The Water Efficiency of Retrofit Dual Flush Toilets

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Statement of Use
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Executive summary

As new resource developments become increasingly difficult attention has focused upon the potential water savings that various efficiency measures can achieve. The use of water for toilet flushing constitutes around 30% of domestic water consumption, and therefore attention has turned to reducing the quantities used for this activity. One of the water efficiency solutions for toilets is the use of retrofit kits which can be installed to convert existing siphon cisterns into dual flush toilets.

This project sought to determine the effectiveness of dual flush toilets as a water efficiency measure. This was done via an eight month study of five retrofit devices in 33 customers' homes in West Sussex. The study was jointly funded by Southern Water and the Environment Agency and required the relaxation of byelaws which prohibited the use of dual flush systems.

The study compared the average volume per flush before and after dual flush installation, as measured by a meter and logger installed on the inlet pipe to the cistern. Data was collected from the logger at monthly intervals and processed using bespoke in-house software. The study also included an examination of the savings that resulted from the installation of the Save-a-Flush cistern displacement device.

The average dual flush saving observed during the trial was 27%, equivalent to a volumetric saving of around 2.6 litres per flush. But there was a high degree of variability in the savings observed at the individual property level, from a maximum saving of 64% to a net increase in use of 28%.

The 27% average savings resulting from dual flush installation compared to an 11% average saving observed at 16 properties that had the Save-a-Flush bag installed.

The study demonstrated that double flushing does not necessarily increase significantly as a result of dual flush installation. This is a notable finding given previous misgivings about dual flush technology. In addition, it was shown that savings were greater in smaller households with one or two occupants, compared to larger properties with bigger families. The results also indicated that savings were greater at properties with only one WC.

The study has been based upon a relatively small number of properties, therefore, any extrapolation of the results on a wide scale should be treated with caution. However, the results are encouraging and taken at face value it is estimated that the blanket installation of dual flush systems could reduce domestic consumption by some 8%, equivalent to a national saving of 670 Ml/d. There also appears to be an incentive for metered households to install dual flush because the study has shown that the purchase and installation costs of the retrofit kits could be recovered in a little over one year.

From a water company perspective, the study suggests that a 1Ml/d saving in water supplied could cost around £0.6M, which compares favourably with the costs of more traditional water resource development schemes. However, we must also recognise that this project did not look at the likely life span of the devices, and therefore has not attempted to compare costs on a whole life basis.

Introduction

Background

It is clear from recent drought events that the balance between the supply and the demands for water is sometimes marginal. Traditionally, the water industry has looked to new resource schemes to maintain this balance, however many of these options are no longer viable in the context of the tight regulatory environment and increasingly stringent economic and environmental legislation. Most companies accept this, and are now adopting a 'twin track' approach to ensure a future supply-demand balance.

With encouragement from government and the regulators, water companies have recently focused their attention on the potential of 'demand management' as a means to help rectify supply-demand imbalances. In the past, demand management has been synonymous with leakage control and domestic metering, however this term now covers a broader spectrum of initiatives including devices and schemes which result in water efficiency.

The Environment Agency (EA)/UKWIR define demand management as:

'The implementation of policies or measures which serve to control or influence the consumption or waste of water'.

Such options include water audits, cistern displacement devices and free leak repairs.

The use of water for toilet flushing[a] constitutes around 30% of average domestic water consumption, and therefore much attention has focused upon reducing the volume used for this activity. One of the water efficiency solutions for toilets is the use of retrofit kits which can be installed to convert existing siphon cisterns into dual flush toilets. The Saving Water report[b] suggested that converting standard toilet cisterns to dual flush could potentially save 850 Ml/d across England and Wales at a cost of 18 pence per cubic metre.

This project was initiated by the Environment Agency and Southern Water to assess the savings available from retrofit dual flush toilets. A parallel study, trialling a separate set of devices has also been undertaken jointly by the Environment Agency and Anglian Water. The present study has also examined the effectiveness of Save-a-Flush bags. These are cistern displacement devices, widely distributed to Southern Water customers, which are designed to reduce flush volumes by approximately one litre per flush. The objectives and set-up of the project are described more fully in the following sections.

Study Objectives

The original objective of this study was set out in a Method Statement[c], as follows:

'To evaluate the effectiveness of dual flush toilets as a water efficiency device and to determine potential savings in water consumption by retrofitting dual flush devices to existing single flush cisterns. To assess how customers are likely to utilise dual flush options.'

Specifically, the aim of the study was to undertake domestic trials of a range of retrofit devices and assess the realistic savings that could result from their use. A further aim was to compare dual flush savings with reductions achieved by installing Save-a-Flush bags. By carrying out the study in 'real life' situations, it was hoped that the results obtained would reflect the genuine savings that can be attained from these technologies. The study would also allow the direct comparison of savings using the two methods on a property by property basis.

In addition, feedback from the customers involved in the trial and the plumbers who undertook the installation of the devices was thought to be invaluable in assessing the practical feasibility and user friendliness of the equipment. This information would also determine whether householders need guidance to achieve optimum use of the dual flush system.

Project Set-up

The project was funded jointly by the Environment Agency and Southern Water and was managed by a steering group comprising staff from the two co-funders of the project. Several key issues were agreed by the steering group at project set-up, as outlined below:

- The study would trial devices from a number of manufacturers
- The study would attempt to recruit approximately 35 triallists
- The study would seek to compare six months of dual flush operation with one month of background operation.

Project Budget

The Steering Group estimated that a maximum of 35 properties could be monitored within the project budget. The total project costs were £67,500. This equates to a cost per property of £1929, but of this sum, only about £400 related to the installation and capital cost of the monitoring equipment. The majority of the remainder was taken up by the costs of collection, collation, processing and presentation of data, with some allowance for project management.

Water Byelaws and Regulations

The Water Byelaws introduced on 1 July 1981 stated that every flushing cistern in domestic premises shall be dual flush. This replaced the existing byelaw requirement for a maximum (single flush) volume of 2 imperial gallons (9 litres) and came about as a response to the 1976 drought.

[a] *Climate change and the demand for water, (1996), HMSO*
[b] *'Saving Water', NRA 1995*
[c] *Method Statement for the Trial of Dual Flush and Variable Flush Devices in Domestic Toilets' Southern Water. August 1998, Appendix A*
[d] *See Appendix B*

New model byelaws were drafted between 1986-89 and became effective from 1st January 1989. From the 1st January 1993 dual flush cisterns were prohibited unless they were as direct replacements for such a cistern purchased prior to that date. In those same byelaws the maximum (single flush) was reduced to 7.5 litres.

The new Water Supply (Water Fittings) Regulations 1999 came into force in July of that year, allowing the re-introduction of (siphonic) dual flush cisterns on new installations. However, paragraph 25 (6) states that '…a single flush cistern may not be replaced by a dual flush cistern'. It is understood that this restriction will apply to the operation of the cistern mechanism, as well as the cistern itself. As a result, retrofit options for dual flush installation are still prohibited under the 1999 Regulations. Indeed, a relaxation of these byelaws was required from DETR for the purposes of carrying out this investigation[d].

The question that has not been answered is why were dual flush cisterns prohibited under the 1989 byelaws? It has been suggested that users may not have understood that a "short flush" was obtained by 'pushing the handle and letting go' as opposed to 'push and hold' for the "long flush". As a result, it is believed that double flushing was often required, thereby negating any potential water savings. It would appear that the decision to prohibit dual flush was taken entirely on such anecdotal evidence. No detailed studies were carried out to support the assertion.

PROJECT METHODOLOGY

Survey Method

Numerous options were considered during project set-up to identify the most appropriate survey method, relating to the way in which 'normal' and dual flush operation would be compared, and the measurement of differences in flush volume.

Generally, there are two options for determining the effect of a water efficiency measure on consumption: by comparing the volumes used by two similar appliances 'side by side', where one of the appliances has been fitted with a water saving device, or by comparing consumption 'before and after' the installation of a device.

The option of comparing two devices side by side is only viable where patterns of usage at both sites are similar, and for this project this was considered a less reliable option than the 'before and after' method. When considering volumes of water used by toilets, the side by side method would only be viable where two toilets in one property had equal usage, or where toilets at two properties had similar usage. Both these scenarios are considered unlikely, and therefore the more robust 'before and after' method was chosen for this study.

This approach was implemented by measuring toilet flushing volumes before and after dual flush installation at each of the properties studied. There is a possibility that the background period, before dual flush installation, would not be representative of usual toilet flushing rates, for example due to higher household occupancy rates. But to account for this, the comparison of flushing volumes before and after dual flush installation is based upon the volume per flush. This approach is independent of external variable factors such as occupancy and flush rate.

Recruitment Method and Customer Care

The study aimed to monitor how retrofit dual flush devices performed in real life situations, and therefore the project team sought to recruit a number of Southern Water metered domestic customers with 9 litre capacity systems to take part in the study[e].

It was agreed to focus the recruitment of participants from among the residents of the Highdown Drive area of Littlehampton who had previously taken part in water audits initiated by Southern Water. Potential triallists were sent a letter outlining the project and invited to attend a public meeting at which both Southern Water and the Environment Agency staff described the objectives of the study and the manner in which it was proposed to conduct it. The Littlehampton triallists were offered a free water butt or a £20 ScottishPower voucher as an incentive to take part in the study.

This recruitment exercise resulted in a lower number of participants than expected, despite encouraging attendance and enthusiasm at the public meeting held to promote the scheme. Of the 198 customers contacted originally, 38 said they would be interested in taking part in the study. However, only 18 were assessed by the plumber as being suitable for installation, because of access difficulties for the meter and logger. The final number of recruits from this group was, in fact, only fifteen.

In order to increase the number of participants, another area, this time in Lancing, was targeted. Again, these customers had previously taken part in Southern Water domestic water use audits, and again an incentive was provided, although the value of the vouchers offered was increased to £50. Of the 196 customers mailed in this exercise, 46 expressed interest in taking part in the trial, 18 of whom were included after plumbing inspections.

The total number of triallists actually recruited was 38, including five members of staff from the Environment Agency who volunteered for the study to help boost participant numbers and three customers held on a reserve list, who were to be brought into the trial if problems occurred elsewhere. In fact, by the end of the trial, all 38 customers had taken part, with usable data being obtained from 33 of them.

The recruitment method, the incentives offered and the inclusion of Environment Agency staff in the trial meant that the participants were not

[e] *Customer Correspondence is presented in Appendix C, and press articles are given in Appendix D*

necessarily representative of the wider population. Additionally, the motivation for inclusion in the trial was not the same as would be the case for metered customers who wished to save water and therefore reduce their bills. However, it is difficult to avoid these factors in a project of this nature and despite the limitations, the study is considered to be a valid survey of real life use of new dual flush technology.

Customer care was of paramount importance during the study. All installation and download visits were by appointment so that the customer knew who was coming and when to expect a visit. In addition, the Southern Water Call Centre and the local police were informed of the project so that any queries or problems could be directed back to the project team as soon as possible.

Customer queries were dealt with as quickly and efficiently as possible, and the contracted plumber was on call to deal with the rare leaks that occurred. During the trial several participants asked to withdraw and they were replaced with customers from the reserve list.

Monitoring Method

Several options were considered for monitoring each flush, including level sensors within the cistern and mercury switches connected to the toilet handle. The final choice of meter and logger on the inlet pipe was, however, the most straightforward method and the one which had proven to be successful in similar trials undertaken by Anglian Water. By directly monitoring flow into the cistern this method isolated the appliance of interest, once more removing the influence of extraneous factors which could have confused the situation. This, combined with the measurement of saving per flush, is considered 'best practice' using the technology available.

Monitoring of consumption during the trial was undertaken using a domestic Kent PSM-LT water meter cut into the inlet pipe into the cistern. This was connected to a Technolog DCM data logger, configured to 'event' recording. The meter gave a pulsed output every 0.5 litres which was received and recorded by the logger.

The DCM loggers are designed specifically for logging data from domestic consumption meters and have a 64k capacity. This provided enough storage for between 2 and 4 months of data depending on the number of events occurring per unit of time (i.e. the number of flushes per day). Despite this capability, visits to download data were generally made every 4 to 6 weeks to ensure large amounts of data were not lost in the event of logger failure, and more importantly to maintain customer contact.

Installation of the meters and dual flush devices were undertaken by a local plumber, contracted to Southern Water. Installation took place in several stages. The initial phase involved a survey of each candidate property for suitability. This included an assessment of the cistern to determine which devices could be installed, and a review of the configuration of the inlet pipe to assess whether the installation of a meter was practicable without significant disturbance to existing fittings.

Once a property had been identified as suitable, the meter and logger were installed and background monitoring commenced. Test data were collected from the logger to ensure the electronic data corresponded to the volumes measured by the meter. The capacity and associated flush size of the cistern was also recorded. After approximately one month, the plumbers returned to the property to install the dual flush device in the cistern. The customer was instructed in the operation of the device and all original components were retained for reinstatement where possible.

The feedback from participants was invaluable in assessing the performance and user friendliness of the various devices. A questionnaire[f] was used on each download visit to monitor the ongoing satisfaction of the householder with their particular device. Details of any significant changes in residency or periods of absence were also recorded at this time.

The two stage nature of the project, combined with the introduction of reservists at various phases, meant that not all participants had their dual flush system installed at the same time. Table 1 summarises the data collected. In total almost 250 months of data were obtained from all properties, and the study involved 81 customers and 6 different devices, as described more fully in Section 3.

Table 1: Data collection

Months of data	Number of Properties
2	1
3	0
4	2
5	1
6	2
7	3
8	15
9	9

[f] *See Appendix E*

DEVICES TESTED

Introduction

The devices chosen for the trial were selected from a number that were offered for inspection by their manufacturer. Three suppliers were initially chosen to allow comparison in performance between devices in terms of cost, ease of installation and operation and durability. The chosen suppliers were Mecon, Peter Brann and Cistermiser.

Mecon Devices

Mecon is a small Irish company specialising in the development of dual flush retrofit devices. The company offered two devices for trial, the standard dual flush device and an interrupter device, which had not been trialled before.

The standard device (Plate 1) is operated by two small delayed action floats in a chamber attached to the cistern wall. The flush operation is controlled by the user via a pull-tag. This device can be configured to default to either a long or a short flush. Both options were trialled.

The interrupter unit (Plate 2) comprises a push-button unit installed in the blanked handle hole in the cistern wall. The operation of the push button introduces air into the siphon, curtailing the flush. Mecon therefore effectively provided three different devices for trial.

Brann Device

The device, developed by Mr Peter Brann, was also in its prototype stage at the beginning of the trial. It also operates by breaking the siphon via the introduction of air, as controlled by a dial which fits around a special handle (Plate 3). The unit has three flush settings, corresponding to three different length tubes which break the siphon when the water level in the cistern falls below the level of the bottom of the tube.

Cistermiser Device

Cistermiser are a well known manufacturer of urinal controls and other sanitary control devices. The company offered a dual flush version of a standard single flush hands-free operated device, which used a drop valve instead of the usual siphon to actuate the flush (Plate 4). The unit comprises the flap valve mechanism connected to two infra-red sensors which operate either a short or long flush when a hand is passed in front of the sensor.

EcoFlush Device

An opportunity to include a fourth device in the study arose in December 1999. The EcoFlush Device, from Gesek is operated in a similar way to the Brann device, and also has three flush size settings (Plate 5).

RESULTS

Introduction

This section summarises the results of the study. The overall savings observed will be presented, followed by more detailed analyses which examine the relative performance of each device used in the study. The effects of occupancy rates and the number of toilets in each property on savings will also be reported.

In the past, double flushing has been considered a problem associated with dual flush toilets. The findings of a separate study into the double flushing rates observed in this trial will also be presented. Further analysis will investigate the ratio of long to short flushes observed at selected properties and whether there was any evidence for a reduction in savings ('bounce-back') during the period of the study. The final parts of this section will present the qualitative observations of the participants and plumbers involved in the study on the devices tested.

Table 2 outlines the key characteristics of the properties studied. Full tabulated results are presented in Appendix F. The savings quoted are based on the average difference in flush volume before and after dual flush installation. Generally, any cistern displacement devices in place at the start of the study were removed from the toilet, so that the savings observed were based upon the operation of a 'normal' cistern. However there were a small number of properties where this did not occur. These are annotated with a 'CB' (calculated background), in Table 2, and the savings for these properties are calculated based upon measured cistern volumes. Table 2 also highlights the properties where the Save-a-Flush cistern displacement device was installed.

Table 2: Summary of properties studied

Property code	Location	Device type	Monitoring Sequence	Occupants	>1 WC	Months of Data
1	L'hampton	Brann	CB,DF	1		8
2	Lancing	Brann	B,SF,DF	2		8
3	L'hampton	Brann	B,DF	2	Y	8
4	L'hampton	Brann	CB,DF	2		8
5	L'hampton	Brann	CB,DF	2		8
6	L'hampton	Brann	B,DF	2	Y	4
7	Lancing	Brann	B,SF,DF	3		8
8	L'hampton	Brann	B,DF	5		8
9	Lancing	Brann	B,SF,DF	6	Y	9
10	Lancing	Cistermiser	B,DF	1		6
11	Lancing	Cistermiser	B,SF,DF	1		9
12	Lancing	Cistermiser	B,DF	2		8
13	Lancing	Cistermiser	B,SF,DF	2		8
14	Lancing	Cistermiser	B,SF,DF	2		6
15	L'hampton	Cistermiser	CB,DF	2		9
16	L'hampton	Cistermiser	B,DF	2		7
17	Lancing	Cistermiser	CB,DF	2		5
18	Lancing	Ecoflush	B,DF	1		4
19	L'hampton		B	6	Y	2
20	L'hampton	Mecon H	CB,DF	1		7
21	Lancing	Mecon H	B,DF	4	Y	8
22	Lancing	Mecon H	B,SF,DF			7
23	L'hampton	Mecon I	CB,DF	1		9
24	Lancing	Mecon I	B,DF	3	Y	9
25	Lancing	Mecon I	B,SF,DF	3	Y	8
26	L'hampton	Mecon I	B,DF	3		8
27	Lancing	Mecon I	B,SF,DF	4		9
28	L'hampton	Mecon I	B,DF	4		9
29	Lancing	Mecon L	B,SF,DF	1		9
30	Lancing	Mecon L	B,SF,DF	2		8
31	L'hampton	Mecon L	B,DF	2		8
32	Lancing	Mecon L	B,DF	3		9
33	L'hampton	Mecon L	B,DF	4		8

NB: In 'Monitoring Sequence' column,
B = background,
CB = calculated background,
SF = Save-a-Flush installation
DF = dual flush installation

Overall Savings

The average percentage saving resulting from the installation of retrofit dual flush devices for all properties in the study was 27%. This is based upon an average 'background' flush volume of 9.6 litres and an average dual flush volume of 7 litres, and equates to a saving per flush of 2.6 litres, on average. The average saving resulting from the installation of the Save-a-Flush displacement bag (at 16 properties) was 11%. This is based upon an average background flush volume of 9.8 litres for these properties, with an average Save-a-Flush volume of 8.8 litres, a saving of one litre on average. This, together with the minimum and maximum savings observed at individual properties is presented in Table 3.

Table 3: Overall savings

	Save-a-Flush (%)	Dual Flush (%)
All Properties	11.2	27.1
Minimum	-9.6	-27.5
Maximum	32.8	63.8

The maximum dual flush savings observed at a single property was 63.8% on average. This, together with the fact that savings at 19 of the 32 properties in which a dual flush mechanism was installed, were greater than the average, is encouraging. Despite this, the minimum observed saving for both the dual flush devices and a save-a-flush bags was negative. While there are possible reasons for this at individual properties as discussed later, it does indicate that the picture at each property is necessarily complex.

