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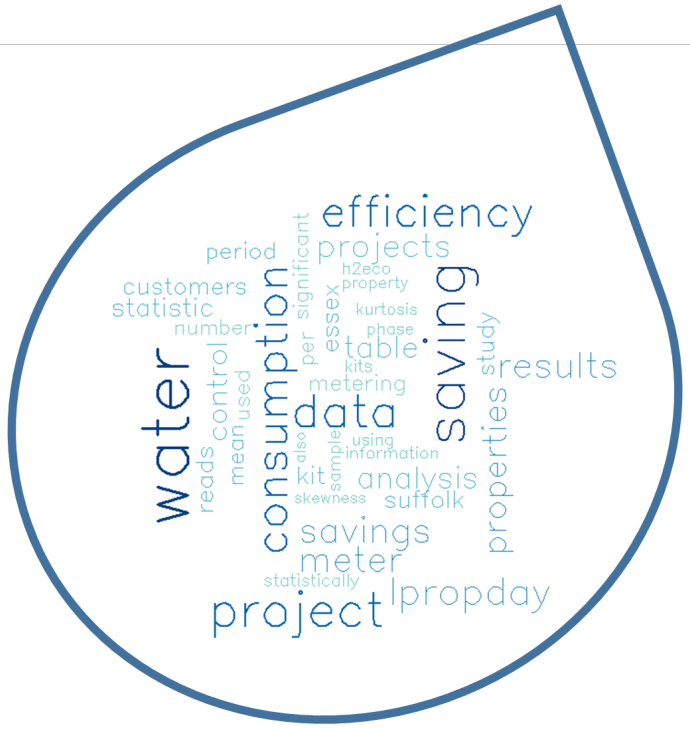
Dŵr Cymru Cyfyngedig on behalf of the water efficiency collaborative fund

Water efficiency evidence base statistical analysis

Final report



Report number: 1096

July 2015

Report title:	Water efficiency evidence base statistical analysis
Report number:	1096
Date:	July 2015
Client:	Water efficiency collaborative fund via Dŵr Cymru
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Executive Summary

Project background

Water companies have been testing and applying demand management solutions, principally in small pilot studies, for a number of years. The Water Efficiency Evidence Base was created to help water companies identify the most effective approaches to water efficiency retrofit programmes. Phase I was published in 2008 and used evidence from around 20 water efficiency projects in domestic properties. Phase II, published in April 2011 contributed to the body of evidence that had been built up through retrofitting both homes and schools. The Environment Agency (EA) led an independent review of the Water Efficiency Evidence Base in 2011-2012.

The Collaborative Fund has now commissioned this project to update the Evidence Base with new water efficiency projects. The Collaborative Fund consists of the majority of Water Companies.
The analysis carried out by Phase I and II and the review by the EA confirmed that some of the water efficiency projects did lead to reductions in water consumption. Since the review was published a number of new water efficiency studies have been completed by water companies. In addition, some companies have increased levels of metering and in a few cases also run projects to test grey and rainwater harvesting systems.

The overall approach taken to deliver the project consisted of four key steps:

