11 dead leg

section of pipework through which no water flows, usually created by closing a pipe after the removal of a terminal fitting

- 3.12 depression storage**
volume of water lost from surfaces, e.g. by evaporation or absorption, before run-off commences
- 3.13 dip sample**
sample of water collected by immersing a container into a body of water and withdrawing it
- 3.14 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 (modified)]
- 3.15 infiltration**
<into the ground> the movement of surface water or treated effluent into the ground
- [BS EN 1085]
- 3.16 green roof**
roof covered with vegetation
- 3.17 nominal capacity**
dimensional volume of the maximum capacity of water that can be retained within the tank, e.g. up to the overflow
- 3.18 non-potable water**
any water other than potable water
- NOTE Non-potable water can also be referred to as "unwholesome" water.*
- 3.19 overflow**
device that relieves the system of excess volume
- 3.20 point of use**
point where water is drawn by the user either directly or by connecting an apparatus
- [BS EN 1717]
- 3.21 potable water**
water suitable for human consumption that meets the requirements of Section 67 of the Water Industry Act 1991 [7]
- NOTE Potable water can also be referred to as "wholesome" water.*
- 3.22 public mains water**
wholesome water supplied by a water undertaker, licensed water supplier, Scottish Water or the undertaker as specified in the Water Industry Act 1991 [7] in England & Wales, the Water (Scotland) Act 1980 [8] in Scotland, or the Water and Sewerage Services (Northern Ireland) Order 2006 [9] in Northern Ireland
- 3.23 rainwater**
water arising from atmospheric precipitation

3.24 rainwater butt

cask set on end to store rainwater for garden watering

3.25 return period

average period of time within which the depth or intensity of rainfall for a given duration, e.g. 5 min, 24 hr, will be equalled or exceeded once

3.26 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]

3.27 spillover level

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

** 3.28 sustainable drainage**

management of rainwater (including snow and other precipitation) with the aim of reducing damage from flooding, improving water quality, protecting and improving the environment, protecting health and safety, and ensuring the stability and durability of drainage systems 

3.29 stormwater control

measures to control the rate and quantity of surface water run-off

3.30 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]

3.31 tank

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

3.32 working capacity

maximum capacity of water that can 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  *Text deleted.*  of rainfall;
- the size and type of the collection surface;
- the number and type of intended applications, both present and future.

 **NOTE** For combined rainwater and greywater systems see BS 8525. 

4.1.2 Calculation methods

COMMENTARY ON 4.1.2

The three approaches to sizing recommended in 4.1.2 are based on methods given in DIN 1989-1.

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 (see 4.1.2.4).

[A1] *NOTE 1 The storage capacity of rainwater harvesting systems for stormwater management of runoff is given in Annex A. The use of rainwater harvesting for stormwater management (see A.1) may only be applied in situations where the average run-off yield is less than the average non-potable demand. This is because of the low likelihood of significant spare storage in the tank occurring at the time of a large storm when average yield is greater than demand. [A1]*

NOTE 2 The simplified approach is not suitable for commercial premises as the assumptions relating to demand are not applicable. The intermediate approach may be used for certain commercial and industrial premises, [A1] but only those with relatively consistent daily demands [A1] such as schools and offices.

[A1] *NOTE 3 For larger rainwater harvesting systems, the size of the system may benefit from using the detailed approach to ensure a cost-effective solution is developed. [A1]*

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 rainfall variation; however, it should be noted that construction above a certain size based on rainfall for that area provides very limited additional benefit unless stormwater attenuation is intended.

NOTE 4 The size of the tank will also affect how often the stored water overflows. Occasional overflowing can be useful for maintenance and might have benefits for water quality.

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 plan area draining to the storage tank should be established in accordance with BS EN 12056-3, 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 plan 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 approach 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:

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

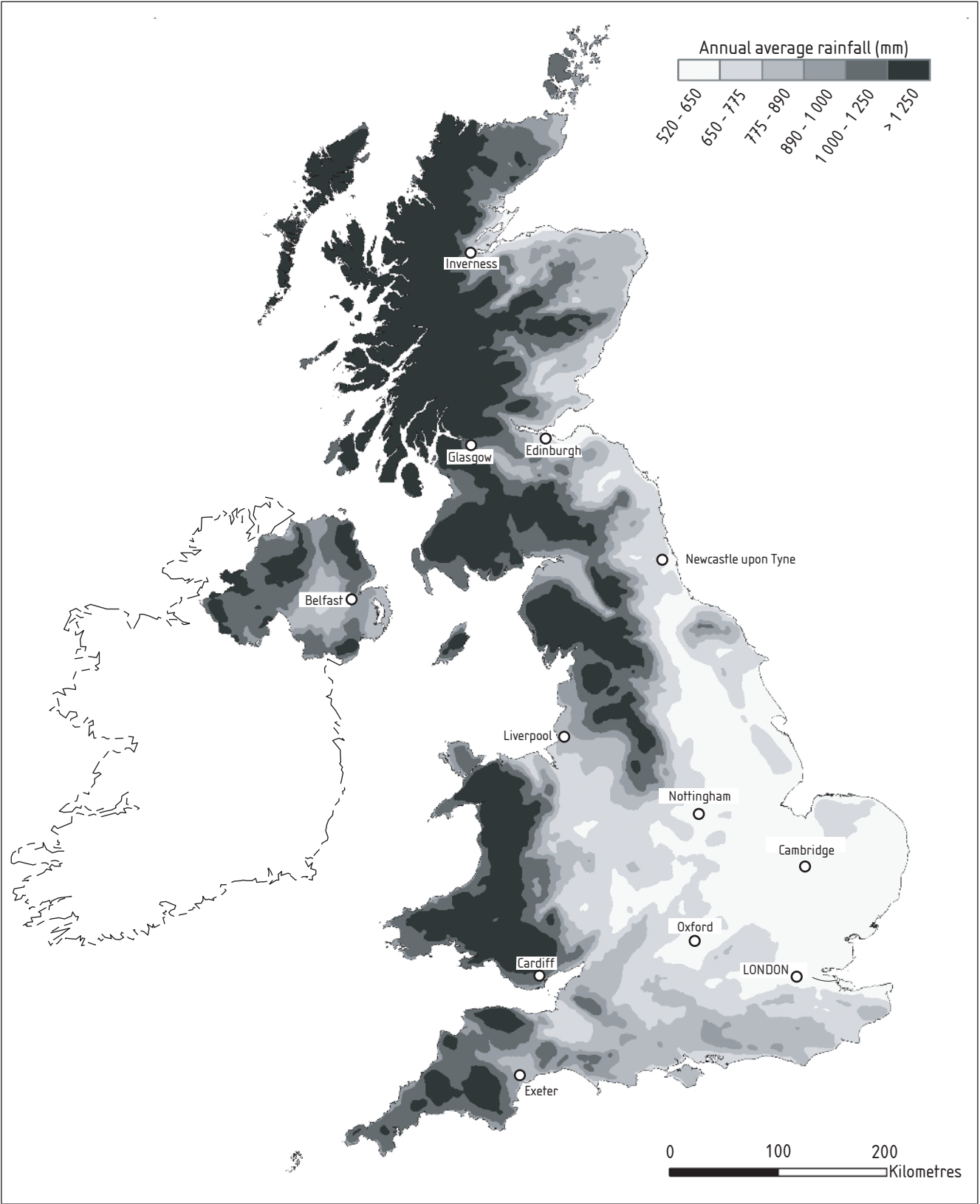
The storage is based on the general rule of 18 days of average rainfall, which caters for the variability of rainfall that occurs in the UK. Provision of greater storage capacity offers very little additional benefit. Around 80% of all the effective run-off from the collection surface in the year will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

It is noted that sizing for non-potable supply alone provides a limited beneficial element for stormwater control. However, as this volume is relatively small, it is normally ignored when designing for stormwater control.

*The integrated sizing approach (see **A.1**) may only be applied in situations where the average run-off yield is more than the average non-potable demand. This is because of the low likelihood of significant spare storage in the tank occurring at the time of a large storm and, if the demand is greater than the yield, the back-up supply could be used excessively.*

A1

Figure 2 Annual average rainfall depths across the UK (1961 – 1990)



A1

Figure 3 Storage capacities for non-potable domestic water based on $\overline{A_1}$ Text deleted. $\overline{A_1}$ average annual rainfall and roof size for small populations (simplified approach)

