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# Retrofitting variable flush mechanisms to existing toilets

July 2005

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# Executive summary

Toilet flushing has traditionally represented the largest single use of water in households, accounting for around 30% of total domestic water use. While the Water Supply (Water Fittings) Regulations 1999 reduced the maximum volumes of new toilets to 6 litres, a large proportion of existing housing stock has toilets which flush 7.5 litres or more.

Retrofit variable flush devices convert an existing single flush siphon cistern to a variable flush mode, offering a potential for reducing existing flush volumes without the expense of a complete toilet replacement.

This project is a collaboration between the Environment Agency and the following water companies:

Anglian Water
Bournemouth and West Hampshire Water
Environment Agency
Essex & Suffolk Water
Southern Water
South West Water
Sutton and East Surrey Water
Tendring Hundred Water
Thames Water
Three Valleys Water

The project built on the results of a previous trial of retrofit variable flush devices. Its aim was to explore further whether retrofit devices are suitable for demand management programmes.

Two devices – Ecoflush and Variflush – were trialled in domestic properties. The project used water consumption data gathered from 136 properties and feedback collected from 271 customers.

In the weeks after the devices were installed, water demand fell by an average of 8.5% per property. There was a wide variation between properties. This depended largely on the way the devices were used, the size of the household and type of the property. There was not any significant difference between the two devices.

Feedback from customer and installers was generally positive, although it included comments about improvements needed.

Savings could potentially be increased in two ways. First, by targeting specific groups of customers; second, making sure they know how to use the devices correctly.

The devices could help reduce domestic demand for water. However, the overall benefits would depend on how the devices are promoted and distributed. It might be necessary to conduct pilot studies on a wider scale to establish the take-up rates by customers.

# 1 Introduction

Flush toilets have traditionally represented the largest single use of water in households. They account for around 30% of total domestic water use. Water Supply (Water Fittings) Regulations 1999 reduced the maximum flush volume from the previous 7.5 to 6 litres. The Regulations also allowed dual flush technology, banned under the previous Water Byelaws, to be used again.

The Regulations reduced the flush volumes in new properties and in properties where older toilets are replaced. Many existing houses, though, have toilets that flush 7.5 litres or more. In an effort to reduce domestic demand, water companies have been offering customers free cistern displacement devices (CDDs), such as Hippo and Save-a-flush bags. These devices are easy for customers to fit and are useful as an interim demand management measure. They do not necessarily offer large water savings, though. In some cases, they may even make the flush less effective, leading to double flushing.

Several retrofit variable flush devices have been developed which potentially offer a more robust solution to reducing flush volumes than CDDs. Retrofit devices referred to here convert an existing single flush siphon cistern to a variable flush mode. (The merits of valve and siphon technologies have been discussed elsewhere (Grant, 2002)). Typically, the user is given a choice between a full and a reduced flush volume. Most of these devices are designed for DIY installation.

In a joint 1999 Southern Water and Environment Agency project, retrofit variable flush devices reduced flush volumes by an average of 27% (Keating and Lawson, 2000). The results of the project were instrumental in changing the Water Supply (Water Fittings) Regulations 1999, which previously prohibited the alteration of flush mechanisms.

Following the relaxation of the Water Regulations, a number of water companies agreed to take part in a larger scale trial. The aim of the trial was to assess whether retrofit variable flush devices could help reduce domestic water demand.

Southern Water initiated this project, which grew into a collaboration between nine water companies and the Environment Agency. The project set out to obtain a robust dataset on which companies could base their future demand management schemes.

The partners in this project were:

Anglian Water
Bournemouth and West Hampshire Water
Environment Agency
Essex & Suffolk Water
Southern Water
South West Water
Sutton and East Surrey Water
Tendring Hundred Water
Thames Water
Three Valleys Water

# 2 Project objectives and scope

The project objectives were to:

- quantify water savings at the household level resulting from the installation of retrofit variable flush devices;
- assess how well the devices performed;
- assess differences between devices;
- consider how various household variables might influence the amount of water saved;
- assess the viability of a wider scale programme of installation.

The project included first, retrofitting variable flush mechanisms in a sample of existing metered domestic properties in each water company supply area, and then monitoring changes in consumption at the meter level. The study was concerned only with measuring reductions in overall domestic water use. It did not look at other factors affecting demand.

# 3 Methodology

## 3.1 Devices

The two devices chosen for this project had been previously assessed in the 1999 project involving Southern Water and the Environment Agency: Variflush (manufactured by Peterton) and Ecoflush (manufactured by Gesek). Both devices are relatively easy to fit to an existing single flush cistern. In addition they both save a significant volume of water, and both were favourably assessed by customers and fitters. These two devices provide the options of a minimum, medium or maximum flush. The maximum volume is the same as the toilet's original flush volume.


**Figure 1 Variflush A**


**Figure 2 Variflush B**


**Figure 3 Ecoflush white**

Both products interrupt the operation of the siphon within the cistern by introducing air to it. A small drill hole is made in the top of the siphon and a pipe is connected to it, so that air can be fed from the variable flush device into the top of the siphon to interrupt its operation. The volume of the flush varies according to the setting the user chooses.

Ecoflush allows air to bleed into the siphon at different rates on minimum (MIN) and medium (MED) settings. On the MIN setting, the largest bleed hole is opened and the greatest amount of air is allowed in during the flush, interrupting the siphon's operation early. The MED setting has a slightly smaller bleed hole. This interrupts the siphon's operation later, allowing a greater flush volume. On MAX setting, no bleed hole is active: the siphon operates normally. There is also a simple airflow valve built into the pipe connector that is inserted into the top of the siphon. This allows the airflow to be adjusted if the flush volumes need fine-tuning.

**Figure 4 Ecoflush components**

**Figure 5 Fitted Ecoflush**

Variflush has two open-ended dip-tubes of different lengths projecting down from the unit. When the MIN setting is selected, the shorter pipe connects to the siphon. During the flush, when the water level falls below the level of the pipe, air enters the pipe and interrupts the siphon. On the MED setting, the longer pipe is connected. This allows a longer flush before interruption. No pipe is connected on the maximum setting, so the siphon operates normally.

Variflush comes in two types: type A (left- or right-hand) and type B. In Variflush type A, the selector knob is incorporated in the handle, much the same way as the Ecoflush device. Type B Variflush is just a selector knob. It can be fitted without disturbing the existing handle in the spare blanked handle hole.

**Figure 6 Variflush A components**

**Figure 7 Fitted Variflush A**

### 3.2 Project design

The joint study was designed to maximise the benefits to participating companies while keeping the project costs to a minimum. Each company monitored the effect of variable flush devices in a sample of households in its supply area. Companies used the same methodology and worked to a common timescale. The Environment Agency then pooled and analysed all the data.

#### 3.2.1 Proposed design

All companies worked to a common protocol to ensure consistent data capture. This included sticking to project timescales when installing and downloading the loggers, installing the devices and monitoring. Specifically, it was planned that:

- each company would trial both devices;
- each company would install devices in a similar number of households;
- loggers would be installed on the household meters before the devices were fitted, to record how much water was used before the installation;

- devices would be fitted to all household toilets where possible;
- monitoring would continue for an agreed period before and after the devices were installed. Periods of increased water consumption (such as half term, Easter school holidays and the onset of garden watering in spring) would be avoided;
- initial and final questionnaires would gather data on occupancy, the numbers of toilets with and without devices installed and the type of household;
- users would be asked to give feedback on how easy the devices were to use and how well they performed; fitters would be asked to report back on how easy the devices were to fit and how robust their design was;
- the combined dataset would be analysed to maximise the sample size and reduce statistical uncertainties.

### 3.2.2 Project timetable

The following timetable was specified for the project:

**Table 1 Project timetable**

| | |
|---|---|
| November/December 2003 | Recruit participants |
| 2nd week January 2004 | Install loggers to monitor background consumption |
| Week commencing 16thFebruary 2004 (half term) | Install variable-flush devices and logger downloads |
| Before April 2004 (to avoid Easter break) | Final logger download* |
| From summer 2004 | Analysis and final report |

* Where possible, loggers were to remain in place to allow for further downloads if necessary and possible phase 2 of the project in autumn 2004.

### 3.2.3 Customer recruitment

Only properties with a metered supply were sought for the project. Each water company recruited its own volunteers through a variety of methods, as described in Table 2.

**Table 2 Recruitment methods and property numbers***

| Water company | Method of recruitment | Initial sample size | Final sample size in trial |
|---|---|---|---|
| Anglian | Random 1,000 customers with loggable meters; participants in previous water efficiency projects | 50 | 34** |
| Bournemouth & West Hampshire | Meter optants and occupier change; 400 selected and sent letters, 97 responded; 20 ultimately chosen and logged | 20 | 10 |
| Essex & Suffolk | Meter optants | 50 | 39 |
| Southern | Housing Association tenants | 54 | 51 |
| South West | Meter optants, Housing Association tenants and new properties | 53 | 53** |
| Sutton & East Surrey | Meter optants and new properties | 10 | 10 |
| Tendring Hundred | Meter optants | 20 | 20** |
| Thames | Unmeasured pcc monitor volunteers who switched to meters but were still monitored as before transfer | 60 | 58 |
| Three Valleys | Meter optants and previous meter reading project | 50 | 32 |
| **Total** | | | **200** |

* See also Table 3 for data used in analysis
** Not used in joint analysis for reasons described under 3.2.6.

### 3.2.4 Project management

Once they had been pre-selected by each company, customers in the initial sample were invited to participate in the project. They were sent questionnaires asking about the types of toilet in the house, occupancy data and other information. For an example of the initial questionnaire, see Appendix A. Participants were chosen on the basis of the responses received. A preliminary visit was arranged during which the logger was installed and the meter read. Several companies followed this up fairly quickly with a second visit to check that the logger was working and get the first data download.

The devices were fitted and the logger data downloaded during the week beginning 16 February 2004. All companies aimed to fit devices to all toilets in each house to avoid uncertainties regarding use and to achieve a reasonable level of clarity of the results. The choice of devices was, on the whole, arbitrary, though some companies did let the customer choose. In cases where the chosen device could not be installed for technical reasons, the fitter would substitute the other design.

All companies aimed to install roughly equal numbers of Variflush and Ecoflush devices. The fitters made sure that the customers knew how to operate the devices and affixed stickers with instructions on toilet cisterns.

Companies downloaded the final logger information in April 2004. Because of the Easter break and likely changes in the pattern of demand due to the expected warmer weather, an arbitrary cut-off date for data inclusion was set at 15 April.

Once the project was completed, customers were asked to complete a final questionnaire (see Appendix B), which was conducted largely by telephone. This was to confirm information from the initial survey and solicit customer feedback on the devices installed, such as how acceptable they were, how easy they were to use and a general opinion of the devices as a water saving measure. Companies removed the devices at this stage if customers requested them to do so. Feedback on installing the devices was also collected from the fitters.

Companies could choose to remove loggers after the project. Several, though, opted to leave them in place so that data could be downloaded several months later to confirm the sustainability of water savings.

### 3.2.5 Data collection

Consumption was logged at 15-minute intervals in each property. Daily aggregates were provided for the analysis. The companies were asked to provide these aggregates to the Environment Agency in an agreed format.

As well as logger and meter data, the information from the customer questionnaires was collated along with billing records from the previous 12 months and property classification data (using ACORN – see glossary). Meter readings and billing data were used to verify the logger results. In a number of cases, there seemed to be a discrepancy.

### 3.2.6 Deviation from agreed methodology

#### 3.2.6.1 Participating properties

The original intention was for each company to meter some 50 properties. This was not achieved for a number of reasons, for example:

- customers changed their minds about taking part;
- customers expressed interest but could not be contacted;
- water meters were not suitable for logging (though some companies changed meters to enable data collection);
- toilet cisterns were not suitable for retrofit (for instance, *flush-and-let-go/flush-and-hold* dual flush, valve dual-flush, slimline cistern types or other design-related reasons);
- customers moved house during the study period;
- customers already had a device fitted and failed to mention it at selection stage.

Overall, 200 properties participated, with numbers in each company area listed in Table 2.

#### 3.2.6.2 Timescales

Anglian Water and Tendring Hundred could not comply with the agreed timescales (see Table 1) because of a lack of resources. Their datasets were analysed separately, but the results are discussed in the context of those obtained from the joint analysis.

#### 3.2.6.3 Data collection

The logging equipment for South West Water was delivered late. No logger data was therefore available, and their results are based on meter readings only. This dataset was analysed separately and results are discussed below.

#### 3.2.6.4 Data quality

In spite of initial checks, the flow data from a number of loggers was very much higher than expected for domestic consumption. Consequently, the decision was taken to remove from the analysis all those properties where the logged daily consumption exceeded twice the average daily consumption from the previous year and where the per capita consumption (*pcc*) was over 250 litres/head/day.

Any household where not all toilets had been retrofitted was also excluded. The analysis of savings in these partially retrofitted households is discussed separately in section 4.6.

Table 3 shows how many properties were analysed.

**Table 3 Property numbers submitted and used for the joint analysis**

| Company | Company No. | Original sample size | Final sample size |
|---|---|---|---|
| Bournemouth & West Hampshire | 1 | 10 | 8 |
| Essex & Suffolk | 2 | 39 | 29 |
| Southern | 3 | 51 | 48 |
| Sutton & East Surrey | 4 | 10 | 9 |
| Thames | 5 | 58 | 28 |
| Three Valleys | 6 | 32 | 14 |
| **Total** | | **200** | **136** |

Individual company datasets may not be representative of the wider population. The pooled dataset does, however, cover a range of social groups and property types more typical of a random cross-section of the national housing stock (ODPM, 2004) (see Table 4). The average occupancy ratio of the pooled dataset was 1.9 persons/property, in line with the average metered occupancy in England and Wales (OFWAT, 2003-2004).

