BNWAT20: Very low water use water closets - Innovation Briefing Note

Version 2.0

This Briefing Note and referenced information is a public consultation document and will be used to inform Government decisions. The information and analysis form part of the Evidence Base created by Defra's Market Transformation Programme.

1 Summary

This Innovation Briefing Note outlines the current situation regarding water closets (WCs) available on the market, and considers how the introduction of ultra-low flush toilets (less than 3 litres) could impact on the demand for water by 2020. The barriers to uptake and the critical issues that need to be resolved before the toilets can be widely installed are considered, and an action plan that would result in solutions to these issues is suggested.

Household demand for water is rising, and is predicted to continue to rise owing to population growth and changes in occupancy and lifestyle. WCs currently account for up to 33.5%[1] of water consumption in households, particularly in older properties.

WCs are functional, as opposed to luxury, water-using appliances so they offer considerable potential for driving down household water demand without requiring a change in user behaviour. This will depend upon the availability of more water-efficient WCs. The replacement cycle for WCs is estimated to be around 15 years and they tend to be replaced for reasons of style, colour etc, rather than failure (except in the case of breakages). Therefore, the current limited availability of styles for very low flush volume WCs will act as a barrier to the selection of these units rather than a less efficient design. Pricing in the longer term should not be a barrier to uptake as currently available water-efficient WCs tend not to be priced higher than the market average. The long-term (10-year) decline in the price of base-line (inefficient) water-using equipment is expected to be 2.45%. Reductions in the price of water-efficient equipment of between 5% and 15% are expected, but it is recognised that the price of efficient products is never likely to be lower than the price of inefficient products. Current example prices for WCs are approximately £163 for a 6/4-litre dual-flush toilet, £275 for a 4.5-litre toilet, but surprisingly only £120 for a 4.5/3-litre dual-flush[2] toilet.

[1] MTP (2006). *Sustainable Products 2006 - Policy Analysis and Projections*. www.mtprog.com
[2] Environment Agency (2007). *Assessing the cost of compliance with the Code for Sustainable Homes*. www.environment-agency.gov.uk

Dual-flush toilets with flushing volumes as low as 4/2.6 litres are currently available on the UK market. In Scandinavia, dual-flush toilets with a 4/2-litre flush are widely available. Toilets with flushing volumes as low as 1.5 litres are currently being developed in the UK.

Very low flush WCs are defined for the purpose of this Briefing Note as those with an effective flush[3] of lower than 3 litres, for both single and dual-flush models. The WC must be able to connect to the existing drainage and sewerage system and be acceptable to stakeholders in terms of style and design. In order to be legally installed within buildings supplied by water companies, new WCs must meet the regulator's specification within the Water Supply (Water Fittings) Regulations 1999.

To encourage uptake of very low flush WCs and stimulate the market, standards that reflect emerging technology are required. Coupled with this, research into the potential impacts of a high uptake of very low flush WCs on sewerage systems (eg blockage rates) is required.

Modelling work shows that the uptake of very low flush WCs in the UK market potentially offers water savings of up to 47 Megalitres/day, or 17,155 Megalitres/year.

2 Sector profile

WCs have a very long service life (around 15 years, although many will last for longer if the flushing mechanism is maintained) and are most likely to be replaced for reasons of style rather than failure. They account for up to 33.5%[4] of water consumption in households, particularly in older properties.

In the UK, the cistern volumes of WCs installed in existing housing can vary widely. Cisterns installed up to the 1960s were of the order of 20 litres capacity, at which time the volume was reduced to 13 litres. The flush volume was further reduced to 11 litres and subsequently to 9.5 litres, with dual-flush becoming optional in 1981. All of the dual-flush cisterns had the same method of operation (ie 'pull and release' gave a 'half' flush whilst 'pull and hold' gave a 'full' flush). This requirement remained until 1993 when 7.5 litres maximum flush volume was introduced. The installation of dual-flush WCs was banned because of anecdotal reports that double flushing was leading to increased water use compared with single-flush cisterns. Flushing volumes have since been reduced to 6 litres or less, with the Water Supply (Water Fittings) Regulations 1999 making it a legal requirement not to install any WC with a flushing volume greater than 6 litres. It should be noted that the regulations prevent the installation, not the sale, of WCs with higher flush volumes. The regulations also allow the installation of dual-flush and valve flush mechanisms and the inclusion of internal overflows rather than the previous requirement for an external (overflow) warning pipe.

