Water efficiency in new homes

An introductory guide for housebuilders

REVISED JULY 2010

NHBC Foundation
Housing research in partnership with BRE Trust

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FOREWORD

Consumption of water in UK households has been growing steadily in recent decades as we have enjoyed better standards of cleanliness and more water-using appliances, such as power showers, have become standard features in many homes. Increasing consumption, together with a growing number of households, has put pressure on water supply in parts of the UK and it is likely that this problem will worsen as our climate changes.

The Code for Sustainable Homes encourages homes to be designed to conserve this increasingly precious commodity. Even at entry level, Code Level 1, internal water consumption has to be limited to 120 litres per person per day (compared with the average UK consumption of 150 litres). From October 2009, all new homes in England and Wales will need to comply with Part G of the Building Regulations, which limits total consumption to 125 litres. Water efficiency has now become an issue that must be embraced by designers, specifiers and housebuilders.

This guide, specifically intended for the smaller builder, provides an introduction to water efficiency. It outlines the standards being encouraged by the Code for Sustainable Homes, the Building Regulations and the *Water Efficiency Calculator for New Dwellings*. The technologies used to achieve water efficiency – ranging from simple tap flow restrictors all the way through to greywater recycling systems – are described, together with some key issues associated with each. The guide will, I hope, prove an invaluable point of reference.

One of the issues that has been raised in relation to water efficiency is the potential effect that lower WC flush volumes may have on the performance of drainage systems and the NHBC Foundation is also supporting research in this area. The work, being undertaken currently by WRc, is due to report towards the end of 2009 and will provide future useful evidence on this subject. This is all part of the NHBC Foundation's remit to commission and disseminate practical research of benefit to the housebuilding industry in the UK.

Rt. Hon. Nick Raynsford MP

Chairman, NHBC Foundation

REVISED EDITION

This edition of Water efficiency in new homes has been revised to correct errors on the first edition to Table 7 on page 32.

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ABOUT THE NHBC FOUNDATION

The NHBC Foundation was established in 2006 by the NHBC in partnership with the BRE Trust. Its purpose is to deliver high-quality research and practical guidance to help the industry meet its considerable challenges.

Since its inception, the NHBC Foundation's work has focused primarily on the sustainability agenda and the challenges of the government's 2016 zero carbon homes target. Research has included a review of microgeneration and renewable energy techniques and the groundbreaking research on zero carbon and what it means to homeowners and housebuilders.

The NHBC Foundation is also involved in a programme of positive engagement with government, development agencies, academics and other key stakeholders, focusing on current and pressing issues relevant to the industry.

Further details on the latest output from the NHBC Foundation can be found at www.nhbcfoundation.org.

NHBC Foundation Advisory Board

The work of the NHBC Foundation is guided by the NHBC Foundation Advisory Board, which comprises:

GLOSSARY

Aeration fitting	Terminal fitting that uses entrained air to add bulk to a flow of water
Air assisted WC	Innovative WC that uses air to displace the waste to the drainage system
Angled filter	Particulate filter not set perpendicular to the flow of water, in order to provide a large surface area of filter in a compact design
Biological aerated filter (BAF)	Wastewater treatment system that pumps air through the water. This aids the biological breakdown of the pollutants
Ceramic cartridge	Engineered element of a tap or shower valve that controls the flow of water and is made from a stone-like material. Due to the small waterways they have a high flow resistance and may require high pressure water supplies. The normal design consists of two discs that rotate to align holes that will let water pass through the valve. This enables the valve to be fully opened in just a quarter turn of the handle. Ceramic cartridges have the potential to outlast conventional 'rubber' washer tap works, but tend to be more expensive
Click tap	See water brake
Code for Sustainable Homes (the CSH)	Specification for various Levels of sustainable dwellings. Full details are available from the websites www.communities.gov.uk/thecode or www.planningportal.gov.uk/england/professionals/en/1115316369681.html
Coliform	Type of bacteria used as an indicator of the possibility of contamination of a water source by pathogenic organisms
Drain syphon	Component installed in a drainage stack or underground drain that collects wastewater until a set volume is achieved and then discharges the whole volume at once. The component contains no moving parts and uses syphonic action to evacuate the collection chamber. Typical discharge volumes for domestic applications are around 16 litres
Faecal streptococci	Streptococci are lactic acid bacteria. The presence of faecal streptococci indicates the presence of faecal pathogens in water
Greywater	Wastewater from baths, showers, wash-hand basins and washing machines, ie wastewater that is unlikely to contain faecal matter or high levels of organic material
Integral strainer	Coarse particulate filter to catch any particles that could otherwise damage the downstream appliances, fittings or valves

Legionella	Common term for the various species of *Legionella Pneumophila* bacteria that can cause a flu-like illness. It was first identified after an outbreak at a Legionnaires' meeting in the USA in 1976
Limescale	Calcium deposits from hard water that build into layers on surfaces where water is heated or evaporates
Membrane	Material used in ultra-filtration of water to remove impurities down to virus scale
Potable water	Water that is suitable for drinking (see wholesome water below)
Proximity sensor tap	Tap that uses electronic sensors to detect body parts close to the water outlet, and therefore does not need to be touched to operate. The tap may be battery, low voltage or mains powered
Submerged aerated filter (SAF)	Wastewater treatment system that pumps air through the wastewater. This aids the biological breakdown of the pollutants
Sanitary pipework	Pipes and fittings used to convey wastewater from appliances to a drainage system
Sewer	Pipe used to collect wastewater from multiple drains
Stormwater	Rainwater that has fallen during a heavy and prolonged downpour. This includes rainwater which has not entered a rainwater collection/drainage system
Sustainable drainage system (SUDS)	Stormwater management scheme that uses natural processes and structures to control, treat and dispose rain and stormwater (formerly sustainable urban drainage system)
Terminal branch	Water supply pipe leading to a single outlet
Terminal fittings	Water supply fittings at the ends of pipes such as taps, showerheads and valves
UV light	Ultraviolet (UV) light of specific wavelengths that can be used to 'kill' bacteria and microbial cells to produce potable water
Wastewater	Water that has been used and discharged into a sanitary pipework or drainage system
Water brake	A resistance (which may be overcome) that inhibits the opening of a lever operated tap or shower valve
Wholesome water	Term used for potable water in Buildings Regulations 2000 Part G (due to come into force in October 2009)

1 Introduction

Over the years the volume of water consumed in the UK has generally increased, although recently there has been a slight fall (Fig. 1). The increase is mainly due to an increase in the total number of homes and an increase in the number of appliances that use water. People's attitudes to water use have also changed. For example, power showers and appliances such as whirlpool baths and hot tubs have increased in popularity. This increase in water use has led to implications for the ability of the existing infrastructure to supply sufficient water.

Water is a finite resource. However, less than 1% is fresh water suitable for human consumption. As the population rises, and levels of affluence also increase, water consumption also increases. This situation has led to water stressed areas, not only in dry parts of the world where it is expected, but also in many developed countries including the UK. The approach the UK has adopted is to manage both supply and demand. The promotion of water efficiency is a key aspect of demand management.

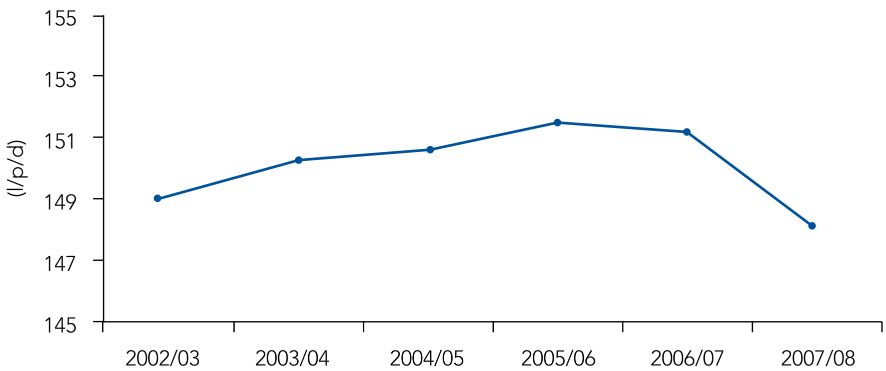


Figure 1 Water consumption trend.[1]

Water efficiency has been a minor consideration in the design of homes for many years. The Code for Sustainable Homes (CSH) encourages water efficiency by making internal water use a mandatory element and provides a major incentive for developers and builders to consider water efficient features.[2] This is further reinforced by the introduction of the *Water Efficiency Calculator for New Dwellings*,[3] that was launched in May 2009, which links the CSH to the new Part G of the Building Regulations in England and Wales (currently an approved draft[4]). The new Part G is expected to come into force in April 2010 and, to ensure that safe and efficient water systems are provided, will include requirements for temperature controls on hot water systems as well as water efficiency requirements.

Note that the *Water Efficiency Calculator for New Dwellings* replaces previous versions of water calculations included in *The Code for Sustainable Homes technical guide*.[5]

The average consumption of potable water has been calculated to be about 150 litres per person per day. This figure is arrived at by taking the total water consumption for the UK and dividing it by the population; and does not therefore represent 'typical' consumption.

Traditionally, water efficiency in homes has been achieved by reducing the use of water by decreasing the flush volume of WCs and encouraging people to have showers instead of baths. However, the current strategy is focused on the conservation of water and the potential to not only reduce the amount of water we use, but also the amount of water we waste. In recent years, low flush volume designs have become standard and have reduced the significance of WCs as a part of total water use. To further reduce impacts, water efficient fittings (taps, baths and showers), water efficient appliances (dishwashers and washing machines) and water recycling systems (rainwater harvesting and greywater recycling) are now available.

Using rainwater or recycled greywater for WC flushing and other functions, including irrigation and other external uses, instead of mains water can lead to more flexibility in the selection of appliances and fittings. However, it makes plumbing systems more complex.

This guide provides guidance for designers, specifiers and builders about water efficient homes.

2 Water efficient products

Water efficiency is an important aspect of sustainable design and water efficient products (fittings, appliances and systems) can use significantly less water than conventional products. However, it is important that these products achieve the desired function without compromising on performance or having a negative impact on occupant lifestyles.

Water efficient products do not generally cost more than conventional ones, although the range of fittings is rather limited. It is worth noting that a selection of the products listed below are likely to be needed to achieve the water efficiency requirements of the CSH at various Levels. The benefits and potential problems of using water efficient products are discussed further in this section.

Water efficient products include:

- low flow taps
- low volume flush WCs
- reduced volume baths
- low flow showers
- low water use washing machines
- low water use dishwashers
- rainwater harvesting systems
- greywater recycling systems.

2.1 Low flow taps

Low flow taps are available within the same price range as conventional taps (from £10 to £1000 for a pair/monoblock). The unit price may increase by around £5 to £10 if flow restrictors or aeration fittings are added. Low flow taps only reduce water consumption where the flow rate dictates the amount of water used. As taps are frequently used to provide water to fill containers, a reduced flow rate tap may be an inconvenience as the filling process may be prolonged.

Previous water calculations included in *The Code for Sustainable Homes technical guide*[5] tended to emphasise the contribution made by tap flow rates. The *Water Efficiency Calculator for New Dwellings* includes a 'fixed use' component for taps that takes into account the contribution of filling containers (such as kettles, cups and saucepans). Wash-hand basin and kitchen sink taps are now treated differently by the *Water Efficiency Calculator for New Dwellings*[3] (see the Appendix for details). The flow rates from wash-hand basin taps are multiplied by a factor of 1.58, but kitchen sink tap flow rates are only multiplied by 0.44. The fixed use component that is added to the flow rate component is 1.58 litres per person per day for wash-hand basin taps and 10.36 litres per person per day for kitchen sink taps. Hence, any flow regulator or restrictor will have a greater impact on the calculated consumption from a wash-hand basin tap than a kitchen sink tap.

Flow regulators tend to be fitted either to the tail of the tap or the tap's spout. Low cost taps may not be fitted with threaded spout outlets, so inline restrictors or regulators may be the only option. Improved pipe insulation or a temperature maintained circulatory system might also be needed so that the reduced flow of water will retain its desired temperature.