**Table 4 Distribution of property types by company**

| Company | Property type | | | | Total |
|---|---|---|---|---|---|
| | Flat | Terraced | Semi- | Detached | |
| 1 | 1 | 0 | 1 | 6 | 8 |
| 2 | 2 | 3 | 6 | 18 | 29 |
| 3 | 31 | 6 | 8 | 3 | 48 |
| 4 | 2 | 2 | 5 | 0 | 9 |
| 5 | 5 | 4 | 11 | 8 | 28 |
| 6 | 0 | 1 | 5 | 8 | 14 |
| **Total** | **41** | **16** | **36** | **43** | **136** |
| As % of participating properties | 30 | 12 | 26 | 32 | 100 |
| National housing stock profile (%)** | 17 | 26 | 33 | 23 | 99 |

** Survey of English Housing, 2004, ODPM

# 4 Data analysis

We analysed the pooled dataset to maximise the sample size and to ensure the robustness of the results. We included data from all companies whenever logger data was not required, (i.e. when analysing questionnaire results). For all analysis relying on logging results, we used data from companies listed in Table 4 only.

### 4.1 Pre-installation consumption

Figure 8 illustrates the average pre-installation consumption (litres/property/day) in each company's households and the associated 95-percentile confidence interval around these values. Differences between companies reflect the wide variation in property type and sample sizes. Pooling the data from all 136 properties gives a mean household consumption before installation of 244 litres/property/day.

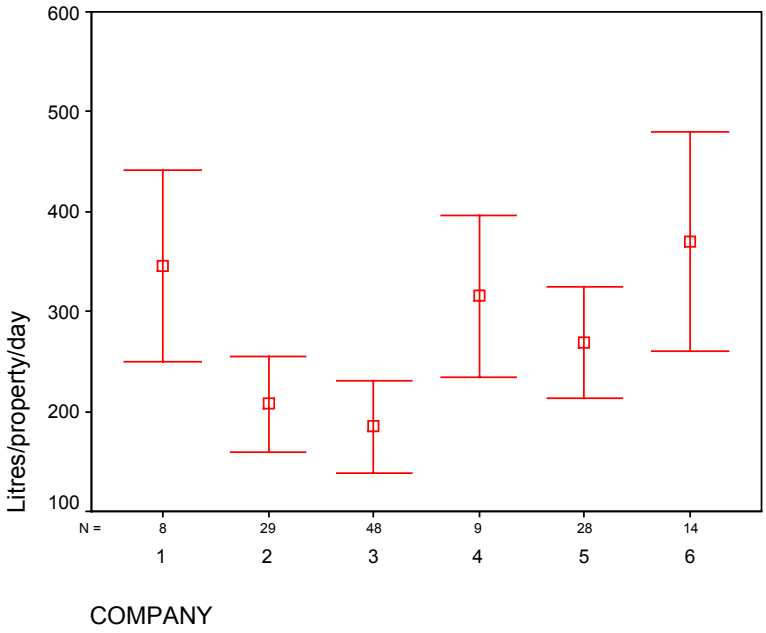



**Figure 8 Mean pre-installation consumption rates by company**

### 4.2 Changes in water consumption after device installation

We analysed data recorded between 1 January and 15 April 2004. This was in order to exclude times when we expected water-use to rise, such as the Easter holiday and warmer weather. Data taken when the devices were being installed was also excluded.

For each property, we worked out the average daily consumption before and after installation. The difference between these two figures demonstrated how much water each property could save by using the variable flush device.

If $Q_p$ and $Q_q$ represent the average daily consumption (litres/day) in each household during the pre- and post- installation periods respectively, then the absolute change in consumption is ($Q_p$ - $Q_q$). The relative percentage change in consumption is ($Q_p$ - $Q_q$)*100/ $Q_p$.

The 136 households used, on average, 20.8 litres/property/day less after the devices were installed. This represents about 8.5% of their pre-installation consumption. Inevitably, there were large variations in water

use between individual households. The 95% confidence interval around the mean saving ranged from 5.6% to 11.4%.

Table 5 shows the average reductions in household consumption in each company sample. Figure 9 shows the relative percentage savings and 95-percentile confidence intervals around the mean for each company's dataset.

The spread of results, as illustrated by the 95-percentile confidence intervals, is relatively large. Significantly, quite a few (35 out of 136) properties, found in all company's datasets, recorded an *increase* in consumption after the retrofit installation. The reasons for this are unclear. It could in part be due to initial flush volumes being less than the cistern capacity. But without measuring individual flush volumes, this cannot be substantiated.

**Table 5 Reduction in consumption by company**

| Company | Number of properties | Mean reduction in consumption (l/p/d) |
|---|---|---|
| 1 | 8 | 22.3 |
| 2 | 29 | 11.1 |
| 3 | 48 | 19.5 |
| 4 | 9 | 44.6 |
| 5 | 28 | 24.6 |
| 6 | 14 | 15.8 |

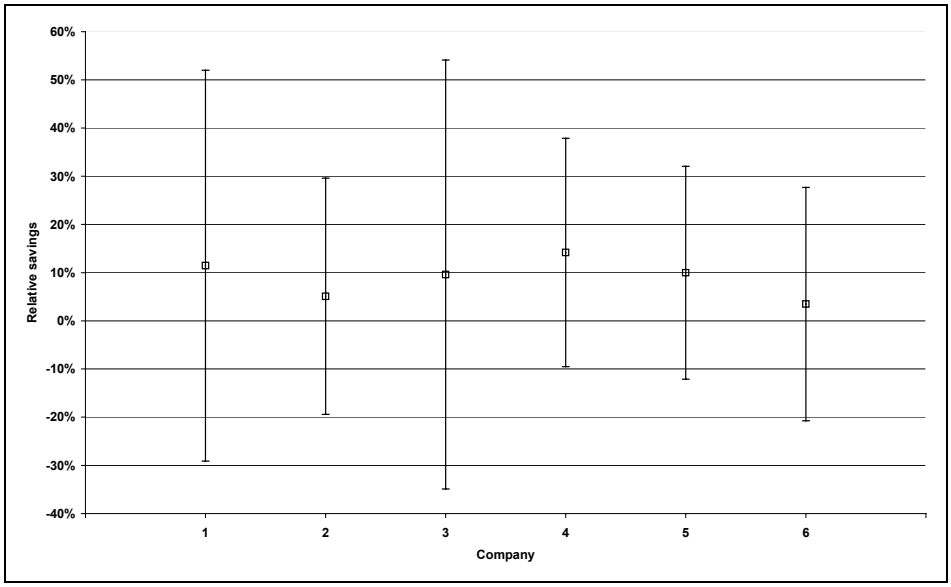



**Figure 9 Relative reduction in household consumption**

### 4.3 Influence of household variables

#### 4.3.1 Water consumption and property type

Properties were characterised as flats, terraced, semi- or detached. Table 6 and Figure 10 illustrate the reductions in consumption recorded in each property type.

**Table 6 Reduction in consumption by property type**

| Property Type | Number of properties | Mean Reduction in consumption (l/p/d) |
|---|---|---|
| Flat | 41 | 23.2 |
| Terrace | 16 | 34.9 |
| Semi-detached | 36 | 20.7 |
| Detached | 43 | 11.4 |

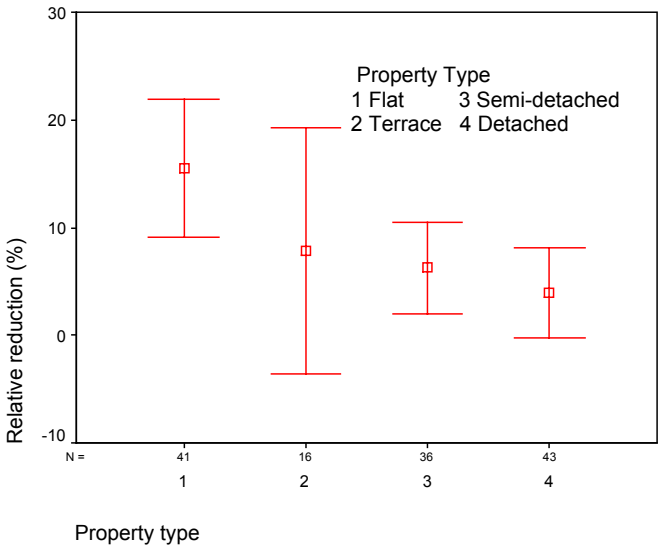



**Figure 10 Reduction in consumption by property type**

The total volume of water used for flushing in each property is proportional to occupancy, the flush volume and how often the toilet is flushed. It is likely to be independent of overall domestic consumption, hence the lower relative percentage savings in larger properties.

### 4.3.2 Changes in *per capita consumption*

**Table 7** and **Figure 11** illustrate the distribution of occupants by property type. Overall, 263 people lived in the 136 properties, yielding an average occupancy ratio of 1.9, but varying between 1.2 in the flats to 2.4 in the detached houses.

**Table 7 Property occupancy rates**

| | Occupancy rate | | | | | | |
|---|---|---|---|---|---|---|---|
| **Property Type** | **1** | **2** | **3** | **4** | **5** | **6** | **Total** |
| Flat | 32 | 9 | 0 | 0 | 0 | 0 | 41 |
| Terrace | 8 | 4 | 2 | 2 | 0 | 0 | 16 |
| Semi- | 12 | 12 | 7 | 4 | 0 | 1 | 36 |
| Detached | 10 | 20 | 3 | 5 | 5 | 0 | 43 |
| Total | 62 | 45 | 12 | 11 | 5 | 1 | 136 |

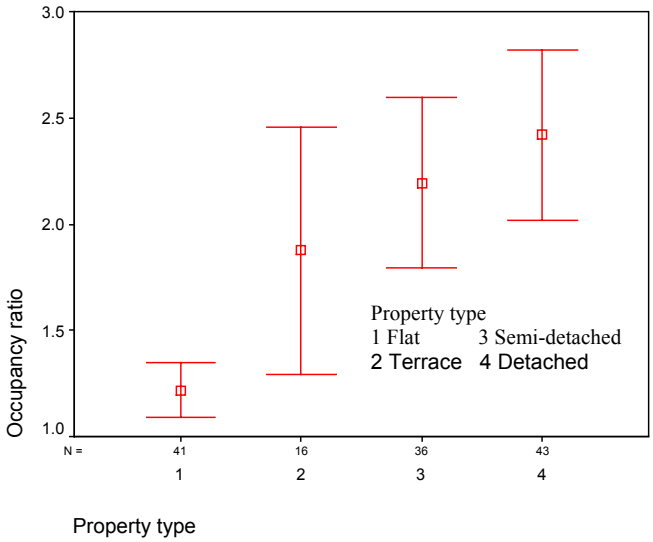



**Figure 11 Occupancy ratios by property type**

Using the notation of section 4.2, the *per capita* reduction in each property is defined as $(Q_p - Q_q)/N$, where N is the number of residents in the household.

Table 8 and Figure 12 illustrate the change in *per capita consumption* (pcc) in relation to property type. Overall, the observed mean reduction in *pcc* was 13.2 litres/head/day.

**Table 8 Reduction in *per capita* consumption**

| Property Type | Number of properties | Mean reduction in *pcc* (l/h/d) |
|---|---|---|
| Flat | 41 | 20.9 |
| Terrace | 16 | 20.1 |
| Semi-detached | 36 | 9.1 |
| Detached | 43 | 6.7 |

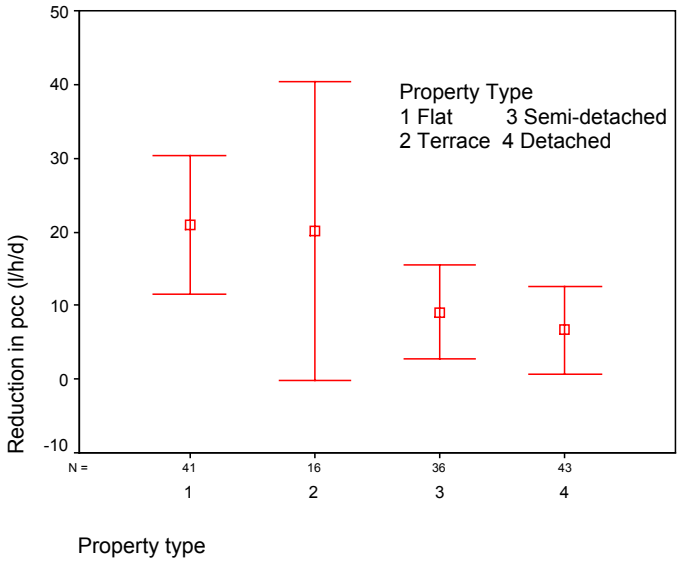



**Figure 12 Reduction in per capita consumption by property type**

The daily per capita consumption (*pcc*) is the sum of all the components of demand. Toilet use is the one component that is generally independent of the total *pcc* volume, but this changes depending on the volume of the cistern. The relationship between the *pcc* in individual households and the subsequent changes in consumption following device installation are explored in Figure 13. The figure demonstrates the considerable degree of scatter between the two variables. This indicates little relationship between the two. It supports the suggestion that the savings are a proportion of a relatively fixed flush volume, not the overall water use.