From 1 January 2001, the Water Supply (Water Fittings) Regulations allowed the installation of dual-flush cisterns. The regulations require a clear indication of operation and a maximum part-flush of two-thirds of the full flush. Currently, the

[3] BNWAT05: *Water closets - water efficiency performance tests*, defines and explains the term 'effective flush'.
[4] MTP (2006). *Sustainable Products 2006 - Policy Analysis and Projections*. www.mtprog.com

majority of dual-flush cisterns have nominally 6/4 litres or 6/3 litres flush volume, which manufacturers claim account for 75%-80% of all sales[5]. The majority of the remainder of sales are WCs with a 6-litre single flush, although dual-flush toilets with flushing volumes as low as 4/2.6 litres are currently available on the UK market. Ultra-low 4/2-litre dual-flush WCs are also available which use a drop-valve flushing mechanism, but these are currently not approved under the Water Fittings Regulations.

Advances driven by regulation have reduced the flush volume of WCs. The scope for further reductions in flush volume based upon conventional technology is declining.

3 Technology drivers

3.1 Energy reduction

It may appear that in most instances water is energy-free. However, water use and energy use are inextricably linked[6], with energy being used whenever water is used by consumers.

There are three primary areas of energy use with regard to water:

- Energy embodied in the water supplied.
- Energy used to heat domestic hot water and for central heating.
- Energy used in appliances (eg dishwashers, washing machines and pumps).

The above are sometimes referred to as 'the carbon content or carbon footprint of water'.

The embodied energy of water is the relevant factor regarding the flush volume of WCs. Pumping operations to move water from the point of extraction, through its various treatment stages and to the consumer require a significant amount of energy. Hence, reducing the flush volume of WCs will impact on the amount of water pumped, resulting in a reduction in the energy used.

It is likely that the concept of the carbon content of water will become an increasing driver for future regulations and water-saving measures.

The wastewater from the WCs will also require energy-consuming treatment, and this is discussed further in section 3.2.

3.2 Waste minimisation

The water used to flush toilets is normally of drinking water quality standard supplied via the water distribution system, unless rainwater harvesting or grey water systems have been installed within buildings. Water-efficient WCs use lower volumes of water per flush than conventional models whilst still achieving the same functional standards. Using an efficient WC therefore causes less wastage of high-quality treated water.

[5] National Water Conservation Group, Minutes of meeting, 1 October 2001.
[6] For more information see BNWAT18: *Accounting for the trade-off between energy and water use - Innovation Briefing Note*, at www.mtprog.com

In addition, the wastewater discharged from WCs has to undergo energy-consuming treatment so that it may subsequently be discharged into the environment. Therefore, using smaller flush volumes decreases wastewater quantities, thereby reducing the energy consumed by the wastewater treatment processes.

3.3 Water utilisation

Nominal flush volumes do not necessarily reflect the actual flush volumes of installed WCs. This is due to two factors: the installation and performance of WCs and user behaviour. The former can be addressed by improved design and installation whilst the latter requires the education of users to change their behaviour.

WC flushing mechanisms can be divided into those with valves and those that are valve-less, with the former sub-divided into single-flush and dual-flush or (for domestic installations) into drop-valves and flap-valves. In the UK the only valve-less flush mechanism currently available is the siphon, which was a legal requirement under the Water Byelaws (superseded by the Water Supply (Water Fittings) Regulations 1999). Currently, most dual-flush WCs use drop-valve mechanisms which allow the use of double buttons to activate the full and part flushes.

For siphons, the Water Fittings Regulations require any dual-flush device to default to full flush, the reverse logic to the dual-flush siphons of the 1980s in which the default was the half-flush. The current logic is that it is better to accidentally select the full flush and clear the bowl rather than accidentally selecting the part-volume flush which may not clear the bowl, thus requiring a repeat full flush.

Single-flush and dual-flush toilets are currently available that are more water efficient than the minimum required by the Water Supply (Water Fittings) Regulations. There are also a number of retrofit flushing devices available for reducing the flush volume of existing cisterns, but their effectiveness with older toilet bowls designed to be flushed with higher volumes of water has not been proved. It is essential that any proposed water-saving measures do not adversely affect the flushing performance of WCs, otherwise repeat flushing will take place and more water will be used.