Device Performance

Figure 1 illustrates the average savings achieved by each individual dual flush device and the Save-a-Flush displacement bag. The highest savings, 39.2%, were observed in properties using the Mecon high default system. This mechanism will deliver a high volume flush unless the user intervenes by pulling on the tag. The next best performance, 31.2%, came from the Mecon low default system. In contrast, this device delivers a low volume flush unless there is user intervention.

This result is slightly counter-intuitive, as one would expect a device that dispenses a low flush as a default to save more water than one where the user has to specifically select a low flush. Care must be taken when interpreting these results, however, because only three properties were fitted with the high default system.

The next best savings were observed at properties with Cistermiser systems installed, where the saving per flush was 28.9% on average. This was a positive result for a device which suffered from a number of operational problems, and was generally not favoured by either the customers or the plumber. Some customers reported flushing was accidentally triggered, that being the case the overall saving would be less than 28.9%.

Close behind the Cistermiser was the Brann device, which saved 24.4% of total flush volume on average. The lowest savings observed from the original set of five devices tested was 22.4% from the Mecon interrupter system.

Figure 2 illustrates the average performance of all the dual flush devices at each of the properties. This plot provides further information on the relative performance of each device, and gives an indication of the consistency of savings that could be achieved.

The first striking characteristic of this graph is the negative savings observed at property '9', where a Brann device was installed. It is now understood that the family at this property regularly foster children for short periods of time. The negative savings observed may therefore result from improper use of the device. Removing this property from the study would result in an average saving at Brann properties of 30.6% and an overall saving of 28.6%.

There is one other property, number 13, where average flush volumes increased after dual flush installation. The cause of this is unclear, but the average flush volume during the background monitoring phase was very low at 6.7 litres, hence any savings would be marginal at best. Removing this property from the study would result in an increase in the average savings at Cistermiser properties to 29.1%, however overall savings are barely affected.

There were two other properties where the Brann device was installed and where savings were disappointing, but further investigation has not shown any clear reason for this. Despite this, the other six households using this device benefited from consistent savings of 29% to 39%, with property number 1 recording the lowest average dual flush volume of just 3.7 litres per flush.

The savings at Cistermiser properties ranged from 13.4% to 63.8% and contain the two highest individual savings observed in the trial. Property 10 had the second lowest average flush volume after dual flush installation, 4.2 litres per flush.

The small amount of data available for the EcoFlush device suggest respectable levels of saving of around 20% from this system.

Savings resulting from the installation of the Mecon interrupter device are varied, with three properties only achieving savings around 10%, whilst three other households benefit from savings of over 20%. Results for the Mecon high flush default device were also varied and show inconsistency which may result from the need for user intervention.

The final device tested was the Mecon low flush default device. Savings were generally lower than those observed elsewhere, but were far more consistent, with four of the five devices

delivering average savings within 6% of each other. This demonstrates that this device is able to achieve dependable levels of savings in a range of household situations.

Figure 3 compares the savings achieved in those properties where both the Save-a-Flush bag and the dual flush device were tested. The figure illustrates that the dual flush device saved more water per flush than the displacement device at 11 out of the 16 properties examined. But this is to be expected, as the particular Save-a-Flush bags used were designed to save one litre per flush only. However, in five properties the Save-a-Flush bag performed better than the dual flush device.

The reasons for this are generally specific to each cistern. For example, at Property 25, the measured saving per flush arising from the Save-a-Flush installation was over 2.5 litres, but a properly installed Save-a-Flush bag should only reduce the flush volume by one litre. It is now thought that a saving of this volume occurred because the Save-a-Flush bag was obstructing the full movement of the ball-cock, thus preventing full refill of the cistern. Elsewhere (e.g. Property 13), it appears that a 'fit & forget' displacement device is more appropriate to a particular household than a dual flush installation.

Double Flushing Analysis

One of the principal arguments against the use of dual flush toilets is the perceived high degree of double flushing that is necessary[g]. Double flushing occurs when the initial low volume flush is insufficient to clear the pan and a second (or third) flush is used. It is possible that a high prevalence of double flushing could negate the water saving benefits of dual flush systems.

There are a number of parameters which can be drawn from the data collected to assess the occurrence of double flushing. The most obvious is the flush volume, but this is complicated particularly when variable flush volumes occur. Another option is to analyse the change in flush patterns that occur when the interval between flushes is varied.

Each 0.5 litre volume that passed through the meter on the inlet pipe was recorded by the logger as a single event, or 'pulse'. The analysis employed by Southern Water assumed the termination of a single, complete flush when 300 seconds had elapsed without an event being recorded after the previous pulse. Therefore a standard single flush of 9 litres appeared in the logger output as 18 consecutive 0.5 litre pulses followed by at least 300 seconds of zero flow. This is complicated when one considers that a similar sized event (in terms of volume) would occur when two 4.5 litre flushes were separated by less than 300 seconds.

This second scenario could be considered a double flush, but would not be registered as such when using a 300 second separation to define single flush events. However, if the two 4.5 litre flushes were 120 seconds apart (for example), and the interval between pulses was reduced to 60 seconds, then these events would be recorded separately.

Therefore, by varying the interval, which defines the separation of flush events, it is possible to determine the percentage of flushes that occur between certain intervals. In fact, comparisons were made between flush size distributions, as defined using a separation of 60 seconds and 300 seconds.

A small sample of properties was selected for analysis to assess the likely occurrence of double flushing. However, it should be noted that it is not actually possible to determine whether two flushes close together constitute a double flush, or are two separate events. Table 4 summarises the percentage of flushes separated by between 60 and 300 seconds at four properties.

Table 4: Percentage of flushes separated by between 60 & 300 seconds at selected properties

Property	Device	Pre Dual Flush	Post Dual Flush
A	Mecon Low	1.9	5.2
B	Mecon High	3.1	5.1
C	Mecon Interrupter	8.2	4.2
D	Brann Device	4.0	5.1
Average (%)		**4.3**	**4.9**

The data indicates that the average increase in double flushing rates as a result of dual flush installation is only 0.6%. This is very encouraging, for it suggests that double flushing does not increase significantly when dual flush is installed. Despite this, double flushing at Property A rises nearly threefold from 1.9% to 5.2%. This relatively large increase is probably a result of the low flush volume being set to approximately 3 litres, which is possibly too low for an existing domestic cistern.

As a separate issue, this exercise validated 300 seconds as the interval with which to define the separation of normal flushes. It was found that a separation of less than this value resulted in the frequent splitting-off of the 'tails' of normal flushes leading to isolated pulses, because as a toilet fills slowly towards its maximum level the interval between logger pulses increases.

Ratio of Long to Short Flushes

The savings described above provide evidence that users of dual flush systems can operate the low flush option effectively. Analysis of the ratio of long to short flushes can help to understand the way in which these savings are made. Unfortunately, it was not possible to categorise average flush volumes into long and/or short at those properties fitted with Mecon Interrupter,

g For a full analysis, refer to: Appendix G : 'Dual Flush Trial, Double Flushing Analysis', Southern Water Report No. 90001/TR/00/21 March 2000

Brann and Ecoflush units because of the range of volumes being measured.

However, Figure 4 illustrates the proportion of total flushes at six selected properties that could be defined as either long or short. There is a high degree of variability in the ratio of long to short flushes, but in these six properties, short flushes constitute at least 42% of all events. Amongst all the properties in this study, number 20 recorded the highest overall saving per flush at 50%, with 96% of all flushes defined as short. This should be compared with the property (number 33), having the next highest proportion of low flushes, which had a saving of 38% overall.

Bounce-back

One of the problems of undertaking a study of this nature is the effect the experiment itself has upon the participants. For example, it would be normal to expect the triallists to make extra efforts to use the devices correctly, or even to an extreme, at the outset of the project and this could have resulted in over-estimates of the long term savings that could be achieved. Indeed, the principal reason for monitoring over six months was the hope that any initial effects of the installation would wear off, and that some bounce-back in the level of savings initially observed would be measurable.

Figure 5 illustrates examples of bounce-back at three properties. The initial savings observed at each of these locations diminishes over each of the dual flush periods, each of approximately one month in duration. However, it is encouraging that these three installations are the only ones that clearly demonstrate any significant bounce-back. When the changes in savings are viewed over time, as grouped by device, there is only limited evidence of bounce-back, as illustrated in Figure 6.

Savings made by the Brann and Cistermiser devices do diminish over time, although the average saving made by the Brann device over the whole period is within 10% of the savings made within one month of installation. Of all devices, Cistermiser appears to suffer most from bounce-back, with average savings falling from 34% to 21% in five months, before recovering to 29% in the final month of the study.

The average savings resulting from the Mecon interrupter and low flush default devices remain consistent throughout the monitoring period, however savings from the Mecon high default device actually increase over time, rising from 33% to 47% over the study period. This may be an effect of the low sample of properties using this device, or could reflect a learning process as customers adapt to the function of a new system.

It is concluded that bounce-back is present in some individual properties, but it is less apparent when all the results are analysed together, and therefore it can be considered a relatively minor phenomenon, over the duration of this trial. Whether higher rates of bounce-back would occur over longer periods is less certain.

Effect of Property and Household Type

The study aimed to recruit a number of households of differing types and sizes to assess the effect of dual flush in different environments. Two key variables have been used to examine the effect of household type and size: (1) number of occupants and (2) number of toilets in each household. Figure 7 compares the average savings achieved overall (in all properties) with the savings made in:

- Single occupancy properties,
- Properties with two occupants,
- Properties with more than two occupants,
- Properties with one toilet,
- Properties with more than one toilet.

The data suggests there is an inverse relationship between occupancy rate and savings resulting from dual flush installation. Single occupancy properties saved an average of 37% as a result of dual flush installation, whilst households with two occupants saved 27% and multiple occupancy residences saved 20%.

This is intuitively correct, as one would expect savings to diminish as more people had to adapt to the operation of a new system. Indeed, this result suggests that perhaps it would have been better to provide operating instructions to all residents, rather than just those individuals present when the installation was carried out.

Table 5: Distribution of occupancy rates

Occupancy Rate	Number of properties
1	7
2	14
3	5
4	4
>4	3

It should be noted that the sample population in this study is slightly biased towards retired couples and individuals. This is partly a result of the two areas selected for the study having relatively large proportions of elderly residents, but also because there is perhaps a tendency for trials such as this to attract volunteers from these particular population groups. Table 5 summarises the distribution of occupancy rates amongst the participants.

Most of the residents in the single and two person occupancy households could be considered as retired or elderly. In fact 21 out of the 33 properties (63% of the sample) are in this category. The remaining households in the study could generally be considered as family households with one or more children of varying ages from toddlers to teenagers.

The second analysis undertaken to determine the effect of property type upon dual flush savings reviewed the effect of having more than one toilet in the house, when only one of the appliances had been fitted with dual flush. In the sample population there were seven properties with more than one toilet and Figure 7 illustrates that the savings at these locations were almost half the savings made at properties with only one WC.

The dual flush installation was undertaken in the most convenient of the toilets in each property, and there was no pattern to the selection of the one to be converted. As a result, some of the retrofitted WCs were in the main bathroom for example, whilst others were in a downstairs cloakroom or an en-suite bathroom. Because of this, usage rates were variable, but the savings quoted are per flush, and therefore any reduced usage of a second toilet would not have an impact on potential savings. It is suggested that the principal reason for reduced savings in properties with multiple WC's is the difficulty in adapting to the dual flush system, when at least one other toilet in the property is operated with a normal single flush.

The above analyses have considered the effects of household size and number of toilets as separate issues, but the two are likely to be closely linked. It may be summarised therefore, that savings resulting from dual flush installation are likely to be greatest in smaller properties with one or two occupants, and be reduced in larger properties where a family may be resident and where only one of the toilets has been converted to dual flush.

Increased savings should be possible in larger houses with one or more toilets, if all appliances are fitted with dual flush, for example in newly built properties.

Customer and Plumber Feedback

The savings that dual flush systems can achieve are closely linked to the user friendliness of each device and the ease with which consumers are able to adapt to its operation. Similarly, the ease of installation is an important factor in considering the cost-effectiveness of dual flush as a demand management measure. This section reviews the feedback received from the trial participants and the plumbers who undertook the installations. The findings presented here can be considered to be as equally important as the quantitative data presented previously.

Pro-forma questionnaires and data sheets were used to note participants comments on the operation of their dual flush system. Table 6 contains examples of comments made over the course of the trial. These comments are not exhaustive and could be considered as 'exception reports' where the customers had specific comments. The questionnaires were also used to collect standard information on the cistern size and occupancy rates from participants in the trial.

Generally, the Brann system was the most successful in terms of user friendliness, perhaps because most people were happy to leave the flush size set to medium. This may explain the relatively low savings achieved by the device, compared to others, and may indicate that further operating guidance is necessary. The plumbers felt the Brann device was comparatively easy to install and the device is considered to be relatively robust. The EcoFlush device was similar in installation, appearance and operation to the Brann device, but benefited from a more professional finish.

Despite its relatively high savings, the Cistermiser device came in for the most criticism. Several people commented that the device was often triggered inadvertently when cleaning around the toilet or even getting in and out of the shower, and that the closure of the flap valve led to loud noises in their plumbing systems. Participants were also uncomfortable with the need to replace the batteries in the system, and would rather the system could be fitted and forgotten. The complexity of the Cistermiser device, and the need to remove the siphon from the cistern also meant the system took the longest to install of all the devices. It is possible the complex nature of the device may affect its robustness and longevity.

The Mecon devices received variable responses. It was commonly felt that the fabrication of the high/low default flush devices was not sufficiently sturdy, and the devices often did not give a positive response when operated. Some comments, as summarised in Table 6, refer to snagging or kinking of the string component and the durability of the device is therefore questionable. The plumbers felt the system was awkward to install and were not confident that the various components would remain as installed. They recommended the use of standard fittings to connect the hose into the

Table 6: Examples of customer comments

Property Code	Type	Comments
1	Brann	Low setting adequate
2	Brann	No problems. Saved consumption.
3	Brann	Very good idea
5	Brann	Leave on medium flush - never use full flush.
6	Brann	Occasionally had to double flush with Save-a-flush. Brann is excellent system
7	Brann	Usually leave on Medium flush Young children double flush on low flush.
8	Brann	Save-a-flush made flush too short. Leave on medium flush
9	Brann	Children tend to double flush
14	Cistermiser	Usually use low flush, however low flush leaves a residue in bowl
15	Cistermiser	Very loud noise as valve opens and closes, I don't like it. Save-a-flush was better.
16	Cistermiser	Flush was too small with Save-a-flush bag. Sometimes cistermiser flushes spontaneously.
17	Cistermiser	Always need to use full flush to get rid of paper.
20	Mecon H	Occasionally the tab gets trapped
22	Mecon H	String keeps kinking and snagging on cistern.
24	Mecon I	Sometimes double flush but generally a good idea
25	Mecon I	Automatic device would be better.
27	Mecon I	Forget to press the button. Save-a-flush was better.
28	Mecon I	Forget to press the button because can't see it.
30	Mecon H	Low flush doesn't appear to be working
31	Mecon L	Short flush is adequate
32	Mecon L	Have to use more bleach - low flush should be longer. Occasionally double flush
33	Mecon L	Rarely use maximum flush.

head of the siphon, as used in the Brann and EcoFlush systems.

The Mecon interrupter was considered, by the plumbers, to be one of the neatest systems on trial, although there was concern about how widely it could be installed, given the requirement for two holes in the cistern wall. A number of participants commented that they often forgot to press the button, and it is felt that the performance of this device is particularly dependent upon the commitment of the user. Despite this, the device appeared to be relatively robust.

Table 7 summarises the qualitative assessment of the devices on trial. It indicates that the Brann system comes top in all categories, tying with the Mecon Interrupter device for robustness/durability and aesthetic appearance. The Mecon High/Low default devices score poorly, as does the Cistermiser system.

By way of comparison, only two of the 16 customers who had Save-a-Flush bags installed were unhappy with their operation, due in both cases to perceived inadequate flush volumes.

DISCUSSION

Interpretation of results

The results presented in the previous section are encouraging for they suggest, albeit based on a small number of properties, that the installation of retrofit dual flush devices could reduce the volume of water used for toilet flushing by approximately 27% on average. Toilet flushing accounts for around 30% of the water used in the home, hence the blanket installation of retrofit dual flush devices could reduce domestic consumption by approximately 8%, equivalent to a saving of some 670 Ml/d across England and Wales. This is less than that estimated by the former NRA but, nevertheless, represents a significant saving.

For comparison, Save-a-Flush bags could reduce domestic consumption by some 2.4%, which is equivalent to around 200 Ml/d nationwide.

Table 7: Summary of qualitative assessment of dual flush devices (based on triallists and plumbers reports)

Category	Best Device	Worst Device
Ease of installation	Brann	Mecon H/L
User friendliness	Brann	Mecon H/L/Cistermiser
Robustness & durability	Brann/Mecon Int.	Mecon H/L
Aesthetic appearance	Brann/Mecon Int.	Cistermiser/Mecon H/L
Universality	Brann	Mecon Int./Cistermiser

Cost Implications

The total cost of each operational device is the sum of the unit cost of the system itself plus the cost of installation. The approximate cost of the Brann and Mecon kit is £10 per unit. Following discussion with the plumbers contracted to undertake the fitting of the systems in this trial, the cost of installing these kits, based upon 1000 units, is estimated to be around £10 per unit, giving a total cost for each operational device of approximately £20.

Assuming the flushing frequency recorded in this trial (approximately 5 flushes per person per day), a saving of 2.6 litres per flush, a typical occupancy ratio of 2.5 persons per property, and typical water and wastewater charges of 150 p/m3, then the purchase and installation costs of a device in measured households could be recovered in a little over one year.From a water company perspective, a 1Ml/d saving, based on the above assumptions, would require the installation of over 30,000 devices, costing in excess of £0.6M.

In contrast, the Save-a-Flush bags save one litre per flush or some 13 litres per property per day based on the above assumptions. Consequently, a 1Ml/d saving would require the installation of some 80,000 bags. However the Save-a-Flush bag is distributed via mail shot, which has typically resulted in a 30% take-up, therefore over a quarter of a million deliveries would be required. Since the unit cost of buying and posting each bag is 80p, the total cost of the 1Ml/d saving would be of the order of £0.2M.

Consequently, the cost of installing dual flush systems to save 1 Ml/d of water is almost three times greater than the cost of saving the same volume through Save-a-Flush installation

In order for the 'twin track' approach towards water resources to be effective, water efficiency strategies such as dual flush retrofit need to be considered in the same context as other water resource schemes. Such schemes typically cost between £0.75M and £1.5M per megalitre, hence dual flush installation bears comparison with these more traditional schemes, when reviewed objectively.

CONCLUSIONS & RECOMMENDATIONS

Conclusions

The study has successfully demonstrated that genuine savings can be made through the installation of certain displacement devices and retrofit dual flush systems in real life domestic situations. That is not to say that savings were achieved at every single property but that, on average reductions in flush volumes were observed.

Savings varied from device to device, and it appears that users do require well designed, device specific instructions in order to optimise savings. This was evident with the Brann system, where many users simply left the flush size on the medium setting. However, appropriate operating instructions could maximise savings in large households, where reductions in flush volume are depressed.

The results from this study suggests that double flushing does not necessarily increase as a result of dual flush installation. This finding, together with the overall results, contradict the long held belief that dual flush toilets do not save water because of double flushing.

The costs per megalitre of Save-a-Flush and dual flush installation are favourable when compared to standard estimates of new resources, although total savings may be relatively modest. Save-a-Flush is about 60-70% cheaper than dual flush, however potential savings are also much lower.