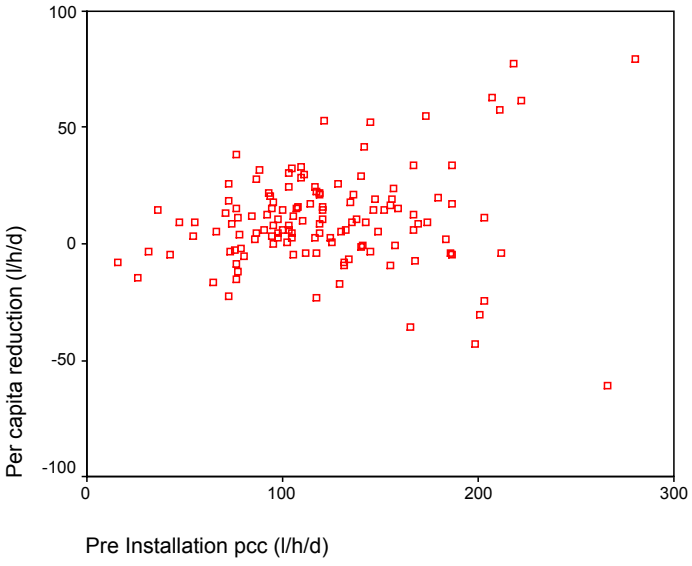



**Figure 13 Absolute changes in consumption with respect to pcc**

### 4.4 Changes in water consumption and number of devices fitted

One of the project objectives was to fit devices in all toilets in households taking part. This was not always possible for a variety of reasons. In some cases, for example, it was simply not possible fit the devices to particular cistern designs. Customers in other households did not want them fitted for aesthetic reasons.

In addition to the 136 households where all toilets were retrofitted (and which were used in the analyses described above), there were a further 41 households where only some of the toilets had the devices fitted.

On average, properties where all toilets were retrofitted saved 20.8 litres/property/day, or 8.5% of the initial water consumption. The 41 properties where only some toilets were retrofitted saved an average of 5% with 68% confidence limits. These lower savings confirm previous results (Keating and Lawson, 2000), but the wide confidence limit suggests caution in interpreting the results. The savings achieved in these properties clearly vary depending on how often people use the various toilets.

### 4.5 Cost benefit of fitting the devices

#### 4.5.1 Benefit to water company

The devices clearly affect household consumption. For water companies, they present an attractive option for reducing the domestic demand for water. The overall cost and benefit of a wider scale programme would, however, depend largely on factors outside the scope of this project, for instance:

- how devices are distributed – promotion, subsidised sale, free provision or fitting by the company;
- customer take-up rates;
- costs of customer liaison: if devices are fitted free, this could include the costs of processing customer data, arranging appointments and providing a customer service;
- costs of fitting the devices;
- the marginal cost of water.

#### 4.5.2 Benefit to customer

Only customers on measured charges benefit financially. The average price for water and sewerage (assuming 92.5% rate of sewer return) in England and Wales is £1.87 per cubic metre (OFWAT, 2005-2006).

The average volumetric savings in this study were 20.8 litres/property/day, which equates to 7.6$m^3$/year. In financial terms this would translate to a saving of £14.20 per year.

The retail price of the devices at the time of writing is around £20, giving an average payback of just under 17 months. This period will decrease if the devices are provided at a subsidised cost.

It is important to bear in mind that the above figure is an average. Savings to customers will vary according to water company area, occupancy and other factors. The water and sewerage costs vary across the country, from the lowest of £1.32 to the highest of £3.09/$m^3$. Accordingly, the annual savings would vary from £10.03 to £23.48, with the respective payback from 24 to 10 months.

The water costs quoted above are for 2005-06. They will increase during the rest of the 2005-2010 period, yielding further financial benefits to the customers.

### 4.6 Changes in consumption relative to the device installed

Two different types of devices were fitted: Ecoflush and Variflush. The way they work is described under Methodology. 71 households were fitted with Variflush, while Ecoflush was fitted in 57 households (see Table 9).

**Table 9 Distribution of retrofit devices by company**

| Device type | | | | Total |
|---|---|---|---|---|
| **Company** | **Ecoflush** | **Variflush** | **Both** | |
| 1 | 2 | 3 | 3 | 8 |
| 2 | 10 | 16 | 3 | 29 |
| 3 | 25 | 23 | 0 | 48 |
| 4 | 3 | 5 | 1 | 8 |
| 5 | 8 | 19 | 1 | 28 |
| 6 | 9 | 5 | 0 | 14 |
| **Total** | **57** | **71** | **8** | **136** |

Figure 14 shows the relative savings by device type, while Table 10 summarises the results.

Households fitted with Variflush saved on average 9.3% of their original water use. Households fitted with Ecoflush saved an average of 7.9%. Statistically, there is no difference in performance between these two devices, reflecting the wide sample variances and different numbers of properties in each subset.

In eight households, both devices were fitted. These households showed average savings of only 3.5%. The reasons for this much lower figure are not known. It is possible that occupants were unsure how to use them.

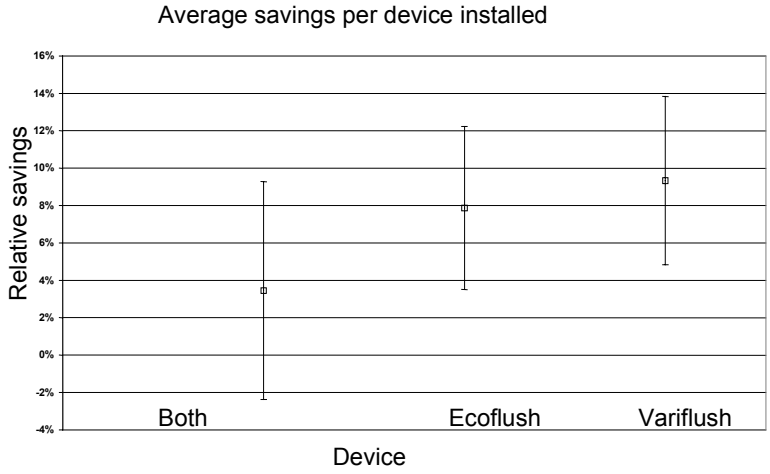



**Figure 14 Average savings per type of device installed**

**Table 10 Reduction by device type**

| Device type | Number of properties | Mean reduction in consumption (l/property/d) |
|---|---|---|
| Ecoflush | 57 | 16.9 |
| Variflush | 71 | 24.0 |
| Both installed | 8 | 9.8 |

### 4.7 Customer feedback analysis

Once the data logging phase was over, feedback on the general use of the devices was obtained from the trial participants through a telephone survey. Questions allowed yes/no answers and gave respondents the chance to make other comments. Completed questionnaires were obtained from 271 households. Table 11 below lists the distribution of completed questionnaires by company and device installed.

**Table 11 Distribution of customer questionnaires**

| Company | Device installed in property | | | | Number of completed questionnaires |
|---|---|---|---|---|---|
| | Variflush | Ecoflush | Both | Unknown | |
| Anglian | 12 | 16 | 4 | | 32 |
| Bournemouth & West Hants | 7 | 5 | 2 | | 14 |
| Essex & Suffolk | 22 | 14 | 2 | | 38 |
| Southern | 24 | 25 | | | 49 |
| South West | 22 | 23 | | | 45 |
| Sutton & East Surrey | 6 | 3 | 1 | | 10 |
| Thames | 23 | 15 | 1 | 15 | 54 |
| Three Valleys | 13 | 16 | | | 29 |
| **Total** | **129** | **117** | **10** | **15** | **271** |

Here are the responses to the questions, along with and a broad interpretation of the results:

**Question 1 In general did you/your family find the flush device easy to use?**

| Installed Device | Answer | | Totals |
|---|---|---|---|
| | Yes | No | |
| Variflush | 122 | 7 | 129 |
| Ecoflush | 104 | 13 | 117 |
| Both | 14 | 1 | 15 |
| Unknown | 8 | 2 | 10 |
| **Totals** | **248** | **23** | **271** |

Most respondents found the devices easy to use. Of those that did not, more Ecoflush users (11%) had difficulty than Variflush users (5%).

**Question 2 Did you/your family regularly use different flush settings on the device or did you stick to one setting?**

| Installed Device | Answer | | | Totals |
|---|---|---|---|---|
| | Used one setting | Variable settings | Not known | |
| Variflush | 33 | 94 | 2 | 129 |
| Ecoflush | 29 | 86 | 2 | 117 |
| Both | 6 | 9 | 0 | 15 |
| Unknown | 3 | 7 | 0 | 10 |
| **Totals** | **71** | **196** | **4** | **271** |

More than 26% of respondents claimed that only one flush volume was regularly selected in their household. There was little difference between users of the two devices.

**Question 3** **Did you/your family find that occasionally you had to flush more than once to clear the toilet pan?**

| Installed Device | Answer | | Totals |
|---|---|---|---|
| | No | Yes | |
| Variflush | 56 | 73 | 129 |
| Ecoflush | 37 | 80 | 117 |
| Both | 8 | 7 | 15 |
| Unknown | 1 | 9 | 10 |
| **Totals** | **102** | **169** | **271** |

Almost two thirds of the respondents claimed that 'double-flushing' was occasionally necessary. But given the responses to the earlier question about using variable or fixed flush volumes, the following additional question can be posed: *Do those who only use one flush setting double-flush more frequently than those who use the device correctly?* The results in the table below suggest that this is not necessarily the case. Those who stick to a single short flush are just as likely to double-flush as those who do not stick to one flush setting.

| | Use of variable flush settings | | | Totals |
|---|---|---|---|---|
| Double-flushing | No | Yes | Unknown | |
| No | 23 | 76 | 3 | 102 |
| Yes | 48 | 120 | 1 | 169 |
| **Totals** | **71** | **196** | **4** | **271** |

We do not have any data on double-flushing frequency prior to device fitting, so we ca not assess whether the devices had any effect on rates of double-flushing.

**Question 4** **Has the device made you/your family think about using water wisely?**

| Installed Device | Answer | | Totals |
|---|---|---|---|
| | Yes | No | |
| Variflush | 108 | 21 | 129 |
| Ecoflush | 94 | 23 | 117 |
| Both | 10 | 5 | 15 |
| Unknown | 8 | 2 | 10 |
| **Totals** | **220** | **51** | **271** |

81% of respondents said they were more aware of using water wisely as a result of the trial. The remaining 19% claimed that using the device had not encouraged them or their family to think about using water wisely. It is not clear why this group wanted to take part in the study, except perhaps to save money. However, a few of those who answered "No" claimed they were already using water wisely.

**Question 5** **Are you happy to keep the device after the trial has ended?**

| Installed Device | Answer | | Totals |
|---|---|---|---|
| | Yes | No | |
| Variflush | 121 | 8 | 129 |
| Ecoflush | 97 | 20 | 117 |
| Both | 15 | 0 | 15 |
| Unknown | 8 | 2 | 10 |
| **Totals** | **241** | **30** | **271** |

Most participants wanted to retain the device after the trial ended, although fewer of those in this group were Ecoflush users (83%) than Variflush users (94%). Most of those who wanted to keep the devices considered themselves/families to be 'water wise'.

| Wish to retain the device after the trial | Water wise | | Totals |
|---|---|---|---|
| | No | Yes | |
| No | 17 | 13 | 30 |
| Yes | 34 | 207 | 241 |
| **Totals** | **51** | **220** | **271** |

**Question 6 Would you recommend the device to others?**

| Installed Device | Answer | | Totals |
|---|---|---|---|
| | Yes | No | |
| Variflush | 110 | 19 | 129 |
| Ecoflush | 86 | 31 | 117 |
| Both | 13 | 2 | 15 |
| Unknown | 7 | 3 | 10 |
| **Totals** | **216** | **55** | **271** |

Most participants claimed that they would recommend the device to others. Though again fewer of this group (74%) were Ecoflush users than Variflush users (85%).

**Question 7 Would you be prepared to buy the device at a cost of about £20?**

| Installed Device | Answer | | Totals |
|---|---|---|---|
| | Yes | No | |
| Variflush | 74 | 55 | 129 |
| Ecoflush | 57 | 60 | 117 |
| Both | 7 | 8 | 15 |
| Unknown | 4 | 6 | 10 |
| **Totals** | **142** | **129** | **271** |

Slightly more than half of the participants claimed they would buy the device for £20, but the Ecoflush users were proportionately more likely to say no.

### 4.8 General comments from installers and customers

The companies involved collected feedback from installers while the devices were being fitted. This is summarised below. The individual companies' reports in Appendix A have more detail. Here, too, is a summary of the reasons why devices were subsequently removed or replaced, along with customers' general comments.

The feedback from installers was mixed and often conflicting. Some preferred Variflush, others thought that Ecoflush was simpler to install and more universal.

Specific comments included:

- Ecoflush could not be fitted to slimline cisterns;
- Ecoflush fitted slimline cisterns while Variflush did not;
- Ecoflush handle was too chunky, making it difficult to use;
- Variflush B was easier to install as no handle had to be changed;
- Variflush B's design obstructed the ball valve in slimline cisterns;
- Variflush was too complicated (three different models);
- Variflush's three different models meant that it could be fitted to most cisterns;
- Variflush had smaller diameter thread, making it more suitable for cisterns with smaller diameter holes;

- Variflush's safety clip was too flimsy;
- Variflush's air pipe was made from hard plastic and difficult to bend.

Several devices had to be removed. Others had to be replaced during the project. Reasons included:

Removal:
- Variflush – aesthetic reasons (2)
- Variflush – broken handle (2)
- Variflush – broken flange and loose dip pipe (1)
- Variflush – not working properly (5)
- Variflush – stopped flushing (1)
- Ecoflush – not working properly (7)
- Ecoflush – handle coming out (1)
- Unknown – not working properly (3)

Replacement:
- Ecoflush – setting mechanism sliding to maximum setting (5)
- Variflush – plastic retaining clip faulty (1)
- Variflush – breakage (1)
- Unknown – breakage (1)

Some of the reasons above reflect installers' comments on durability. Some customers also commented on the 'prototype' nature of the devices, indicating that some design issues may need to be resolved. Some customers commented that three settings are too many.

Detailed comments can be found in companies' reports in Appendix A. Appendix C contains the conclusions from the more recent customer focus group exercise conducted by Essex & Suffolk Water, which reinforces customer comments on robustness, aesthetics and ease of use.

# 5 Discussion of the results

## 5.1 Reductions in consumption

These results compare favourably to those from the previous study (Keating and Lawson, 2000), which achieved a 27% reduction in the flush volume, estimated to equal to 8% of domestic demand.