Taps with water brakes, commonly known as 'click' taps, are available in most manufacturers' ranges. The workings of a typical click tap are shown in Figure 2. As the operating lever is raised, the water flow is increased. Water brakes are normally set to enable about 50% of full flow to be achieved, although other percentages could be produced. Additional force to overcome the water brake is required to open the tap any further. Once overcome, the lever will move as easily as before towards full flow. Whilst water brakes can be incorporated during the manufacture of pillar and rotary taps, they are normally only fitted to monoblock mixer taps. Although previous water calculations included in *The Code for Sustainable Homes technical guide*[5] resulted in lower water usage values if water brake taps were specified, the *Water Efficiency Calculator for New Dwellings* has reduced the emphasis upon flow rate and there is no additional element that deals with water brake taps.

Figure 2 Section through a click tap with a water brake.

Click taps have the potential to save water in use, but they do have some limitations. Firstly, because they use ceramic cartridge technology (with smaller waterways than traditional rising washer taps) they are generally only suitable for high pressure systems. High pressure systems are usually mains or pumped water fed, and will deliver a dynamic pressure in excess of 1 bar (some 'high pressure' fittings even require pressures in excess of 3 bar to operate properly). Secondly, the extra resistance imposed by the design can be a problem for people with limited strength in their wrists. The use of a click tap with an additional flow restrictor may not have a cumulative impact as the click tap may no longer be able to decrease the peak flow by 50%.

The use of proximity sensor taps, which are electrically powered and do not require the user to touch them, also helps to reduce water consumption. However, proximity sensor taps are usually more appropriate for public buildings rather than in the home. They are more expensive and require either a transformer and a mains supply or a long life battery.

2.2 Low volume flush WCs

Dual flush WCs (eg 6/4 litre) have become standard and are available within the same price range as single flush WCs (from £40 to £1000). If a drainage syphon is also used (see section 5), the cost per dwelling could rise by about £500.

Low volume flush WCs help reduce water consumption. The legal maximum flush volume for a new WC is 6 litres according to the Water Supply (Water fittings) Regulations 1999. However, the flush volume may be somewhat higher than this because the cistern will fill as it is flushing. WCs with 6 litre flushes have evolved from 7.5, 9 and greater flush-volume WCs. It is unlikely that standard flush volumes can be reduced much further without innovative technology such as air assisted flushing. Dual flush WCs are now becoming common, providing the user with two options: a short flush for clearing liquids and a full flush for clearing solids.

In the last century, most WCs in the UK were flushed using syphons. Since 1999, the number of WCs fitted with valve outlets has increased rapidly and today, most new cisterns have valve outlets. Whereas syphons were virtually leakproof, outlet valves can allow some leakage, particularly over time as they wear. One key reason why valves have taken over from syphons is that syphons need around 2 litres to start them but valves will work at any flush volume. Valves therefore have a greater potential to produce efficient low volume flushes.

Until recently, WCs with integrated wash-hand basins were only available in countries such as Japan, the USA, Australia and Scandinavia, although a model is now available in the UK (Fig. 3). The tap water in these appliances supplies the cistern, thus conserving water (the wash-hand basin taps can be excluded from the *Water Efficiency Calculator for New Dwellings*). These appliances also reduce the floor area required which is advantageous if space is limited. The tap water is normally cold, but warm water can be provided. Sanitising cistern blocks, or other means should be used to minimise the risk of microbiological and biological growth in the cistern.

Figure 3 Caroma Profile WC with integrated wash-hand basin.

2.3 Reduced volume baths

Reducing water volume is often achieved by using a lower overflow outlet. Baths with lower overflow outlets are available at a negligible additional cost (conventional baths cost approximately £100 to £4000). However, water efficient cast iron baths cost over 30% more than conventional baths due to high moulding costs and lack of demand.

Reduced volume baths generally have volumes of less than 150 litres to the overflow (without anybody in the bath) and can help reduce water consumption. The reduced volumes may be achieved by shaping the bath to provide a depth of water with a reduced width (Fig. 4) or by lowering the overflow. Shallow baths have the same footprint as conventional baths, but can be safer for young children and easier to access for elderly people.

Figure 4 A reduced volume bath.

Reduced volume baths may not be satisfactory for all users. Some people may find bathing uncomfortable in a bath with a reduced width. A higher bathroom air temperature may be required if all of the body cannot be immersed in a bath with a reduced water depth. Not all baths are specified in the same way and care is needed when comparing their water capacities. A reduced volume bath is available with a declared capacity of just 30 litres. However, the manufacturer specifies volumes with the displacement of an 11 stone (70 kg) man – therefore the true volume (of 116 litres) is not clear. Baths labelled under the Bathroom Manufacturers Association (BMA) scheme use a different method to determine their volumes (see Further information).

2.4 Low flow showers

Low flow rates are usually achieved by substituting a conventional showerhead with a water efficient one, which are widely available in the UK. Low flow showers are available as a complete unit (showerhead, hose, valve, tray and cubicle) and are available within the same price range as conventional models (£500 to £12 000). Although low flow showers may reduce consumption by modulating the flow rapidly or by aeration, simple low cost showerheads are also available that provide a good area of spray and impact sensation by optimising the faceplate design.

Aerated showerheads use a mixture of air and water to create the illusion and 'feel' of more water and can reduce water consumption by up to 30%. They are designed to achieve the desired performance without affecting the user's experience of the shower. Figure 5 shows an aerated showerhead that saves water by producing water droplets instead of a continuous spray. Aerated showerheads are readily available in the UK and can help reduce water use. Prices are comparable to conventional showerheads (£8 to £70).

Figure 5 An aerated showerhead – water is formed as droplets rather than as a continuous spray.

Flow rates well below 8 litres per minute are typical for electric showers. Electric showers generally provide low flow rates because the water temperature produced is limited by the amount of heat their heating elements can transfer to the flowing water. As the water is supplied directly from the mains there is no limit to the volume of hot water.

Satisfactory shower performance is very subjective and often based upon personal preferences, so the specification of an efficient, multi-function showerhead will give users a level of choice and may reduce the likelihood of the showerhead being replaced.

However, some users may not like using low flow showers if, for example, a longer shower duration is needed. Where the flow rate is too low, showering time may actually increase, leading to a rise in water consumption. Low flow showerheads tend to have smaller holes for the water to flow through, which are prone to blockage by grit and scale. They also produce smaller or lighter water droplets which cool more rapidly and result in cooler showers. Higher water or bathroom air temperatures may therefore be required.

When specifying a shower, the following factors should be considered:

- the available water temperature and pressure from the specified hot water system design
- variations in supply pressure and volume of hot water available
- flow rate at the available or specified dynamic water pressure
- air temperature within the shower cubicle or bathroom
- ease of use and clarity of controls.

2.5 Terminal fitting flow restrictors

Terminal fittings, such as taps and showerheads, may have their water consumption reduced by limiting their flow rates. As showers are usually used free flowing, restricting the flow through a showerhead will have a greater impact on the water consumption calculated using the *Water Efficiency Calculator for New Dwellings* than a similar restriction to a tap.

Figure 6 Flow restrictor inside tap inlet.

The flow of water from a tap can be reduced by fitting a flow restrictor in the tap itself or in the supply pipework. These devices impose a physical constriction that reduces the volume of water that can pass though the fitting. An isolation valve, partially closed to restrict flow, is not a permanent solution although a user could make this ad hoc adjustment themselves to limit splashing and assist with a water efficient strategy. Figure 6 shows a flow restrictor which has been fitted inline in the inlet (or tail) of the tap. Flow restrictors fitted in this location are generally tamper resistant. However, it is not easy to check the devices after installation and poor access may make them difficult to maintain.

Alternatively, flow restrictors can be installed at the outlet in the spout of the tap. Devices fitted in this location are easy to maintain. However, the benefits may not be realised as the user can easily remove the fitting. The finish of the tap may also be damaged during maintenance. Figure 7 shows the normal three elements of an outlet restrictor: a metal threaded element holder, the restrictor element and the sealing washer.

Figure 7 Typical outlet flow restrictor components.

Flow restrictors are useful for controlling fill rates, through taps and float operated valves, and reducing splashing.

Flow restrictors are vulnerable to the build-up of scale and blocking by debris over time. To improve access for maintaining these fittings, the installation of an inline filter in the pipework is recommended. Manufacturers of regulators and restrictors will often incorporate filters in the body of the fitting (Fig. 8). The fitting may need to be removed from time to time to check and clean the filter. Angled filters are also available which have filters that can be removed for cleaning without dismantling the pipework.

Although the technologies are different, the terms 'restrictor' and 'regulator' are often used interchangeably (see section 2.6), so it is important to check that the device is suitable and determine flow versus supply pressure characteristics. The restrictor should also be an appropriate size for the pipe or tap.

2.6 Flow regulators

A flow regulator which relies on deformable elements does not provide a fixed restriction, but can be used as an alternative to reduce water use. As the pressure and flow rate change, the elements deform in a way that limits the flow rate independent of supply pressure. They are sometimes called 'pressure-compensating flow limiters'.

Figure 8 Combined isolation and flow regulator with integral strainer.

Figure 9 shows the resilient components of a flow regulator. They are particularly useful in balancing hot and cold water supplies in mixers where supply pressures are variable and good control of flow rates is required. For example, in a specification for the CSH for installation of a shower, a regulator would ensure that the flow rate was limited to the set value, independent of the supply pressure and the spray pattern selected by the user.

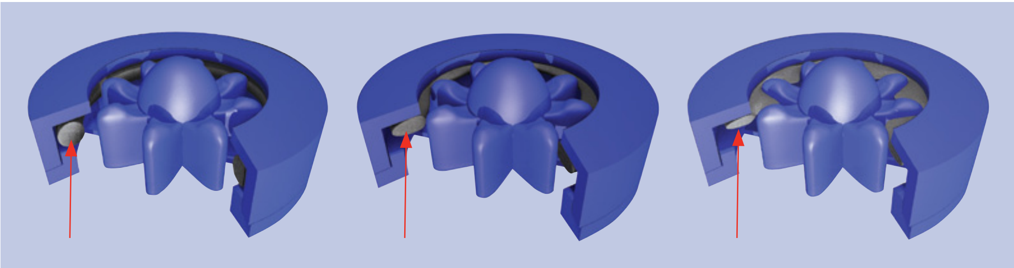


Figure 9 The components of a pressure-compensating flow limiter, showing the O-ring moving and deforming under different pressures.

The typical performance of a pressure-compensating flow limiter, compared with a conventional flow restrictor, is shown in Figure 10. The flow is constant once the water pressure exceeds about 1.5 bar.

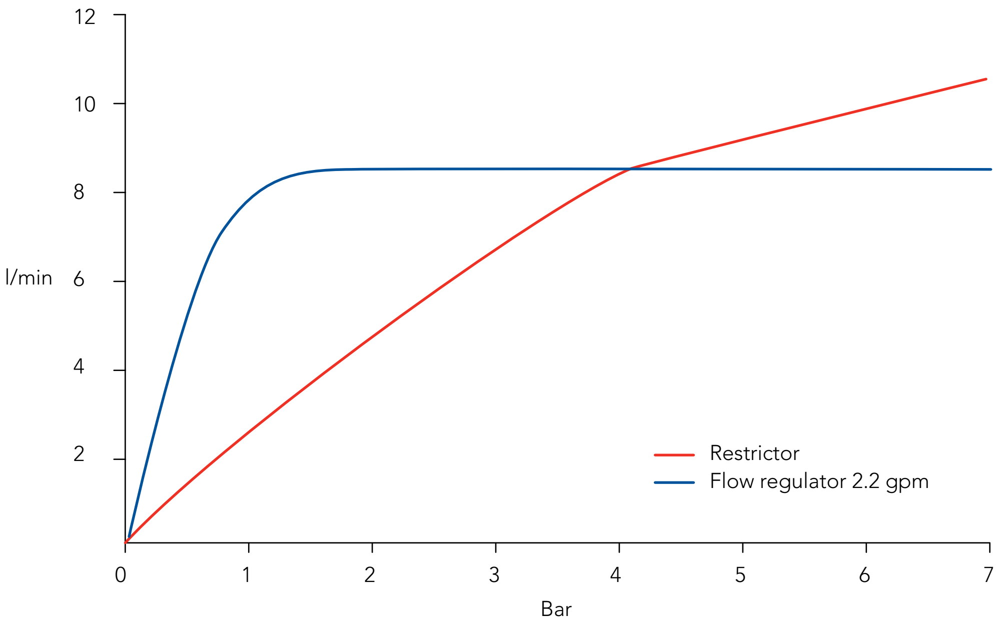


Figure 10 Comparison of a conventional restrictor with a pressure-compensating flow limiter insert.