3.4 Changes in society

The key driver behind growth in household demand for water is population growth. Figures are currently rising, with the population of England and Wales forecast to rise from approximately 53.05 million in 2004, to 62.20 million in 2020, an increase of 9.15 million.[7] The average household occupancy also impacts on water usage. This has decreased from 2.86 people in 1971 to 2.34 people in 2002 and is expected to fall further to 2.14 people in 2021. The reduction is due to an increasing number of single-person households, which the Government predicts will grow from 6.2 million in 2001 to 8.7 million by 2021, an increase of 2.5 million.

Work by Herrington[8] has shown that the *per capita* water use of WCs reduces as the number of people in the household increases. Further work by WRc has also

[7] BNXS25: *UK household and population figures 1970-2020*, MTP Cross Sector Briefing Note.
[8] Herrington, P., *Climate change and the demand for water*, Final report to the Institute of Hydrology and the Department of the Environment. HMSO, 1996.

confirmed this relationship[9]. This may not necessarily mean that the number of visits to the WC by each person is influenced by the number of people in the household, but that there is a relationship between the propensity to flush the WC and occupancy. The reasons for this are not fully understood but are likely to be behavioural. One possibility is that larger households usually include children who may not flush the WC as frequently as adults. Another reason may be that people in one or two person households are more likely to be in the house during the day (eg retired people).

The population growth and demographic changes are leading to increasing demand for housing, although building rates have dropped by 50% over the past 30 years. At the same time the average number of WCs installed in new housing has risen from 1.2 per private dwelling in 1971 to 2.6 per dwelling in 2001. It is important to note, however, that the number of WCs in a property is unlikely to affect usage and, therefore, water consumption.

WCs are most likely to be replaced as part of the refurbishment of a bathroom rather than as an individual item. Bathroom suites tend to be replaced for reasons of style (colour and design) rather than failure. On average, bathroom fittings are replaced every 15 years, long before they cease to be serviceable, but there is a wide range around this average.

Some factors can be a barrier to WC 'upgrade' where a complete bathroom suite is not being replaced. For example, colour can be an issue as many colours that were standard in previous years are now either no longer available or available only as a special order, generally at an additional cost. Similarly, whilst modern sanitary ware can complement very old or rustic interiors, ornate basins and modern WCs often clash. The availability of a replacement water-saving WC in the desired style or size will influence the decision to replace with such a unit or a less efficient WC of the required style. However, colour and style can also act as a driver to replace the complete suite.

Style and size are also factors in the selection of water-efficient WCs in new housing. Developers require WCs in a range of different styles and prices to suit the available space, type and price range of the property.

Social trends can adversely affect improved water efficiency, with heavy water use in the home often seen as an aspect of rising living standards (eg the installation of top-of-the-range appliances such as high flow power showers). WCs, however, are generally considered to be a functional appliance, although some may be marketed as having a 'luxury' style. Therefore, all other factors being equal, provided it does not adversely affect performance, improved water efficiency is likely to be considered as a benefit when selecting a replacement WC.

[9] Marshallsay, D., *Understanding domestic water use in context of demand management and forecasting*, IDS-Water Whitepaper.
http://www.idswater.com/Common/Paper/Paper_13/Understanding%20domestic%20water%20use%20in%20the%20context.htm

3.5 Globalisation of production and markets

Whilst all countries offer a range of WC styles, the UK appears to have the widest range. In Germany and Scandinavia there are dimensional standards that allow replacement using the same screw holes, without leaving a "shadow of the old".

WC suites are usually in one of five configurations: close-coupled, low-level, high-level, back-to-wall concealed cistern and wall-hung concealed cistern. Styles are usually chosen by consumers on the basis of style and fashion, with the high-level WCs seen as traditional, and close-coupled and concealed as modern or 'European'. Commercial installations tend to favour concealed cisterns for ease of cleaning and vandal resistance, while many domestic ones have recently selected this format for style. In the last five years, UK consumers have begun to embrace wall-hung and back-to-wall WCs[10], which had previously been sold only in Germany. This reflects the desire to keep bathrooms clean, simple and functional.

The Water Efficiency Labelling and Standards (WELS) Scheme in Australia[11] applies national mandatory water efficiency labelling and minimum performance standards to household water-using products, including washing machines, dishwashers, toilets, showers, taps and urinals. These, in combination with the energy labelling scheme, could be used as a benchmark.

In Australia and Germany, the 6/3-litre dual-flush WC is becoming more the norm, while in Scandinavia, the 4/2-litre dual-flush WC is now commonly installed.