Each of the companies participating in this trial also analysed their own datasets (see Appendix A). The average savings calculated from these subsets vary from 6% to 16%. The variations are because of the different size and nature of their datasets and the different methods of analysis.

There are large variations between individual properties. This was also seen in the previous study (Keating and Lawson, 2000), where results varied from a maximum 64% reduction in flush volume to a net increase of 28%.

Wide variations are almost inevitable in any project where human factors play a part. Domestic demand fluctuates on daily basis, and the differences cannot always be explained. In addition, the devices tested in this trial were controlled by the user, and so the volume of water flushed depended on what setting they chose. All those taking part were told in detail how the device worked, and a 'how-to-use' label was affixed to each cistern. But the results suggest that customers did not always use the devices correctly. The fact that a third of them admitted that they never changed the setting proves this.

The toilets' original flush volume is probably another reason for the wide variation in water savings. This trial included retrofitting nominal 9, 7.5 and 6 litre flush cisterns. Cistern volumes were not measured directly. Instead, customers were asked to estimate how old the toilet was, which gave an indication of the likely cistern volume. This, though, may not be accurate. The nominal flush may also be quite different from the actual flush, because of variations in pressure, refill rates and volume adjustment.

Net increases in consumption were observed in 35 out of 163 properties. We do not know exactly why, but incorrect use may be a factor. Some customers may have been tempted to leave the device on the lowest setting to save as much water as possible. This clearly cannot be delivered if the flush is not of sufficient volume to clear the pan and the user ends up flushing twice or more.

Fluctuations in the size of households may be another factor. In a large-scale programme, this would not necessarily be an issue. But increases in consumption (due to long-term visitors, for example) could be seen in this relatively small sample of 136 properties.

The previous study (Keating and Lawson, 2000) found that increases in consumption after retrofitting were related to the size of the household. There, the largest increase was seen in a family fostering children on short-term basis. The relatively frequent change of occupants, combined with the lack of education in using the device, was considered to be the likely reason for the observed increases.

The amount of water saved depends heavily on whether customers use the devices correctly. It is therefore of paramount importance that customers know how to use them properly. For this reason, these devices may not be appropriate for use in public buildings where it is not possible to educate everyone who might use the toilets. .

The correlation between occupancy and the volume of savings was also apparent in this study. The largest per-person savings are achieved in smaller households. This has implications in terms of targeting customer groups to achieve best results. Smaller households, particularly with retired occupants, may provide the highest benefits both to the company, in terms of reducing demand, and to the occupants, in terms of reduced water bills.

The increases seen in some properties may have been caused by previously lowered cistern volumes, which the installers may have adjusted back to their nominal settings. No information was gathered during installation to investigate this further.

However, even with the observed increases in 25% of the participating properties, the overall average achieved reduction of 8.5% of the pre-installation per property consumption is significant enough for these devices to be used in larger scale demand management projects. With careful targeting and appropriate education, the savings could be higher.

In 136 properties, all toilets were converted to variable flush. But 41 households were only partially retrofitted. The results clearly show that the fully retrofitted properties save the most water. This is not surprising, and the two main reasons for this are probably that:

- If only some toilets have a reduced flush volume, the overall amount of water flushed daily is likely to be higher than in similar properties with all toilets retrofitted;

- Users in partially retrofitted households may find it harder to get into the habit of using the devices correctly. If different toilets operate on different principles, it would be more difficult to remember to adjust the dial before flushing.

### 5.2 Savings and per capita consumption

There was a clear link between the volume of savings and the type of property (and occupancy rates). But there was no relationship between the initial per capita consumption and the level of savings. This is not surprising, because the per person flush frequency is relatively stable and, as a component of the domestic demand, is likely to be independent of socio-economic factors. The two main factors affecting the overall flush volumes are first, the cistern capacity, and second, whether the occupants are at home all day. The latter may have influenced the larger savings seen in smaller occupancy properties (where lower occupancy may be related to retired occupants).

### 5.3 Type of device, preferences and robustness

On average, properties equipped with Variflush saved more water. But the differences between the two devices on trial were not statistically significant, due to the large variations between properties.

Slightly more customers (see chapter 4.7) preferred Variflush, both for ease of use and in terms of whether they would recommend the device to others. Feedback also suggested that three settings on the devices offered too much choice. The devices' robustness and aesthetic features could also be improved.

The mixed feedback from installers did not suggest any major differences in terms of how easy the devices were to install. Again, though, some elements of the design could be improved to make fitting easier and to increase the robustness of the devices.

### 5.4 Application in demand management schemes

The trial results suggest a good potential for reductions in domestic demand. The overall savings would, however, depend on many factors.

Nearly half of the customers taking part in the trial said that they would not buy the device at the current retail price of £20. This suggests that unsubsidised promotions on a wider scale might have a limited impact, particularly among unmetered customers.

Subsidising the device may increase take-up rates. Interest among customers would depend on the level of metering in the given area, the price of water and the final purchase price of the device. Southern Water promoted the devices in 2004 at a subsidised purchase price of £12. The promotion was open to some 50,000 customers in Sussex, but only a handful bought one.

Providing free devices is likely to generate the most interest and reach unmetered customers who lack the financial incentive to buy the device. Free fitting would help, too – not only would it ensure that the device is properly fitted, but there would also be some degree of after-care in case of problems. However, take-up rates from a wide-scale, free fitting programmes remain unclear at this stage, and can only be assessed by pilot fitting schemes.

The overall cost of a wider-scale fitting programme depends very much on the take-up rates, installation costs and the level of customer liaison necessary. The experiences of the companies involved in this trial showed that the cost, and the level of service obtained from contractors, varied. One route that could be explored further is liaison with housing associations. If the water company provided the devices and housing association plumbers fitted them, for example, such a partnership could help maximise potential savings and ensure correct fittings, instructions and customer care.

Finally, these devices are designed for retrofitting in older style siphon toilets. They will not provide the same level of savings in households where toilets have been installed or replaced after January 2001. Also, not all older cisterns can be retrofitted. Concealed cisterns and those with handles on the side, for example, ca not be converted. Slimline cisterns may also be difficult to retrofit. So the overall proportion of toilets that could be converted is not clear. This and customer take-up rates are the main factors affecting the final benefits of any future retrofit schemes.

# 6 Conclusions and recommendations

Retrofitting variable-flush devices to existing toilets in domestic properties achieved an average reduction in demand for water of 8.5% per property.

Savings could be increased by targeting customers in smaller properties and making sure that customers know how to use the devices correctly.

Not all cisterns can be retrofitted; the proportion of those likely to be suitable is not known.

There were no significant differences between Variflush and Ecoflush in terms of water savings achieved, nor in ease of fitting or robustness, although there was a slight customer preference for Variflush.

The aesthetics, robustness of design and ease of operation of the devices trialled could be improved.

The overall benefit of using variable flush devices in demand management projects depends on how the devices are distributed and on customer take-up rates. More customers are likely to take up the device if it's provided and fitted free of charge. Customers are unlikely to take up the device without a subsidy. Metered customers, who would almost immediately see the financial benefits of using less water, are more likely to use the devices than unmetered customers.

Wider-scale pilot studies are needed to establish take-up rates and overall benefits for demand management.

# Appendix A Companies' reports

### A1. Anglian Water

**Methodology**

Customer selection
One hundred customers were identified and then invited to take part in the variable flush project. These customers were selected from a group of users that had expressed an interest or had previously been involved in similar domestic consumption water efficiency trials.

Of the original one thousand invitation letters issued only 110 customers responded (approximately 10%). The participants were located in an urban area within one major town which reduced associated project management cost.

A desktop assessment focusing on cistern suitability resulted in 55 of the 110 properties being selected for inclusion in the trial. This fell to 34 because some of the respondents did not fulfil the necessary criteria.

Ten properties were found not to have loggable meters. Here, the variable flush devices were installed, but only meter readings were available for consumption analysis.

**Table A1.1 Property details**

| Property Type | Property numbers |
|---|---|
| Bungalows | 2 |
| Semi-detached houses | 9 |
| Detached houses | 15 |
| Terraced houses | 8 |

**Table A1.2 Occupancy details**

| Occupancy level | Property numbers |
|---|---|
| 5 | 2 |
| 4 | 5 |
| 3 | 1 |
| 2 | 20 |
| 1 | 6 |

Contractor selection
Three local plumbing companies gave quotes for undertaking and managing the project as follows:

- conduct pre-installation surveys, including installation of loggers and initial meter reading;
- make appointments with participants to install devices;
- install variable flush devices, take interim meter check reading and audit download of loggers (to ensure data capture function);
- take interim check meter reading and download interim loggers after agreed period;
- conduct the final download and remove loggers, taking final check meter reads;
- provide appropriate customer service response (only relating to devices installed).

The work was given to the installer that could offer the best overall package.

**Products**

Terminology
Left-handed cistern – cistern with the flushing handle on the left.
Right-handed cistern – cistern with the flushing handle on the right.
Two-hole cistern – cistern with the flushing handle options on the left or right, with the unused hole being plugged with a cosmetic cover.

As previously stated, two types of variable flush devices were selected:

1) Variflush (manufactured by Peterton)
The 'A' device is suitable for both left- and right-handed cisterns.
The 'B' device is suitable for two-hole cisterns, and the original flushing handle remains in place.
This product was supplied with a chrome finish-flushing handle as standard.

2) Ecoflush (manufactured by Gesek)
This device is suitable for both left- and right-handed cisterns.
This product was supplied with a white finish-flushing handle, but is available in various finishes (i.e. chrome and polished brass).

Details
Fifty-four devices were provided and installed free of charge in each of the selected 34 properties.

**Table A1.3 Devices used**

| Device | Numbers installed |
|---|---|
| Variflush | 22 |
| Ecoflush | 32 |

Other factors
The type of toilet cistern dictated which device was installed. The installer was given the freedom to select and install the most appropriate device for each cistern type. Participants were offered a choice of devices only if it was practical to do so.

**Feedback at installation**

Participants with existing chrome finished flushing handle favoured a chrome-finished handle on the device.

The installer reported that the 'Variflush' 'B' device was generally easier to install. This is because it could be installed on cisterns without the need to change the existing handle, provided there was a blanking hole on the other side of the cistern. Here, the variable flushing device could be fitted through the blanking hole.

The 'chunky' nature of the 'Ecoflush' handle could interfere with the normal flushing and could trap fingers or knuckles against the cistern cover.

It was not possible to install devices in slimline cisterns or those that had a cover secured by a screw to the top of the siphon.

Some participants did not like the adhesive instruction label and did not want it stuck on the cistern. They usually agreed to stick it somewhere else nearby (i.e. wall or door).

There were no reported problems with appointments or access issues.

**Data Collection Issues**

There were no notable data collection issues.
All logging data was successfully downloaded at the specified intervals. Meter check readings and logger audit checks were taken throughout the trial period.

Trial Closure
Questionnaires were sent to the 34 participating properties; 32 responded.

**Devices removed and associated problems**

No devices installed have been permanently removed. There were some associated problems with the durability of certain devices. Six devices were replaced throughout the trial due to malfunction.

**Table A1.4 Devices replaced**

| Device | Number | Problem |
|---|---|---|
| Ecoflush | 5 | Setting mechanism sliding to maximum setting |
| Variflush | 1 | Plastic retaining circlip on flushing handle faulty |

**Analysis of the results**

The data was excluded from the joint analysis as the agreed timescales for the trial could not be adhered to – the device installation took place in May/June 2004.

Of the 33 properties that were monitored, three showed increases in the average water consumption after the devices were fitted.

Overall, the trial demonstrated that water savings of 15.7% could be achieved. This saving was calculated by comparing the daily average after the devices were fitted to that before the devices were fitted.

**Table A1.5 Summary of results**

| Ref No. | No. WC | No. of full time employed adults | Children <16 | No. of occupants | Device Installed | Date of Installation | WC flush before | WC flush after | PPC before (litres) | PPC After (litres |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 4 | 0 | 4 | Eco x 1 | 07.06.04 | 9 | 7 | 435 | 305 |
| 2 | 1 | 0 | 0 | 1 | Vari A x 1 | 21.05.04 | 12 | ? | 184 | 116 |
| 3 | 1 | 0 | 0 | 1 | Vari A x 1 | 19.05.04 | 9 | 10 | 179 | 207 |
| 4 | 1 | 1 | 2 | 5 | Eco x 1 | 26.05.04 | 7 | 7 | 390 | 260 |
| 5 | 1 | 0 | 0 | 1 | Eco x 1 | 18.05.04 | 9 | 8 | 166 | 122 |
| 6 | 1 | 0 | 0 | 2 | Vari A x 1 | 18.05.04 | 10 | 9 | 318 | 291 |
| 7 | 2 | 2 | 2 | 4 | Vari A x 1 Eco x 1 | 18.06.04 | 13 | 12 | 365 | 269 |
| 8 | 2 | 0 | 0 | 2 | Eco x 1 Vari B x 1 | 21.05.04 | 10 | 10 or 6 | 289 | 273 |
| 9 | 2 | 1 | 3 | 5 | Eco x 1 Vari A x 1 | 26.05.04 | 9 | ? | 738 | 344 |
| 10 | 2 | 1 | 2 | 4 | Eco x 1 Vari B x 1 | 01.06.04 | 11 | 9 or 11 | 356 | 375 |
| 11 | 2 | 2 | 0 | 2 | Vari A x 1 Vari B x 1 | 27.05.04 | 7 | ? | 225 | 147 |
| 12 | 2 | 0 | 0 | 2 | Eco x 2 | 07.06.04 | 10 | 9 | 369 | 314 |
| 13 | 2 | 2 | 0 | 2 | Eco x 2 | 04.06.04 | 9 | 8 or 10 | 330 | 364 |
| 14 | 2 | 0 | 0 | 2 | Eco x 2 | 02.06.04 | 10 | 7 | 279 | 224 |
| 15 | 2 | 0 | 0 | 2 | Vari A x 1 Vari B x 1 | 19.05.04 | 9 | ? | 334 | 269 |
| 16 | 3 | 0 | 0 | 2 | Eco x 3 | 01.06.04 | 12 | ? | 524 | 507 |
| 17 | 1 | 1 | 0 | 2 | Vari A x 1 | 02.06.04 | 11 | 10 | 203 | 196 |
| 18 | 1 | 1 | 0 | 1 | Eco x 1 | 03.06.04 | 10 | 7 | 925 | 479 |
| 19 | 1 | 0 | 0 | 1 | Vari A x 1 | 19.05.04 | 9 | 8 | 174 | 159 |
| 20 | 1 | 2 | 1 | 4 | Vari A x 1 | 26.05.04 | ? | ? | 336 | 192 |
| 21 | 2 | 2 | 0 | 2 | Eco x 2 | 08.06.04 | 11 | 11 | 319 | 266 |
| 22 | 3 | 1 | 2 | 4 | Eco x 3 | 27.05.04 | 12 | 9 | 624 | 511 |
| 23 | 1 | 0 | 0 | 2 | Vari A x 1 | 18.05.04 | 13 | 8 | 363 | 327 |

- Frequency plots compared 'before' and 'after' data to see if we could detect a smaller use of water per flush. We followed the same methodology used by Essex & Suffolk Water (see page 35).
- Results were rather unclear, but there were maybe 10 properties that appeared to have reduced their flush. Volumes varied.
- Analysis remains limited due to the fact that the meter was only fitted to the stopcock and not the WC(s) in question. A very simple look at average daily flow both before and after, though, shows that most properties seem to have reduced their average daily consumption.
- Again, we cannot draw a great deal of information from this as higher use prior to the device being fitted may be due in part to the warmer weather and garden watering.