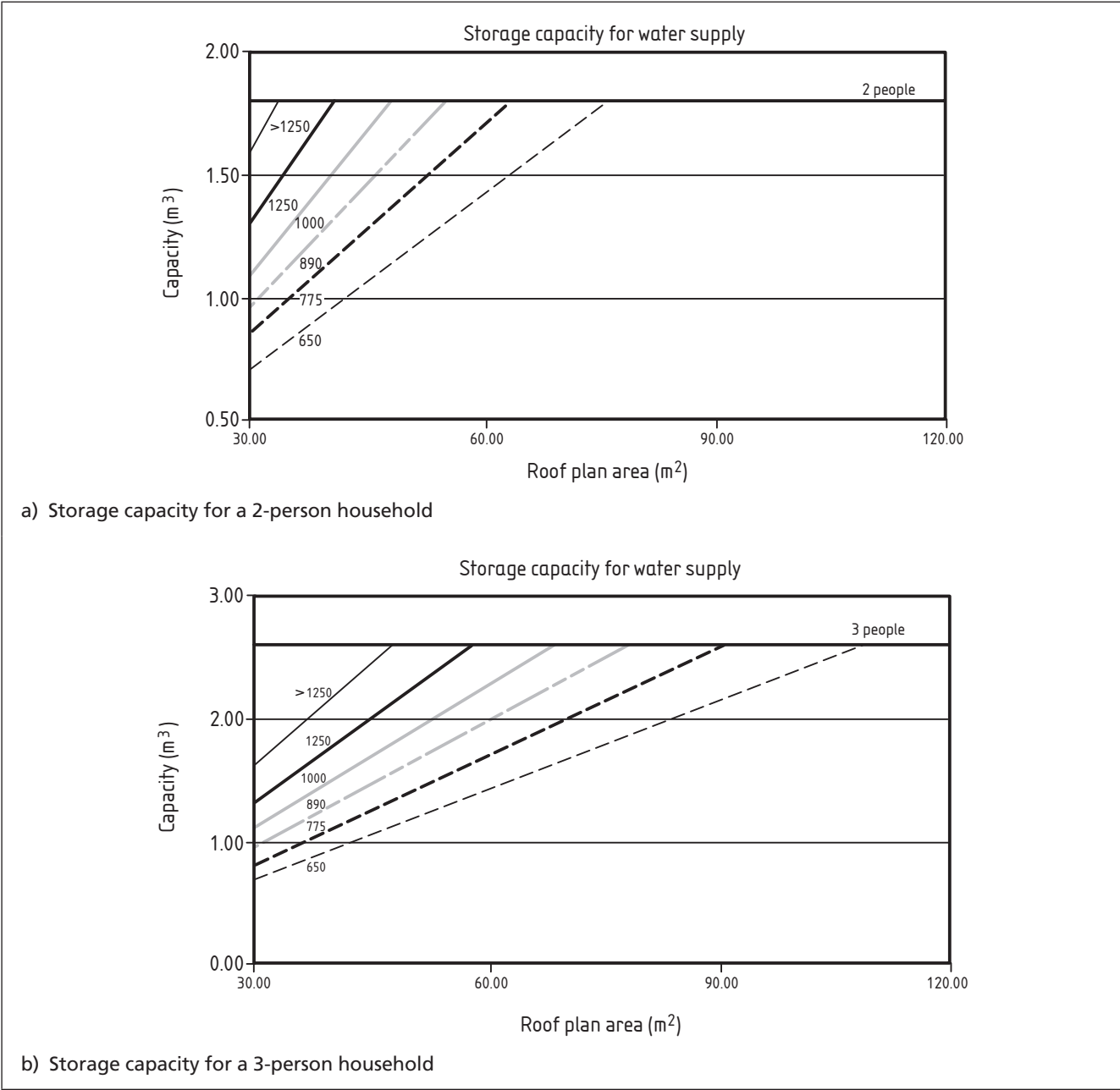
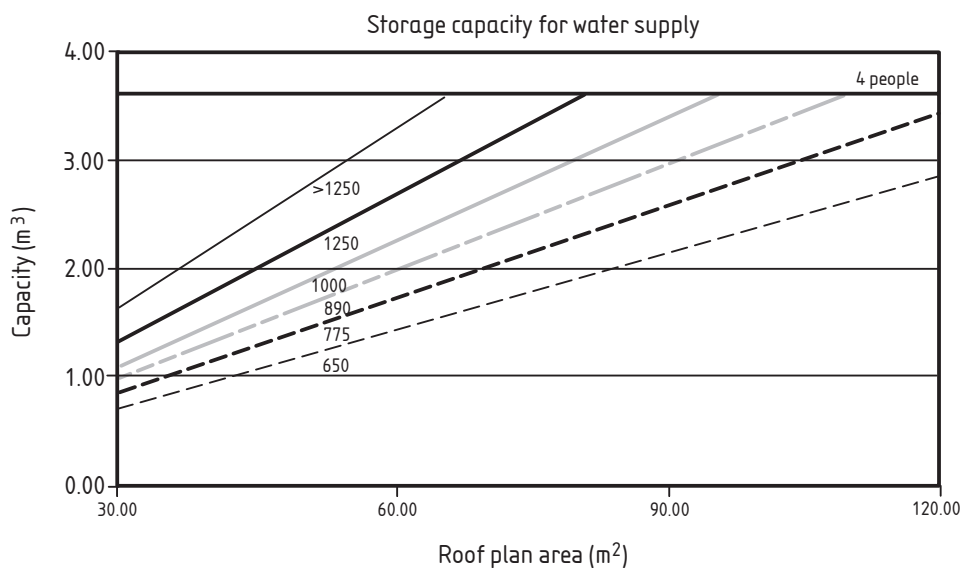