2.7 Aeration fittings

Restrictors can be purchased with different flow rates and outlets (usually spray or aeration). Spray outlets can function at much lower flow rates than aeration outlets. However, aeration outlets only aerate the water above a threshold flow rate and pressure. This can encourage the user to turn the tap on more to increase flow and thus use more water than necessary to obtain the aerated effect. At low flows, an aerated tap produces a dribble that cannot be easily controlled. As aerated fittings only work with high pressures, they will not be a practical solution with cistern-fed water systems or when pressure-reducing techniques have been specified.

Figure 11 Build-up of limescale on an aerating tap outlet.

When an aeration outlet is fitted to a tap that was originally supplied with a conventional outlet, it is likely to protrude further. The space between the tap and the wash-hand basin may therefore become restricted, particularly with small wash-hand basins and backflow prevention air gaps may become compromised. In hard water areas, the fine meshes within the aeration outlets are prone to build-up of limescale as shown in Figure 11. Build-up of limescale on a conventional tap can be removed fairly easily. However, aeration outlets need to be removed and dismantled in order to remove limescale effectively. Although some limescale-resistant devices are now available, an aeration outlet needs regular maintenance to ensure the benefits of aeration continue.

2.8 Low water use washing machines

Most modern washing machines use less than 60 litres per washing programme. The volume of water consumed will tend to increase with the dry load capacity of the washing machine.

Before the introduction of the *Water Efficiency Calculator for New Dwellings* water calculations included in the *Code for Sustainable Homes technical guide*[5] did not take load into account so there was a risk that small load washing machines would be specified (to obtain a low water consumption value). This could result in the householder having to use the washing machine more frequently than if a larger capacity one had been installed. The *Water Efficiency Calculator for New Dwellings* uses a 'litres per kilogram of dry load' figure to enable a suitable efficient washing machine to be specified. However, irrespective of capacity, low water use washing machines may cost slightly more than conventional models as they use additional technology to reduce the quantity of water consumed. Where the washing machine model is known, its declared water consumption can be used in the *Water Efficiency Calculator for New Dwellings*. However, where the model is not known, or no washing machine is to be provided or installed, the default value for a washing machine must be included in the calculation.

The EU energy label (Fig. 12) is affixed to all washing machines at the point of sale. Water consumption value and dry load capacity should be given near the bottom of this label. Water consumption and load capacity values are derived from standard tests using a specific cotton load washed at 60°C.[6] Although these values provide a benchmark, actual water consumption and load capacities will depend on the washing programme and options selected by the user. For example, lower temperature washes may require more water and have a reduced load capacity. The label shown in

Figure 12 has a water consumption per kilogram of dry load of 11. As the dry load is less than 12, the energy label also shows the ecolabel flower symbol. The ecolabel is a voluntary labelling scheme used by goods and services having a lighter environmental footprint. Although many washing machines might be expected to display the flower symbol, currently there are no washing machines, or dishwashers, available in the UK with such a declaration.

Although the layout of the energy label is simple, manufacturers often the supply the label in two parts: the main label which includes the coloured bars and categories, and a second label that shows the declared values which is affixed to the right of the main label. This convenient method of labelling relies upon the staff at the point of sale sticking the labels together and onto the washing machines. The result is often a misaligned label and sometimes the wrong label is affixed. To avoid such problems, some manufacturers print the complete label on the washing machine packaging. As Figure 13 shows, even this method does not guarantee a complete, coherent label. All energy labels need to be carefully read to determine the declared water consumption.

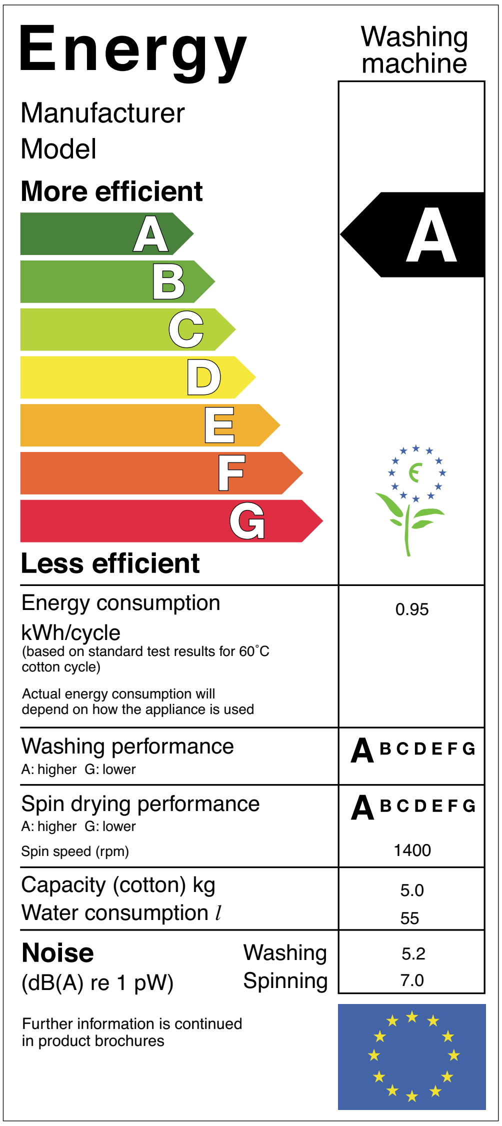


Figure 12 Washing machine energy label, including ecolabel flower symbol, dry load capacity and water consumption in litres for a 60°C cotton wash.

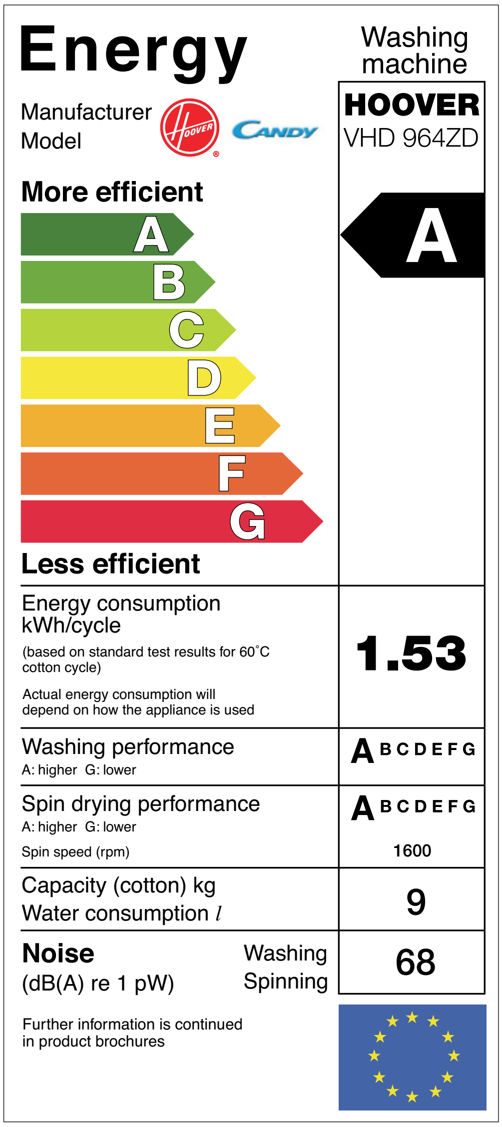


Figure 13 Example of an energy label from washing machine packaging showing an ambiguous capacity and water consumption declaration.

2.9 Low water use dishwashers

The small variation in water consumption between water efficient and conventional machines generally means that additional costs for water efficiency are negligible. Similarly to washing machines, the volume of water consumed will tend to increase with the number of place settings designed to be accommodated in the machine. The water calculations included in the *Code for Sustainable Homes technical guide* did not take load into account so there was a risk that dishwashers with only a small number of settings would be specified (to obtain a low water consumption value). This could result in the householder having to use the machine more frequently than if a larger capacity machine had been installed. As the maximum load of most dishwashers varies from 8 to 12 place settings, water consumption per place setting is an important parameter and is now used in the *Water Efficiency Calculator for New Dwellings*.

Low water use dishwashers are similar in price to conventional dishwashers. As for washing machines, the energy label is affixed to all dishwashers at the point of sale. However, as explained in section 2.8, the energy label needs careful interpretation (Fig. 14). The water consumption value for the appliance is given near the bottom of the label. These values provide a benchmark and are derived from standard tests using a 12 place setting load of crockery and utensils with the soiling baked on at 80°C (BS EN 50242:1999).[7] Actual water consumption will depend upon the washing programme and the options selected by the user, and may not correspond to the water consumption stated on the energy label. Even if a dishwasher is not to be installed or provided, the default value for a dishwasher must be included in the calculation.

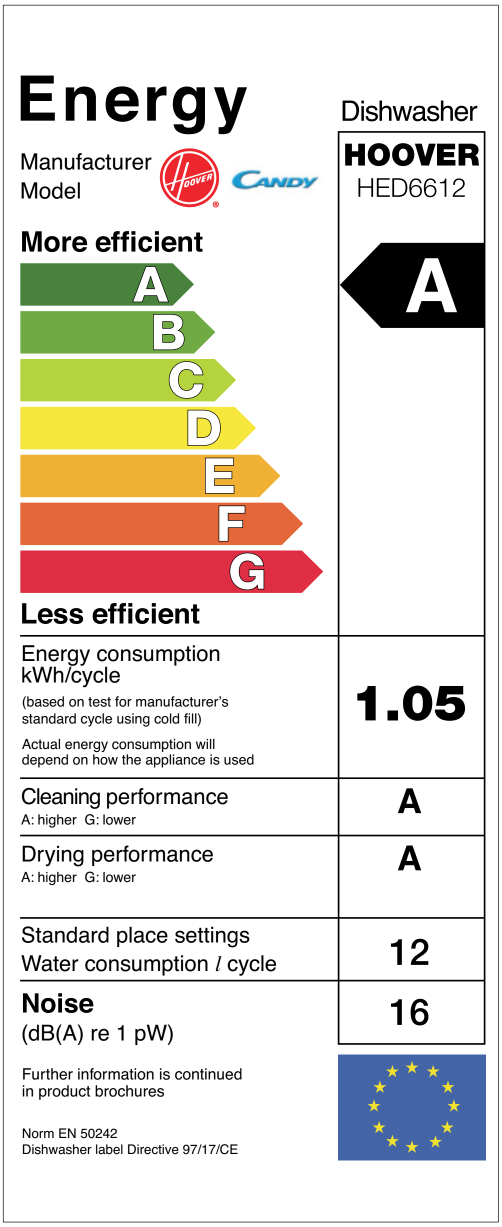


Figure 14 Example of an energy label from dishwasher packaging showing an ambiguous capacity and water consumption declaration.

2.10 Water recycling systems

If some home water requirements are to be provided from non-potable sources, such as a rainwater harvesting system or greywater recycling system, then the total cost of one of these systems would include the purchase cost of the equipment (approximately £100 to £10 000), the installation cost (including any excavation) and the running costs. Plumbing and installation costs will depend on the type and layout of the dwelling. Costs may be increased due to the need for separated water supply systems to prevent contamination of the potable supply with any non-potable water.

To achieve a desired water appliance specification for a dwelling, water recycling systems may be used to allow higher flow rates or volumes at critical fittings than would otherwise be possible at the specified Code Level. However, this may increase the energy used by the dwelling as energy may be needed to operate the water recycling system.

All mains water in the UK is supplied to drinking water quality. However, less than 10% of mains water is actually used for drinking. There is scope, therefore, for the use of non-potable water for many domestic applications. The intended use of the water will determine the water quality required, and therefore the treatment needed. Although municipal supplies of non-potable water are not generally available in the UK, local sources may be available and could be used. The Building Regulations Part G – *Sanitation, hot water safety and water efficiency*[4] is introducing the option to use non-wholesome (non-potable in other words) water for appropriate applications where it is of 'suitable quality'.

Recycling systems must be maintained correctly by the user, and occasionally serviced, to ensure that they operate efficiently and safely. This may involve a simple inspection and cleaning of filters, or a regular replenishment of consumables such as biocide and ultraviolet (UV) lamps. Systems are normally designed to fail safe, ie if there is a problem they will revert to a mains supply. While this may maintain safety, it can have a detrimental impact on the water efficiency of the system. Therefore, mechanisms should be set up to ensure regular maintenance of individual and communal water reuse systems.