This investigation has taken much effort and commitment from all of the project team at Southern Water and the Environment Agency, but has only been possible with the co-operation of the customers who took part in the trial.

Recommendations

The preferred device in this study was the Brann unit, but the data and comments supplied by users suggests there was a tendency to leave the dial on the medium setting. It is recommended that the device be further tested with only two settings available.

This study has been based upon a relatively small number of properties that do not necessarily represent the wide demographic or socio-economic characteristics at the company level or indeed, national level. Further, it is possible that the recruitment method may have resulted in a sample population with particular motives or predisposition to save water.

As a result, it is recommended that further studies should be carried out using a more statistically representative sample of properties. It is likely that this will require a significantly larger sample size, but may only be possible as a collaborative project between a number of parties.

The study has demonstrated that the perceived double flushing problem associated with dual flush systems is not significantly different from that associated with single flush systems. The findings presented here may therefore help to promote changes in the Water Supply (Water Fittings) regulations 1999, which remain a barrier to the wider introduction of retrofit dual flush cisterns.

[h] *Water & Sewage Bills, 1999-2000, OFWAT*

Plate 1: The Mecon high/low default Flush Device

The photograph illustrates the device as seen by the user, with pull-tag which is operated to attenuate the flush. A label provides instructions.

Plate 2: The Mecon Interrupter Device

The device is operated by the green button on the left of the cistern wall. This introduces air into the siphon, arresting the flush when pressed. The logger is just visible underneath the bottom of the cistern

Plate 3: The Peter Brann Device

The dial selector around the toilet handle determines the size of the flush, based upon the length of the three tubes which extend below the device (not visible). The siphon is broken when the water level in the cistern falls below the bottom of the tube selected.

Plate 4: The Cistermiser Device

The device is operated by passing ones hands in front of the silver sensors mounted on the front of the cistern. This operates the flap valve, seen here topped by a white plastic cap. The box on the left contains the device actuator and batteries to power the system. The logger is visible in the lower right corner of the picture

Plate 5: The EcoFlush Device

The dial device is operated in a similar way to the Brann system. The meter on the inlet pipe is clearly visible.

Figure 1 Average Percentage Water Saved per Flush by Device

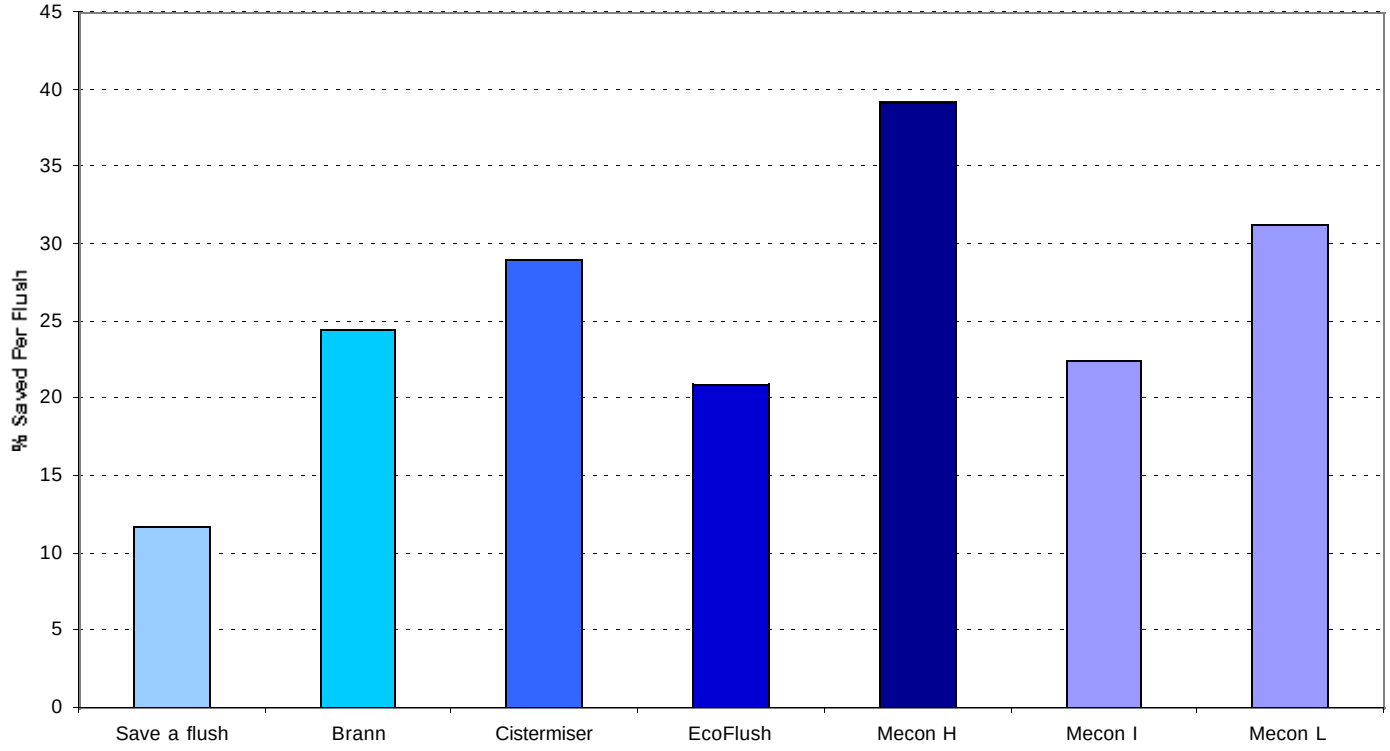


Figure 2 Percentage Savings at each Property

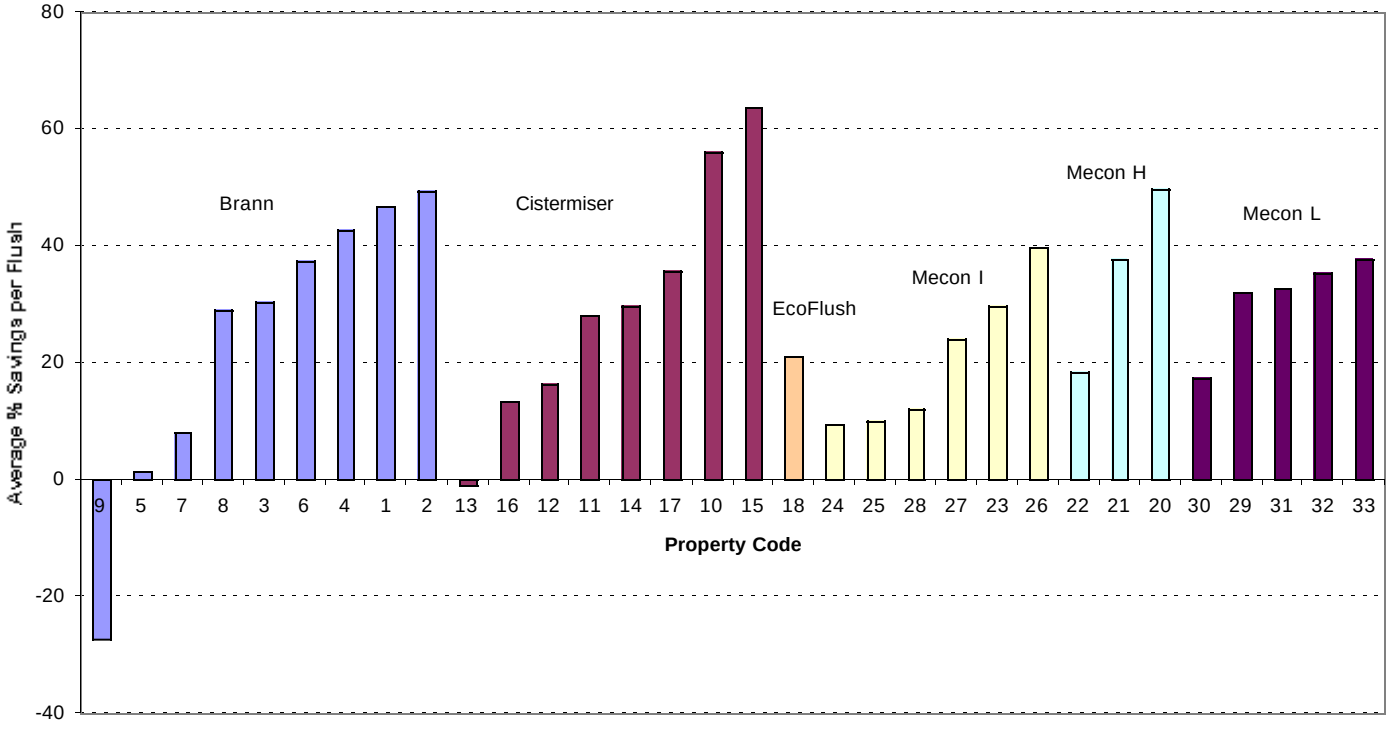


Figure 3 Comparison of savings resulting from Save-a-Flush and Dual Flush installations