3.6 Economic factors

Price comparisons for WCs are more complicated than for white goods. WCs tend to be fitted and often supplied by plumbers, and the installed cost will vary depending upon factors other than the purchase price of the unit, such as the ease of installation. The price also often reflects the style and quality of WCs rather than the water efficiency. This differs from white goods, where the cheaper appliances tend to be less efficient in terms of performance and resource use whilst the more efficient machines are more expensive. Generally, low-level suites are the cheapest, with off-the-floor wall-hung concealed suites the most expensive.

4 Goals

- To reduce the average volume of water used for flushing WCs by the increased installation of ultra-low flush WCs (<3 litres flush volume) that are acceptable to all stakeholders in terms of style, design and ease of use.

- To develop ultra-low flush WCs that can be connected to the existing drainage and sewerage system.

- To set standards that will preclude the installation of the current 6-litre and 6/4-litre flush WCs by 2015 (eg via either the Building Regulations or the Water Supply (Water Fittings) Regulations).

[10] The Bathroom Manufacturers Association (2006), *Bathroom Trends*.
[11] www.waterrating.gov.au

- To set standards that reflect emerging technology, thereby encouraging the continuous development of WCs with decreasing flush volumes.

- To develop standards and test methods for ultra-low flush WCs by 2012 to promote confidence with respect to flushing effectiveness, the volume of water used and to address potential issues regarding the drainage system.

- To encourage product information for WCs that gives clear data about their flush volumes.

5 Effect on MTP scenarios

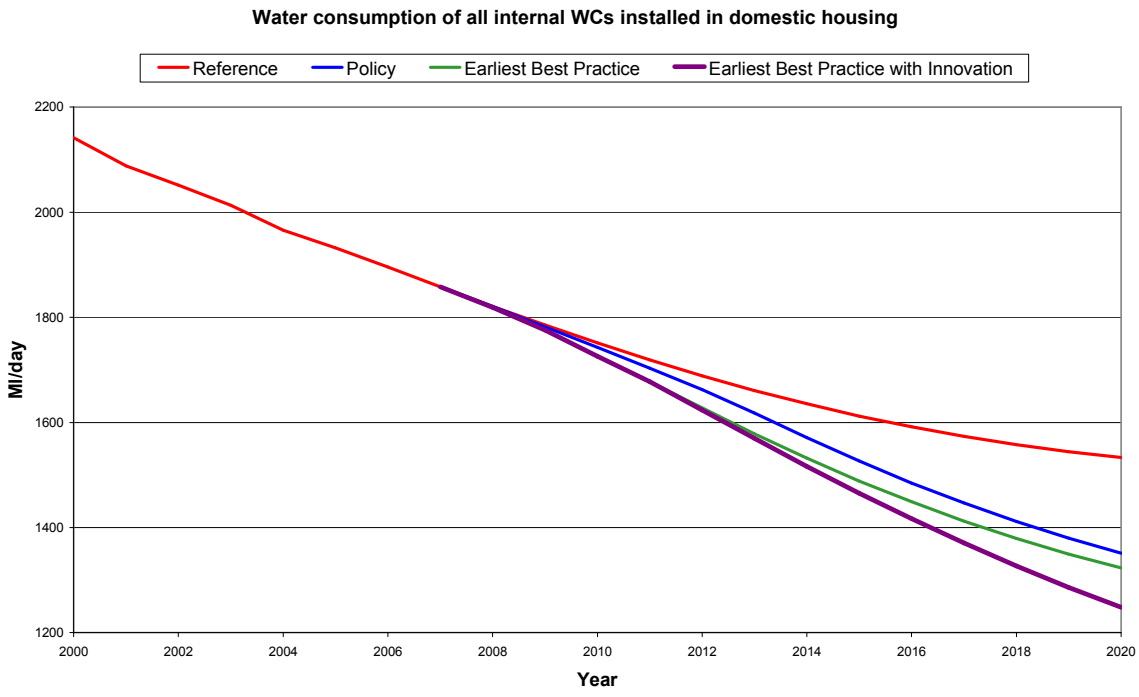
The impact of achieving the goals contained in this Innovation Briefing Note would be seen on the Earliest Best Practice (EBP) line within the MTP models and Policy Brief. It is thought that a significant impact would be seen on overall water consumption if the very low flush volume WC goals were achieved.