2.10.1 Rainwater harvesting systems

Rainwater is an alternative supply of non-potable water. Rainwater harvesting systems range from the simple water butt to large-scale buried tanks that can provide rainwater for a range of uses and may also contribute to stormwater management. Within the CSH, rainwater harvesting is a means of achieving the mandatory element of the management of Surface water run-off from developments (Sur1), as well as contributing to the mandatory Indoor water use (Wat1), and optional External water use (Wat2), issues.

Systems available in the UK vary in capacity, application, complexity and cost. The relevant British Standard BS 8515 *Rainwater harvesting systems – Code of practice*,[8] was published in early 2009. It covers most current systems, excluding water butts, and includes stormwater management design options.

Rainwater is usually collected from roofs. The roof area must be large enough to allow sufficient rainwater to be collected to provide a net saving of potable water. Generally, an area of at least 50 m^2 will be required for most single dwellings. If there is insufficient roof area, rainwater can be collected from other surfaces provided pollution levels are expected to be low (eg patios). However, suitable filtration systems will need to be incorporated.

The small roof areas of some new dwellings limit the applicability of single dwelling rainwater harvesting units to areas where high rainfall occurs. If an incorrectly sized rainwater harvesting system is installed, it could become dependent upon a mains water supply and negate any potential savings. To compensate for areas with lower annual rainfalls, the effective area of the roof may need to be adjusted to provide sufficient rain to supply the designated applications. Where a sufficient collection area is not available, consideration could be given to the use of greywater recycling systems for WC flushing. Greywater recycling systems are simpler to specify as the specification for the other appliances dictates the volumes of greywater available.

Collected rainwater can be used for WC flushing, watering gardens and washing cars. It is important that reclaimed rainwater used for toilet flushing is free of solid matter as the water would be held in the WC cistern and pass through an inlet valve. The water may also need to be disinfected to reduce the risk of bacteriological growth.

The CSH permits rainwater to be used in washing machines if it has been suitably treated. Suitable treatment systems include biological aerated filters, submerged aeration filters, reed beds, membranes and UV light. Water for use in washing machines must exceed the minimum bathing water quality standard. This is because the final rinse water sets the standard of cleanliness of the clothes. There is disagreement among washing machine manufacturers whether reclaimed rainwater is suitable for use in their washing machines and some recommend that it is used for only one wash in four. It should be noted that using collected rainwater in washing machines could potentially cause clothes to become discoloured due to contamination from leaf litter or other debris.

Rainwater harvesting systems should be properly designed, installed and regularly maintained to prevent cross contamination between potable water and non-potable water, and to manage potential health and safety risks. As rainwater can be stored for several months, a large storage tank is required. A large excavation is likely to be required for an underground tank which can be costly, and energy is needed for pumping water from the storage tank. Rainwater systems do not necessarily provide a very reliable source of water (eg there may be a limited supply of water for irrigation during summer months when most needed) and may consume large volumes of mains supplied back-up water. Additional energy consumption, and the environmental impact of using these treatment systems, must be weighed against the potential water savings.

Box 1

There is ambiguity when references are made to 'bathing water quality' as there are various classifications for bathing waters. The Bathing Water Directive (2006/7/EC)[9] has been harmonised with the Water Framework Directive (2000/60/EC)[10] and includes bathing water standards for both coastal and inland waters. Coastal water criteria values are generally half those set for inland waters. As most of the national and manufacturers' 'standards' for reused water were developed prior to the 2006 directives, references to 'bathing water quality' can be assumed to relate to a previous edition (1975) of the Bathing Water Directive (76/160/EEC)[11] that only dealt with coastal waters. This directive used total coliforms, faecal coliforms and faecal streptococci as the criteria, but the 2006 Bathing Water Directive[9] only uses intestinal enterococci and *Escherichia coli*.

The minimum bathing water quality according to the 2006 Bathing Water Directive[9] is:

Intestinal enterococci (cfu/100 ml)	330
Escherichia coli (cfu/100 ml)	900

The previous minimum standard was:

total coliform organisms/100 ml	10 000
faecal coliform organisms/100 ml	2000

2.10.2 Greywater recycling systems

Several greywater recycling systems are available in the UK. Greywater is strictly defined as wastewater without faecal matter, although it is generally regarded as wastewater from baths and showers. Greywater recycling systems vary in capacity, application, complexity and price. A greywater recycling system, which includes treatment of the water, typically costs about twice as much as an equivalent rainwater harvesting system and is more costly to run because of the greater risk of faecal matter contamination and the need for disinfection. However, some greywater recycling systems on the market do not use any form of treatment prior to reuse (normally for some irrigation uses). Treatment can vary from settlement to clarify the wastewater (Fig. 15), through various forms of filtration, to reverse osmosis and membrane technology sometimes combined with UV light to produce high quality non-potable water. Although there is currently no published British Standard for greywater recycling systems, two draft Standards are available (BS 8525-1 *Greywater reuse systems – Code of practice*[12] and BS 8525-2 *Greywater reuse systems – Test methods and requirements*[13]) and are expected to be published by 2010. In the meantime, specifiers and installers should carefully examine manufacturers' claims and follow their instructions. Some systems are now available which integrate rainwater use and greywater recycling.

Untreated greywater is normally stored for no more than 24 hours before use or discharge due to the rapid breakdown of contaminants that occurs and the build-up of bacteria which causes unpleasant odours. Greywater can be stored for longer if it is treated. The storage tank volume should be roughly equivalent to the anticipated daily demand. As the dwelling occupants generate greywater, supply is linked to demand. Suitable greywater (either treated or untreated) can be used for flushing WCs and irrigating lawns. However, greywater may not be suitable for use through a sprinkler or hose (eg when watering gardens or washing cars) due to the increased risk of ingestion (as an aerosol) if the water is sprayed. Treated greywater may also be used for supplying washing machines for some wash programmes.

Greywater recycling systems should be designed and installed properly, and maintained, to manage potential health and safety risks. Care should also be taken to prevent contamination of the potable supply with any non-potable water. If an underground storage tank is used, an excavation is likely to be required. Energy is required for treatment and pumping water from an underground tank, and regular skilled maintenance is also needed.

Figure 15 The Ecoplay unit allows all the water from the bath or shower to drain away and be used to flush the toilet.

Although single house water recycling systems only are discussed in this guide, communal systems incorporated into a sustainable drainage system (SUDS) may also be considered. An advantage of a communal water recycling system is that maintenance and management may be shared between users. However, long-term implications for upkeep, ownership, metering and mains back-up also need to be considered.

2.11 Other methods

Other water efficient appliances, fittings and practices are available. Table 1 summarises products and near-to-market appliances which can help save water.

Table 1

Current and near-to-market water efficient products

Current products	Near-to-market products
4/2.6 dual flush WC suites	1.5 litre air assisted WC (transport of waste is more efficient)
30 mm and 50 mm cistern outlet valves	75 mm cistern outlet valves (faster flush may enable less water to be used)
50% click taps	<50% click taps, eg 25 or 30%
Water recycling systems using chlorine and filters	Low cost membrane and filtration-based water recycling systems
Steam assisted clothes washing machines	Detergent-less washing machines and ion technology machines with reduced rinse requirements

2.12 Waterless appliances and fittings: Composting toilets

A composting toilet is a dry or waterless toilet which relies on natural processes to make compost. Modern systems are easier and less time consuming to maintain than traditional designs. There are usually two chambers: one in use and the other left to decompose. A handful of wood shavings or straw is dropped into the toilet after each use to aid ventilation and prevent bacteria giving off excess nitrogen in the form of ammonia. Vent pipes from each chamber prevent the toilet from generating odours and a drain is required to take away any excess liquid. Recirculation foam toilets or water-flushed WCs with vortex separators can be used to enable composting systems to be fitted in conventional housing, although this technology is unlikely to be widely adopted.

2.13 Sourcing water efficient fittings and appliances

The water efficient fittings and appliances discussed in this guide are widely available in the UK from a range of suppliers. Different criteria are used by suppliers for listing water efficient washing products. Some suppliers use manufacturer's data only, whereas other suppliers list products which have been tested and verified for water efficiency. Water consumption values provide a useful benchmark, but may not relate to the specific use patterns of the user.

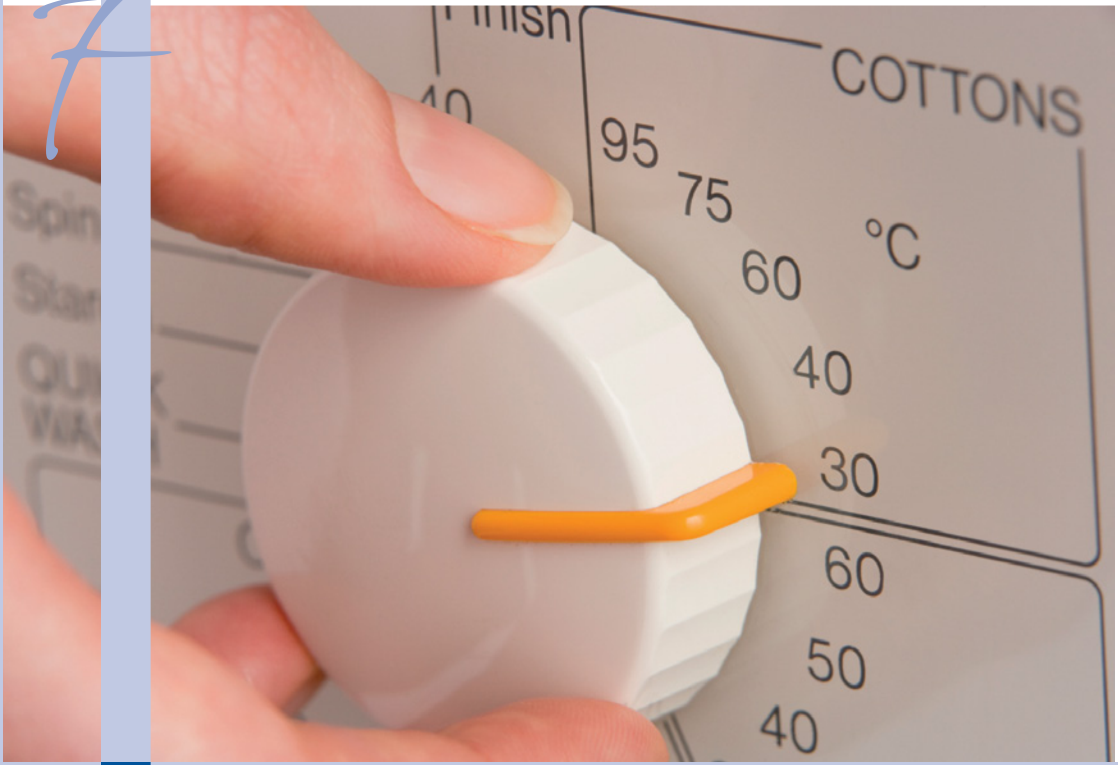
It is unusual for any one manufacturer to produce a full range of top-rated water efficient washing appliances. Waterwise has compiled tables of water efficient washing machines and dishwashers based on the manufacturers' information. The tables contain the consumption figures expressed as litres per kilogram, for washing machines, and as litres per place setting for dishwashers. These tables are free to view online on Waterwise's website and are regularly updated.[14]

Information on water efficient product listings is summarised in Table 2.

Table 2

Information on product listings

Product listing	Products covered	Data quality	Notes
Bathroom Manufacturers Association (BMA) www.bathroom-association.org	Bathroom appliances	Manufacturer's declaration that the BMA labelling scheme criteria has been met	BMA labelling criteria is not consistent with the CSH or NHBC criteria
Enhanced capital allowance (ECA) and water technology list (WTL)	Water products that meet ECA criteria	Only verified products	Mainly aimed at commercial and non-domestic users, but should be of use to domestic users for some products
Waterwise www.waterwise.org.uk	Washing machines and dishwashers	Manufacturer's data only	The top 20 rating scheme is reviewed regularly and is free to access
www.greenbooklive.com	BRE Global certified environmental products	Only verified data	Free online database designed to help specifiers and end users identify 'green' products



3 Changing people's behaviour

By saving water in the home, bills can be reduced (particularly for customers on a revenue water meter). Reducing the consumption of hot water will cut the cost of heating the water. The energy needed by the water suppliers for treating water can also be cut, helping to reduce carbon dioxide emissions and impact on climate change.