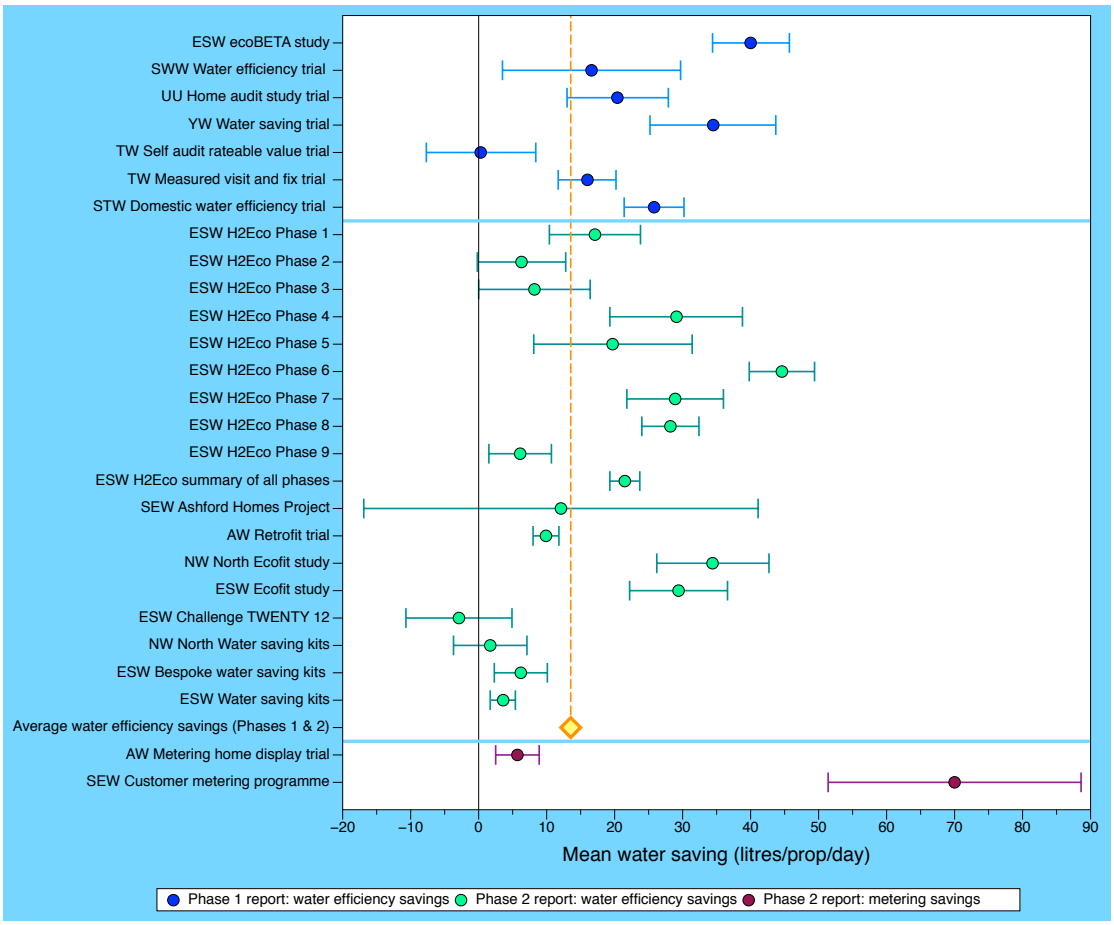
1. The identification of suitable water efficiency projects and datasets. This was achieved by contacting all water companies and asking them for information and then compiling an exhaustive list.
2. Select a short list of projects and data for review and statistical analysis. This was done by scoring and ranking the projects against defied criteria.
3. Detailed analysis of the short listed projects. A range of statistical, contextual and qualitative analysis was applied to the project data sets. An output from this step was statistical tables and summary information in a consistent format.
4. Reporting and dissemination. This report shows the findings and results from the analysis.

Project delivery and results

Twenty water companies were contacted asking for information on any completed large scale water efficiency projects (not included in previous Evidence Base), any studies quantifying the impact of metering on demand and information and results from rainwater and grey water system projects. Information was provided for about fifty water efficiency, metering and grey and rain water recycling projects.

This project has presented statistical analyses for 25 water efficiency projects three metering projects and one greywater recycling project. The water efficiency projects include nine studies completed by various water companies; the nine phases of the Essex & Suffolk Water H2Eco project (reported as four sections here); and seven projects analysed and presented previously. This is the most extensive and comprehensive analysis of water efficiency projects undertaken in the UK to date.

The figure below is a meta-analysis chart allowing the comparison of the results from all of the projects analysed in this project.



Meta-analysis of Phase 1 and Phase 2 water efficiency and metering projects

The results presented in this figure indicate that reductions in consumption are likely to occur as a result of water efficiency activity, and that overall, an average saving of 13.5 litres per property per day can be achieved. The 'average water savings (phases 1 and 2)' is the mean of all the mean water savings weighted by the number of observations in each study (illustrated by the yellow diamond). This is equivalent to around 3.5 per cent of average consumption.