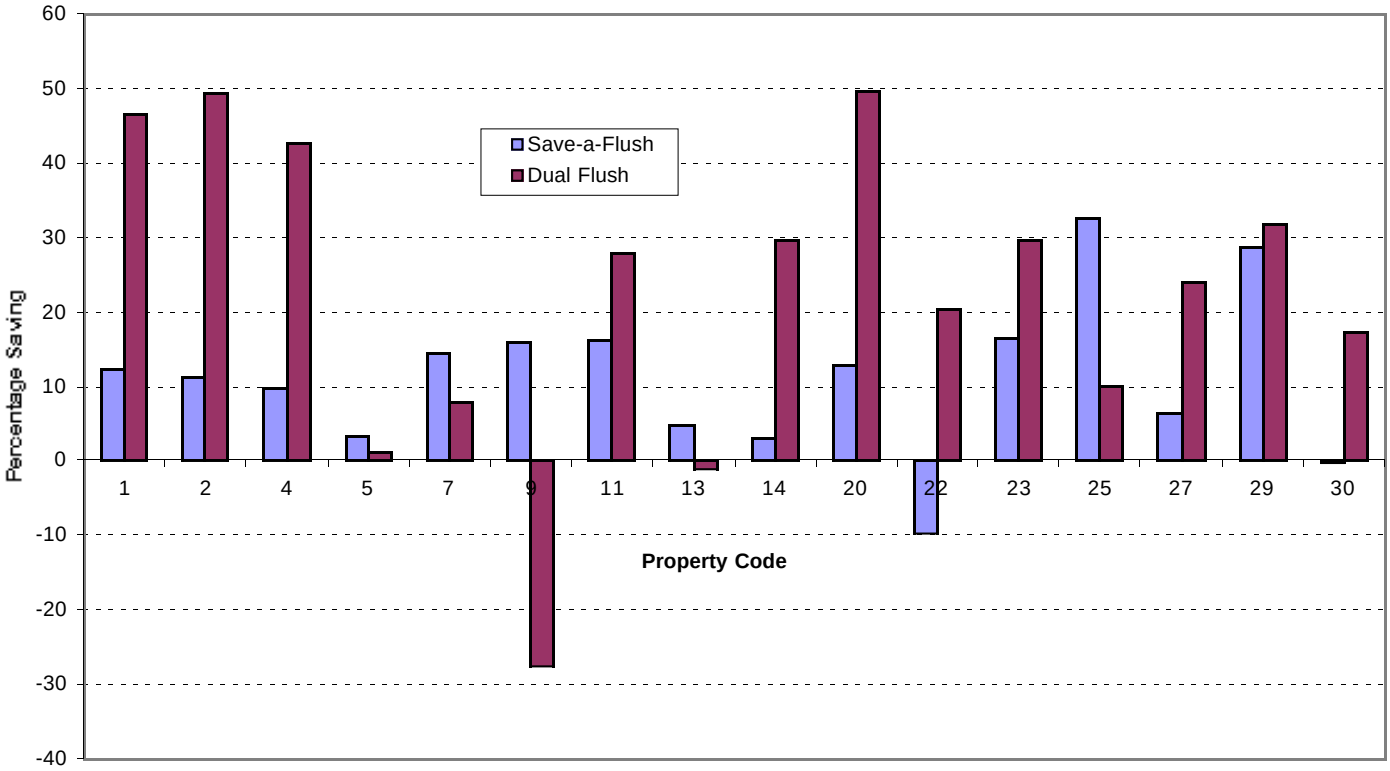


Figure 4: Ratio of Long to Short Flushes at Selected Properties

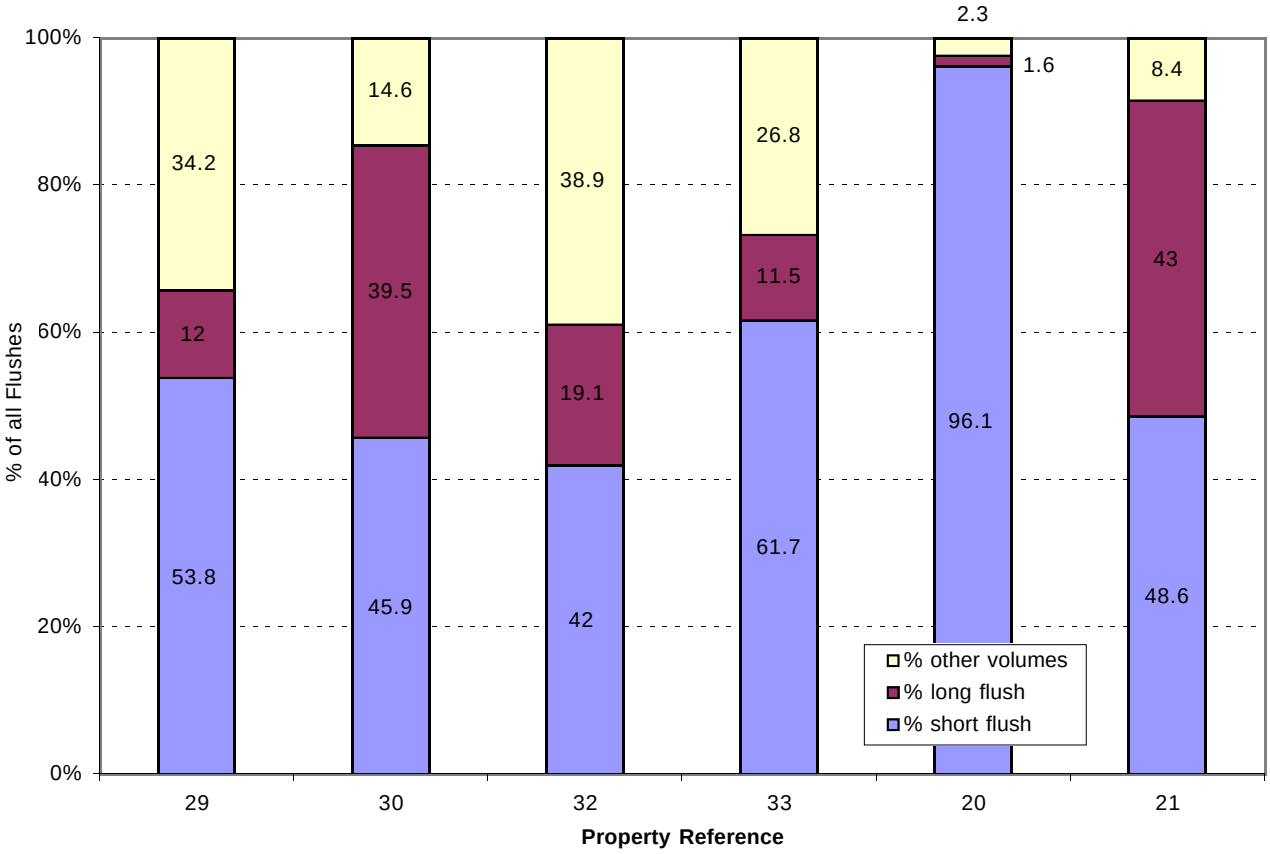


Figure 5 Evidence of Bounce-Back at three selected Properties

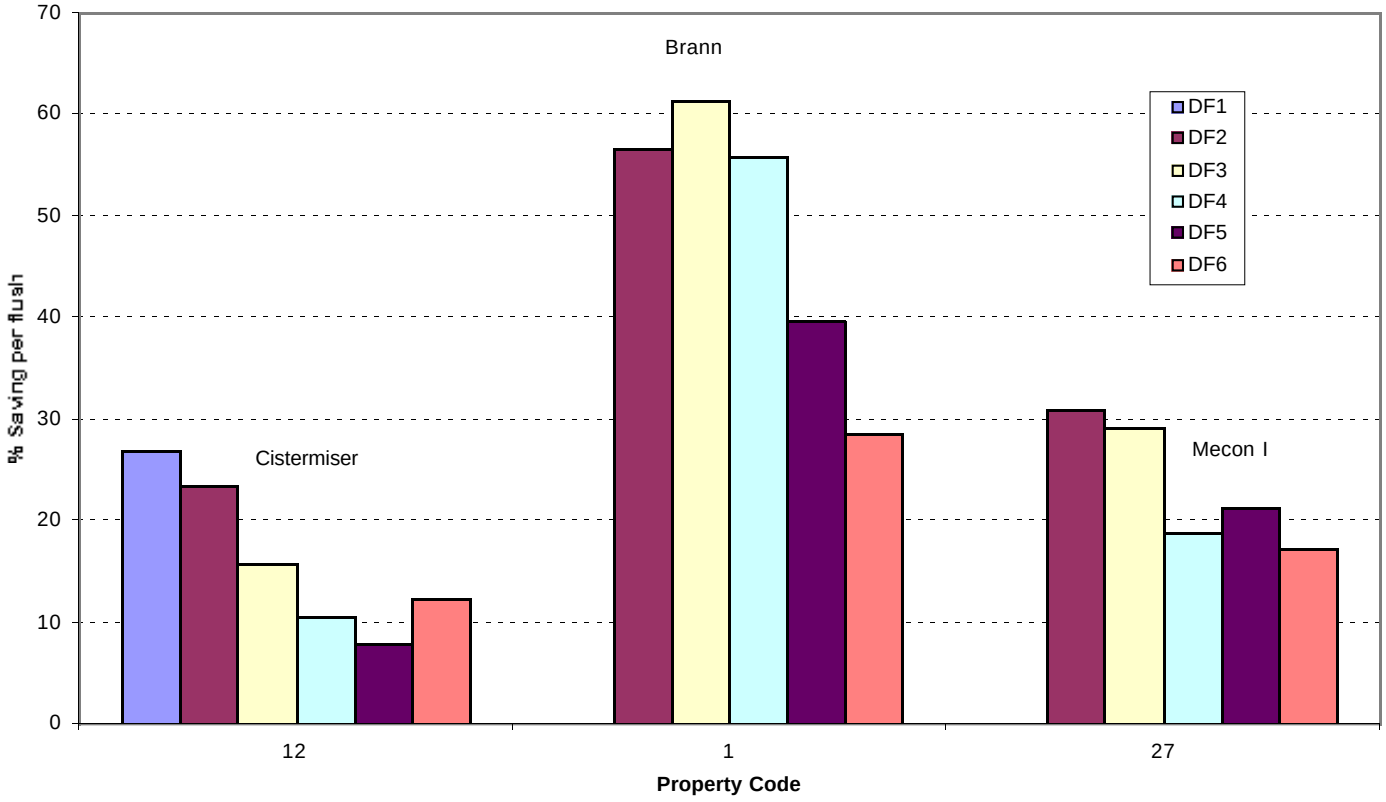


Figure 6 Changes in savings over time, by Device

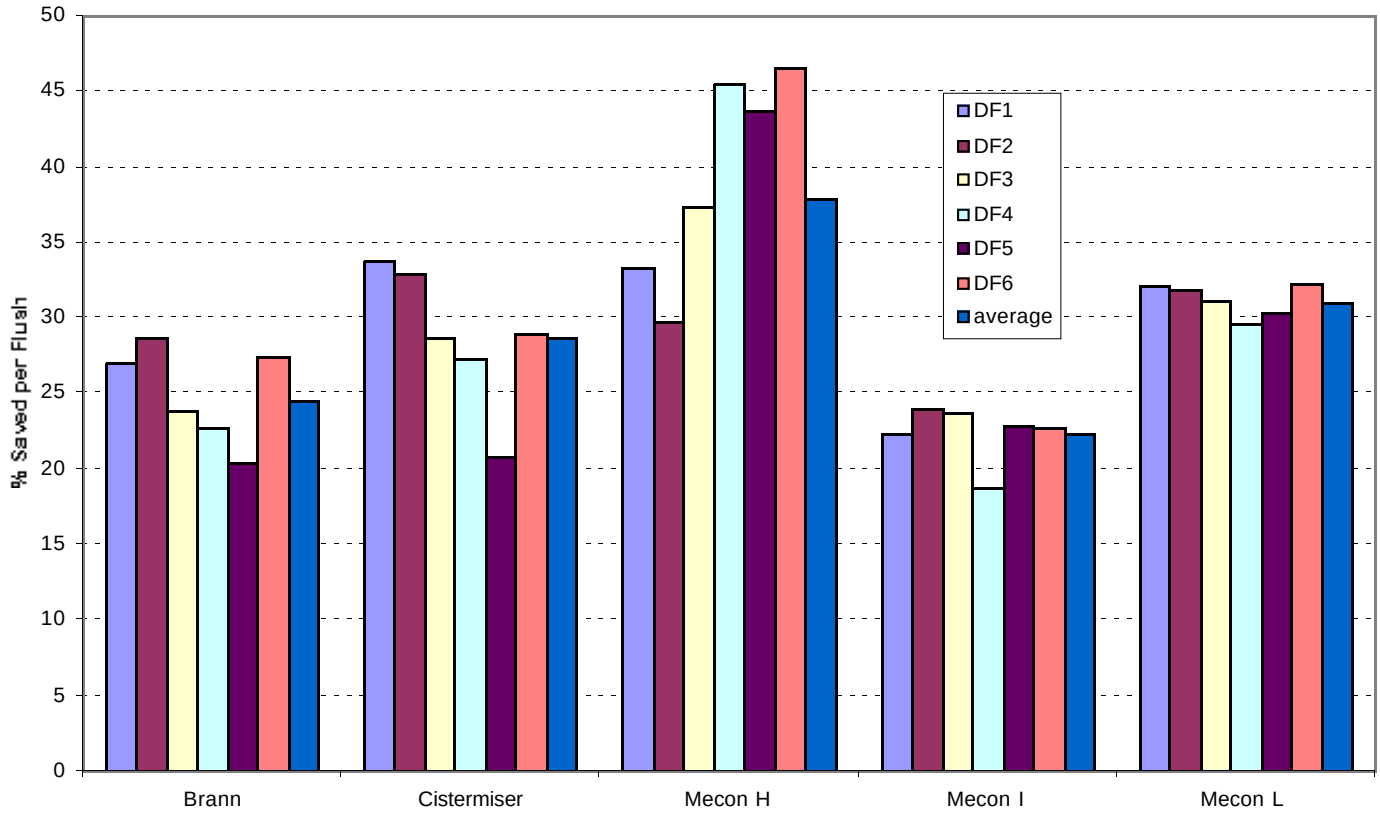
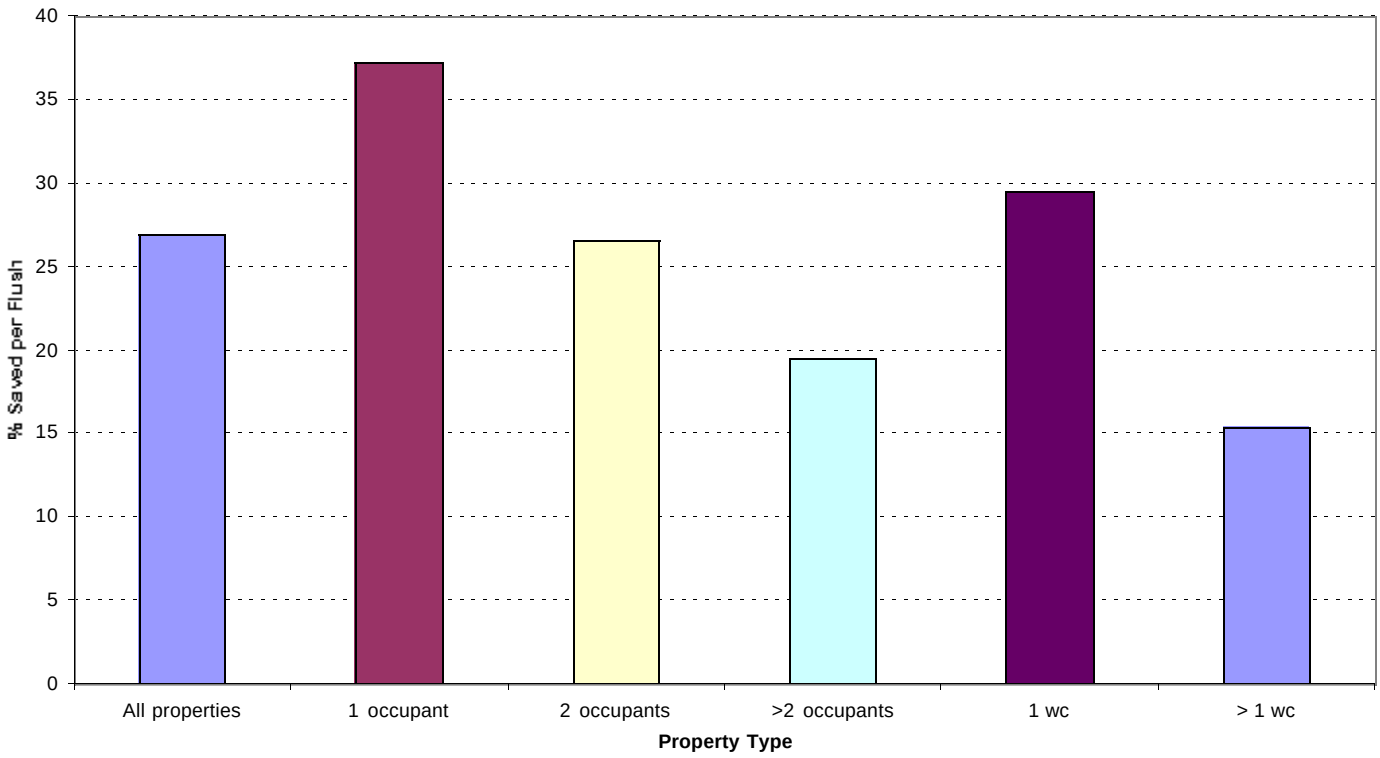


Figure 7 Comparison of Savings in different Household types



METHOD STATEMENT FOR THE TRIAL OF DUAL FLUSH AND VARIABLE FLUSH DEVICES IN DOMESTIC TOILETS

Project Objectives

To evaluate the effectiveness of dual flush toilets as a water efficiency device and to determine potential savings in water consumption by retrofitting dual flush devices to existing single flush cisterns. To assess how customers are likely to utilise dual flush options.

Project Team

The project will be undertaken by Southern Water Asset Group (SWAG) in close liaison with the Project Team, which comprises of the following individuals:

David Howarth
Manager, National Water Demand Centre, Environment Agency
Joe Pearce
Team Leader, Water Resources Management, Sussex Environment Agency

Jon Crooke
Water Strategy Manager, Southern Water Services

Dave Styles
Regional Bye-laws Co-ordinator, Southern Water Services

Terry Keating
Chief Statistician, Southern Water Assets

Rob Lawson
Senior Hydrologist, Southern Water Assets

Pre-trial Assessment

A Pre-trial assessment of meters and devices will be undertaken to assess the suitability of the various meters, logger and dual flush device options before installing the equipment in customer properties. This pre-trial assessment will utilise washroom facilities at operational Southern Water Services sites and last approximately six weeks.

Trial Participants & Customer Contact

Potential participants in the trial will be identified from customers previously involved in a water audit of their homes. This audit covered 197 properties in the Highdown Drive area of Littlehampton, West Sussex. These customers will be invited to take part in the Dual Flush Trial and those interested will be introduced more fully to the trial and the equipment being used at a public meeting to be held locally in late September, to be attended by representatives of Southern Water and the Environment Agency.

The properties of those still interested in participating in the trial will be individually assessed in terms of suitability for meter and logger installation during early October, and the equipment will be installed in late October. The initial six month trial period will allow consumption to be measured over the more stable winter period, when occupancy rates remain relatively stable and customers are less likely to be unavailable due to holidays.

A customer contact will be identified within SWA for the duration of the trial who will also be responsible for downloading data and maintaining the flow logging equipment in the customer premises. As customer service is of paramount importance to Southern Water, the customer contact will be fully aware of all customer service considerations. In addition all relevant functions of Southern Water, including Customer Services and Area Distribution staff, and the Environment Agency will be kept fully informed of the trial as it progresses.

Dual Flush Devices Selection & Installation

A number of dual flush devices of slightly differing design are currently available, these include:

- Mecon
- Cistermiser
- Ecoflush
- Brann

The proposed strategy is to trial these devices in the operational sites and possibly reduce the number of types to be installed into customer premises. The number and types to be installed will ultimately depend upon the number of customers wishing to take part in the trial, the availability of the devices and their performance in the pre-trial assessment.

All retrofitting of dual flush devices will be carried out by CORGI registered plumbing contractors working under contract to Southern Water. These contractors will undertake the initial fitting, re-instatement after the trial, maintenance and emergency callouts associated with the study. The customer point of contact for any such emergency arising from the installation or a request for the early removal of the equipment will be SWA in the first instance and not the contractor.

Meters & Loggers

A number of meters will be assessed for their suitability for in-house installation during the pre-trial period. Key attributes are meter accuracy under a range of pressure conditions, compatibility with the selected logger and meter proportions/aesthetics. Price will also be a factor. Likely suppliers will be either Kent or Schlumberger, both of whom manufacture domestic water meters.

Various logger options will be assessed for ease of use (set-up, download, data review etc.), compatibility with meters, proportions/aesthetics and price. Three suppliers have been asked to take part in the pre-trial assessment: Wessex, Radcom and Technolog.

Byelaws

It will be necessary to relax the byelaws relating to the use of dual flush appliances in order to install the equipment in customer premises during the trial. An application for this will be made to the DETR.

Post Trial Audits

At the end of the trial, which will last for a minimum of six months, the equipment will be removed and each site returned to its original condition, unless the customer wishes to retain the equipment (with the full understanding that from then on its is their responsibility). It is also proposed to carry out a customer survey to obtain their views on the reliability, practicalities and ease of use of the equipment. This survey will be carried out by SWA staff

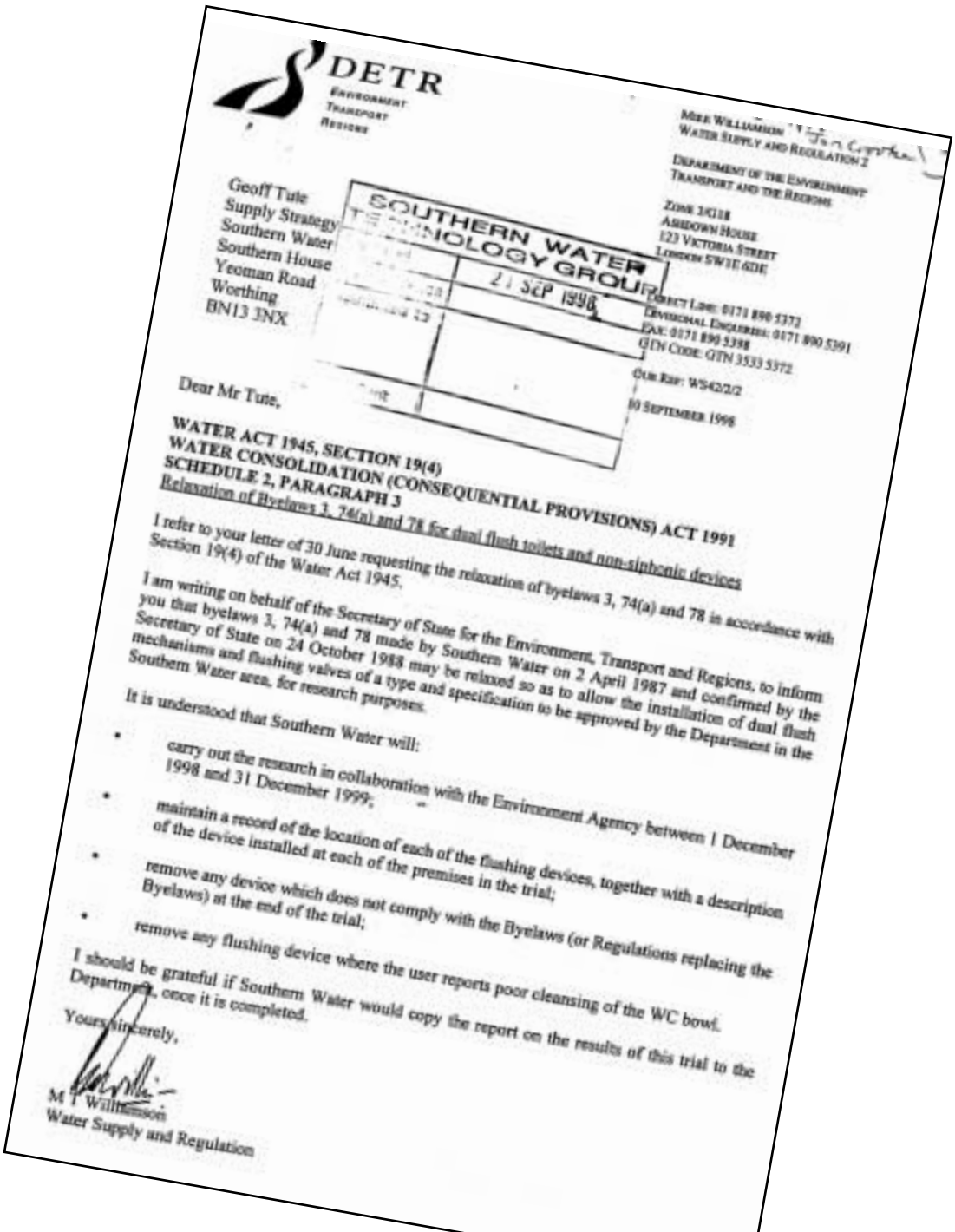
Reporting

The data collected from each house will be analysed by SWA and assessments made of the volume of water used in flushing. The savings made through the installation and use of each dual flush device will be estimated. Comparisons will be drawn between the various devices being trialled.

The results will be presented in a report to the Project Team.

August, 1998

APPENDIX B: RELAXATION OF BYELAWS



DETR
Environment Transport Regions

Mike Williamson
Water Supply and Regulation 2

Department of the Environment Transport and the Regions

Zone 3/G18
Ashdown House
123 Victoria Street
London SW1E 6DE

Direct Line: 0171 890 5372
Divisional Enquiries: 0171 890 5391
Fax: 0171 890 5398
GTN Code: GTN 3533 5372

Our Ref: WS42/2/2

30 September 1998

SOUTHERN WATER
TECHNOLOGY GROUP
21 SEP 1998

Geoff Tute
Supply Strategy
Southern Water
Southern House
Yeoman Road
Worthing
BN13 3NX

Dear Mr Tute,

WATER ACT 1945, SECTION 19(4)
WATER CONSOLIDATION (CONSEQUENTIAL PROVISIONS) ACT 1991
SCHEDULE 2, PARAGRAPH 3
Relaxation of Byelaws 3, 74(a) and 78 for dual flush toilets and non-siphonic devices

I refer to your letter of 30 June requesting the relaxation of byelaws 3, 74(a) and 78 in accordance with Section 19(4) of the Water Act 1945.

I am writing on behalf of the Secretary of State for the Environment, Transport and Regions, to inform you that byelaws 3, 74(a) and 78 made by Southern Water on 2 April 1987 and confirmed by the Secretary of State on 24 October 1988 may be relaxed so as to allow the installation of dual flush mechanisms and flushing valves of a type and specification to be approved by the Department in the Southern Water area, for research purposes.

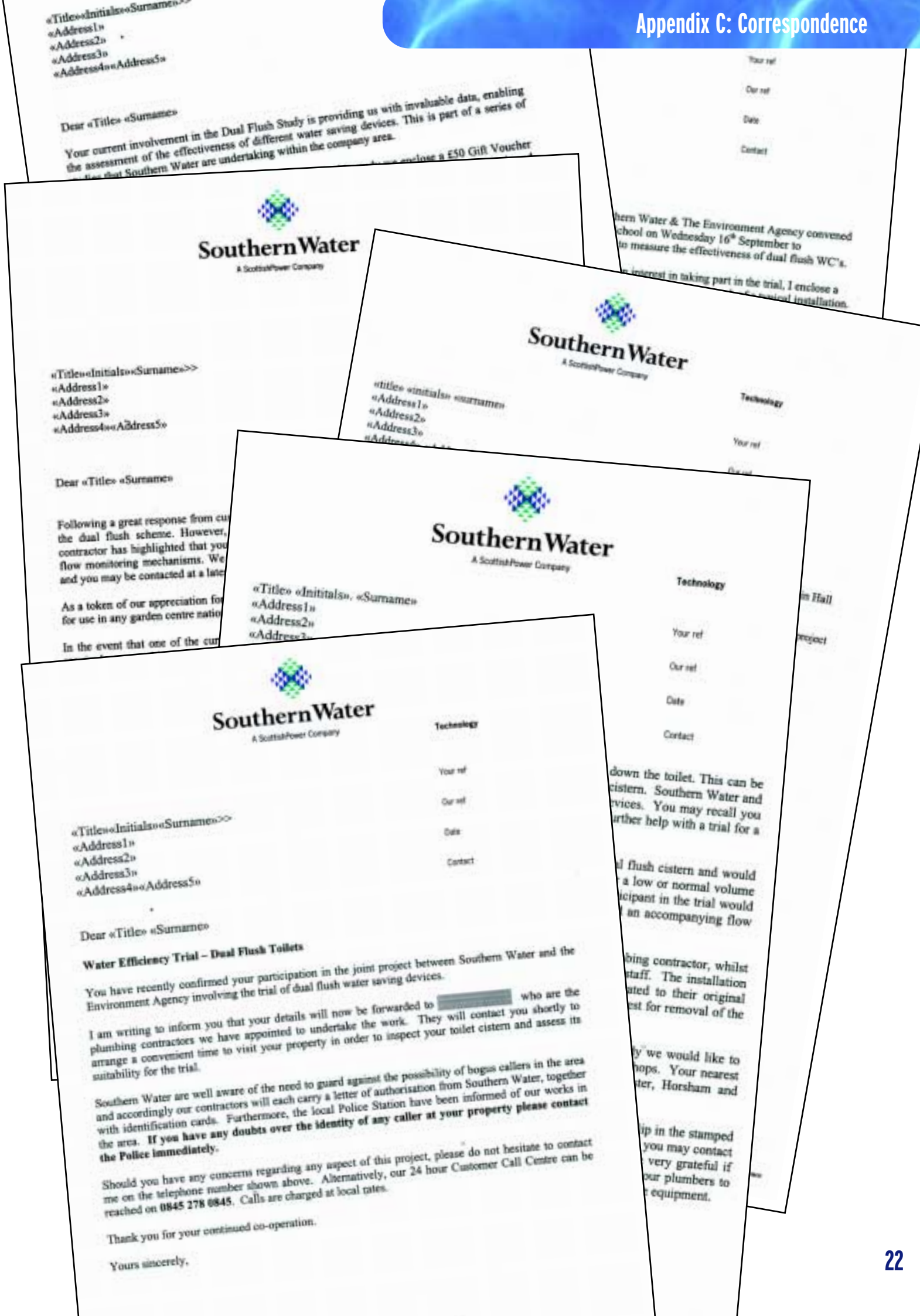
It is understood that Southern Water will:

- carry out the research in collaboration with the Environment Agency between 1 December 1998 and 31 December 1999;
- maintain a record of the location of each of the flushing devices, together with a description of the device installed at each of the premises in the trial;
- remove any device which does not comply with the Byelaws (or Regulations replacing the Byelaws) at the end of the trial;
- remove any flushing device where the user reports poor cleansing of the WC bowl.