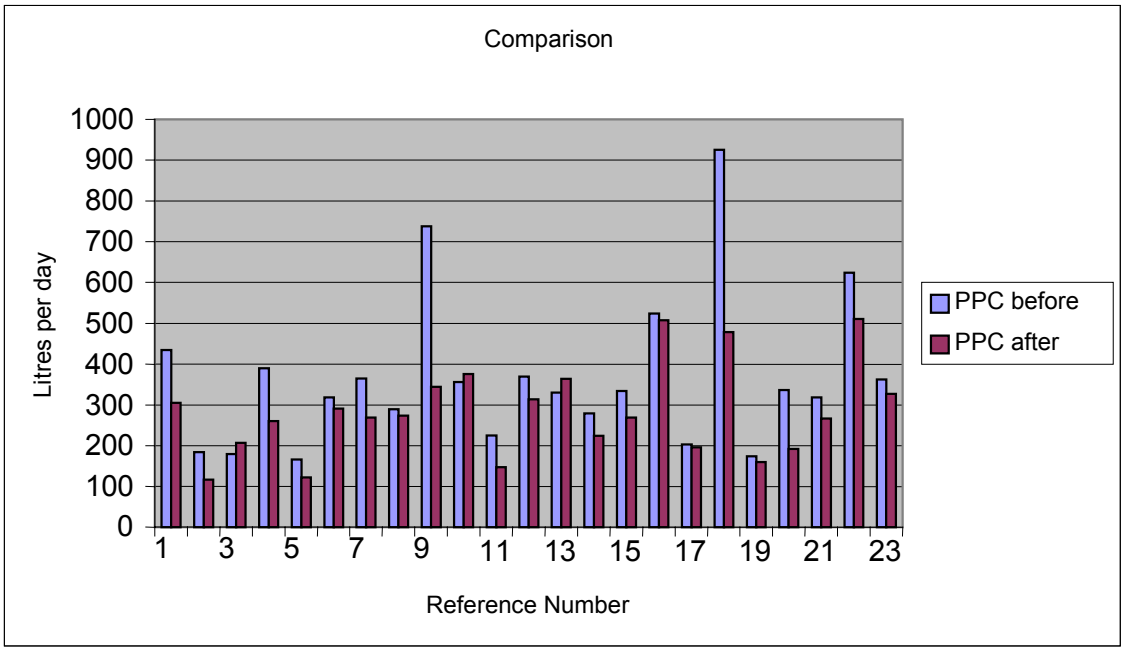



**Figure A1.1 Graphical comparisons of PPC**

Factors influencing the results

Several factors may have contributed to the trial results:

- overall water consumption measured at household level;
- unseen leakage not identified;
- water use by specific household appliances included;
- WC pan moulding may affect flush performance;
- WC location in premise may affect flush performance;
- soil pipe installation design or configuration may affect flush performance;
- foul water configuration installation design or may affect flush performance;
- flushing volume settings could be readily adjusted by occupier;
- occupants taking holiday during trial period;
- occupants having guest and visitors during trial period;
- extended monitoring period.

## A2. Bournemouth and West Hampshire Water

### Methodology

Customer selection
To narrow down suitable properties, the company produced a list of 13,120 recent customers whose properties had been fitted with Sensus Sn610 or Sn620 meters, enabling data logging. Addresses were chosen in specific areas to minimise travelling. They were spread over three different pressure regimes. Letters were sent out to 400 customers inviting them to take part. We offered to supply the cistern devices and fit them for free. They would also be entered into a prize draw for £25 worth of tokens for responding. We had 97 completed questionnaires returned.

We tried to select properties with more than one occupant in the property and no history of sewer blockages. The toilet cisterns had to be 7.5-9 litre capacities without handles on the side face of the cisterns. In the past, we have experienced not being able to fit Ecoflush devices to cisterns with handles on the side. The 22 selected addresses were inspected to check that the meter/stopcock chambers were not leaking and that the data loggers could be connected to the meters and inserted into the chambers. One of the addresses could not be logged and another cancelled, as they would be away during the trial, leaving 20 taking part.

Contractor selection
The contractor selected was a self-employed maintenance man who had previously installed water butts on a project for us. He provided individual rates for installing and removal of the devices. He was cheaper than a qualified plumber would have been.

We asked customers to tell us which days and times would be most convenient for the contractor to install the devices. This information was passed to the contractor, and he made the appointments and organised his work.

### Products

For the trial, 20 Ecoflush devices and 20 Variflushes were purchased. The Ecoflush can be installed in both left- and right-handed cisterns. Four were purchased in gold finish, the rest in chrome. We also bought 15 right-hand type ‘A’ Variflush and one left-hand, also four type ‘B’.

### Feedback at time of installation

Our contractor found that in some cisterns only the Variflush could be fitted as the hole in the cistern was too small to fit the Ecoflush. In these cases, no choice could be given the customer. Where the Ecoflush could be fitted, a choice of finish was given.

**Table A2.1 Devices used**

| Types fitted | Number |
|---|---|
| Variflush Type ‘A’ right-hand | 14 |
| Variflush Type ‘A’ left-hand | 1 |
| Variflush Type ‘B’ | 4 |
| Ecoflush Gold | 1 |
| Ecoflush Chrome | 7 |

The two products have different diameter threaded sleeves that go through the cistern wall. The Variflush is 18.6mm diameter, one millimetre smaller than the Ecoflush. The contractor preferred the Variflush in its different types as it could be fitted to most cisterns.

### Feedback from customers and removal of devices

One householder told us that the handle on the Variflush had broken and he had put his old handle back in. No details were given as to how or where the unit had broken.

Two customers asked for the units to be removed. One thought the Variflush that had been installed was unsightly. The other customer had an Ecoflush and a Variflush. There was no problem with the Ecoflush, but the Variflush was broken where the flanged body with the markings MIN, MED and MAX meets the threaded sleeve that goes through the cistern wall. This may have been due to over-tightening on installation or rough treatment. The longer of the two dip pipes had also come loose.

**Data collection issues**

After the final inspection, 20 addresses were selected and data loggers installed on all the meters on 13 January 2004. During the project, the meters were read and downloaded at the same time to enable verification of the data on the following dates: 20 January, 19 February, 1 March and 13 April.

Two new data loggers had faulty body gaskets and filled with water, preventing them from being read by infrared. The data from one was recovered, but data from the other lost was lost. Another logger recorded zero flow and the fault was not seen early in the trial, as the pit was always flooded. The data from the loggers was validated against the meter readings for each site, and seven sites did not match. The reason why the data did not agree was traced to the types of transducers being used on the meters. Some of them were missing pulses. The others were producing double and sometimes treble the number of pulses that should have occurred.

**Analysis of the results**

Only data from ten addresses where the logger data agreed with the meter readings was submitted to the Environment Agency for analysis.

Although the logger data did not correspond with the flow through the meter, in some cases it did give an indication as to when water was being used, and was used in our own analysis. When calculating the daily averages, the number of days when no water was used was deducted from the total number of days. We used this information and the meter readings to calculate daily average use. The daily averages calculated were based on a larger number of properties than the data submitted for analysis to the Environment Agency.

From the original 20, we could use meter readings from 16 addresses. The reasons four were excluded were:

- no flow data from logger as the transducer was incorrectly fitted;
- property had a leak on the meter/stopcock chamber;
- householder moved during the trial leaving the property empty;
- when the contractor called, he found the householder already had an Ecoflush installed but had not told us.

Of the 16 properties we used, two showed an increase in consumption after the devices were fitted. One had a 3.35% increase in daily average, the other 0.12%.

Overall a 14.75% saving was calculated from the daily average after the devices were fitted as compared with the daily average before.

## A3. Essex & Suffolk Water

### Methodology

Customer selection and number
Fifty properties that met certain criteria (e.g. the property was metered externally and fitted with a 9 or 7.5 litre flush WC) were to be recruited. The customers also had to be willing to take part in this project. From a discrete geographical area within the postal code areas of SS15 5 and SS15 6, 1,446 properties were approached about the project using the standard questionnaire and letter. This resulted in 260 responses.

Plumbers visited potential properties and made sure that answers given in the questionnaire were accurate, that the toilets could be converted and made a note of any restrictions on the type of mechanism suitable for fitting. From this information, 42 properties were chosen. A further eight properties were recruited by the plumber cold-calling at properties already mailed but who had not responded.

Contractor selection
H2O Water Services Limited (H2O) were chosen to carry out customer recruitment and vetting and were also responsible for installing the devices.

Difficulties encountered
During the project, various problems occurred when trying to fit the devices. As these problems only arose part way through the project, there was no time to recruit new properties and collect a significant period of baseline data. The following problems were experienced:

- two properties refused to have the device fitted, although they had been aware of the aims of the project and the need to have the toilet changed;
- sixteen properties were lost due to problems with their toilet, which meant that the device could not be physically fitted on all toilets within the property;
- two properties were lost because after repeated attempts to contact them to fit the device, no contact could be made.

This left 30 properties with devices fitted and good logger data. This highlights the need to recruit more properties than are needed in order to allow for a proportion to drop out.

### Products

The number of products installed in the 30 properties was as follows:

**Table A3.1 Devices used**

| Products | Number of properties |
|---|---|
| Variflush | 17 |
| Ecoflush | 10 |
| Mixture of Variflush + Ecoflush | 3 |
| Total | 30 |

### Feedback at time of installation

The Ecoflush could not be fitted to slimline cisterns, which automatically meant the Variflush had to be fitted to these toilets. Despite instructions to plumbers to allocate devices in equal numbers, more Variflush than Ecoflush devices were installed.

The customers were not given the choice of device. When some people saw the colour of the handles, they were not keen to have the device fitted, as they did not match with the colour of the rest of the bathroom.

Initially, the plumbers seemed to prefer the Variflush mechanism to the Ecoflush. When they actually came to fitting the device, this view changed as the plumbers found that the Ecoflush was actually simpler and quicker to fit. This was due to the smaller hole that had to be drilled into the cistern. They found that the safety clip provided with the Variflush was less substantial than the Ecoflush and were worried this would fail during use. They also commented on the Variflush air pipe being made of 'hard' plastic. This made it difficult to fit, and to overcome this, it needed warming in order to make it more pliable.

Only one property had to be revisited after the device was fitted. The customer called to say they were experiencing difficulties with their toilet. This turned out to be a problem with the ball valve. This problem may have existed before the device was fitted, but as this could not be proved, the toilet was mended and the customer was satisfied with the service they received.

**Data collection issues**

The loggers were downloaded monthly; a meter reading was also taken at the same time to validate the logger data. The loggers were installed in order to collect at least six weeks of pre-installation data to provide a baseline consumption. Four loggers failed at the start of the project, but they were all replaced as soon as possible. This meant that on these properties, there was only four weeks' data available before the devices were installed. This is still a significant period, and these properties were included in the analysis. Equal time periods before and after the installation date were used in the analysis and the data was treated as weekly data to include the effects of weekend usage. Two sets of logger data did not match the meter readings, and so these also had to be discounted from analysis.

**Number of devices removed**

Of the 30 properties, four wanted the devices removed (two properties with Variflush devices and two with Ecoflush devices). The main reason for this was that people felt the devices did not save water and they kept the device flushing on maximum flush volume. One person did not like the colour and style of the device.

**Data analysis**

The average relative reduction in water consumption from 28 properties was 7.5%. This excluded the two properties that had failed logger data.

We could not conclude from this that any change in consumption was due solely to the change in toilet device. However, as flow rates were recorded at every 15-minute period, analysis of the lower flows associated with toilet flushing (3 –15 litres) was undertaken. By comparing the frequency of lower flows, a more certain conclusion can be made concerning the actual amount of water saved due to the installation of the dual flush device.