Customers can become more water efficient by reducing the amount of water that is wasted, rather than by restricting use. This can be achieved by making small behavioural changes, choosing water efficient products and by recycling water. Customers should be given information on the benefits of reducing water usage, and how to use water efficient products and recycle water efficiently.

Ways of reducing the amount of water wasted in the home and garden include:

- using dual flush toilets as intended and using full flush only when needed
- having short showers rather than baths
- using water efficient appliance models such as washing machines and dishwashers
- repairing leaks as soon as possible
- using a watering can rather than a hose or sprinkler to water the garden
- collecting rainwater in a water butt to irrigate the garden
- attending to dripping taps, wash-hand basins, kitchen sinks and WCs.

Care must be taken when specifying water efficient products in order to achieve the desired function without compromising on performance. Important factors to consider include:

- bath filling time
- kitchen vessel filling times (eg kettle, washing-up bowl)
- showering sensation.

Although low flow taps and flow restrictors can help reduce water consumption, low flow rates may be an inconvenience to some users. The time taken to fill baths, wash-hand basins, kitchen sinks and kitchen vessels will depend on the tap flow rate.

4 Water supply issues

4.1 Hot water supply system selection

The type of hot water system in a home may limit the choice of water efficient products. For example, as already mentioned, aerated fittings only aerate the water above a threshold flow rate and will not be a practical solution if a low pressure system has been specified. If a mains pressure system has been specified it may also influence the type of water efficient products that can be used.

A simple combination boiler provides unlimited hot water at mains pressure. Due to the instantaneous water heating system, the hot water is delivered at a low flow rate which will make bath filling slow. A flow switch triggers the hot water function of combination boilers, so if the outlet has a restricted flow, the flow may be insufficient to operate the combination boiler and hot water will not be obtained. The boiler manufacturer should be able to provide advice.

Storage combination boilers have a small buffer storage tank. This enables higher flow rates and simultaneous use of appliances and fittings requiring hot water. It also eliminates the problem of low flow not being adequate to fire the boiler.

An unvented hot water storage system will enable multiple simultaneous discharges, but should be correctly sized so that the supply volume of hot water is adequate. The space consumed by an unvented hot water storage system is at least twice that of a storage combination boiler.

4.2 Water hardness

Hard water has high levels of dissolved minerals, particularly calcium and magnesium salts. Most of the eastern half of England is supplied with hard water.

4.2.1 Hard water problems

Hard water causes limescale to build up in pipes, washing machines and hot water systems. Showerheads become blocked and it forms on baths, wash-hand basins and taps. Limescale damages washing machines and dishwashers resulting in higher maintenance costs and a shorter life. Thermal conductivity rates and efficiency in water heaters can also be reduced. Heating limescale wastes money and increases boiler running time, leading to increased fuel costs. It can reduce volumes in hot water cylinders and increase the risk of harbouring Legionella bacteria.

4.2.2 Water softeners

Water softeners are used to treat hard water. The cost of a domestic water softener depends on its size but is generally between £350 and £1000. Conventional water softeners work by ion exchange and must be regularly filled with salt (sodium chloride) which can cost the householder between £30 and £150 each year. Salt is required to enable the softener to replace the limescale-producing calcium and magnesium ions in the water with sodium ions.

When installing a water softener, provision should be made for its associated salt supply. As the Department of Health and BS 6700[15] does not recommend drinking artificially softened water, additional pipework is required for a supply of unsoftened water to a designated drinking water tap. Regular access will also be needed to maintain the softener.

Water softeners are a well established means of removing hardness. Modern water softeners are available with low regeneration volumes. The regeneration volume is the amount of water consumed during the regeneration of the ions in the resin block, central to the conventional ion exchange water softener. This water is in contact with the salt supply that provides the sodium ions to replace the calcium ions in the hard water. Early water softeners used large volumes of water during regeneration due to their design and the use of timed regeneration cycles. However, modern resin blocks are designed to be far more efficient and are only regenerated when required, and not simply on a time basis. The *Water Efficiency Calculator for New Dwellings* includes ion exchange water softeners. Where the regeneration volume is less than 4% of the water used between regeneration cycles, the softener is excluded from the water consumption calculation. Where the regeneration volume is greater than 4%, the regeneration volume in excess of 4% is used in the calculation, not the whole regeneration volume.

Alternative types of water softeners are also available such as physical treatment devices. They do not require a salt supply, but may require an electricity supply. See Further information at the end of this guide for more information on the various forms of water treatment.

4.3 Water pressure and flow rate

Water companies aim to supply water to the customer's stop tap at a minimum water pressure of approximately 1 bar. This is sufficient to supply water up to 10 m higher than the stop tap in the street. Water supplied from a cold water storage tank (normally in a loft) will be at a more or less constant pressure related to the height of the storage cistern above the outlet. In most dwellings, water pressure from this type of system will be less than 1 bar (a head of 2 m will result in a static pressure of 0.2 bar).

It is worth noting that, to enable a comparison between flow rates, the *Water Efficiency Calculator for New Dwellings* compares fittings at an industry standard of 3 bar pressure. Different pressures generally result in different flow rates. It is normal for supply pressure to vary throughout the day and steps can be taken to minimise pressure variations.

If the supply pressure is higher than 3 bar, it can be reduced by fitting a pressure reducing valve at the supply inlet to the dwelling. This will ensure that the supply to the fittings is reduced proportionally. Care is needed to ensure pressure reducing valves are appropriately specified. Where supply pressures fluctuate greatly, a pressure limiting valve may also be required to prevent pressures exceeding a set level.

For pressures below 3 bar, some form of pressure boosting may be needed to achieve flow rates which are acceptable for the end user. A booster set normally comprises a pump, an accumulator, a break pressure tank and a pressure limiting valve. Various capacity booster sets are available for single rooms, whole buildings or estates. Water companies in certain areas frequently install booster sets to compensate for water supply pressure reduction.

The water pressure at an outlet depends on the supply pressure and the sizes of the pipes and fittings. Figure 16 illustrates how pipe diameter can affect pressure and flow rate (based on a diagram produced by the University of Greenwich).

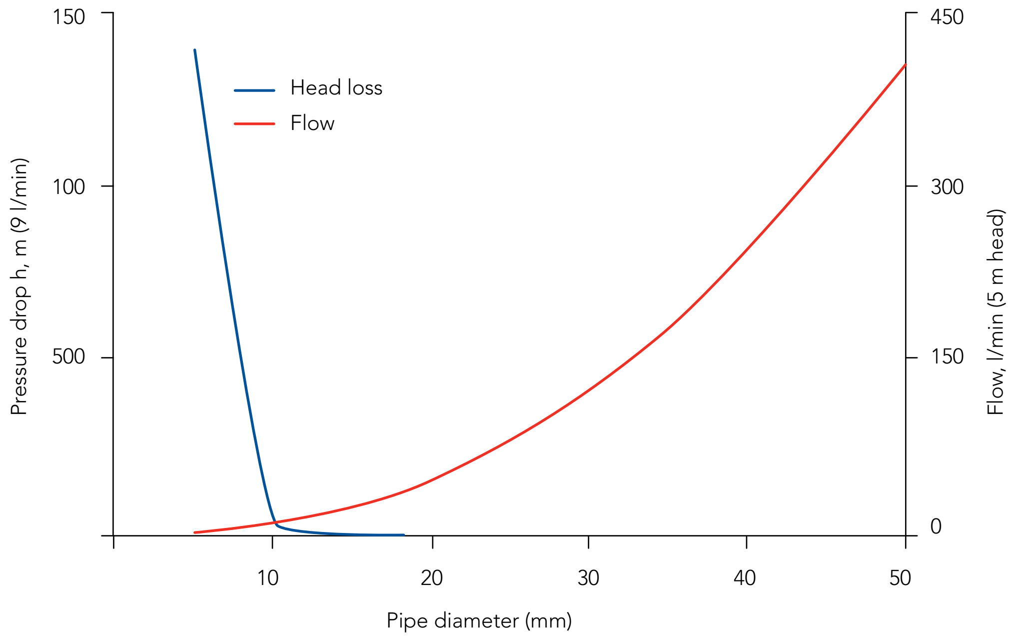


Figure 16 The variation of pressure drop and flow rate for various pipe diameters with a head of 5 m water gauge and a flow of 9 litres per minute respectively.

Pressure losses are considerable when small bore pipes are used. Small bore pipes and low flow terminal fittings are used to minimise thermal losses, risk of stagnation and Legionella multiplication (see section 4.4). Booster sets may be needed (even in high pressure regions) to enable the specified pressures to be achieved at the terminal fittings. A modern booster set is shown in Figure 17. Although the normal design curves (as in the Chartered Institute of Plumbing and Heating Engineering *Services design guide*[16] and BS 6700[15]) can be used to size the water distribution pipework in a dwelling, care must be taken to ensure that the specified water efficient flow rates are used instead of the normal assumed values.

Figure 17 Domestic booster set with a 200 litre tank and 8 litre pressure vessel.

4.4 Avoidance of stagnation

Although guidance documents (including BS 6700) have often advised against stagnation in water pipes, very few practical solutions have been suggested for domestic premises. The drive towards zero and near-zero carbon dwellings is producing very well insulated buildings with reduced water demand. As the availability of water pipes other than 15 mm and 22 mm diameter is limited in the UK there is a risk that water turnover rates may be reduced and the temperatures of all water pipes will approach the ambient temperature, which could lead to proliferation of microbial growth and Legionella. To minimise the risk, both hot and cold water pipes should be well insulated and steps taken to minimise stagnation.

One way of minimising stagnation is to size the pipework correctly for the anticipated demand and minimise the length of any pipe leading to an individual outlet (the terminal branch). Where a high-use sentinel fitting (the appliance at the end of the water supply branch) is installed, water will be regularly drawn through the branch ensuring maximum turnover of the water in the pipe. In other situations different measures will be needed, eg to ensure frequent circulation in terminal branches of infrequently used outlets. Although pumped circulation systems are used in some non-domestic systems, they are rare in dwellings. A recent introduction to the UK market is the Kemper Hygiene System that uses a venturi effect to induce movement in terminal branch loops when water is drawn through the main branch (Fig. 18).

The concept of the fitting is based on venturi nozzle technology. A small pressure difference between flow pipe A and return pipe B causes a flow around the branch loop.

Although such a fitting will produce circulation in a pipe loop when all the downstream appliances are used, if only one outlet is opened downstream the flow around the loop would be negligible. By incorporating a flow regulator into the venturi, circulation can be induced around the loop at far lower flows (Fig. 19). Such water supply loops are only needed where water turnover rates are low in the branch. Figure 20 illustrates a system where the water supply layout has been arranged to minimise stagnation. Although a WC is normally a high use appliance, if it is supplied with non-potable water it will not contribute to the draw-through of potable water.

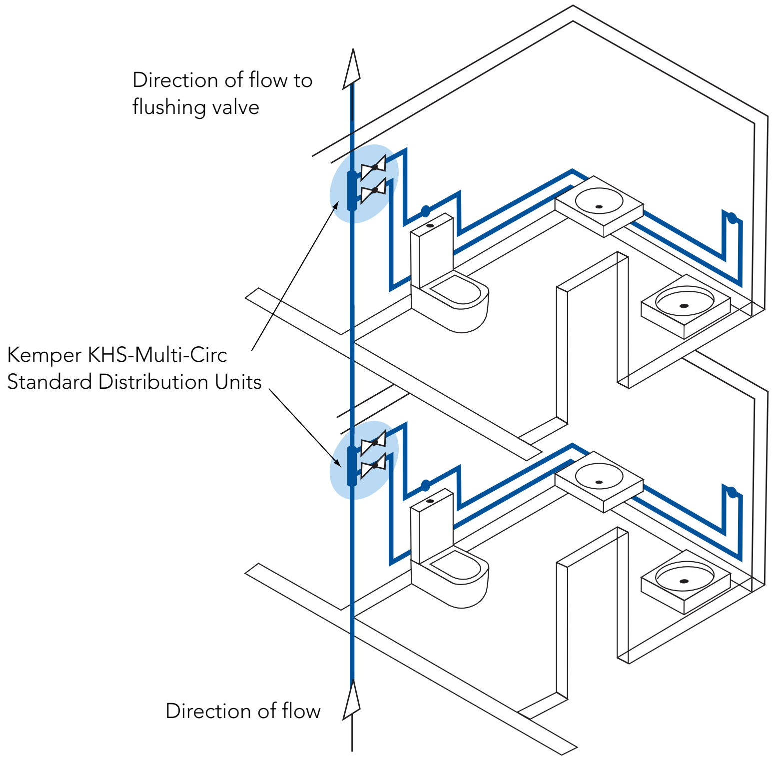


Figure 18(a) Water supply layout incorporating the Kemper KHS-Multi-Circ Standard Distribution Unit (Fig. 18b).