I should be grateful if Southern Water would copy the report on the results of this trial to the Department, once it is completed.

Yours sincerely,

M T Williamson
Water Supply and Regulation



«Title»«Initials»«Surname»>>
«Address1»
«Address2»
«Address3»
«Address4»«Address5»

Dear «Title» «Surname»

Your current involvement in the Dual Flush Study is providing us with invaluable data, enabling the assessment of the effectiveness of different water saving devices. This is part of a series of

Your ref
Our ref
Date
Contact

hern Water & The Environment Agency convened
chool on Wednesday 16th September to
to measure the effectiveness of dual flush WC's.

n interest in taking part in the trial, I enclose a

Southern Water
A ScottishPower Company

«Title»«Initials»«Surname»>>
«Address1»
«Address2»
«Address3»
«Address4»«Address5»

Dear «Title» «Surname»

Following a great response from cu
the dual flush scheme. However,
contractor has highlighted that you
flow monitoring mechanisms. We
and you may be contacted at a late

As a token of our appreciation fo
for use in any garden centre natio

In the event that one of the cur

Southern Water
A ScottishPower Company

«title» «initials» «surname»
«Address1»
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Technology

Your ref

Southern Water
A ScottishPower Company

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«Address3»

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Your ref
Our ref
Date
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in Hall
project

Southern Water
A ScottishPower Company

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Contact

«Title»«Initials»«Surname»>>
«Address1»
«Address2»
«Address3»
«Address4»«Address5»

Dear «Title» «Surname»

Water Efficiency Trial – Dual Flush Toilets

You have recently confirmed your participation in the joint project between Southern Water and the Environment Agency involving the trial of dual flush water saving devices.

I am writing to inform you that your details will now be forwarded to [redacted] who are the plumbing contractors we have appointed to undertake the work. They will contact you shortly to arrange a convenient time to visit your property in order to inspect your toilet cistern and assess its suitability for the trial.

Southern Water are well aware of the need to guard against the possibility of bogus callers in the area and accordingly our contractors will each carry a letter of authorisation from Southern Water, together with identification cards. Furthermore, the local Police Station have been informed of our works in the area. **If you have any doubts over the identity of any caller at your property please contact the Police immediately.**

Should you have any concerns regarding any aspect of this project, please do not hesitate to contact me on the telephone number shown above. Alternatively, our 24 hour Customer Call Centre can be reached on **0845 278 0845**. Calls are charged at local rates.

Thank you for your continued co-operation.

Yours sincerely,

down the toilet. This can be
cistern. Southern Water and
vices. You may recall you
rther help with a trial for a

l flush cistern and would
a low or normal volume
icipant in the trial would
an accompanying flow

bing contractor, whilst
staff. The installation
ated to their original
est for removal of the

ly we would like to
hops. Your nearest
ter, Horsham and

ip in the stamped
you may contact
very grateful if
our plumbers to
equipment.

Littlehampton & Rustington Guardian 17/9/98

FLUSH IN A PAN PROBE

LITTLEHAMPTON has been selected as the centre of a major study on flushing the loo!

By Patrick Formoy

Experts on water conservation want to know how savings could be made on the millions of gallons lost each year through our lavatory cisterns.

An estimated one third of all water supplied goes down the pan. Littlehampton is regarded as a priority area because, unless water savings can be found, costly water schemes will have to be carried out inland in the surrounding countryside.

Thirty-five homes in the town are playing their part in the study, being conducted by the Environment Agency and Southern Water.

The homes will have a dual flush cistern and a water meter fitted to existing toilets. Data from the meters will be collected over an eighteen-month period.

The Agency says there are great water savings to be made. The dual flush cistern gives the choice of a long flush (equivalent to the common one-flush cisterns) as well as a short one.

David Howarth, from the demand management centre of the Agency, said: "A short flush uses about half the water, about 4.5 litres, compared with nine litres.

"Over the course of a year a single household could save around 12,900 litres of water (assuming three quarters of the flushes are short). This has obvious benefits to the environment as it would reduce water abstraction from rivers and boreholes.

"If you scale this figure up to a town, county or all of the Southern Region we are looking at saving hundreds of millions of water each year.

"The benefits to the plants and animals in our rivers and lakes will be enormous, especially during periods of drought."

Jon Crooke, Southern Water's water efficiency manager said: "Dual flush toilets could be a useful way of saving water.

"It is estimated that a third of all water supplied is flushed down the toilet. If the trial is successful the increased use of dual flush toilets could save millions of litres of precious water."

Littlehampton Gazette 17/9/98

Acquire a good cistern habit

WATER chiefs hope to be flushed with success by the results of a major study on toilet technology launched in Littlehampton last night (Wednesday).

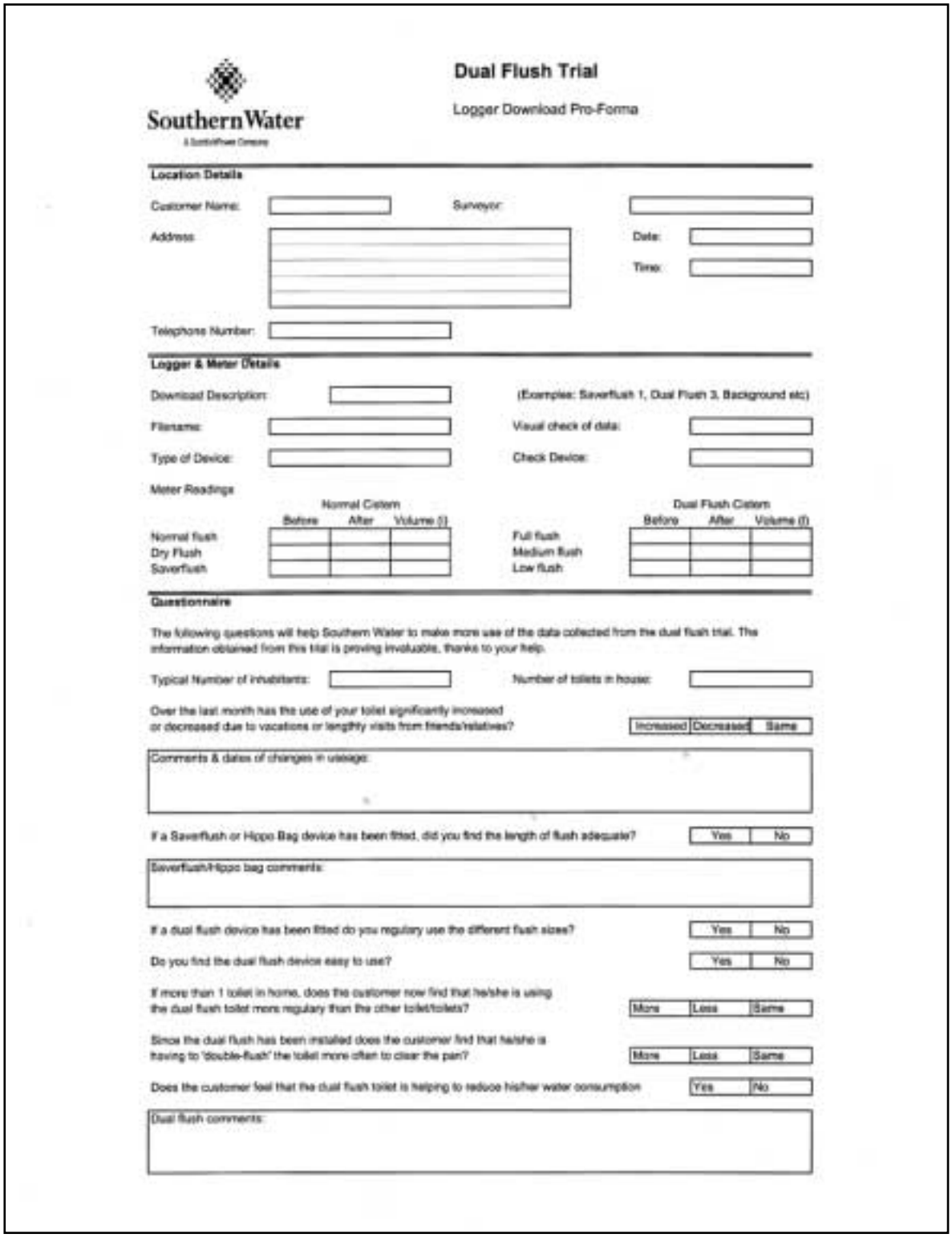
Dual-flush cisterns are to be fitted to loos in 35 homes in the town in a bid to monitor how much water can be saved by the more efficient plumbing.

Officials from the Environment Agency and Southern Water explained the scheme to residents who will be taking part in the trial when it was launched at a meeting at Littlehampton Community School.

The new cisterns offer the choice of a normal, long flush – or a short one using only half as much water.

Environment Agency official David Howarth said, 'Over the course of one year, a single household could save around 12,900 litres of water, assuming three-quarters of the flushes are short.

'This has obvious benefits to the environment as it would reduce water abstraction from rivers and boreholes.'



Southern Water

Dual Flush Trial

Logger Download Pro-Forma

Location Details

Customer Name: | Surveyor:

Address: | Date: | Time:

Telephone Number:

Logger & Meter Details

Download Description: (Examples: Saverflush 1, Dual Flush 3, Background etc)

Filename: | Visual check of data:

Type of Device: | Check Device:

Meter Readings

	Normal Cistern				Dual Flush Cistern			
	Before	After	Volume (l)		Before	After	Volume (l)
Normal flush				Full flush			
Dry Flush				Medium flush			
Saverflush				Low flush			

Questionnaire

The following questions will help Southern Water to make more use of the data collected from the dual flush trial. The information obtained from this trial is proving invaluable, thanks to your help.

Typical Number of inhabitants: | Number of toilets in house:

Over the last month has the use of your toilet significantly increased or decreased due to vacations or lengthy visits from friends/relatives? Increased | Decreased | Same

Comments & dates of changes in useage:

If a Saverflush or Hippo Bag device has been fitted, did you find the length of flush adequate? Yes | No

Saverflush/Hippo bag comments:

If a dual flush device has been fitted do you regulary use the different flush sizes? Yes | No

Do you find the dual flush device easy to use? Yes | No

If more than 1 toilet in home, does the customer now find that he/she is using the dual flush toilet more regulary than the other toilet/toilets? More | Less | Same

Since the dual flush has been installed does the customer find that he/she is having to 'double-flush' the toilet more often to clear the pan? More | Less | Same

Does the customer feel that the dual flush toilet is helping to reduce his/her water consumption Yes | No

Dual flush comments:

Average savings (litres per flush) per property

Brann

Property	Average	% Savings	Min	Max	SAF
9	-2.41	-27.5	-2.9	-1.66	15.98
5	0.15	1.3	-0.34	1.34	3.42
7	0.77	7.9	0.03	1.99	14.56
8	2.90	29.2	2.4	3.35	
3	2.79	30.4	2.47	3.31	
6	3.33	37.4	1.82	4.23	
4	4.01	42.6	3.58	4.49	9.89
1	3.26	46.6	2	4.29	12.29
2	6.61	49.3	6.24	6.92	11.27
Average	30.6				

Cistermiser

Property	Average	% Savings	Min	Max	SAF
13	-0.07	-1.0	-0.36	0.12	4.93
16	1.00	13.4	0.51	1.45	
12	1.63	16.2	0.8	2.72	
11	2.86	28.1	1.56	4.17	16.26
14	2.82	29.8	2.21	3.16	3.27
17	3.60	35.7	3.14	4.47	
10	5.26	55.9	5.06	5.37	
15	5.18	63.8	4.65	5.76	0.00
Average		34.7			

EcoFlush

Property	Average	% Savings	Min	Max	SAF
18	2.33	21.0	2.16	2.53	
Average		21.0			

Mecon Interrupter

Property	Average	% Savings	Min	Max	SAF
24	0.82	9.3	0.51	1.45	
25	0.79	10.1	-0.43	2.29	32.78
28	0.94	12.1	0.48	1.16	
27	2.86	24.0	2.04	3.7	6.62
23	2.35	29.6	2.01	2.82	16.65
26	4.30	39.5	3.71	5.03	
Average		23.1			

Mecon High Default

Property	Average	% Savings	Min	Max	SAF
22	2.01	18.2	1.08	3.35	-9.63
21	3.59	37.5	2.82	4.28	
20	5.36	49.6	5.16	5.52	12.87
Average		35.1			

Mecon Low Default

Property	Average	% Savings	Min	Max	SAF
30	1.87	17.4	0.52	2.45	-0.09
29	2.40	32.0	2.04	2.77	28.70
31	2.53	32.5	2.19	3.56	
32	3.62	35.5	2.89	4.2	
33	4.86	37.7	4.36	5.31	
Average		31.0			

Savings per period per device

Volumetric savings per flush (litres)

	Brann	Cistermiser	EcoFlush	Mecon H	Mecon I	Mecon L	Average
DF1	2.62	3.16	2.53	3.49	2.05	3.16	2.83
DF2	2.79	3.07	2.29	3.12	2.20	3.13	2.77
DF3	2.32	2.69	2.53	3.90	2.18	3.05	2.78
DF4	2.21	2.56		4.75	1.73	2.91	2.83
DF5	1.98	1.95		4.57	2.11	2.98	2.72
DF6	2.67	2.71		4.87	2.09	3.17	3.10
Average	2.43	2.69	2.45	4.11	2.06	3.07	2.84

Savings per flush (%)

	Brann	Cistermiser	EcoFlush	Mecon H	Mecon I	Mecon L	Average
DF1	26.93	33.78	26.80	33.34	22.30	32.13	29.22
DF2	28.67	32.86	24.26	29.81	23.91	31.87	28.56
DF3	23.85	28.72		37.33	23.75	31.09	28.95
DF4	22.70	27.33		45.43	18.78	29.65	28.78
DF5	20.34	20.81		43.66	22.90	30.34	27.61
DF6	27.39	28.98		46.53	22.68	32.27	31.57
Average	24.50	28.70	25.53	37.91	22.33	31.02	28.62

Overall savings

All properties = 33 properties

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.61	8.78	7.02	2.59	1.76	0.82
Minimum	6.7	5.25	3.74	2.96	1.51	1.45
Maximum	13.4	12.07	11.25	2.15	0.82	1.33
Stdev	1.67	2.23	1.75			

Properties with only 1 WC = 26 properties

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.86	8.89	6.95	2.91	1.95	0.96
Minimum	6.70	5.34	3.74	2.96	1.60	1.36
Maximum	13.4	12.07	11.25	2.15	0.82	1.33
Stdev	1.78	2.16	1.68			

Properties with > 1 WC = 7 properties

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	8.68	6.31	7.35	1.33	-1.04	2.38
Minimum	7.78	5.25	5.57	2.21	-0.32	2.53
Maximum	9.56	7.36	11.17	-1.61	-3.81	2.20
Stdev	0.66	1.49	2.06			

Properties with only 1 occupant = 7 properties

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.13	7.21	5.73	3.40	1.48	1.92
Minimum	7.00	5.34	3.74	3.26	1.60	1.66
Maximum	11.10	9.41	8.77	2.33	0.64	1.69
Stdev	1.66	1.71	1.77			

Properties with 2 occupants = 13 properties

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.69	9.40	6.96	2.73	2.44	0.29
Minimum	6.70	6.37	5.25	1.45	1.12	0.33
Maximum	13.40	11.89	11.25	2.15	0.64	1.51
Stdev	1.82	1.93	1.66			

Properties with >2 occupants = 12 properties

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.68	8.02	7.75	1.92	0.27	1.66
Minimum	7.78	5.25	5.97	1.81	-0.72	2.53
Maximum	12.89	11.14	11.17	1.72	-0.03	1.75
Stdev	1.64	2.45	1.51			

Save-a-flush savings for those properties with both BG and SAF values

	BG-SAF		BG-DF	
	Saving (litres)	Saving (%)	Saving (litres)	Saving (%)
Average	1.01	11.17	2.17	20.91
Min.	-1.06	-9.63	-2.41	-27.49
Max.	2.56	32.78	6.61	49.63

Savings per flush for properties with measured BG values

	BG-DF			
	BG (litres)	DF (litres)	Saving (litres)	Saving (%)
Average	9.68	7.66	2.02	20.85
Min.	6.70	5.20		
Max.	13.40	10.77		
St. Dev.	1.72	1.43		

Note: BG = Background, SAF = Save-a-Flush, DF = Dual Flush

Savings by device (litres)

Brann

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.74	8.87	7.36	2.38	1.50	0.88
Minimum	7.00	6.14	3.74	3.26	2.40	0.86
Maximum	13.40	11.89	11.25	2.15	0.64	1.51
Stdev	1.80	2.19	2.59			

Cistermiser

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.35	8.06	6.64	2.71	1.41	1.30
Minimum	6.70	6.37	4.15	2.55	2.22	0.33
Maximum	11.39	9.17	8.45	2.94	0.72	2.22
Stdev	1.55	1.20	1.21			

EcoFlush

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	11.10		8.77	2.33		
Minimum						
Maximum						
Stdev						

Mecon high default

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	10.46	10.74	6.35	4.10	4.39	-0.28
Minimum	9.56	9.41	5.44	4.12	3.97	0.15
Maximum	11.01	12.07	8.77	2.24	3.30	-1.06
Stdev	0.78	1.88	1.79			

Note: BG = Background, SAF = Save-a-Flush, DF = Dual Flush

Mecon Interrupter

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.19	7.67	7.13	2.06	0.54	1.53
Minimum	7.80	5.25	5.58	2.22	-0.33	2.22
Maximum	11.93	11.14	9.07	2.86	2.07	2.86
Stdev	1.79	3.08	1.21			

Mecon low default

	Average flush volume (litres)			Savings per flush (litres)		
	BG	SAF	DF	BG v DF	SAF v DF	BG v SAF
Average	9.82	8.05	6.76	3.07	1.29	1.77
Minimum	7.49	5.34	5.09	2.40	0.25	2.15
Maximum	12.89	10.76	8.88	4.01	1.88	2.13
Stdev	2.24	3.83	1.67			

Note: BG = Background, SAF = Save-a-Flush, DF = Dual Flush

DOUBLE FLUSH ANALYSIS

SOUTHERN WATER REPORT 90001/TR/00/21

Background

One of the principal arguments against the use of dual flush toilets is the perceived high degree of double flushing that is necessary. Double flushing typically occurs when the initial low volume flush is insufficient to clear the pan and a second (or third) flush becomes necessary. It is possible that a high prevalence of double flushing may negate the water saving benefits of dual flush systems. The dual flush trial offers an opportunity to assess the occurrence of double flushing in the properties being studied.