We produced frequency plots comparing before and after data. We expected to observe a peak at flows used for flushing the toilet. If the peak shifted from a higher flow before the device was installed to a lower one after, this would mean there has been a reduction in the flush volume for flushing the toilet. We assumed that the number of times a toilet is flushed per day would not change over the period of logging, i.e. the frequency of the before peak should be similar to the peak after (unless double flushing occurs for the lower volumes). As these devices have more than one setting however, it is unlikely there would be just one peak once the device is installed. Looking at the data after installation, frequencies over a range of flows may need to be compared with a single frequency before. The other consideration is that as the logger only recorded pluses every 15 minutes, some toilet flushes will occur over two time periods, therefore splitting the flow. To overcome these, two data points either side of the peak should also be considered.

For example looking at property 684775 (see Figure A3.1), before the device was installed, there was a peak at 9 litres with a frequency of 128 but including the frequency of 8 and 10 litres, the total frequency or number of toilet events is 202. After the device was installed, the main peak shifted to 8 litres with a smaller peak at 6 litres. The total number of events after was also 202. This is seen in the graph below.

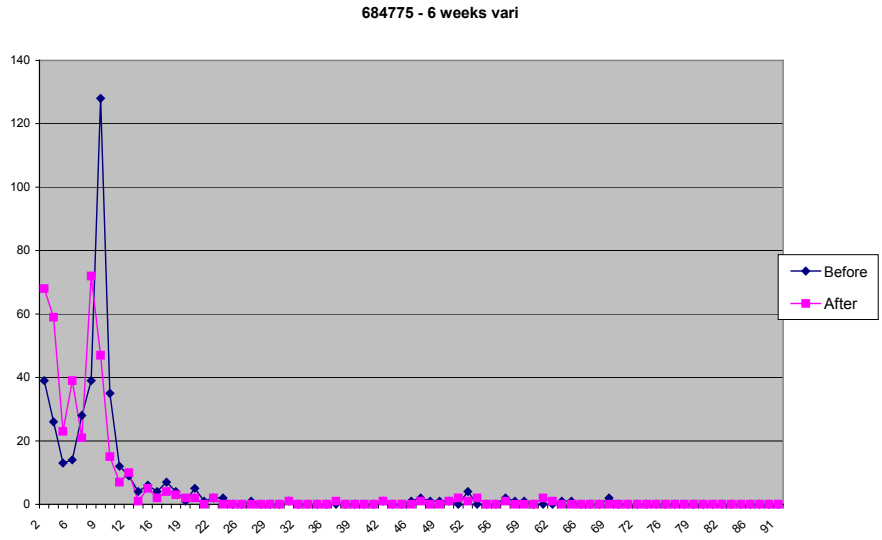



**Figure A3.1 Reduction in volumes flushed in property 684775**

As the numbers of events match before and after, it is unlikely that there was much double flushing. The total volume of water used to flush the toilets can therefore be calculated from multiplying the frequency of events by the flow rate. The saving in this property over the six-week period is therefore 342 litres (1814 – 1472 litres) or 3.5 litres per day. This works out at a saving of 12% of the total water consumption based on the 15-minute data. Looking at the daily total consumption, there seemed to be an increase of consumption of 14% following the installation of the dual flush device. The 15-minute data allows closer analysis of the lower flows associated with toilet flushing, so a more accurate conclusion can be drawn concerning the savings due to the installation of the dual flush device.

The following Table A3.2 summarises the percentage savings in total water consumption associated with each property. This table does not include all properties as seven did not have a shift in peak. Any change in water consumption is not due therefore to the installation of the devices. This substantially increases the confidence in the calculated savings. The savings per flush are also shown in this table. This has been calculated from the assumed litres saved per property per day based on the 15-minute data. This was then divided by the total number of toilet events, giving a saving per flush.

**Table A3.2 Savings per household**

| Household ID | % from daily total | % from 15 min data | Saving per flush (litres) |
|---|---|---|---|
| 692734 | 29.6 | 20.5 | 4.3 |
| 690005 | 25.5 | 15.3 | 2.7 |
| 684775 | 22.5 | 8.4 | 1.7 |
| 689427 | 20.2 | -3.1 | |
| 690653 | 16.5 | 2.5 | 1.4 |
| 692773 | 15.3 | 0.9 | 1 |
| 685621 | 12.2 | 11.9 | 3.6 |
| 692844 | 8.5 | 6.6 | 2.4 |
| 689842 | 8.3 | 7.5 | 2.5 |
| 688359 | 7.8 | 3.0 | 0.56 |
| 698651 | 7.0 | 12.1 | 4.9 |
| 692846 | 1.8 | 6.4 | 1.1 |
| 692851 | 0.9 | 4.5 | 0.9 |
| 688377 | 0.8 | 1.3 | 1.3 |
| 690194 | 0.5 | 0.6 | 0.3 |
| 684782 | -0.1 | 4.3 | 3.1 |
| 685766 | -1.9 | -2.8 | |
| 684745 | -14.1 | 12.0 | 2.4 |
| 690636 | -17.3 | 5.4 | 3.2 |
| Average | 7.6 | 6.2 | 2.2 |

Calculating the saving using the 15-minute data gives an average of 6.2% compared with 7.6% using the daily total data. Although the 15-minute data gives a lower saving, it is still very similar to that calculated from the daily totals. The two results support each other and confirm the savings as a result of installation a dual flush device are on average 7% of the total water consumed.

Looking at the difference between the two devices, the Variflush showed the greatest savings with an average saving of 8.2% based on the daily total data and 7.5% using the 15-minute data. This compared with the Ecoflush that had savings of 6.1% and 3.3% based on the daily total data and the 15-minute data respectively.

## A4. Southern Water

### Methodology

Customer selection and numbers
The company worked with a local housing association, whose tenants had in the last year received meter optant information. A mailing list of all metered properties belonging to the housing association was prepared. All properties with meters whose serial numbers indicated that they could not be logged were excluded. Letters were sent to the tenants of the remaining 225 properties inviting them to take part in the project.

Company staff then visited 70 suitable properties (chosen on the basis of questionnaire responses). This was to assess whether the meter was suitable for logger installation and whether devices could be fitted to cisterns. After this visit, several candidates dropped out (change of mind or could not be reached) but with a further recruitment of three Southern Water staff volunteers, there were 51 properties in the trial. Most were single or double occupancy, with an average occupancy of 1.4.

Contractor selection
Because of the co-operation from the housing association, it was possible to use their plumber to do all fitting work. Company staff installed the logging equipment and, where necessary, changed meters to a pulsed output ones.

All communication – letters, setting of appointments for fitters, and gathering of survey information – was handled by UPM, on behalf of Southern Water. UPM also provided a 24-hours emergency telephone service.

### Products

The original intention was to fit an equal number of devices. Customers were not to be given a choice. Properties were split arbitrarily to ensure that equal numbers of devices were installed. But many changes to this plan had to be made because installation of the intended device was not always possible.

In the end, 27 properties were fitted with Ecoflush and 24 with Variflush (16 type A and 8 type B).

In all cases, the same devices were installed in all toilets in the house.

### Feedback at time of installation and difficulties encountered

The plumber's original preference was for Variflush, which initially seemed to be easier to fit and to give better results. After installations, though, Ecoflush was considered the more versatile of the two since it could be fitted to both left- and right-handed cisterns and even to slimline cisterns. Variflush, which comes in right- and left-handed version, and as type B, was judged to have too many versions. The B type often hit the float, and it often could not be fitted to the slimline cisterns it was recommended for.

### Data collection issues

More than half of the properties were metered internally. Special appointments had to be made to download the loggers.

The week after logger installation, staff visits and initial downloads were carried to identify any equipment problems. Consequently several loggers had to be replaced or reset.

### Removal of the devices

Two customers requested the removal of the devices (one Variflush and one Ecoflush) on completion of the project. In both cases, they said that the toilet did not flush well and often needed double flushing.

Another customer requested the removal of the Variflush type B device two months after the project completion as a matter of urgency, as the device had stopped working. It is not clear why it stopped working.

**Feedback from customers**

Initially, most customers experimented with all available settings. They then tended to use a preferred setting most of the time. Most of the feedback has been favourable, but several customers commented that three settings was too many. Only one customer though it was not worth recommending the device to others. Ten people thought that around £20 to buy the device was too expensive.

## A5. Sutton and East Surrey Water

### Methodology

Customer selection and number
To select customers for this trial, a mail shot was sent to 284 metered properties in a single DMA (District Meter Area). The DMA used was selected based on having properties over a range of ACORN classes and a large number of appropriately metered properties.

A total of 38 (13%) customers replied to the original mailing, and 20 of these were suitable to take part in the trial. Contact was made with each of the customers and, following a preliminary site visit, 10 properties were selected for the trial.

Contractor selection
The trial was managed by a project team of company staff with the installation of the cistern devices undertaken by our sister plumbing company. The project team carried out procurement of all loggers, accessories and cistern devices.

### Products

Each customer was offered the choice of device in the finish of their preference on the understanding that the Company would endeavour to fit the same make of device on all cisterns in the property. In total, 18 devices were fitted (12 Variflush, 6 Ecoflush).

### Feedback at time of installation

Customer's preferences
Four customers expressed no preference of device. Of the remainder, three preferred Ecoflush, and three preferred Variflush.

Contractor's preferences for installation
The plumber expressed no specific preference for either device. In general the Variflush was easier to fit. On a number of occasions, it was impossible to fit the Ecoflush. Because of this, a total of 12 Variflush were fitted and only 6 Ecoflush.

A list of pros and cons was drawn up for each device. In general, the pros were that each device was easy to fit with good, clear instructions. On the cons, the main concerns were that in some cases it was difficult to fit the device and fit the cistern lid properly, and that compared to normal handles the devices seemed 'flimsy'. However, since installation only one unit of the 18 in total fitted has had to be replaced due to breakage.

Difficulties encountered with cisterns
No major problems were encountered. However slimline cisterns were more difficult to fit in than standard cisterns.

### Data collection issues

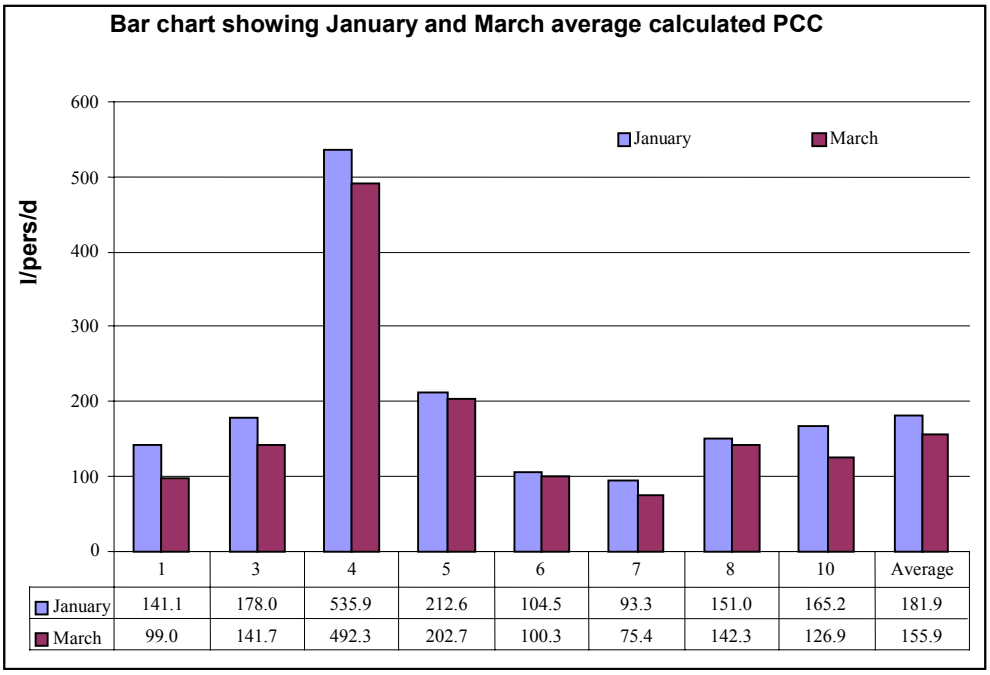
Data were collected every six to eight weeks during the trial period. A company technician visited each site in turn and downloaded the current logger information using a handheld device. At the time of download, a manual meter reading was taken to cross-reference the logged data. Data were processed using Radcom software and then transferred into Microsoft Excel for further analysis.

One property suffered significant problems with the data logger. This resulted in a number of remedial actions being taken, including installing a new pulse unit / cable and replacing the meter. None of these actions rectified the problem in time to provide consistent comparable data suitable for use in the trial.

## Data analysis

Following the trial, each of the customers was contacted and asked a series of questions to determine if any modifications to water use had been made as a direct result of having the devices installed. None of the customers felt that they had modified their water use other than using the device.

During the post-trial survey, one property was found to have been only partially occupied during the latter part of the trial due to commencement of building / construction works. The data from this property was excluded from the analysis.




| | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 10 | Average |
|---|---|---|---|---|---|---|---|---|---|
| January | 141.1 | 178.0 | 535.9 | 212.6 | 104.5 | 93.3 | 151.0 | 165.2 | 181.9 |
| March | 99.0 | 141.7 | 492.3 | 202.7 | 100.3 | 75.4 | 142.3 | 126.9 | 155.9 |

**Figure 5.1 Summary results from variable flush cistern device trials**

Figure 5.1 shows the averaged daily results from the logged data for the January and March – the months preceding and following the installation of the devices. It is clear that in all properties included in the analysis, there has been a visible reduction in water consumption since the devices were installed. Analysis of the dataset demonstrated an average daily saving of 14% in volume of water consumed.

Given the relatively short pre-installation period and the duration of the project from January to April, it would have been of benefit to include a number of control properties to see if seasonal changes contributed to variations in the amount of water used.

## Reasons devices were removed

Customers were offered the opportunity to have the cistern devices removed free of charge at the end of the trial. A limited period in which this could be done was clearly outlined to the customers. None asked for the devices to be removed. During this time, one customer asked for a faulty device to be replaced, which was done free of charge.