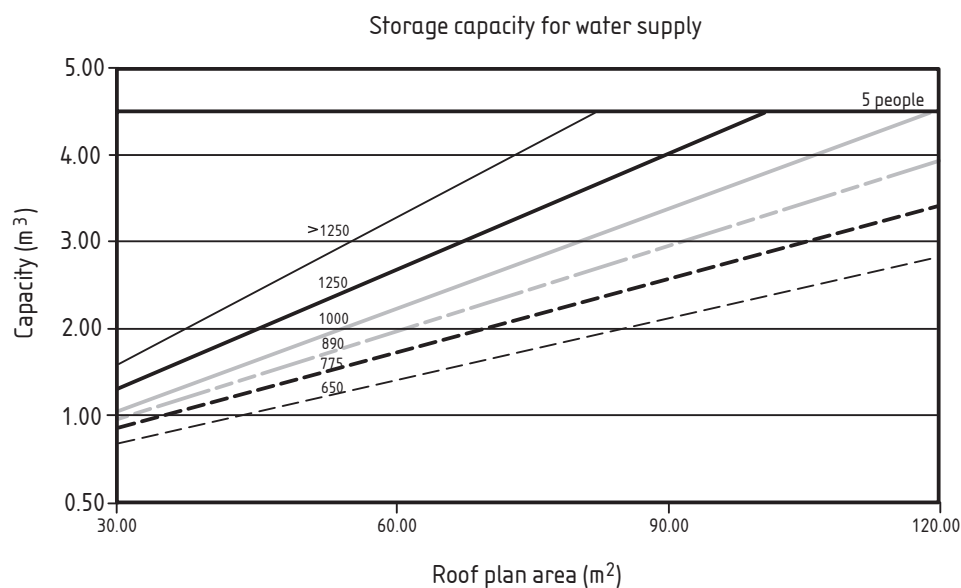