Method of Analysis

There are a number of parameters which can be drawn from the data collected, to indicate the occurrence of double flushing. The most obvious is flush volume, however this is complicated when variable flush volumes need to be considered. Another option is to analyse the change in flush patterns that occur when the interval between flushes is varied. This method is described fully below.

Flush volumes are measured by a meter on the cistern inlet pipe, which is connected to a data logger. The meter delivers a pulse to the logger every time half a litre of water passes through it, therefore the data recorded are a stream of half litre pulses. When the toilet is flushed once, a number of consecutive half litre pulses are observed, constituting the total flush volume. Therefore a 9 litre flush will be made up of 18 half litre pulses.

In order to separate out individual flush events from the data, it is necessary to define an interval between pulses, which effectively separates one flush from another. Thus, once a period of say 5 minutes (300 seconds) has passed after the last pulse of the 18 pulses in a 9 litre flush, that event can be defined as a complete flush. If a second flush were made before the full 300 seconds had elapsed then this flush would be included in the single event. This second flush may be a genuine double flush, or it is possible it could result from a separate toilet use.

In the example above, which corresponds to the operation of a normal cistern, it would be easy to identify double flushes as any event greater than 9 litres, however, this simple example is complicated when variable flush volumes are considered. With a dual flush cistern, there may be a low flush setting with a volume of 4.5 litres and full flush volume of 9 litres. As a result, two low flushes would be indistinguishable from a single full flush, if they were separated by less than 300 seconds, our arbitrary interval. However, if the two 4.5 litre flushes were two minutes (120 seconds) apart, and the interval between pulses was reduced to 60 seconds, then these events would be recorded separately.

Therefore, by varying the interval, which defines the separation of flush events, it is possible to determine the nature of flushes that occur close together. It is also possible to determine the percentage of flushes that occur between certain intervals. Despite this, it is impossible to know whether two flushes, however close together constitute a true double flush, or are, in fact, two separate single events.

Sample Selection

A small sample of properties was selected for analysis to assess the occurrence of double flushing. The selection was undertaken after reviewing histograms showing the distribution of flush volume for each property. Properties were generally selected for analysis if the graphs appeared to indicate some occurrence of double flushing, however one property that showed no signs of double flushing was also selected as a control. Care was taken to ensure each of the five device types being trialled was analysed.

Property A (Littlehampton) – Mecon Low Default Device

This is a single toilet property with two adults and one small child resident. An initial review of the data suggested this installation experienced a high degree of double flushing. The cistern has been fitted with a Mecon device set to low flush default, i.e. the cistern will deliver a low volume flush unless the user intervenes by pulling the tag on the device. The time at which the tag is pulled will determine the size of the larger flush. The default low flush volume is 3.0 litres and the full flush volume of the cistern is 10.8 litres.

Figures 1a and 1b illustrate the distribution of flush sizes when separated by 300 seconds and 60 seconds respectively. Comparison of the two

Table 1: Percentage of events 60-300 seconds apart, Property A

Monitoring Period	Percentage of events 60-300 seconds apart	Percentage of events 60-300 seconds apart when 0.5 litre events are removed
Background	24.5	1.9
DF1	27.6	5.0
DF2	32.9	4.1
DF3	33.2	5.5
DF4	42.2	6.1
Average DF		5.2

figures indicate that there are significantly more low flushes of 0 – 2.5 litres at the lower interval than at the higher interval, in all monitoring periods. There are fewer flushes in the range 2.5 – 5.0 litres (the range in which low volume flushes would fall) at 60 second interval, and similar proportions for the other classes.

The significant increase in very low flush volumes when using the 60 second interval merits further investigation. Figures 2a and 2b are similar to the previous histograms, but split the flush size distribution into half litre classes. It is clear from a comparison of the plots that the 60 second graph includes a significant number of events of 0.5 litre magnitude. Inspection of the raw data suggests that these 'events' are probably the last pulse on the long tail of a regular flush, separated by more than 60 seconds from the rest of the flush. Consequently, it can be concluded that for this property, an interval of 60 seconds is too small to accurately separate flush events.

By comparing the total number of events derived using the two different intervals, it is possible to estimate the percentage of events that occur between 60 and 300 seconds apart. Table 1 summarises the percentages for each of the monitoring periods.

These high percentages suggest a very high proportion of double flushing, however the large number of spurious 0.5 litre events must be taken into account, as illustrated in the second column of data. These data indicate that, even with the spurious events removed, there are more closely spaced events during dual flush (DF) monitoring periods than during the background monitoring. This suggests an increase in double flushing from 1.9 % of all flushes to 5.2 % on average during the dual flush period. Despite this, this property still demonstrates an average saving per flush of 3.7 litres. This is likely to be due to the relative size of the standard full flush volume and the low flush volume, 10.8 litre and 2.9 litre respectively, with the result that two low flushes are still significantly smaller than a single full flush.

As a result, the small number of flushes greater than 12 litre observed in Figure 2a, which may be large double flushes (they are not as notable in Figure 2b) are more than cancelled out by the 40 –60 % of 3 litre flushes. Although this is satisfactory in terms of volumetric saving, the inconvenience to the user should not be forgotten.

Property B (Lancing) – Mecon High Default Device

This is a property with more than one toilet and four regular occupants (two adults, two children). Initial review of the data suggested a low percentage of double flushing. The cistern has been fitted with a Mecon high default device, i.e. the cistern will deliver a large (standard) flush volume unless the user intervenes. The time at which the tag is pulled will determine the exact size of the lower flush volume. The full flush volume was measured at 9.0 litres and the indicative low flush volume was 3.8 litres. This property did not show any signs of significant double flushing on first examination of the data, and was therefore selected as a control.

Figures 3a and 3b illustrate the distribution of flush sizes when separated by 300 seconds and 60 seconds respectively. Comparison of the two figures indicate little overall variation in flush size distribution at the two different intervals, particularly in the two most populous classes between 2.5 litres and 5.0 litres and between 7.5 litres and 10 litres. As in Property A, there is an increase in small flushes between 0 and 2.5 litres with the 60 second interval. There is also a small increase in the number of larger flushes when applying the 300 second interval.

Table 2: Percentage of events 60-300 seconds apart, Property B

Monitoring Period	Percentage of events 60-300 seconds apart
Background	3.1
DF1	8.2
DF2	4.2
DF3	6.5
DF4	1.4

Figure 4 illustrates the distribution of flush sizes using a 60 second interval, and confirms that the increase in very small flushes when using a 60 second interval is a result of 0.5 litre pulses, as observed at Property A. Table 2 summarises the adjusted percentage of flushes that occur between 60 and 300 seconds apart, taking into account the occurrence of these spurious events.

The data suggest that double flushing has increased by 2% after the dual flush installation, although the variation in the above data between dual flush monitoring periods is significant. It may be possible that this is a result of the variation in usage habits as determined by school terms or other lifestyle factors. Despite the apparent rise in double flushing rates, the average overall saving at this property is 2.8 litres per flush. This lower average saving than Property A is likely to be a result of the high default installation in this cistern. This indicates that device type/set-up may be a more important factor in determining savings than double flushing rates.

Property C (Littlehampton) – Mecon Interrupter Device

This is a single toilet property with three adult occupants. The cistern has been fitted with a Mecon Interrupter device, which stops the flush when the user presses a button installed on the front of the cistern. In this way, the user has total control of the flush size up to the maximum volume, which in this case was measured as 10.2 litres. Because of this

flexible user interaction, the analysis of the data for this device is not as straightforward as for other devices with discrete flush options.

Comparison of Figures 5a and 5b illustrates the interesting distribution in flush size that results from using a device with infinitely variable flush volumes. The tell tale peak at 0.5 litres in Figure 5b highlights the misleading 0.5 litre events that are artifacts of using a short separation interval.

Because of the highly variable flush size, it is impossible to determine double flushes from flush size alone. Table 3 therefore summarises the adjusted percentage of flushes that occur between 60 and 300 seconds apart.

The data suggest that double flushing has decreased from 8.2 % to 4.3 % after the installation of the dual flush device, although the percentage rate of flushes during the dual flush periods varies from 1.6 % to 6.7 %. This data variability means it is difficult to draw any conclusions about the variation in double flushing at this property.

Property D (Lancing) - Cistermiser

This is a single toilet property with one adult occupant. The cistern has been fitted with a Cistermiser dual flush device, which has two sensors for
operating pre-set low and normal flush sizes, measured at 4.0 litres and 10.1 litres respectively.

Figures 6a and 6b illustrate the frequency distribution of flush size at 0.5 litre intervals. Figure 5b clearly illustrates the very high percentage of events of 0.5 litre magnitude. A review of the data indicates that for this property, these represent either the tail end of flushes with pulse intervals of more than 60 seconds within the flush, or very slow refill in general.

The hypothesis of slow refill is supported by Figure 5a which illustrates that approximately 12 % of background events were 0.5 litres in magnitude, even with a separation of 300 seconds. In this particular case this may be due the property being located in a block of flats. This observation reinforces the message that a 60 second separation interval between pulses is too short for accurately defining flush events.

Given this high degree of inaccuracy, it is not possible to easily define the percentage rate of double flushing as for the previous two properties. However, Figure 6a illustrates the presence of some 19 – 22 litres events that are not present in Figure 6b. At the 300 second interval these outliers constitute 12 % of all flushes in the background monitoring period, but this value falls to 2.6 % on average during the dual flush period. This reduction may reflect the increased variability in double flush volumes that are possible with the introduction of a low flush option.

Property E (Littlehampton) – Brann Device

This is a two toilet property with a family of four (two adults, two small children) resident. The cistern has been fitted with a Brann device, which has three flush settings (small, medium and large), selected using a dial around the toilet handle.

Table 3: Percentage of events 60-300 seconds apart, Property C

Monitoring Period	Percentage of events 60-300 seconds apart
Background	8.2
DF1	5.7
DF2	6.7
DF3	1.9
DF4	5.8
DF5	1.6
Average DF	4.3

Table 4: Percentage of events 60-300 seconds apart, Property E

Monitoring Period	Percentage of events 60-300 seconds apart
Background	4.0
DF1	4.9
DF2	6.5
DF3	4.2
DF4	4.8
Average DF	5.1

Table 5: Percentage of events greater than 10 litres in volume, Property E

Monitoring Period	300 second interval	60 second interval
Background	8.9	4.0
DF1	10.2	4.2
DF2	6.2	1.4
DF3	9.6	4.8
DF4	12.9	8.1
Average DF	9.7	4.6

The measured volumes of these flushes are 5.5 litres, 6.3 litres and 10.0 litres respectively. The toilet will flush the predetermined volume as defined by the setting on the dial, therefore the user has to intervene if a different setting is desired.

Figures 7a and 7b illustrate the frequency distribution of flush size at 0.5 litres intervals, based on 300 and 60 second separations respectively. Figure 7b highlights the familiar peak at 0.5 litres volume which represents the last pulses of slow refills which are separated by more than 60 seconds from the rest of the flush.

Table 4 summarises the adjusted percentage of flushes that occur between 60 and 300 seconds apart. The data suggest that double flushing increases after dual flush installation from 4 % to 5.1 %. This is a relatively small increase, based on this analysis, however, both plots have distinctive tails of data extending from around 10 litres to 20 litres.

These tails suggest a small degree of double flushing using a combination of flush sizes

(e.g. small & medium,, medium & large, etc.). Table 5 summarises the percentage of flushes greater than 10 litres in volume for both sets of data. The percentage of 300 second events greater than 10 litres is higher than the percentage of 60 second events. This is likely to be a result of the upper limit of flow that can actually enter the cistern within 60 seconds.

The key observation from this data is the relatively small variation in the percentage of flushes above 10 litres before and after dual flush installation. At 300 seconds separation the difference is 0.9 %, whilst at the 60 second separation the difference is 0.6 %. Assuming these events represent double flushes, this equates to an additional 3 to 4 flush events greater than 10 litres after dual flush installation.

Summary and Conclusions

This review has examined a sample of properties within the trial and has concentrated upon one particular method of analysis. With the exception of Property B, which was chosen as a control, the properties examined were chosen based on an initial review of the data, and were selected if they appeared to demonstrate a relatively high rate of double flushing. The data from this study should therefore represent the poorest performing dual flush systems in terms of double flushing.

Much of the analysis undertaken here is based on assessing the changes in the final data that arises from varying the interval, which separates individual flushes. The event record generated using a 300 second separation was compared with one using a 60 second interval.

The 60 second interval produced a higher total number of flushes, however a large percentage of these were 0.5 litre events at the end of slow refills that had been erroneously classified as individual flushes. By identifying and accounting for these, it was possible to compare like with like and determine the additional flushes that were separated by less than 300 seconds.

Table 6 summarises the estimated double flushing rates for each of the properties studied, based on the flushes that occur within 60 – 300 seconds of each other. Flushes occurring this close together are either double flushes or closely spaced but separate events, therefore the assumption that all events occurring within this period are double flushes will result in a over-estimate of the double flushing rate.
Bearing this in mind, the data illustrate that double flushing rates increase only slightly after dual flush installation, from 4.3 % to 4.9 %. It is clear, therefore, that double flushing at the properties examined has not increased significantly as a result of dual flush installation.

Table 6: Percentage of flushes separated by between 60 and 300 seconds at properties A-E.

Property	Pre dual flush	Post dual flush
A	1.9	5.2
B	3.1	5.1
C	8.2	4.2
E	4.0	5.1
Average	4.3	4.9

Figure 1a Property A, 300 Second Separation (Mecon Low Default)

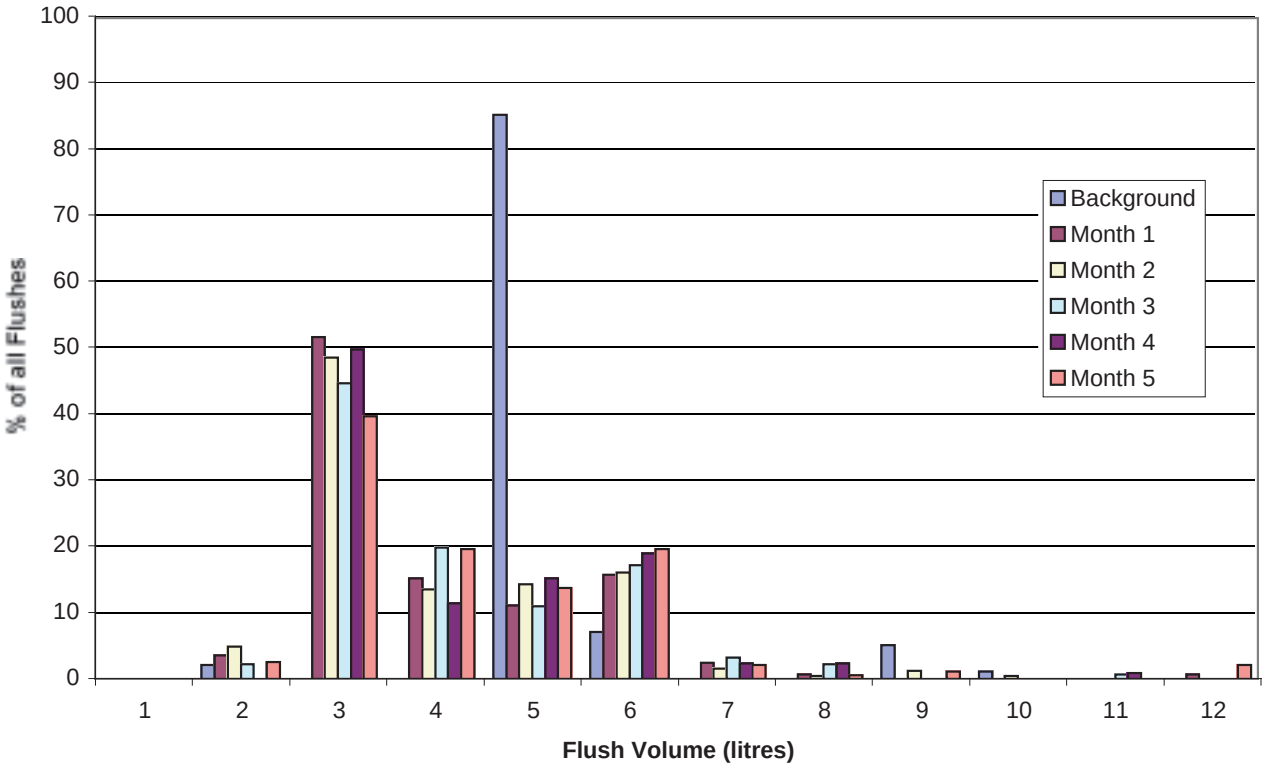


Figure 1b Property A, 60 Second Separation (Mecon Low Default)

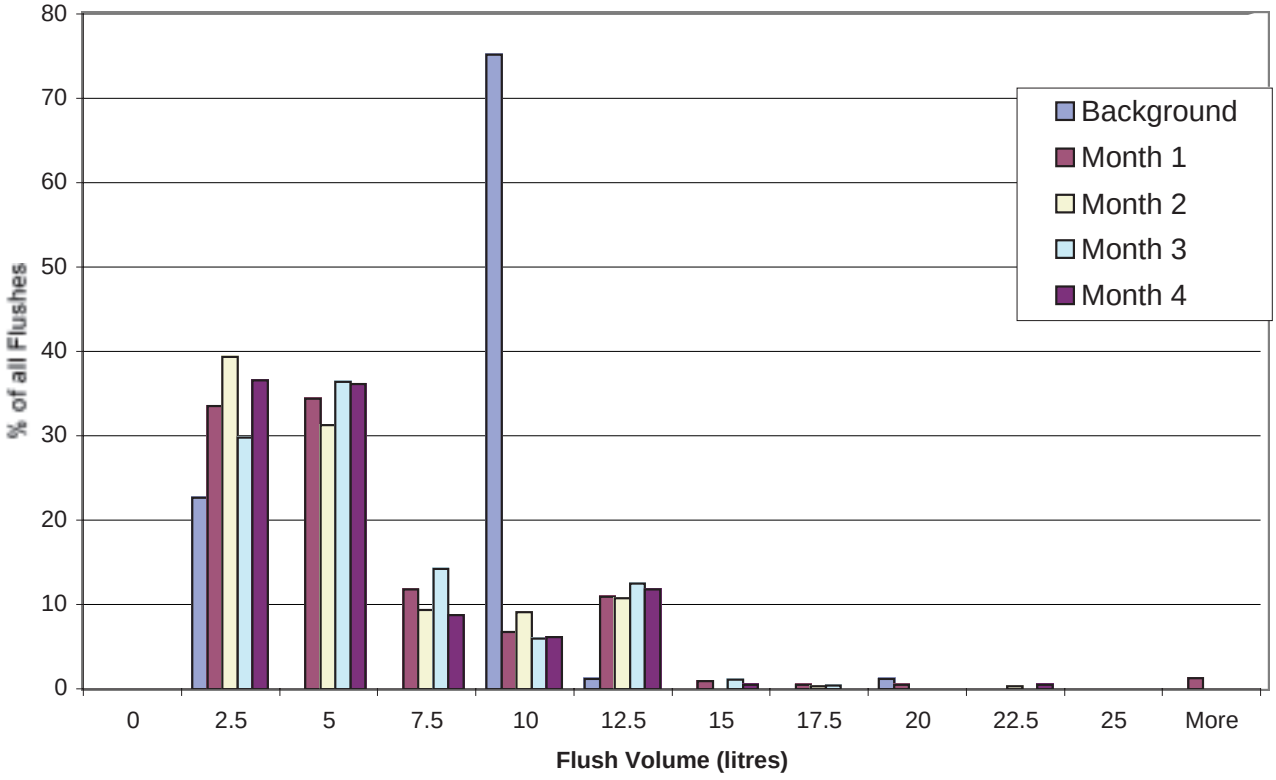


Figure 2a Property A, 300 Second Separation (Mecon Low Default)