## A6. South West Water

### Methodology

Customer selection and number
An initial extract from our customer accounts system offered 6,057 potential participants.

The criteria for selecting these was:

- diversity in socio-economic groups but within easy travelling distance of our HQ offices (Exeter);
- with suitable pulse output meter located outside property with easy access for logging;
- meter installed 2001/2002 to exclude customers newly switched to a meter.

From this initial group the following sub-groups of customers were extracted:

Customers with the title 'Mr'…. or 'Mr and Mrs'…. This group of 362 was chosen to capture families and single men.

Customers with the title 'Dr'…… This group of 59 was chosen to capture professionals and higher earning families.

Customers with the title 'Mrs'…. This group of 170 was chosen to capture mothers of families, single mothers and elderly women living alone.

Customers with the title 'Miss'….. This group of 56 was chosen to capture single and younger women including spinsters.

Customers with the title 'Ms'…… This group of 20 was chosen to capture single mothers and older single women.

Each of the groups above was chosen to include a wide range of housing types.

These final selectees were then sent a letter inviting them to take part in the trial, with a short questionnaire to be completed if they wished to participate.

The final selection of 207 customers was made by hand from those who returned the questionnaire. The final choice was affected by operational issues (such as the depth of meter pit to accommodate the logger), and household size to achieve a range of occupancies. Customers not chosen for the trial were offered a free Variflush/Ecoflush as a token gift. Of the 207 customers, 53 were chosen for the trial.

Contractor selection
All logging and installation work was conducted in-house by water conservation staff.

### Products

Customers were not offered a choice of product to ensure that similar numbers of the two devices were included in the trial. 27 customers got the Ecoflush and 26 got the Variflush. Chrome handles were offered only for Ecoflush.

### Feedback at time of installation

Customers preferences
No choice of device was offered, but where customers had a problem with one device (installation difficulties) the other device was offered as an alternative. The majority of those customers who became aware of the two devices preferred the Ecoflush, mainly for aesthetic reasons.

Contractors preferences for installation
The installer found the Ecoflush the easier of the two devices to fit with fewer difficulties encountered.

Difficulties encountered with cisterns

Cisterns with flat fronts were more suitable and posed fewer problems with either device. The Variflush was particularly sensitive to the cistern design. The small plastic type circlip, which locks the Variflush in place on the flush handle, was found ineffective in some cases and should be improved before this product is promoted in any major roll-out.

In some cases where the toilet pan was fitted with little horizontal clearance to the cistern, the Ecoflush handle was too deep (front to back) to allow the toilet seat to be leant back against the cistern.

**Data collection issues**

New Metrolog 'P' loggers were used for the trial. These were to be passed to our Leakage section once the trial had been completed. Most of the loggers did not complete logging successfully. This is probably because they were not set up correctly. It would have been better to outsource that job to logging specialists.

**Data analysis**

Some analysis is being undertaken in-house but is ongoing at this time.

**Device removal**

Two devices were removed: 1 x Ecoflush, 1 x Variflush. In both cases, the devices were not flushing reliably, and the customers both asked for the original handles to be re-instated.

## A7. Tendring Hundred Water

### Methodology

Customer selection
The company randomly selected a total of 200 customer addresses from a much larger list of existing meter optants. A letter was sent to each individual property inviting the household to take part in the survey. The letter was entitled: 'Trial of Water Saving Devices – Your Chance To Take Part and Save Money'. A total of 26 positive replies were received. Of these, 20 were deemed suitable for the survey.

Although these households were selected at random, the company had a predominance of one (single) or two-people per property occupancy rates. There were children living at just one household. The average occupancy was 1.9, and the average number of toilets was 1.47. The annual water charge ranged from £137.43 up to £588.46 with an average of £265.91. Similarly, the annual consumption prior to fitting the devices was 22.75 $m^3$ (minimum), 204.62 $m^3$ (maximum) and 74.59 $m^3$ (mean).

Due to the limited number of households that were deemed suitable to take part, and considering the relative size of the company, a decision was made to carry out all of the survey work in-house. This included programming and installing loggers, installing the devices, plumbing work, downloading the loggers, analysis of the data and reporting.

### Products

Only Variflush devices were chosen and installed at a rate of one per property. All devices were fitted successfully, representing 100% of target. On arrival at the customer's property, the network technician (company's in-house plumber) was briefed to show the customers the device prior to, during, and following installation and to undertake a comprehensive demonstration with operational advice also provided.

### Feedback from customer

All of the households were happy with the ease of use/performance of the device both at installation and later when the loggers were removed.

One device subsequently broke. The plumber re-visited the premises to investigate and was able to fix the problem without the survey's continuity being affected.

### Data collection issues

Three of the 20 properties failed to log due to hardware and on-site problems, and the total sample number was therefore reduced to 17.

### Analysis of the results

The cut-off date for making comparisons between before and after fitting the devices was 15 May 2004.

The average daily consumption for all 17 households (combined) prior to fitting the devices was 2,996 litres per day. This figure fell to 2,648 litres per day after the installation of the devices. This represents a reduction in volume of 11.62%.

Most of the 17 households selected and logged had occupancy rates of one or two people per household, which has implications on applying the results to a broader range of households. There have been no allowances made for seasonal demand variations, leakage or legitimate usage etc.

It is interesting to note that for the 17 properties surveyed, there was an annual saving per household for the customers of Tendring Hundred Water of approximately £32.00.

## A8. Thames Water

### Methodology

Customer selection and number
Customers were selected from a sub-section of members of our Domestic Water Use Survey. These particular members had joined the DWUS study as unmeasured customers, with their data being used to determine our unmeasured pcc, but have subsequently switched to paying on the measured tariff.

Properties were initially mailed to see if they wished to volunteer, if they were:

- on the measured tariff;
- had returned one of our annual questionnaires regularly/recently (an annual update on occupier, number of residents, water using devices at the property etc).

On the basis of these criteria, we mailed 251 customers. Of these, around 98 responded.

We chose 60 households, which gave a mix of occupancies and number of toilets per household. We had a predominance of single person households, and so also selected some families.

The contractors visited a total of 59 households. The average occupancy was 1.9, the average number of toilets 1.78.

Contractor selection
We used a company called Kemac, who are the plumbing company behind Thames Water Plumbing Services.

### Products

We sent out the promotional literature for both products so the customer could see what the options were.

Some of the households selected asked for Variflush and some for Ecoflush. Of the initial shortlist of 93 customers who expressed a preference, 82 preferred the Variflush.

On arrival at the customer's property the plumbers were instructed to show the customer both devices to ensure they were happy with the product.

Ninety devices were fitted, out of the target of 103; 55 of these were Variflush and 35 Ecoflush.

### Feedback at time of installation

Customers preferences
There remained a general preference for the Variflush – and this appeared to be because of the chrome handle.

Contractors preferences for installation
The plumbers found that the devices were both easy to fit and quick, although the Ecoflush was slightly easier to fit as a smaller hole was needed to be drilled to fit the device.

Difficulties in setting appointments or accessing properties
None for Thames – this was all arranged on our behalf by Kemac. This seemed to work remarkably well.

Difficulties encountered with cisterns
Some cisterns were too old – the plumbers were worried they would break them.

Reasons for devices not being fitted included: concealed cisterns, toilet already with push-button flush etc.

A few specific problems:

- case of the handle too short to grab hold of once installed (the Ecoflush) – appears to be down to shape of cistern;
- cases of the cistern lid no longer seating correctly because equipment too high in cistern chamber (Variflush).

**Data collection issues**

Data was collected by Thames Water Meter Reading Team between 19 April 2004 and 10 May 2004.

A number of the loggers 'flatlined' during the logging period, which meant we did not meet our target of 50 properties with valid data (only 40 valid sites).

**Reasons some devices were removed**

Devices were removed from six properties:

- not working as anticipated/efficiently – only works properly on max setting (3 x Ecoflush, 2 x Variflush);
- handle keeps coming out (Ecoflush); handle broke (Variflush) – same house.

**Feedback from customers regarding ease of use of the devices**

- 49 said they were easy to use;
- 7 said they were not (of which 6 were removed).

**Analysis of the results**

Before usage was average for the period 1/2/04 – 14/2/04 or 1/2/04 – 21/2/04, depending upon installation date of the device. After usage was average for the period 19/2/04 – 31/3/04 or 26/2/04 – 31/3/04. The periods were all whole weeks to ensure there was no distortion caused by different usage patterns at weekends.

Summary results for Thames Water

**Table A8.1 Summary of water savings**

| | |
|---|---|
| Average savings | 37 (+/- 17) l/property/d |
| Maximum saving | 248 l/prop/d |
| Minimum saving | -84 l/prop/d |
| Average % saving | 12% |
| Maximum % saving | 62% |
| Minimum % saving | -13% |

**Table A8.2 Water savings by occupancy**

| Occupancy | Average savings (l/prop/d) | Number of properties |
|---|---|---|
| 1 | 44 | 15 |
| 2 | 45 | 24 |
| 3 | 10 | 2 |
| 4 | 3 | 2 |
| 5 | -15 | 3 |
| **Total** | **37** | **46** |

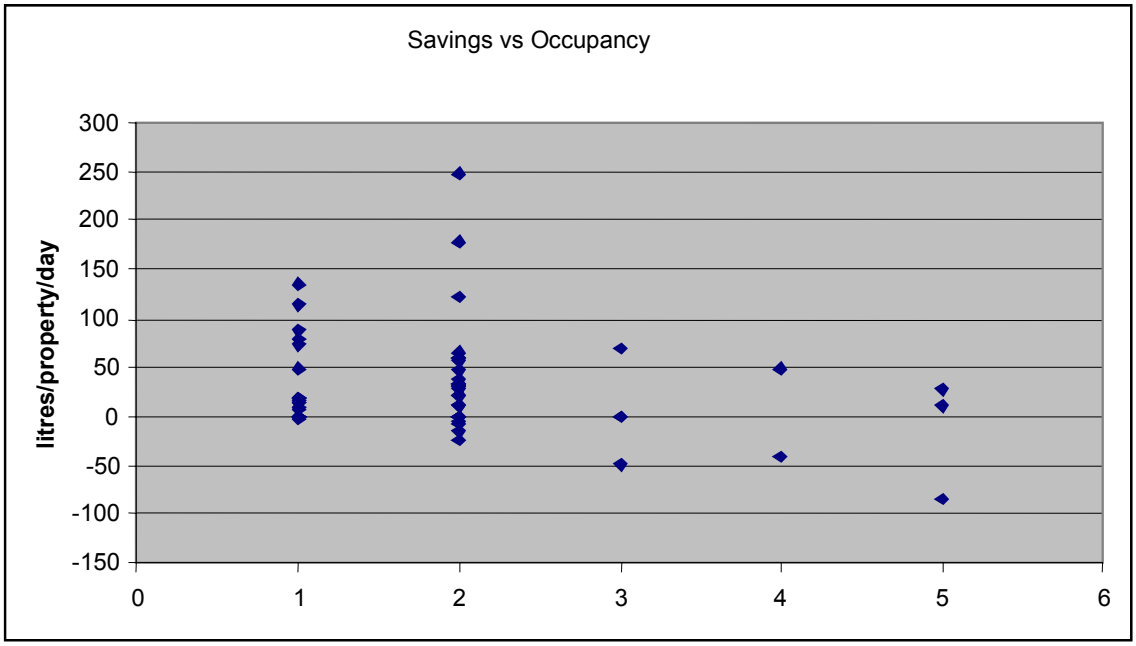



**Figure A8.1 Water savings by occupancy**

**Table A8.3 Water savings by device type**

| Device type | Average savings (l/prop/d) | Number of properties |
|---|---|---|
| Ecoflush | 33 | 18 |
| Variflush | 40 | 27 |

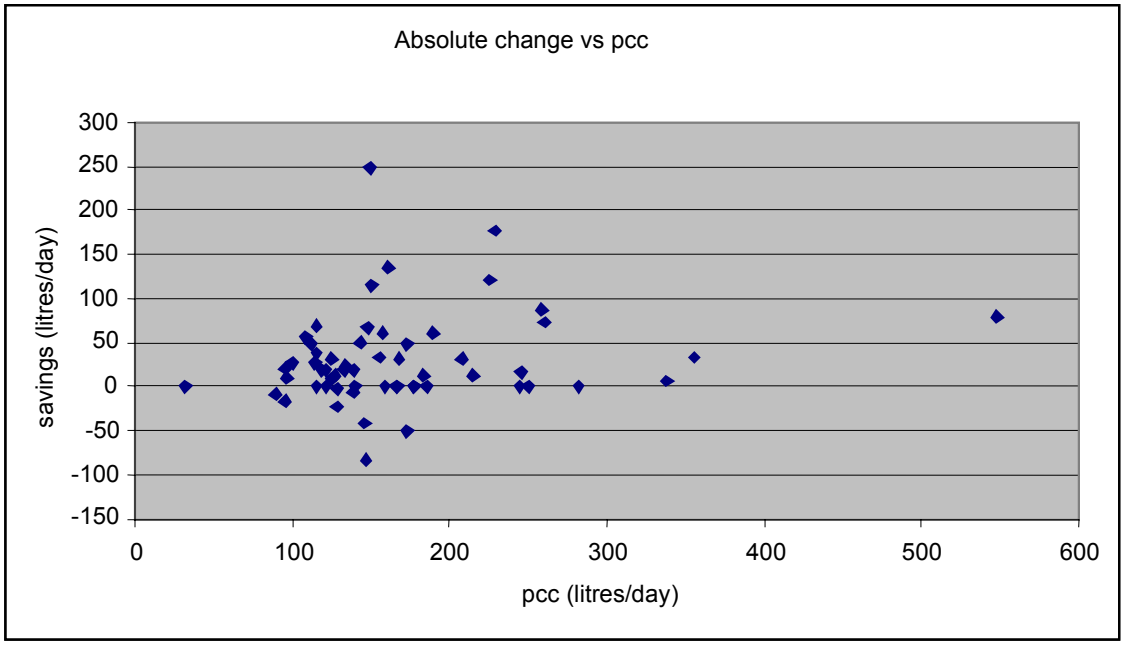



**Figure A8.2 Changes in consumption in respect to pcc**

**Table A8.4 Water savings by number of devices fitted**

| Number of devices fitted | Average savings (l/prop?/d) | Number of properties |
|---|---|---|
| 1 | 52 | 24 |
| 2 | 18 | 18 |
| 3 | 71 | 3 |
| 5 | -84 | 1 |