By 2015, there would be no sales of 6 or 6/4 litre WCs, and by 2012 there would be a significant number of WCs sold with flushing volumes less than 3 litres. By 2020, all WCs sold would have flushing volumes of less than 3 litres, with a considerable number flushing at 1.5 litres.

These savings would be realised only if all the goals were achieved - a combination of innovation, research, and policy change.

Figure 5.1 shows the impact of realising all of the goals on the MTP EBP scenario for WCs.

Figure 5.1 The impact of reaching the WC goals on the EBP scenario



In 2020, the potential reduction in water consumption by WCs is 75 Megalitres/day over the existing Earliest Best Practice projection.

6 Critical issues

6.1 Drainage research

The potential impact of the use of very low flush WCs in conjunction with other water-saving measures, on the design, operation and performance of the current drainage and sewerage system is not understood. There may be a risk that the reduced volume of wastewater will increase the blockage rates of drains and sewers, particularly for those drains and sewers that have intermittent flow such as occurs with those serving one or a small number of properties.

Questions to be resolved:

- Are the current 100 mm and 150 mm diameter waste pipes suitable for reduced flush volumes, or do smaller diameter pipes perform better?
- Are there any downstream wastewater implications?
- What is the optimal wastewater collection profile for the current sewerage system?

The WaND project[12] (Water Cycle Management for New Developments), funded by the Engineering and Physical Sciences Research Council (EPSRC), is focusing on wastewater collection as part of the research. Although focused on new properties, the project will provide information that is relevant to the existing drainage and sewerage system. The aim of the project is to review and develop a new, more sustainable technology wastewater collection system. This will be achieved by:

- Reviewing current innovative alternative collection technologies.
- Reviewing and assessing new small-bore systems.
- Devising and demonstrating the performance of a new low-water use, small-bore system.
- Developing a system model and design rules.
- Establishing the applicability of the system and interactions with other water systems.

6.2 Product development

Currently, the lowest volume flush toilet available on the UK market and approved by the Water Regulations Advisory Scheme[13] is a 4/2.6-litre dual-flush toilet which is designed to be connected to existing drainage systems. As part of the WaND project,

[12] www.wand.uk.net
[13] Water Regulations Advisory Scheme, www.wras.co.uk/Directory/Fittings_Search.asp

a prototype 1.5-litre flush toilet has been trialled[14] which has a unique, patented flushing technology. It uses a siphon flush and has a conventional water trap, ensuring that the WC meets current UK WC regulations.

To drive down the water consumption of WCs, innovation by manufacturers is required to increase the effectiveness of low-volume water flushes.

6.3 Ergonomic labelling

Options for improving the ergonomic labelling and design of water appliances to meet behavioural issues need to be considered. For instance, clear, internationally recognised marking of standard dual-flush controls needs to be designed into appliances. This will help to prevent double flushing of very low flush WCs due to inappropriate use.

6.4 Leakage from flushing mechanisms

It remains to be established whether or not there is a significant difference between the nominal flush volume of a WC and the installed flushing volume due to leakage. Problems with the flushing mechanism could be caused by the build-up of limescale in hard water areas, incorrect installation or mechanical failure. To ensure that very low flush WCs will cause a decrease in overall water consumption, it is necessary to ensure that the actual flush volume reflects the nominal flush volume of the WC.

7 Actions

These suggested actions, if completed, would enable the widespread uptake of very low flush toilets by 2020. The actions are designed to resolve the critical issues outlined in section 6.

7.1 Impact on drainage and sewerage systems

Gather evidence to determine whether the use of very low flush volume WCs will have any detrimental effects on the design, operation and performance of current drainage and sewerage systems. To be completed by 2010.

7.1.1 Progress to date

The Environment Agency has recently published a report into the impact of reductions in water demand on wastewater collection and treatment systems[15]. The links between potable water use, wastewater discharges and the ability for sewer solids to be carried away in the wastewater flows were examined by modelling water-using appliance usage in typical households. The modelling indicated that whilst reduced WC flush volumes offer the greatest demand reduction opportunities, it is these, along with baths, that provide the most significant force to move sewer solids. Evaluation of available evidence indicated that solids movement would be significantly reduced with lower flush volumes and, furthermore, that this could present a problem in drains taking very little flow such as those serving a single property or a few single occupancy properties. The likelihood of blockages and other operational problems could, however, be reduced by changing design standards for

[14] www.propelair.com/WRCpropelairtrials.pdf
[15] EA (2008), *Less water to waste - Impact of reductions in water demand on wastewater collection and treatment systems*, available at http://publications.environment-agency.gov.uk

drainage systems. These alterations could include the use of smaller diameter pipes, pipes with steeper gradients and pipe layouts with fewer pipes taking very little flow.