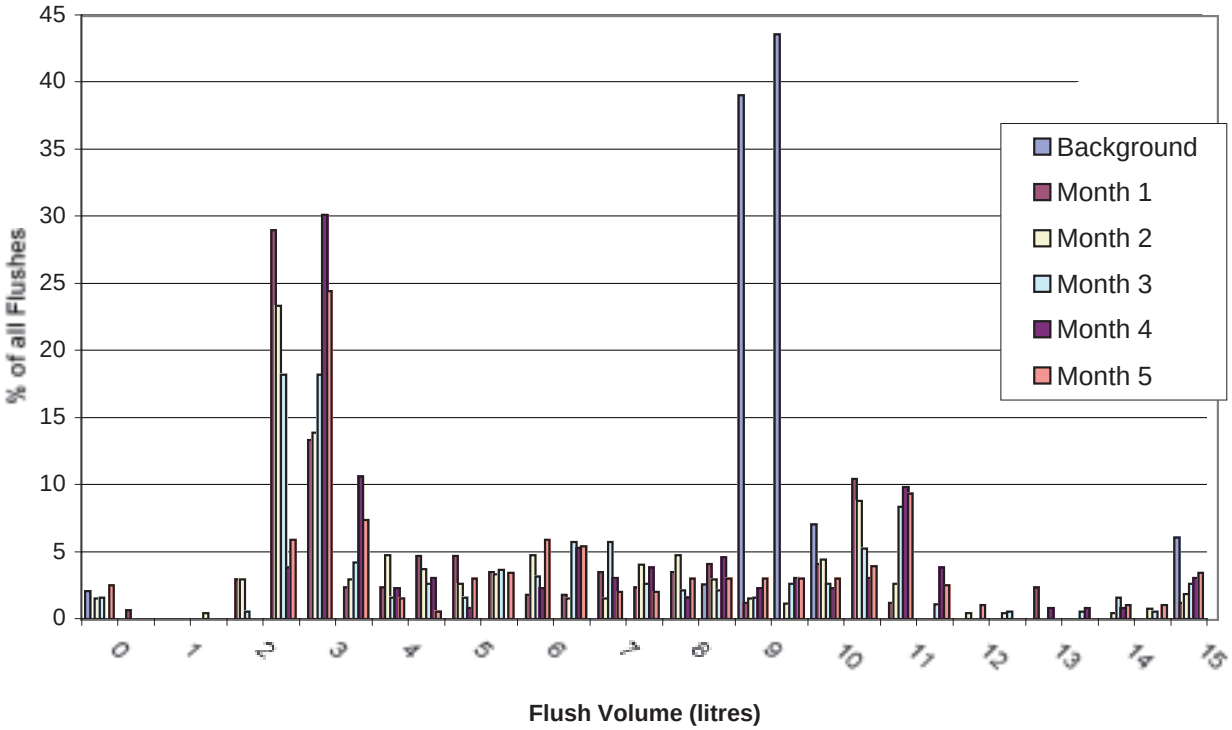


Figure 2b Property A, 60 Second Separation (Mecon Low Default)

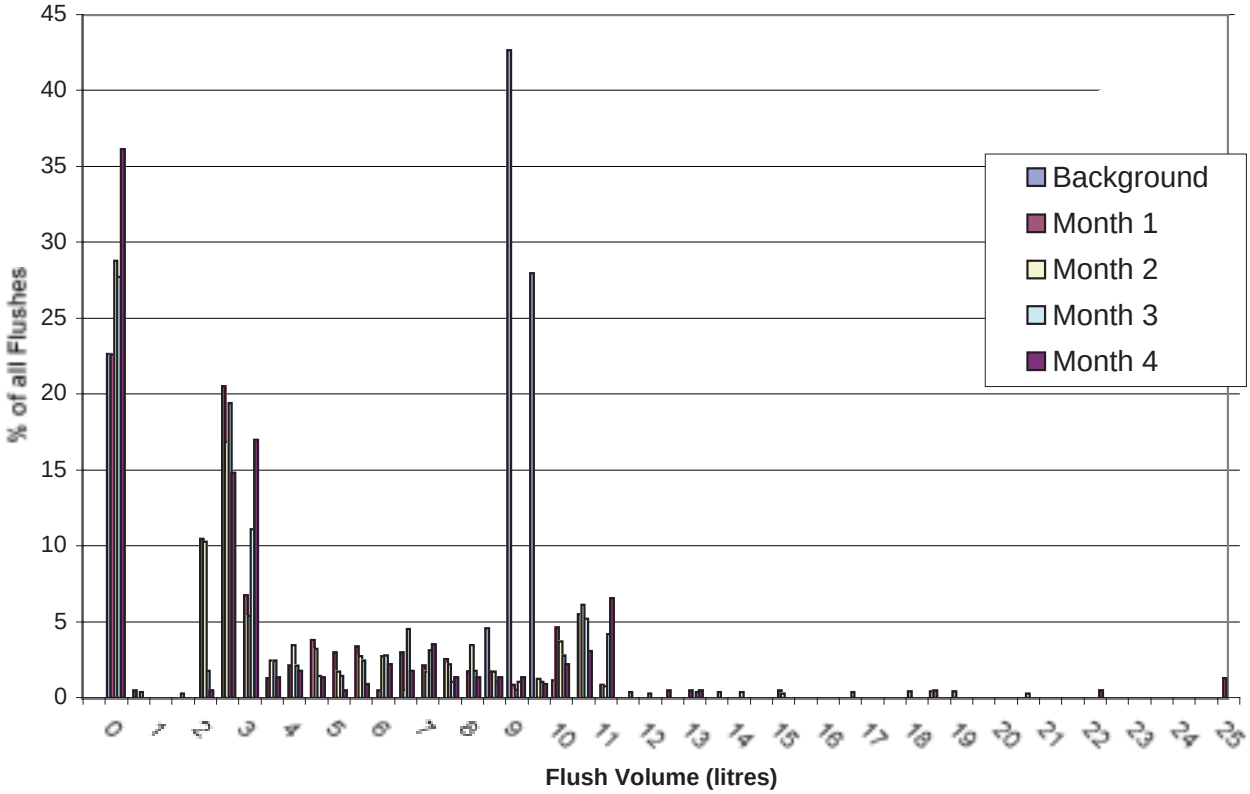


Figure 3a Property B, 300 Second Separation (Mecon High Default)

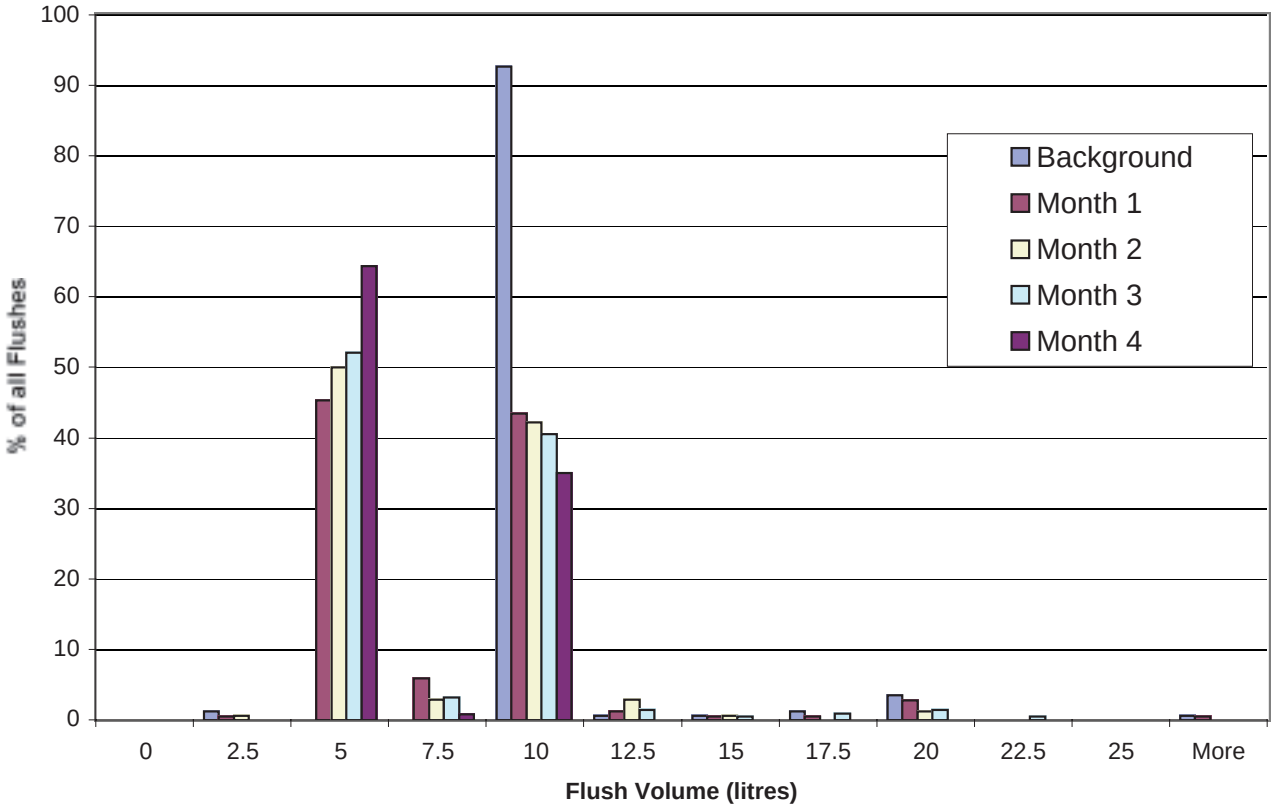


Figure 3b Property B, 60 Second Separation (Mecon High Default)

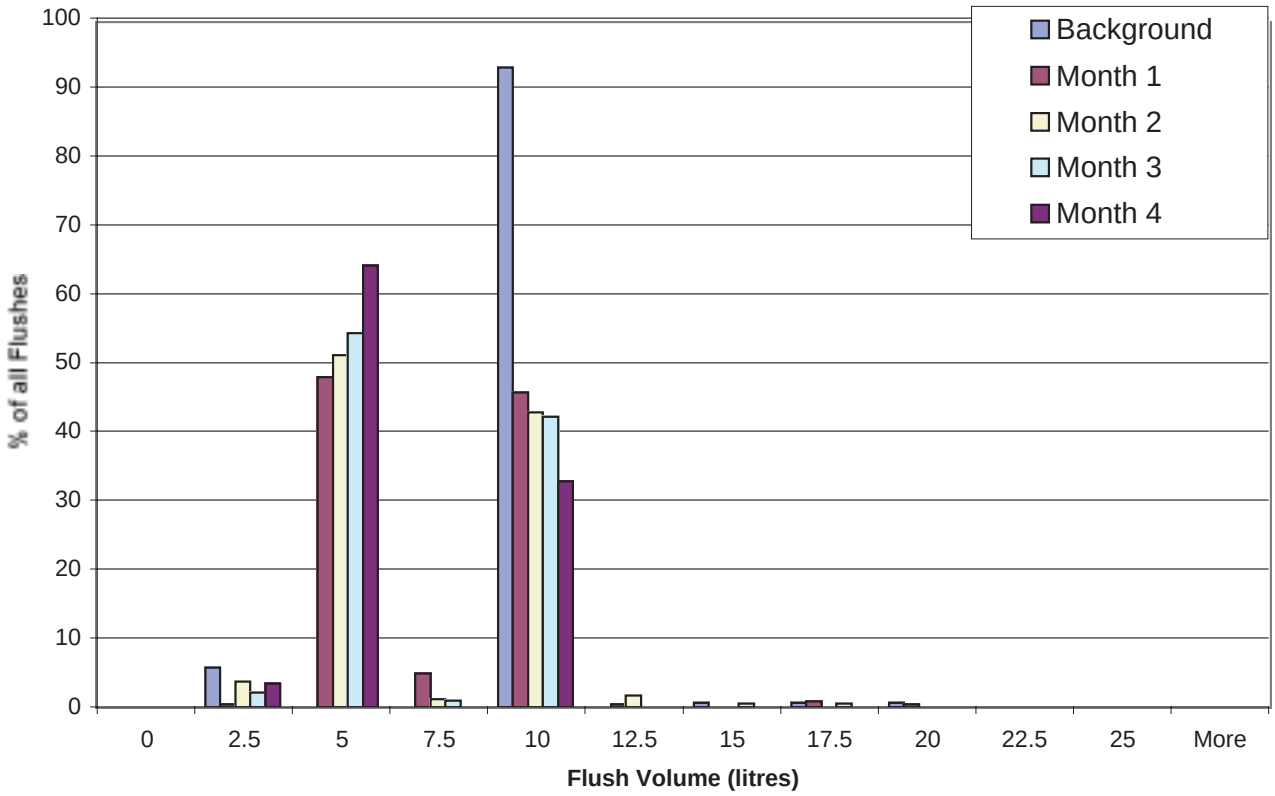


Figure 4a Property B, 300 Second Separation (Mecon High Default)

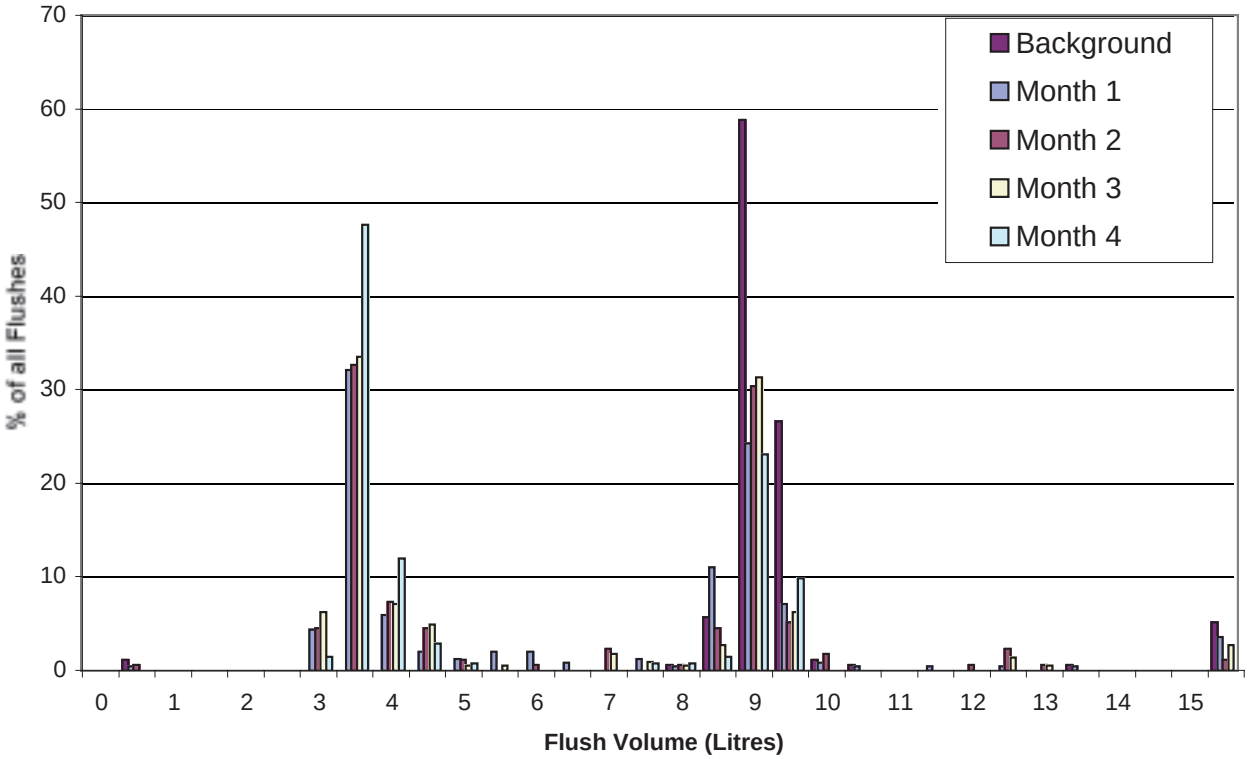


Figure 4b Property B, 60 Second Separation (Mecon High Default)

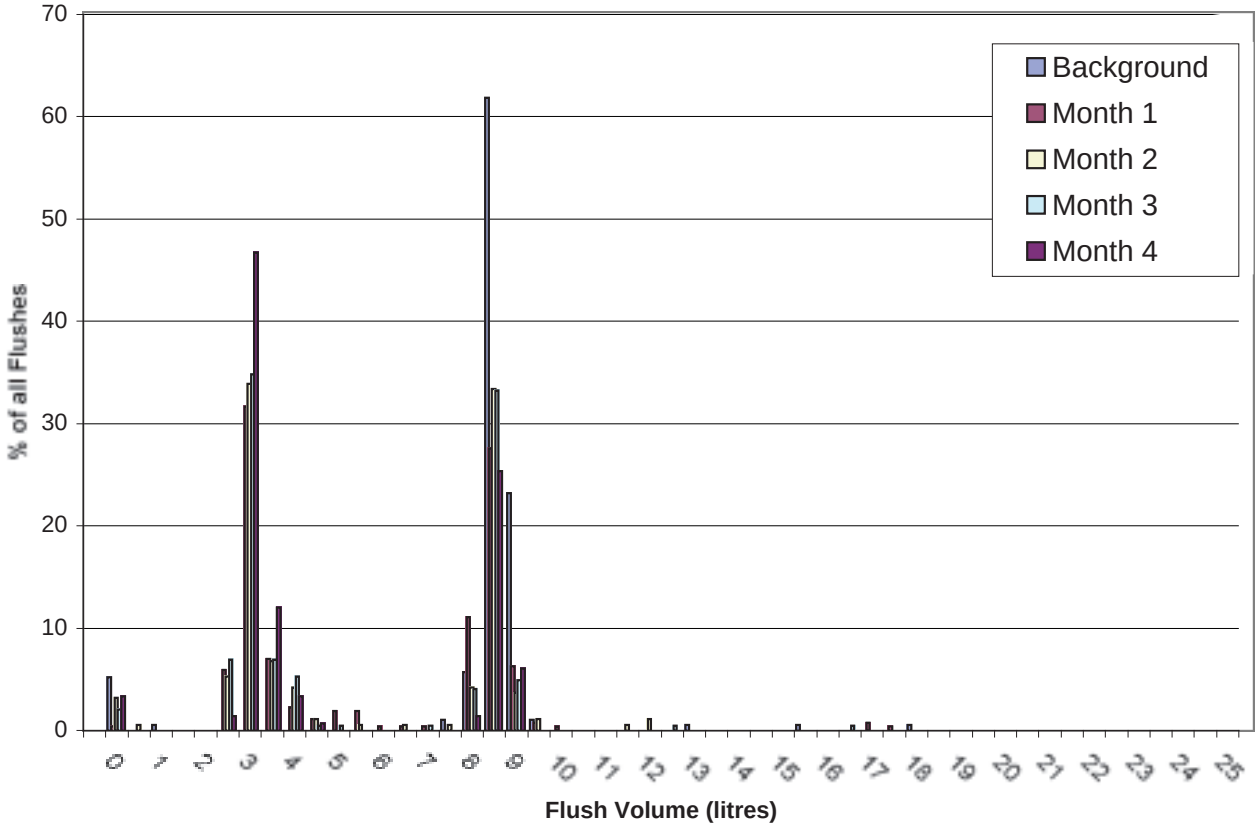


Figure 5a Property C, 300 Second Separation (Mecon Interrupter)