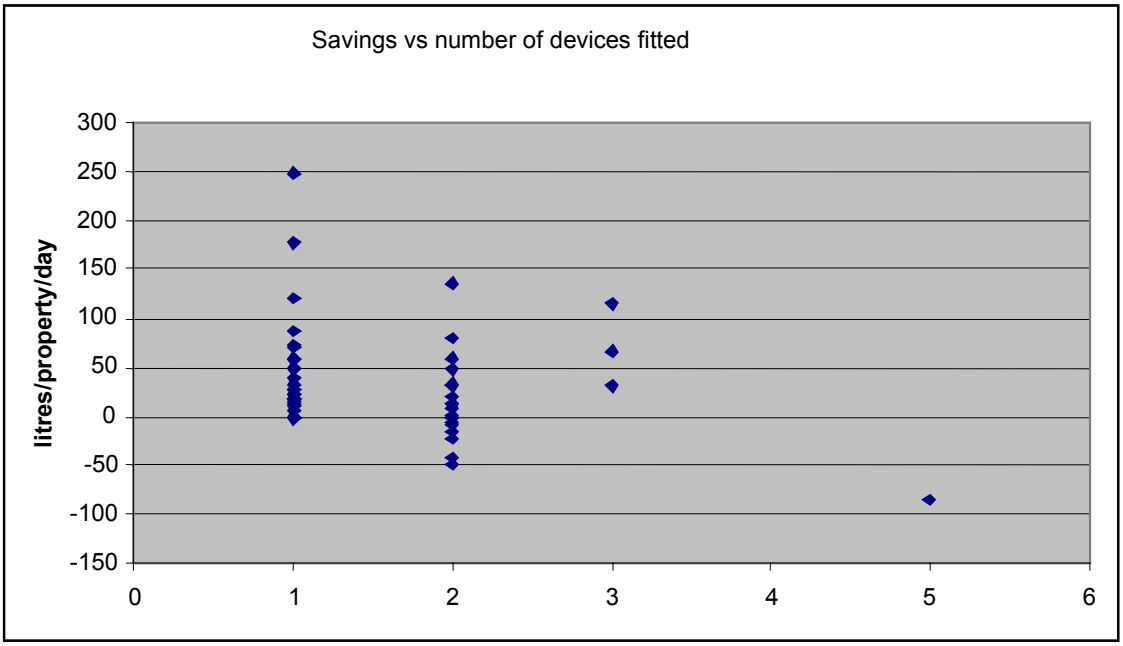



**Figure A8.3 Water savings by number of devices fitted**

## A9. Three Valleys Water

### Methodology

Participating customers were selected from two different sources. Half of the volunteers targeted came from a database of customers who had recently chosen to go pay by metered account (optants). The other half were chosen from a select trial area in the company which has ongoing automatic meter reading (AMR) technology installed.

Letters were sent out to all selected customers in December and January. Those who wished to take part had to return a simple standard questionnaire. Accordingly, 25 customers in the AMR area volunteered to participate. All of these were subsequently included within the trial. A further 64 customers also responded from the new optants group, and 25 of the most suitable were selected. A total number of 50 customers were selected for the final trial. Three Valleys Water did not have a company plumber available to carry out the installation service, so contractors Kemac were engaged to manage the complete installation of the devices on behalf of the company.

### Products/Feedback at time of installation

Of the 50 customers finally selected for inclusion in the trial, 37 had devices successfully installed. The following table provides details and reasons behind the failure to install devices in the remaining 13 households.

**Table A9.1 Reasons why devices could not be fitted**

| Number | Reason |
|---|---|
| 6 | Households could not be contacted by Kemac |
| 2 | Households did not like the devices when they were installed and requested immediate removal |
| 3 | Households no longer wanted to go ahead with the trial |
| 2 | Households could not have the devices installed as cisterns were unsuitable |

It was left to the customer to choose whether they wanted an Ecoflush or a Variflush device fitted and a choice of handle (white, gold or chrome) was also given in case of Ecoflush. The final split was 15 households chose the Variflush option (all of which were type A) and 20 households chose the Ecoflush version.

Removal of the devices
Three devices were subsequently removed following installation upon the request of the customer. The reasons given were:

- the device caused problems with the normal flush mechanism;
- once fitted into the cistern, problems were encountered with the overflow, which was directly above the gas meter. Kemac were slow to respond to the problem, and in the end the customer chose to have the device totally removed;
- one device could not be fitted into the cistern, but the customer chose to keep the two remaining devices located in other toilets within the property.

A further 10 customers opted to have the devices removed after the study period was complete. Of these, two had Variflush devices and eight had Ecoflush devices removed. Reasons for the removal are detailed within the list of suggested improvements / perceptions (see Customer Feedback below).

Contractor issues
When we contacted customers at the end of the trial to see whether they wished the devices to be removed, we found another two customers had to be excluded from the original 37. One customer had an Ecoflush device installed but it did not function correctly, so the plumber agreed to return with a Variflush device, but never came back. Though the customer still chose to continue with the trial, the data was too late to be included. The other customer waited in for the plumber to arrive, but they never did.

Despite requests, we have received no feedback from Kemac with regards the devices or their ease of installation.

**Data collection issues**

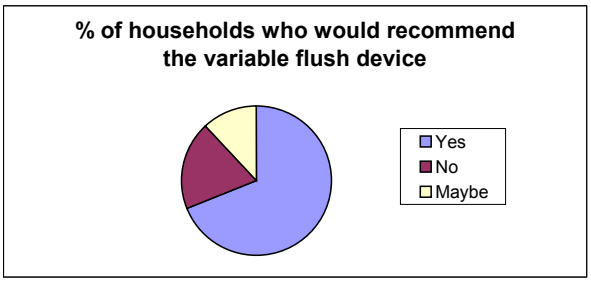
Some of the data required cleaning, as there appeared to be a factoring problem with a small proportion of the logger readings obtained. Ten out of the original 32 data points sent to the Environment Agency for analysis required cleaning work, with two of these being subsequently removed from the study. Once verified against metered readings, the data was resent to the Agency on 14 January following the steering group meeting to discuss the initial findings.

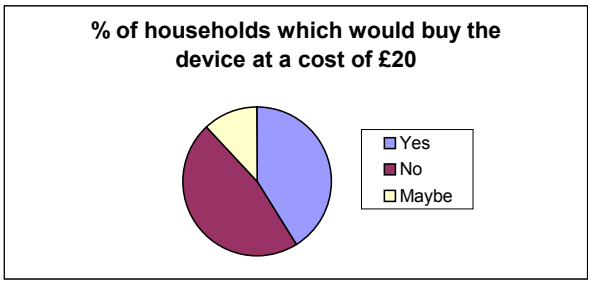
**Data analysis**

Of the two sources used by Three Valleys Water to recruit volunteers, those participants on the Automated Meter Reading (AMR) scheme showed a saving of around 6% overall. Those volunteers recruited from the meter optants group recorded a greater saving of approximately 10%. Overall, this produces a combined saving of around 8% for the Three Valleys Water sample. The observed difference between the two groups can be explained by considering the age of the properties involved. The AMR scheme comprises newer properties built during the nineties and therefore, due to Water Supply (Water Fittings) Regulations 1999, would have smaller cistern volumes than the older meter optant group. Hence flushing volumes would be reduced within the AMR sample.

**Customer feedback**

95% of people found the devices easy to use and frequently used the different settings.
57% experienced some problems, leading to double-flushing.




A number of people thought £20 was a little high, especially when more than one device was required. They would require evidence of significant water savings (hence payback), in order to guarantee that they could recover the cost of the device in a realistic timeframe. A price of around £10 was recommended.

Customers generally expressed the view that the devices were a good idea, but some improvements would be required before it could be accepted and promoted on a wider scale. The main areas highlighted for improvement were:

- **Durability** – the device appeared flimsy, and a few of devices had become faulty by the end of the trial;
- **Adaptability** – some devices did not quite fit in the cistern, which caused problems such as dislodging the cistern lid;
- **Appearance** – the device needs to be more stylish and come in a range of colours/materials so that they fit easily within the existing décor. Many people thought the device looked ugly;
- **Fewer flush settings** – two settings of low/high would prove simpler because there was a lack of definition between the different flush settings;
- **Reliability** – needs to be more consistent in operation to reduce the need for double flushing.

# Appendix B Customer final questionnaire

Cust Ref:

Name:

Address:

Telephone №:

Device(s) installed:

1. **Can you confirm you live in (type of property):**

2. **Excluding students living away from home, how many adults (16 years and over) live at your address?** **…….**

How many of those work full time? …….

How many children (under 16) live at your address? ……..

How many of those are in nappies? ……..

3. **Since February, apart from the installation of the flush device, are there any other reasons why you think your water consumption may have changed? For example:**

☐ You or other family members have been away;

☐ you had visitors;

☐ you had a new washing machine/shower etc installed.

☐ No change

If any change, please provide details:

4. **In general do you / your family find the flush device easy to use?**

☐ Yes

☐ No

Any difficulties?

5. **Do you/your family regularly use the different flush settings on the device, or do you stick to one setting?**

☐ Use different settings

☐ Stick to one setting – which?

Any comments?

6. **Do you/your family find that you have to flush more than once sometimes to clear the toilet pan?**

☐ Yes

☐ No

Any problems/comments?

7. **Has the device made you think about how using water wisely?**

☐ Yes

☐ No

Any comments?

8. **If you could change anything about the device, what would it be?**
   (this question to get as much feedback from the customer as possible)

9. **Are you happy to keep the device?**

☐ Yes

☐ No (arrange for removal)

Why?

10. **Would you recommend it to others ?**

☐ Yes

☐ No

Any comments?

11. **If you did not have the device provided free, would you be prepared to buy it? It normally sells for around £20.**

☐ Yes

☐ No

Any comments?

Thank you for your help. Once we analyse the data we will send you an update note to let you know the results of the project.

# Appendix C Customer Focus Group, Essex & Suffolk Water

**Installation and usage**

Participants consider the need to conserve water in the Essex & Suffolk Water (E&SW) region as very important for all in the community. They consider the fitting of a flush control device to toilets a useful idea. This could be reflected in any promotional content.

Participants prime motive was the saving of water and the positive impact this would have on their bill. This could be reflected in any promotional content.

Participants did have concerns over the effectiveness of the flush especially with solids. They also described a need to clean more often.

They suggested that a more detailed survey of the toilets on their property would be useful to establish likely benefits and address possible problems. To include measuring capacity, checking ball cock position, pan and pipe shapes affecting flow, state of functionality of siphon and diaphragm etc.

Consideration could be given to how best to do this. Fitting a dual flush device to a malfunctioning toilet may exacerbate problems. Alternatively different solutions to the problem of reducing flow e.g. fitting a save a flush could be offered.

Rectifying problems with cisterns would have a cost and liability implication. Do it yourself literature could be considered as part of any instructions left with householders.

Participants found the range of colours and appearance of the devices very limited. Consideration could be given to a wider choice of shades and colour to encourage uptake.

To encourage installation, possible targeting of older properties with low occupancy if metered. Also targeting “older” customers may be an attractive strategy.

**Evaluation of different devices (where fitted)**

Participants found problems with both devices. However they had continued to use the devices by “fixing and making do”. Problems were experienced in durability when switching between flow rates and devices coming loose from the cistern. Consideration should be given to design and/or fitting.

Participants suggested regular monitoring by E&SW would be useful so that if they experienced a problem it could be discussed and remedied. Customers could be asked at installation whether this was a service they would appreciate. There would be cost implications if follow up visits had to be made. Or it could be limited to evaluation trials.

Participants would have liked instructions to have been left with the devices.

Both devices had problems of durability in use, they became loose as well as the minimum flush being described as useless. Design changes need to be considered.

The space available to fit and use the devices is a practical concern on some properties. Both the space under the cistern lid and the proximity of the toilet to walls. This needs to be considered at design stage.

**To obtain customer feedback on possible alternative devices**

Concern was expressed about the ease of use of possible devices for children and those suffering problems with their hands e.g. push buttons. This needs to be considered when designing and offering the best type for installation.

Consideration could be given to doing a pilot during which different devices are evaluated at the same property.

Participants expressed interest in the results gained. Consideration could be given to providing this information if future pilot / sample studies are carried out. This involvement may make it possible to ask the same people to participate in providing feedback over time and on alternative designs.

# Glossary of terms

| | |
|---|---|
| ACORN | ACORN stands for 'A Classification of Residential Neighbourhood' and is a geodemographic classification using census and other data to classify postcodes into neighbourhood categories. The classification has been developed by the marketing-data firm CACI. |

# List of abbreviations

| | |
|---|---|
| AMR | Automatic meter reading |
| CDD | Cistern displacement devices |
| DMA | District Meter Area |
| MAX | Maximum |
| MED | Medium |
| MIN | Minimum |
| ODPM | Office of the Deputy Prime Minister |
| pcc | per capita consumption |
| ppc | per property consumption |

# List of figures

# List of tables

# References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3. ODPM: Survey of English Housing, 2004.

4. OFWAT: Security of Supply, Leakage and the Efficient Use of Water 2003-2004.

5. OFWAT: Tariff Structure and Charges 2005-2006.











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