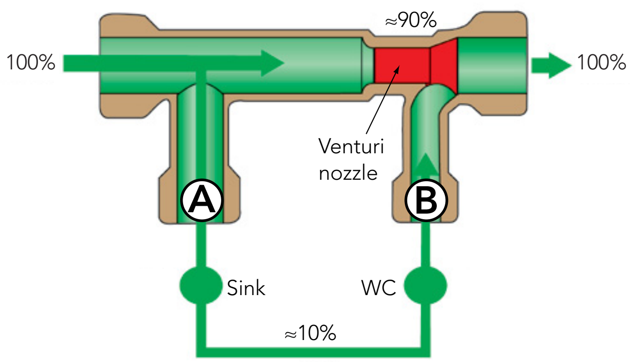


Figure 18(b) Section through a KHS-Multi-Circ Standard Distribution Unit (incorporating a venturi nozzle) creating a flow in an otherwise stagnant supply loop.

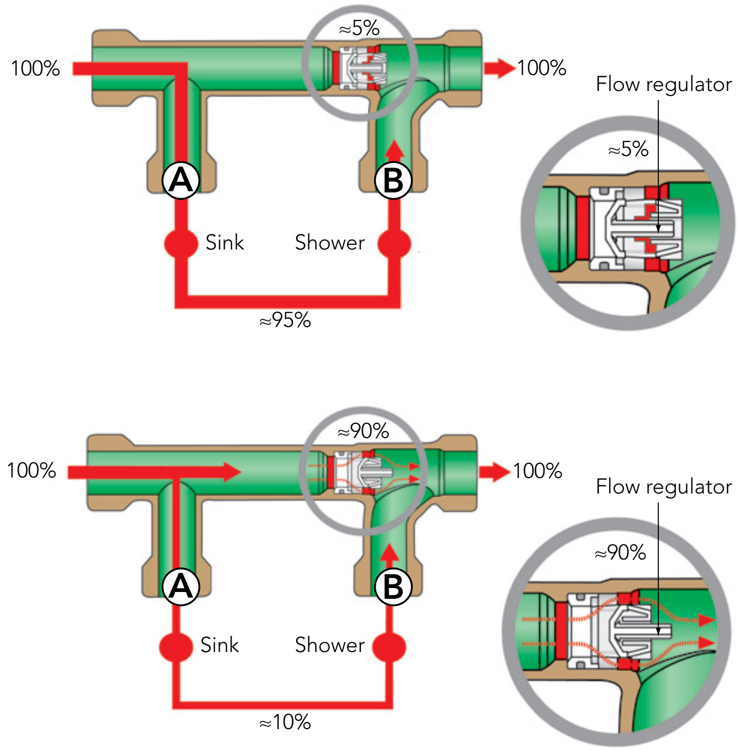


Figure 19 Sections through a KHS-Multi-Circ Dynamic Distribution Unit, incorporating a venturi flow regulator, showing the impact of different flow volumes through the main branch on the circulation within the loop.

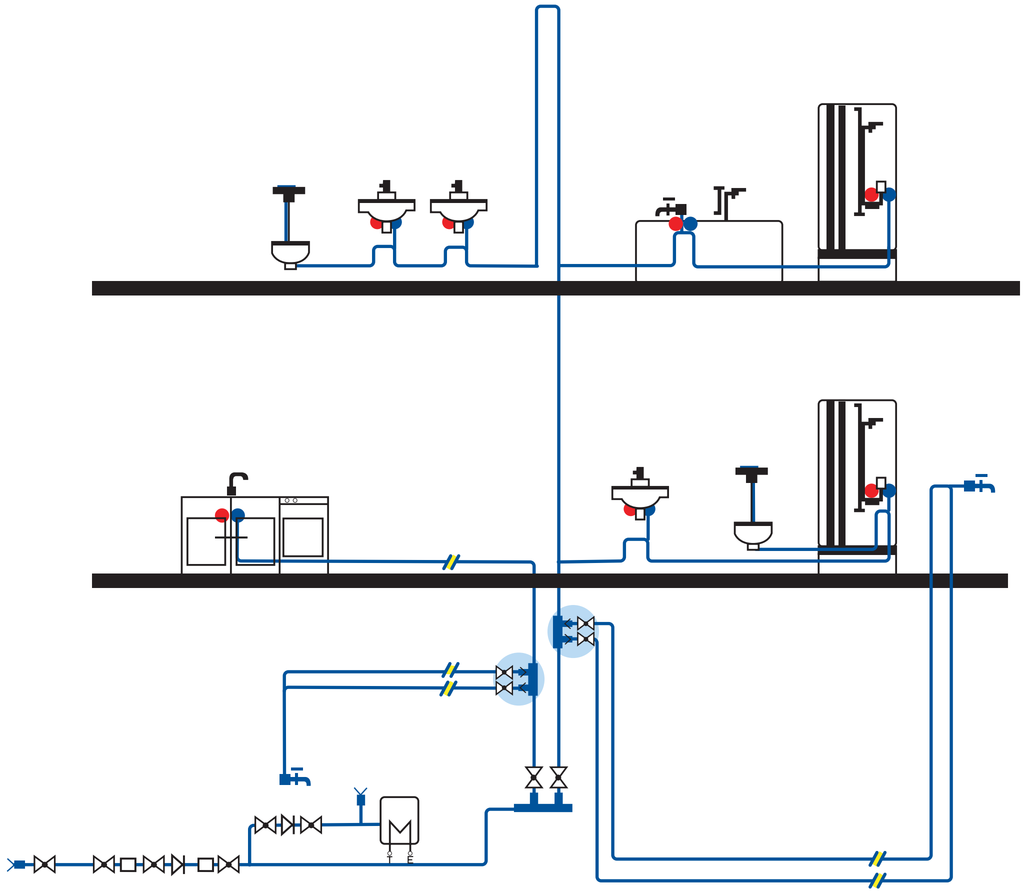


Figure 20 Example of a water supply layout in dwelling with high use kitchen sink, showers and WC, but low use external taps. All terminal branches are kept as short as possible. The vertical loop on the upper floor is for a future extension of the water supply system.

4.5 NHBC Standards and British Standards

4.5.1 Water pressure

While the *Water Efficiency Calculator for New Dwellings* specifies terminal fitting flow rates at 3 bar dynamic pressure, the NHBC Standards (2008)[17] specify flow rates (as shown in section 4.5.2) at a dynamic pressure of at least 1.5 bar. The British Standard Code of Practice for water services (BS 6700[15]) does not specify a pressure.

4.5.2 Flow rates

Table 4 compares recommended flow rates specified in NHBC Standards (2008) and BS 6700. The design flow rate is what should be delivered by the fitting when used on its own; the minimum flow rate is that which the flow should not fall below when simultaneous discharge takes place in the system. (NHBC recommends that the appliances are able to supply water from their terminal fittings at 40°C at the specified flow rates, except kitchen sink taps which should supply water at 60°C.)

Table 4

Comparison of recommended flow rates for NHBC Standards (2008) and BS 6700*

Fitting	NHBC Standards (2008) specified flow rate (litres per minute)	BS 6700 recommendation* (litres per minute)
Shower head (litres per minute)	Design flow rate = 12 Minimum flow rate = 6	Design flow rate = 12 Minimum flow rate = 6
Wash-hand basin taps (litres per minute)	Design flow rate = 9 Minimum flow rate = 6	Design flow rates = 3–9 Minimum flow rates = 1.8–6 (depending upon type and outlet)†
Kitchen sink taps (litres per minute)	Design flow rate = 12 Minimum flow rate = 6	Design flow rates = 12–36 Minimum flow rates = 6–24 (depending upon size of inlet connection)‡

* The data is taken from table 3 in BS 6700.

† BS 6700 differentiates between the terms 'washbasin', 'handbasin' with pillar taps and 'handbasin' with spray or spray mixer taps. Where the washbasin is used, the design and minimum flows are 9 and 6 litres per minute respectively; the design and minimum flows for the handbasin with pillar taps are 6 and 4.2 litres per minute respectively; and for a handbasin with spray or spray mixer taps the design and minimum flows are 3 and 1.8 litres per minute respectively.

‡ BS 6700 differentiates between different nominal tap sizes related to the inlet connection. For a conventional tap with a ½" threaded inlet (G1/2) the design and minimum flows are 12 and 6 litres per minute respectively; for a conventional tap with a ¾" threaded inlet (G3/4) the design and minimum flows are 18 and 12 litres per minute respectively; but where a tap with a 1" threaded inlet (G1) the design and minimum flows are 36 and 24 litres per minute respectively.

4.5.3 NHBC Standards guidance

NHBC recommends that:

- The design flow rate should be available at each outlet when the total demand does not exceed 0.3 litres per second (18 litres per minute). When simultaneous discharge occurs, the flow rate at an individual outlet should not be less than the minimum rate.
- The minimum flow rate should normally be available, but may be less if the pressure of the incoming supply falls below 1.5 bar.
- Instantaneous electric showers are excluded from these criteria.

The guidance given in NHBC Standards is based on BS 6700. The flow rates given in BS 6700 are to be revisited to take account of the need to conserve water and the modern appliances and devices that are on the market. However, these options have to be balanced against the need to provide an adequate water service to the home. BS 6700 is due to be revised in 2009 and NHBC will participate in its revision.

Until revised guidance on flow rates is developed, designers should not ignore the minimum flow rates given in the NHBC Standards when complying with the water requirements of the CSH.

Note: Although BS 6700:2006+A1:2009[15] has been issued, this is an amendment to the 2006 edition and therefore not a full revision. In the latest edition there are no changes to the flow rates shown in Table 4 above.

5 Impact on drain and sewer systems

Wastewater flow rates from water efficient appliances and fittings may not be sufficient to transport solids and clean the pipes. In these cases the guidance set out in BRE IP 1/04 *Drainage design for buildings with reduced water use*[18] should be followed. If low flows are likely to occur in a drainage system, drain syphons or tipping tanks can be used to flush the drains. A horizontal syphon fitted to a drain system is shown in Figure 21 and a drain booster system using a vertical syphon in Figure 22. These boosters do not contain moving parts. They consist of a reservoir of around 16 litres and are fitted to the drain either in the building just above the base of the stack, or outside in a sunken chamber. When sufficient water has been collected to fill the reservoir, the water overflows into the outlet pipe. This starts a syphonic action that evacuates the reservoir and discharges a slug of water into the drainage system at a velocity greater than the self-cleaning velocity for the drainpipe.

The issue of drain gradient for low flow drains is complex. There are a number of variables:

- the appliances that are to be drained (eg WCs, baths and showers)
- the efficiency of the WC flushes
- the amount of water to be collected for flushing drains
- bath, shower and wash-hand basin water may not be available for flushing drains (ie if there is a greywater system installed in the property).

Steep drainage gradients in excess of 20° can lead to separation of the water and solids which can result in deposition. Increasing the head of water behind solids, and therefore the transport distance along the pipe, can be achieved by reducing the pipe diameter. However, use of narrower pipes can lead to an increased risk of drain blockage, particularly if inappropriate items are flushed down the system. In the UK, it is not normal to reduce the drainage pipe diameter below 100 mm.