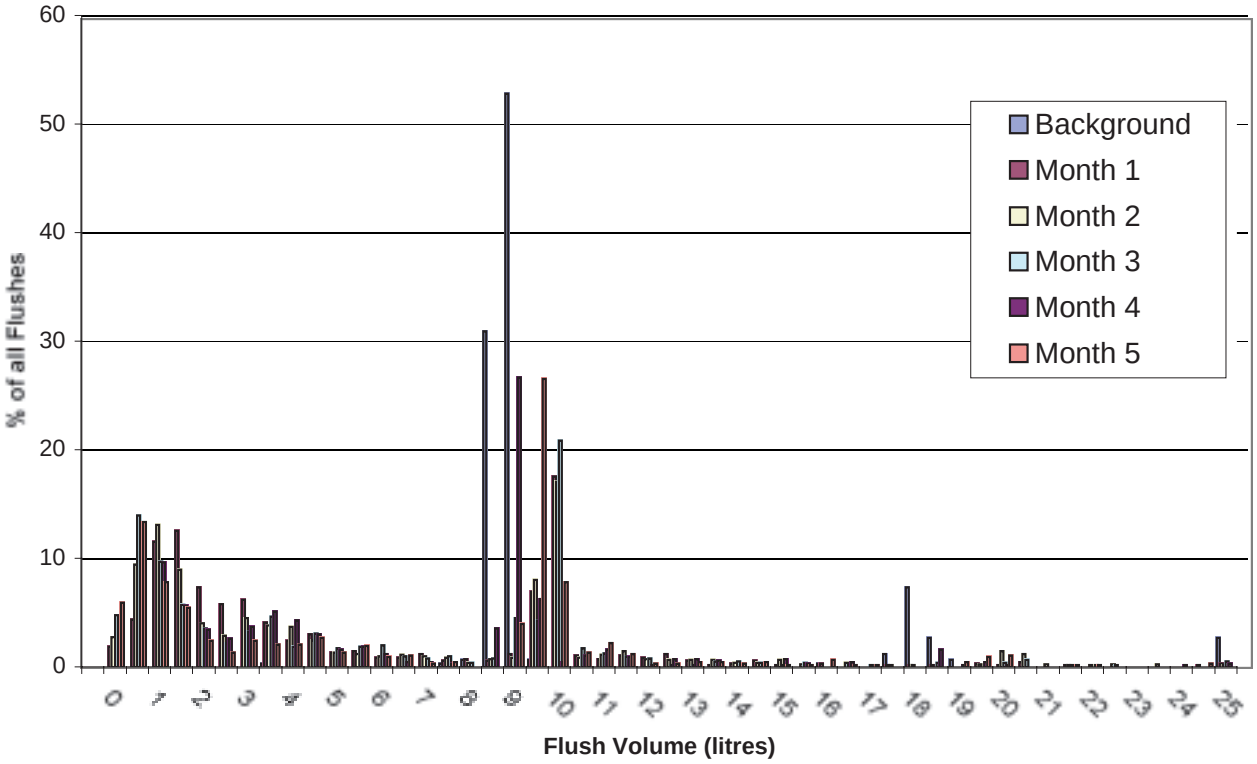


Figure 5b Property C, 60 Second Separation (Mecon Interrupter)

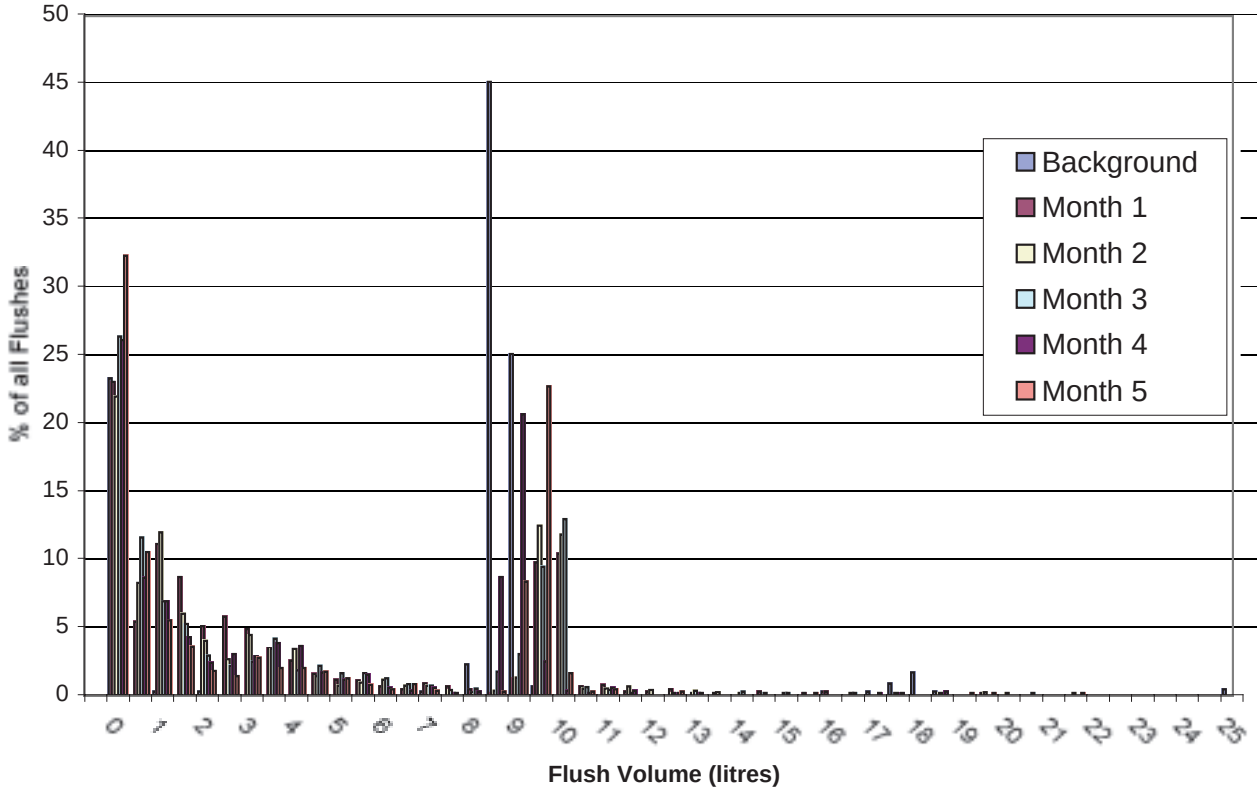


Figure 6a Property D, 300 Second Separation (Cistermiser)

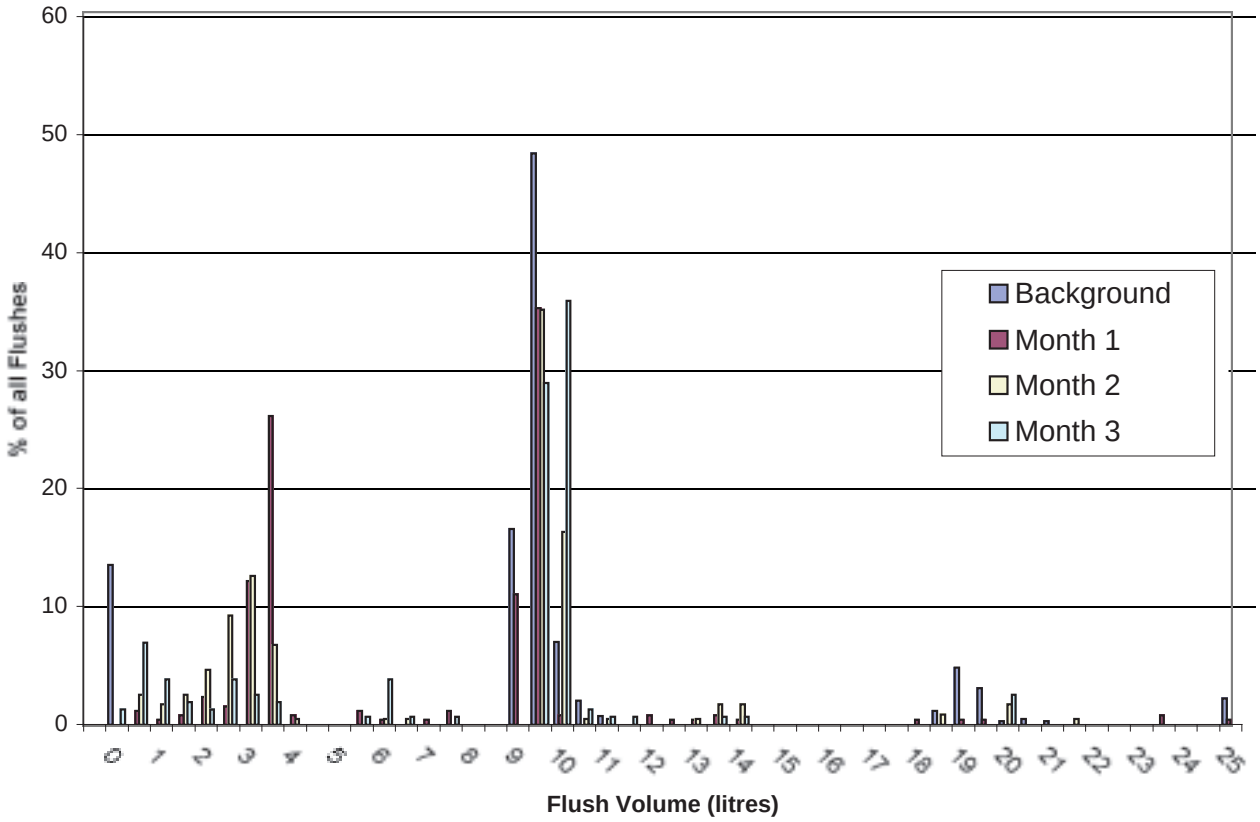


Figure 6b Property D, 60 second Separation (Cistermiser)

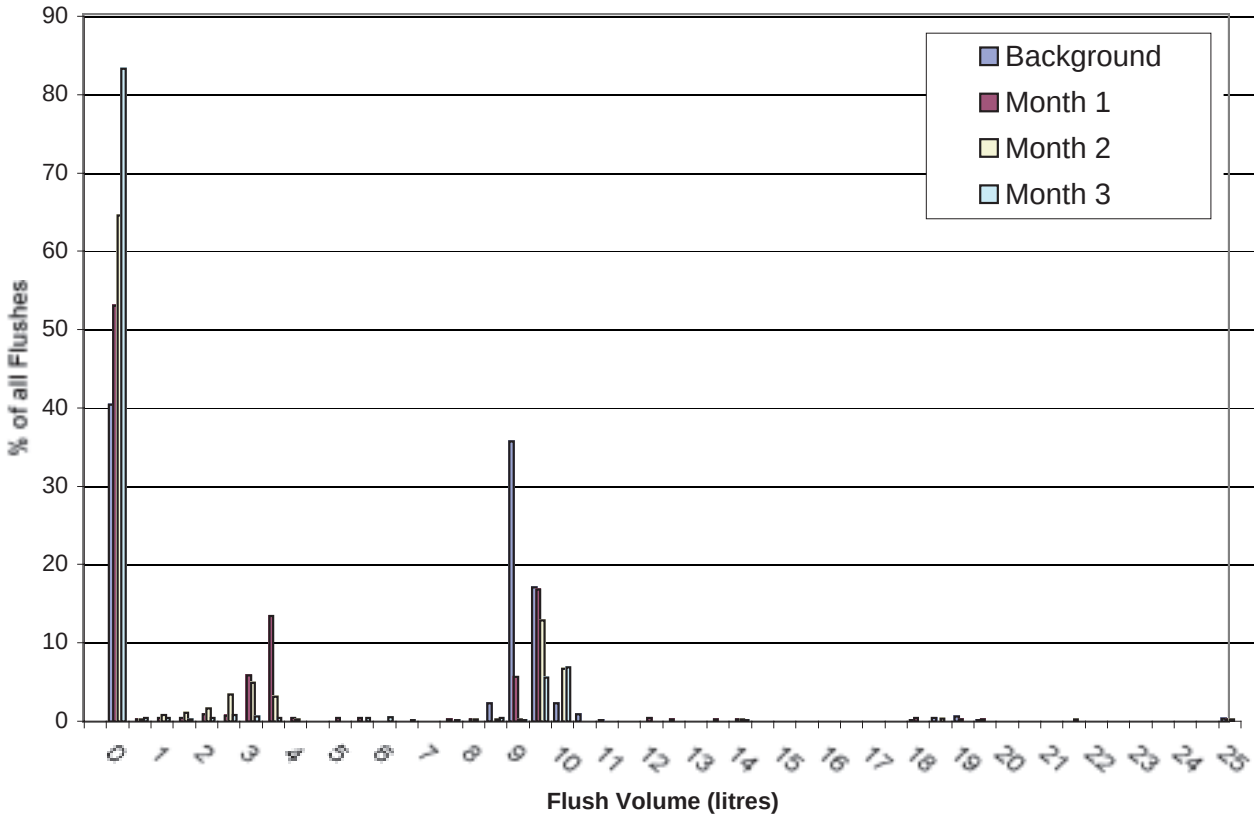


Figure 7a Property E, 300 Second Separation (Brann)

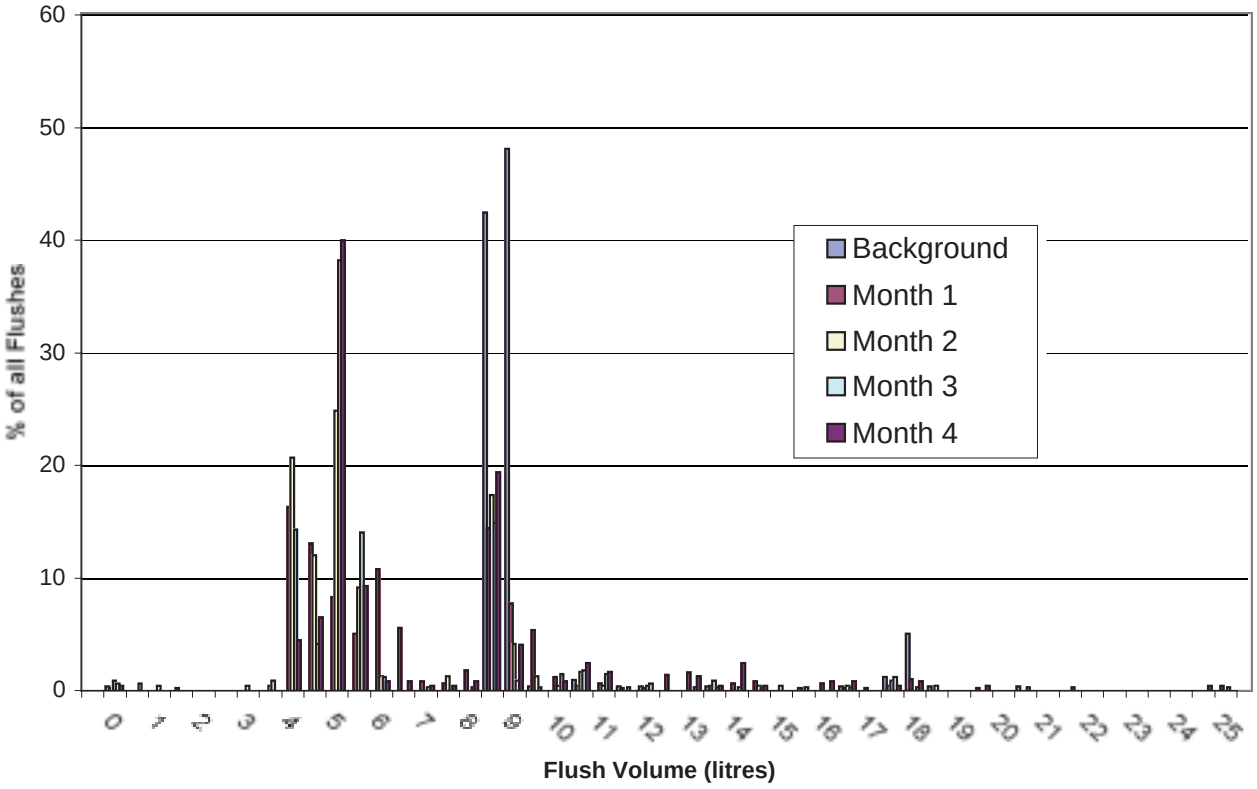
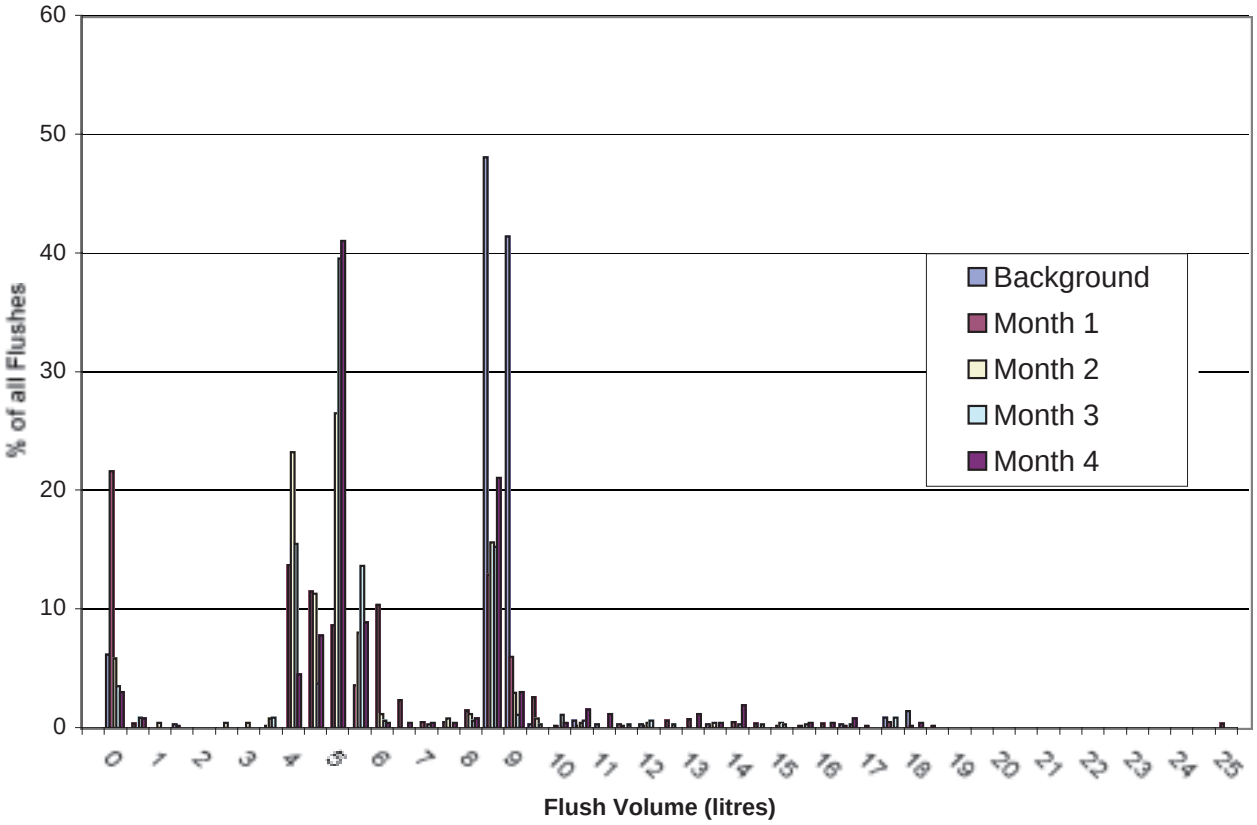


Figure 7b Property E, 60 Second Separation (Brann)



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