7.2 Nominal versus actual flush volumes

Gather evidence to determine whether the actual flush volumes of new WCs reflect the nominal flush volumes. Where differences are seen, investigate the causes to enable the problems to be overcome. To be completed by 2009.

7.2.1 Progress to date

A recent water industry collaborative project investigated the appliances responsible for water consumption in homes built after 2001. In theory, all of the homes in the study would have toilets installed which had nominal flush volumes of 6 litres or less. The study has shown that the average flush volume, across the 70 homes from which data were collected, was 5.93 litres. Homes with a dual-flush WC had an average flush volume of 5.4 litres, and a dual-flush ratio of 23 full to 20 part flushes.

In addition, MTP has conducted a review of evidence available surrounding the issue of leaking WC valves. Responses indicate that this problem is potentially widespread, and that there are many possible causes, including detritus on the valve, more machining of the sealing washer, and incorrect usage and installation. Evidence needs to be further gathered to quantify the scale of the problem, with regards to the proportion of installed WCs that are leaking and the amount of water that is being wasted by the leaks.

7.3 Innovative WC design

7.3.1 Develop innovative flushing technologies

Manufacturers to develop innovative flushing technologies in readiness for compliance with the standard set by amended Building or Water Regulations in the future.

7.3.2 Make innovative flushing technologies available

Manufacturers to make WCs available in a wide price range and a variety of styles, and fitted with innovative flushing mechanisms, by 2015.

7.3.3 Promote sales

Promote the sales of ultra-low flush WCs with 3 litres or less flushing volume, starting in 2012. The aim is that by 2020 no WCs are sold with a flush volume greater than 4.5 litres.

7.3.4 Progress to date

There is an increasing number of manufacturers providing highly efficient WCs to the market, including 4.5-litre single-flush and 4/3.5, 4/2.6 and 4/2 litre dual-flush WCs.

7.4 Amendment of regulations

Liaise with Defra/WSR and CLG with regard to the potential amendment of the Building Regulations and/or the Water Supply (Water Fittings) Regulations to preclude the installation of the current 6-litre and 6/4-litre flush WCs by 2015.

7.4.1 Progress to date

A joint Defra and CLG policy statement[16] was made on 23 July 2007 outlining how the Government intended to respond to views expressed by respondents. This statement is one of the supporting documents alongside the Government's Green Paper, *Homes for the future: more affordable, more sustainable*[17].

As a result of the views expressed, Defra will review the Water Fittings Regulations in 2008 with a view to setting revised maximum water use levels for products.

7.5 Ergonomic labelling

Undertake research into the impact of ergonomic labelling on user behaviour with regard to the operation of very low flush volume WCs. Completion of the research by 2009.

Depending upon the results of the above, reach agreement between manufacturers on the consistent design of symbols for the operation of dual-flush WCs by 2010.

Phase-in these WCs so that by 2015 all new units sold have the agreed ergonomic labelling.

7.5.1 Progress to date

MTP has so far not investigated the possibility of ergonomic labelling, as its focus has been on the issue of valve leakage for WCs.

Related MTP information

Briefing Note BNWAT18: Accounting for the trade-off between energy and water use - Innovation Briefing Note

Briefing Note BN DW WC: Actions to improve water closet design and efficiency - Briefing Note relating to Policy scenario objectives in Policy Brief

Briefing Note BNWAT05: Water closets - water efficiency performance tests

Briefing Note BNXS25: UK household and population figures 1970 - 2020. Cross Sector Briefing Note

Changes from version 1.1

Section 7 updated with progress on addressing the actions identified to overcome barriers to the widespread uptake of very low flush WCs.

Modelling section updated in line with changes in models for 2007-2008.

[16] The full policy statement can be found at www.communities.gov.uk
[17] www.communities.gov.uk/publications/housing/homesforfuture

Consultation and further information

Stakeholders are encouraged to review this document and provide suggestions that may improve the quality of information provided, email **info@mtprog.com** quoting the document reference, or call the MTP enquiry line on +44 (0) 845 600 8951.

For further information on related issues visit **www.mtprog.com**