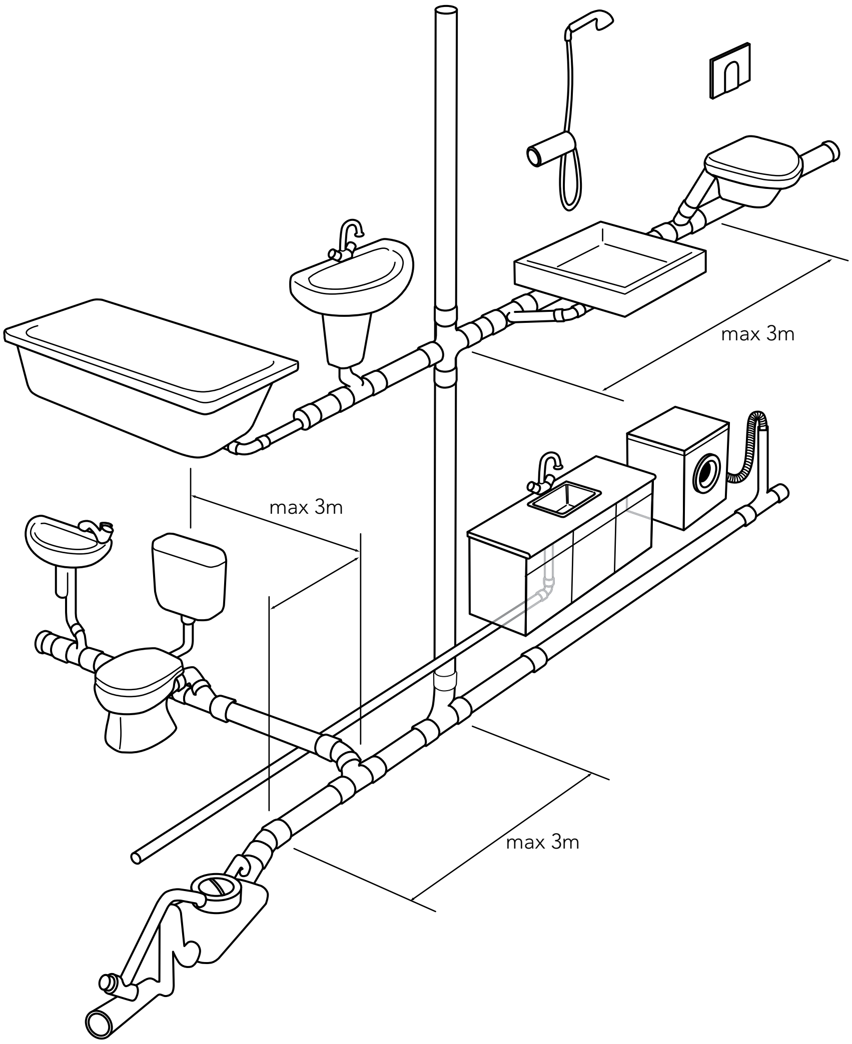


Figure 21 A horizontal syphon fitted to a drain system.

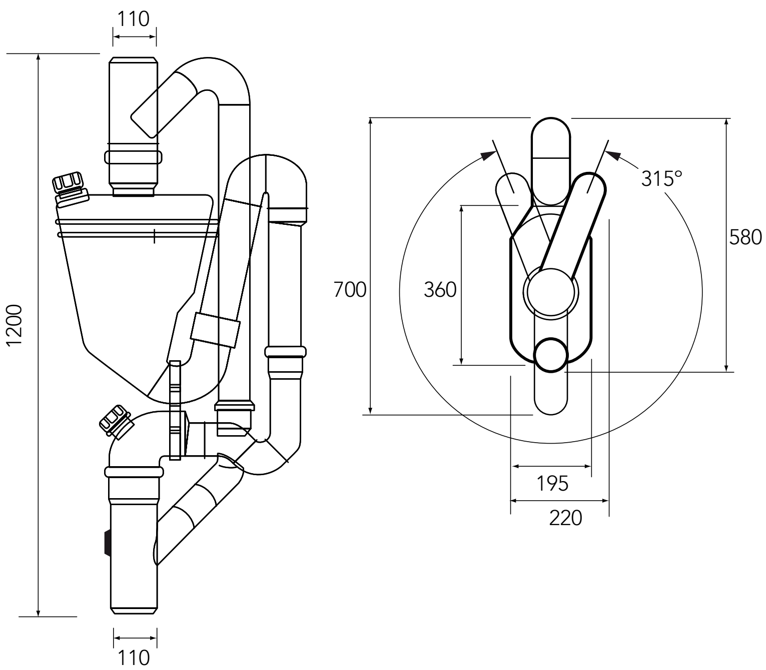


Figure 22 A drain booster vertical syphon for installation near the base of a stack (all measurements in millimetres).

Currently there is reluctance by the sewerage undertakers to adopt small diameter drains or sewers, especially those that have not been designed in accordance with the industry's manual *Sewers for adoption*.[19] At present, best practice is to install drainage systems conventionally and reduce the risk of deposition by ensuring that sufficient water is discharged into each drain. This ensures that drains serving individual appliances are avoided. Also, minimising the number and severity of bends helps to ensure efficient transport of solids.

Another way of addressing low flow, and at the same time maintaining non-separation of solids in steeply sloping pipes, is to apply a spin to the water. The Marscar bowl system (Figs 23 and 24) has steep pipes and swirling inspection chambers, so is less affected by low flows than a conventional system. The Marscar bowl system is applicable in steeply sloping development sites or if the sewers are relatively deep. The use of shallow access chambers also avoids the need for man-entry.

When fitting a Marscar bowl system, great care should be taken to ensure it is installed properly. If the ground is not suitable to support the inspection chambers, alternative systems should be considered.

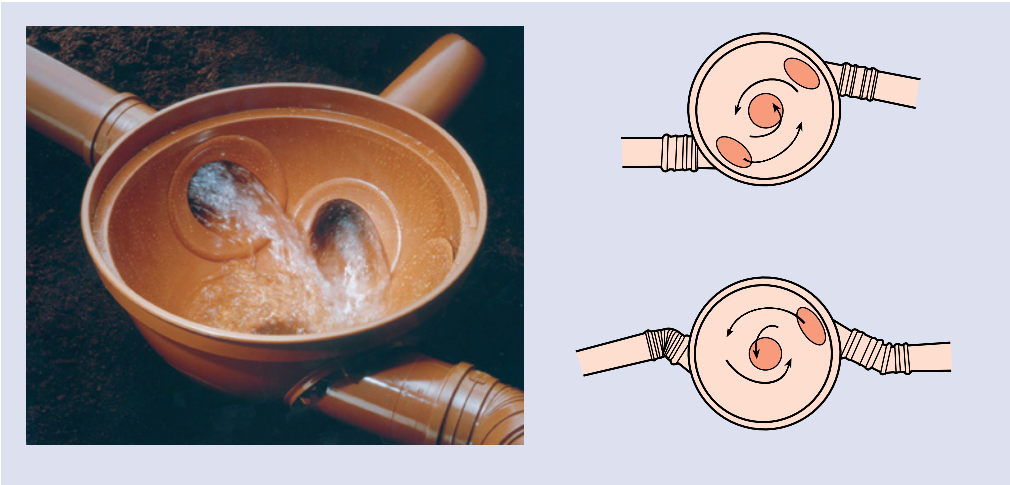


Figure 23 Marscar bowl showing the circular flow of water.

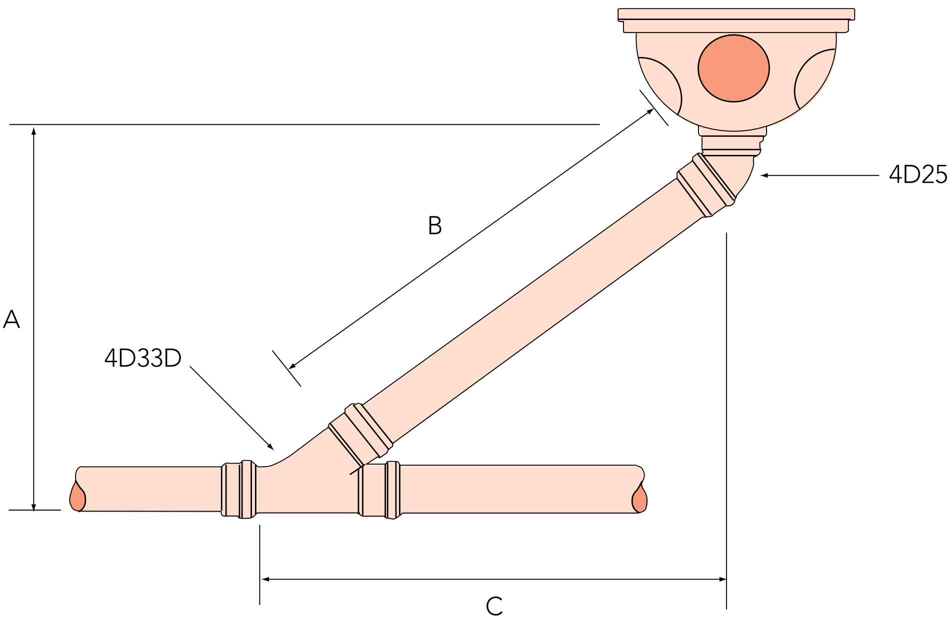


Figure 24 Marscar bowl dropout system enabling shallow access at all depths of drain (letters and numbers represent the part numbers).

6 How to meet the Code for Sustainable Homes water targets

The CSH provides for six Levels of achievement, with Code Level 6 being the highest. Within the CSH's scope, there are three mandatory water consumption target values which are summarised in Table 5. The water consumption targets are achieved by the specification of water efficient fittings and appliances.

Table 5

Code for Sustainable Homes: mandatory minimum standard

Code Level	Code points	Consumption (litres per person per day)
★	1	≤120
★★	1	≤120
★★★	3	≤105
★★★★	3	≤105
★★★★★	5	≤80
★★★★★★	5	≤80

The CSH uses a water calculator (eg the *Code for Sustainable Homes technical guide*[5]) to estimate the expected use of water in each home. The water calculator is a simple spreadsheet which lists fittings, appliances and columns for entering the specified capacity or flow rate. The value is then multiplied by a use factor and the number of uses per person per day.

To meet the levels of water consumption specified in the CSH there are many options. Past editions of the CSH (versions prior to the May 2008 *Code for Sustainable Homes technical guide*) applied different weightings to the appliances; this resulted in a ranking of appliances in which the main contribution to the water consumption was through the tap specification. However, the *Water Efficiency Calculator for New Dwellings* weights appliances in a more level way. This should result in a consumption value, during the use of the appliance, that relates more closely to the actual consumption value.

Although most of the appliances and fittings covered in the past editions of the *Code for Sustainable Homes technical guide*[5] have been included in the *Water Efficiency Calculator for New Dwellings*, bidets have been excluded due to their minimal water consumption, but food waste disposal units are now included.

Potential appliance specifications for achieving the main Code Levels are set out in Tables 6 and 7 using the *Water Efficiency Calculator for New Dwellings*. The use of greywater recycling systems or rainwater harvesting systems has an impact on the specification that can be used for a given Code Level, but Code Level 5 or 6 can be achieved without water reuse using the *Water Efficiency Calculator for New Dwellings*. Any excess reused water greater than 5 litres per person per day can contribute to the external water credit and enable external water features or pools to be included in the dwelling's specification. Although waste disposal units have been included in some examples, water softeners have not; it has been assumed that any unit specified would use less than 4% regeneration water and hence not need to be included in the calculation.

Table 6

Code for Sustainable Homes example specifications without water reuse

Appliance, fitting or system	Code Level 1 or 2	Code Level 3 or 4	Code Level 5 or 6
WC (litre single flush)	4	6/3	4/2.6
Wash-hand basin taps (litres per minute)	9	7	6
Shower (litres per minute)	12	7	6
Bath (litres)	None	150	None
Kitchen sink taps (litres per minute)	12	7	6
Washing machine (litres per kg)	6.20	8.17 (default)	6.20
Dishwasher (litres per setting)	0.71	1.25 (default)	0.71
Waste disposal unit	None	None	None
Water softener (water consumed beyond 4% per person per day)	0	0	0
Rainwater harvesting systems	None	None	None
Greywater recycling systems	None	None	None
Total water consumption (litres per person per day)	**120**	**102.30**	**78.90**

Notes

Code Level 1 or 2 — Meets the CSH specification and the flow rates from the shower, kitchen sink taps and wash-hand basin taps and fully meets the design requirements of the NHBC Standards. However, high efficiency white goods have been specified and a bath has been excluded.