Figure 3 Storage capacities for non-potable domestic water based on A_1 Text deleted. A_1 average annual rainfall and roof size for small populations (simplified approach) (continued)



c) Storage capacity for a 4-person household



d) Storage capacity of a 5-person household

NOTE See Figure 2 for annual average rainfall data.

EXAMPLE

If a house has four residents, the maximum storage that might be useful is 3.6 m^3 . However, if the house is in London, where the rainfall is up to 650 mm according to Figure 2 and the roof plan area draining to the tank is 90 m^2 , the storage capacity ought to be reduced to around 2.1 m^3 in line with Figure 3c). It is not necessary to provide a 3.6 m^3 tank as the tank will rarely store more than 2.1 m^3 and thus very little extra water will be provided over the year.

4.1.2.3 The intermediate approach

NOTE 1 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 is the variables can be 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 or 5% of the annual non-potable water demand.

$$\boxed{A_1} Y_R = A \times e \times AAR \times h \times 0.05 \quad (1)$$

where:

- Y_R is 5% of the annual rainwater yield (L);
- A is the collecting area (m²);
- e is the yield coefficient (%);
- AAR is the depth of annual average rainfall for the location (mm);
- h is the hydraulic filter efficiency.

5% of the annual non-potable water demand should be calculated using the equation:

$$D_N = P_d \times n \times 365 \times 0.05 \quad (2)$$

where:

- D_N is 5% of the annual non-potable water demand (L);
- P_d is the daily requirement per person (L);
- n is the number of persons. $\boxed{A_1}$

Where the system is to provide both non-potable water for domestic use and stormwater control, the integrated sizing approach given in $\boxed{A_1}$ Annex A $\boxed{A_1}$ should be used to estimate the additional storage capacity needed.

NOTE 2 The number of persons in a household could be assumed to be the current household occupancy, or up to 2 persons in each bedroom. Table A.1 in Annex A provides occupancy values which are the national average based on the number of bedrooms in a property, but occupancy in individual houses range widely.

NOTE 3 Uncertainty in the yield coefficient from a roof surface is fairly small for standard pitched roofs. However there are a range of roof types, each of which have their own runoff characteristics. The traditional approach is to use a coefficient which is of the order of 90%. In practice losses are minimal once initial wetting losses have taken place for each event, but to avoid a detailed time series approach a runoff coefficient is usually used.

For the intermediate approach, the coefficients given in Table 1 should be used.

Table 1 Yield coefficients

Surface type	Runoff coefficient
Pitched roof with profiled metal sheeting	0.95
Pitched roof with tiles	0.90
Flat roof without gravel	0.80
Flat roof with gravel	0.60
Green roof, intensive ^{A)}	0.30
Green roof, extensive ^{A)}	0.60
Permeable pavement ^{A)} – Granular media	0.60
Road/pavement – Plastic crates or tanks	0.75

^{A)} The runoff yield is particularly uncertain for these surfaces and design should take account of the possibility of yields that are significantly higher or lower. In particular, the hydraulic runoff behaviour of green roofs depends on their design and the seasons.

COMMENTARY ON 4.1.2.3

The values normally used for each of the parameters in these equations are as follows.

a) 5% of annual demand or supply

This equates to 18 days a year and is needed to take account of $\overline{A_1}$ rainfall and demand $\overline{A_1}$ variability. In practice there are diminishing returns for tank sizes designed using 7 or 8 days.

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) $\overline{A_1}$ Text deleted. $\overline{A_1}$

In general the combination of these two factors 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 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 50 litres per person per day and comprises the demand for WC 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. Also, the daily variation of demand for external use of rainwater is such that the detailed approach for storage requirements ought to be used (see 4.1.2.4).

4.1.2.4 The detailed approach

$\overline{A_1}$ Sizing the rainwater harvesting system for non-potable use for very large schemes where significant economic savings might be achieved or where daily demand or seasonal rainfall is quite variable, storage capacity should be estimated using a continuous rainfall time series that addresses both the demand and rainfall variability.

The uncertainty associated with both the demand and the supply of non-potable water should be explicitly addressed in evaluating options.

NOTE 1 A minimum analysis of daily rainfall events of three years is suggested, but five or more years would be preferable.

NOTE 2 Annex A provides an alternative methodology for sizing rainwater harvesting tanks for stormwater control to avoid the need for extended time series analysis where regular daily demand can be assumed.

NOTE 3 An understanding of the frequency and volumes of discharge of the overflow coming into operation can be found using this method. This has benefits for both evaluating water quality and also the impact on infiltration systems or stormwater systems to which they might discharge.

NOTE 4 The analysis also enables an easy assessment of a number of useful statistics such as how much water might be saved annually and the number of days that no rainwater is available, which might be particularly useful where there is no back-up water supply. 

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 most collection surfaces are likely to be affected by some form of contamination, e.g. animal and bird faeces, soil, grit, hydrocarbons and various chemicals. These contaminants can have negative effects on the quality of the water collected. For further guidance, see 4.3, Clause 6 and Clause 8.

When selecting a collection surface, the following factors should be taken into account, as these can affect the quality and quantity of the collected water:

- a) the surface's materials and their drainage characteristics, e.g. run-off from a green roof will be significantly less than that from a hard roof and is also likely to be affected by a colouration caused by the soil or fertilizers;
- b) the levels of pollution and the risk of contaminants entering the system.

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 greater risk of pollutants entering the system, they should only be used once a specific risk assessment has been completed (see Clause 8).

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 collection surface to the storage tank by gravity or syphonic action.

Pipework should be free draining to avoid stagnation and should prevent contaminated water entering the system from other sources. In addition, sealed gullies should be used at ground level to minimize the risk of pollutants entering the system.

NOTE Conventional rainwater goods and drainage pipes may be used.