Code Level 3 or 4 — Meets the CSH specification using the default values for white goods. The flow rates from the shower, kitchen sink taps and wash-hand basin taps are 1 litre per minute above the minimum normally required by NHBC.

Code Level 5 or 6 — Meets the CSH specification without using any water reuse. However, high efficiency white goods have been specified and a bath has been excluded. The flow rates from the shower, kitchen sink tap and wash-hand basin tap are now at the minima normally required by NHBC.

Table 7

Code for Sustainable Homes example specifications with water reuse

Appliance, fitting or system	Code Level 1 or 2	Code Level 3 or 4		Code Level 5 or 6
WC (litre dual flush)	6/3	6/3	4/2.6	6/3
Wash-hand basin taps (litres per minute)	9	7	7	6
Shower (litres per minute)	12	10	10	8
Bath (litres)	200	180	200	180
Kitchen sink taps (litres per minute)	12	12	12	12
Washing machine (litres per kg)	6.20	8.17 (default)	6.80	6.50
Dishwasher (litres per setting)	0.71	1.25 (default)	1	0.80
Waste disposal unit (litres per person per day)	3.08	None	3.08	3.08
Water softener (water consumed beyond 4% per person per day)	0	0	0	0
Rainwater harvesting systems	Assume 50 m^2 collection area, 0.7 efficient filter, 700 mm rainfall, rainwater used in WC and washing machine for a three-person household	None	Assume 50 m^2 collection area, 0.7 efficient filter, 700 mm rainfall, rainwater used in WC and washing machine for a three-person household	Combined rain and greywater system: Assume 50 m^2 collection area, 0.7 efficient filter, 600 mm rainfall, rainwater used in WC and washing machine for a three-person household
Greywater recycling systems	None	Collected from shower and used in WC flushing and external uses, 80% reuse	None	Combined rain and greywater system: Collected from shower, bath and taps and used in WC flushing, washing machine and external uses, 80% reuse
Total water consumption (litres per person per day)	**109.00**	**103.20**	**96.60**	**79.60**

Notes

Code Level 1 or 2 Meets the CSH specification using one form of water reuse, but without sufficient excess water (0.25 litres per person per day) for any garden use. However, a bath and a waste disposal unit have been specified. The flow rates from the shower, wash-hand basin tap and kitchen tap are at the design flows normally required by NHBC.

Code Level 3 or 4 *Greywater recycling systems:* Meets the CSH specification using one form of water reuse, but an excess of over 44 litres per person per day of greywater for any external use. However, although some more generous fittings have been specified, there is no waste disposal unit. The flow rates from the shower, wash-hand basin taps and shower are above the minima, but the kitchen sink taps are to the design flow normally required by NHBC.
Rainwater harvesting: Meets the CSH specification using one form of water reuse, but without sufficient excess water for any garden use. However, more generous fittings have been specified including a waste disposal unit. The flow rates from the shower and wash-hand basin tap are above the minima normally required by NHBC, but the kitchen sink taps meet the NHBC design flow rate.

Code Level 5 or 6 Meets the CSH specification using two types of water reuse with sufficient excess water for garden use. However, generous fittings have been specified including a waste disposal unit. The flow rate from the shower is above the minima normally required by NHBC, but the wash-hand basin taps are at the minimum flow while the kitchen sink taps meet the design flow.

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7 The future

Many of the elements of the CSH are not linked, eg if a greywater recycling system is specified, the power consumption is not considered. In the future, elements may become more interrelated to improve the sustainability of homes. This may change the methods and technologies that will be needed to achieve the overall targets.

Currently, with innovative water efficient technologies, there may be no benchmarks to determine performance and enable meaningful comparisons between products to take place. However, as quality standards and certified products become available it is likely that these technologies will be called up in codes and regulations to ensure that appropriate sustainable products are used.

In time, new water efficient devices will become available and existing products will be refined and developed. Where new innovations are considered to be suitable, changes will be made to the CSH to keep it up-to-date with the latest technology.

APPENDIX

Water calculator comparisons

Use factors have been determined from historical studies. Although they provide an agreed benchmark from which comparative calculations can be made, they may not accurately predict actual water use in a specific home.

The way in which the water calculations work should be understood before they are used. In particular, it should be noted that the water calculations in previous editions of the *Code for Sustainable Homes technical guide* used a product of typical use volume and usage frequency derived from historical data from *non-CSH dwellings*. The *Water Efficiency Calculator for New Dwellings* and the new edition of the *Code for Sustainable Homes technical guide*[20] has been modified to better reflect normal domestic water consumption and reduce the emphasis on tap specification. Although dishwashers continue to have low significance in the calculation, most other appliances now contribute similar proportions of consumption to the calculation; this has given more flexibility in designing a scheme of appliances and fittings to meet a given Code Level.

The water calculations used in the *Code for Sustainable Homes technical guide* (prior to the May 2009 edition) and the *Water Efficiency Calculator for New Dwellings* are shown in Tables 8 and 9. The calculations show the difference in calculated consumptions for the same specification.

In the example in Table 9, no Code Level was attained as the water consumption was over 120 litres per person per day.

Table 8

Code for Sustainable Homes technical guide[5] calculations

Installation type	Unit of measurement	Capacity/ flow rate	Use factor	Proportion in dwelling maximum = 1	No. of uses per person per day	Litres of water used per person per day
WC (fixed flush)	Flush	–	1.00	–	4.80	–
WC (dual flush)	Full flush	6	0.33	1	4.80	9.50
	Part flush	3	0.67	1	4.80	9.65
Bidet	Litre per use	2.64	1.00	–	2	–
Wash-hand basin taps	Litres per minute	6	0.67	1	7.90	31.76
Shower	Litres per minute	8	5.00	1	0.60	24
Bath	Capacity to overflow	180	0.40	1	0.40	28.80
Kitchen sink taps	Litres per minute	12	0.67	1	7.90	63.52
Washing machine	Typical practice or actual litres per use	49	1.00	1	0.34	16.66
		–	–	–	–	–
Dishwasher	Typical practice or actual litres per use	13	1.00	1	0.30	3.90
		–	–	–	–	–
Water softener	Litres per use	–	1.00	–	1	–
Total internal use						**187.79**

The values shown in red have been inserted in this calculation as examples of capacity/flow rate. The total internal use calculation does not include a figure for a bidet.

Table 9

Water calculation using the *Water Efficiency Calculator for New Dwellings* and the new edition (May 2009) of the *Code for Sustainable Homes technical guide*[20]

Installation type	Unit of measurement	Capacity/flow rate	Use factor	Fixed use (litres per person per day)	Litres per person per day*
WC (single flush)	Flush volume (litres)	–	4.42	0	–
WC (dual flush)	Full flush volume (litres)	6.00	1.46	0	8.76
	Part flush volume (litres)	3.00	2.96	0	8.88
WCs (multiple fittings)	Average effective flushing volume (litres)	–	4.42	0	–
Taps (excluding kitchen taps)	Flow rate (litres/minute)	6.00	1.58	1.58	11.06
Bath (where shower also present)	Capacity to overflow (litres)	180.00	0.11	0	19.80
Shower (where bath also present)	Flow rate (litres/minute)	8.00	4.37	0	34.96
Bath only	Capacity to overflow (litres)	–	0.50	0	–
Shower only	Flow rate (litres/minute)	–	5.60	0	–
Kitchen/utility room sink taps	Flow rate (litres/minute)	12.00	0.44	10.36	15.64
Washing machine	Litres/kg dry load	8.17 (default value)	2.1	0	17.16
Dishwasher	Litres/place setting	1.25 (default value)	3.6	0	4.5
Waste disposal unit	Litres/use	If present = 1 If absent = 0	3.08	0	–
Water softener	Litres per person per day	–	1	0	–
	(5)	Total calculated use (litres per person per day) = (Sum column 4)			**120.76**
				× 0.91 =	109.90

* The figures in this column are the sum total of [Capacity/flow rate × Use factor] + Fixed use litres (litres per person per day). The values shown in red have been inserted in this calculation as examples.

The highlighted value in the bottom right cell (120.76 litres per person per day) in Table 9 is multiplied by the normalisation factor (0.91) to provide the total water consumption figure that will determine the Code Level. In this example, Code Level 1 and/or 2 is attained and an extra water credit is available as the consumption is below 110 litres per person per day.

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Further reading

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BS EN 12056:2000. Gravity drainage systems inside buildings.

WRAS (www.wras.co.uk)

Information and guidance notes

9-07-01. Information for installation of ion exchange water softeners for systems supplying water for domestic purposes.

9-02-04. Information about installing, modifying or maintaining reclaimed water systems.

9-02-05. Marking and identification of pipework for reclaimed (greywater) systems.

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Water softeners and water treatment

The Domestic Water Treatment Association (www.dwta.org.uk).

United Kingdom Water Treatment Association (www.ukwta.org).

General

- **BRE (www.bre.co.uk)** Advice on all aspects of the built environment, including guidance documents on water conservation and the CSH. Water conservation measures can be seen in demonstration dwellings built at the BRE Innovation Park
- **BRE Global (www.bre.co.uk.global)** Management of the CSH scheme, Certification schemes on WCs, terminal fittings and baths, view www.greenbooklive.com
- **Bathroom Manufacturers Association (BMA) (www.bathroom-association.org)** Water efficient products and the water efficient product labelling scheme
- **British Board of Agrèment (BBA) (www.bbacerts.co.uk)** Third party certificates for building components
- **British Standards Institution (www.bsi-global.com)** British, European and International Codes of Practice and Standards for products and systems

- **Chartered Institute of Plumbing and Heating Engineering (CIPHE) (www.ciphe.org.uk)** Register of plumbers and installers of water efficient and sustainable appliances (GreenPlumb)
- **Envirowise (www.envirowise.gov.uk)** Enhanced Capital Allowance (ECA) scheme and the Water Technology List
- **Water Savings Association (www.biggreensmile.com)** List of water efficient products
- **Waterwise (www.waterwise.org.uk)** Lists of water efficient washing machines and dishwashers

NHBC Foundation publications

Open plan flat layouts – assessing life safety in the event of fire This research report is the result of a study examining the options for satisfying the requirements of the Building Regulations. It addresses layout, size, travel distances, enhanced detection options and sprinkler use. In addition it addresses the human implications, including the various reactions, wake up and response times from people occupying the building. ***NF19*** August 2009

Indoor air quality in highly energy efficient homes – a review This review assesses the current state of knowledge on indoor air quality in energy efficient, airtight houses in the UK and elsewhere in the world. It summarises the characteristics of homes built to Levels 4, 5 and 6 of the Code for Sustainable Homes, and discusses the relationship between indoor air quality and occupant wellbeing. ***NF18*** July 2009

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The use of lime-based mortars in new build ***NF12*** December 2008

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Zero carbon: what does it mean to homeowners and housebuilders? ***NF9*** April 2008

Site waste management ***NF8*** July 2008

A review of microgeneration and renewable energy technologies ***NF7*** January 2008

Modern housing ***NF6*** November 2007

Ground source heat pump systems ***NF5*** October 2007

Risks in domestic basement construction ***NF4*** October 2007

Climate change and innovation in house building ***NF3*** August 2007

Conserving energy and water, and minimising waste ***NF2*** March 2007

A guide to modern methods of construction ***NF1*** December 2006

NHBC Foundation publications in preparation

- Efficient design of piled foundations
- Sustainable drainage systems for housing

NHBC Foundation

Housing research in partnership with BRE Trust

www.nhbcfoundation.org

Water efficiency in new homes
An introductory guide for housebuilders

This guide, specifically intended for the smaller builder, provides an introduction to water efficiency. It outlines the standards being encouraged by the Code for Sustainable Homes, the Building Regulations and the *Water Efficiency Calculator for New Dwellings*. The technologies used to achieve water efficiency – ranging from simple tap flow restrictors all the way through to greywater recycling systems – are described, together with some key issues associated with each.

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Housing research in partnership with BRE Trust

The NHBC Foundation has been established by NHBC in partnership with the BRE Trust. It facilitates research and development, technology and knowledge sharing, and the capture of industry best practice. The NHBC Foundation promotes best practice to help builders, developers and the industry as it responds to the country's wider housing needs. The NHBC Foundation carries out practical, high quality research where it is needed most, particularly in areas such as building standards and processes. It also supports house builders in developing strong relationships with their customers.

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