This is an important finding from this project, which confirms that suitably designed water efficiency programmes will reduce household water consumption.

Essex & Suffolk's water efficiency work continues to be of great benefit to the water industry. It would be valuable if other organisations could implement similar water efficiency programmes and research studies to increase the evidence base to include other customer groups and areas of the country.

Based on these findings it is recommend water efficiency programmes should:

- Identify the most effective water saving device;
- Target households that will use it most; and
- Install it as cost-effectively as possible.

A long-term, targeted strategy is likely to deliver greater total savings than a programme that delivers short-term successes but cannot be replicated over several years. However, every plan is different and it is recommended that anyone designing a water efficiency programme discusses their plans with colleagues and peers in the water industry, in order to achieve the best savings possible.

This report demonstrates that a before-and-after control, possibly combined with a side-by-side control can be a very effective method of quantifying the savings from water efficiency activity. It is recommended that water efficiency research should use this study design where possible and appropriate. This report also sets out a simple and consistent approach to statistical analysis that can be adopted by practitioners, to accompany the study-control research method.

It is recommended that more work is done to demonstrate the longevity of water efficiency savings.

The two studies completed on large-scale 'universal' metering programmes suggest broadly similar results, with short-term reductions in consumption of approximately 16 to 18 percent. It is recommended that more work is done to determine savings due to metering, with a greater focus required on measuring household-level consumption before a property becomes metered.

The findings from the review of rainwater and greywater research are disappointing. Several companies have carried out studies into these technologies over the past 10-20 years, but very few empirical results have been published. There is also very little data available from ongoing research in the UK. Evidence from a field trip to Berlin, undertaken during this project, suggests that rainwater and greywater systems can be a success when installed in new communal housing developments (i.e. apartment blocks).

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1 Introduction

1.1 Background

The Water Efficiency Evidence Base was created to help water companies identify the most effective approaches to water efficiency retrofit programmes. Waterwise led the initial development of the Evidence Base and the first report for Phase 1 was published in 2008. It gathered evidence from 20 water efficiency projects in domestic properties that had been undertaken in the UK. Phase II, published in 2011 contributed to the body of evidence that had been built up through retrofitting water efficiency products in homes and schools. Phase III was completed in 2013 and this focused on smaller discrete projects and learning from projects which had been previously completed.

The Environment Agency led an independent review of the Water Efficiency Evidence Base in 2012. The aim of the project was to test its robustness and reliability and to give increased confidence in the data it contains. The review covered principally the Waterwise Evidence Base Phases I and II as well as other evidence on water efficiency measures. Projects in Phase III were not considered to be suitable. The analysis carried out during the study confirmed that most of the water efficiency projects reviewed did lead to reductions in water consumption. The study also identified a number of improvements that could be made to the existing Water Efficiency Evidence Base, which should lead to a greater confidence in the information and ease of interpretation and use.

Since the review was published, a number of new water efficiency studies have been completed by water companies. In addition, companies have increased levels of metering and in a few cases have also run projects to test grey and rainwater harvesting systems. The Collaborative Fund Steering Group agreed the importance of a follow-up project to implement the recommendations and improvements to the Evidence Base following the EA's study, and to update its report with recent projects. The Steering Group also agreed to expand the Evidence Base to include the impacts of metering programmes and grey and rainwater harvesting systems.

This report is the output from this follow-up project.

1.2 Project objectives

The objectives of the project are as follows;

1. Carry out a review of large-scale water efficiency projects completed since April 2010. Conduct a survey of what projects have been undertaken, and select appropriate projects. The data from the respective water companies will then be obtained for statistical analysis. Specifically the objectives of this project were to:

    a. Analyse at least ten new projects not included in the previous Evidence Base analysis.
    b. Provide a method statement agreed by the project Steering Group, of analysis methods used and how the results should be used by water companies and regulators.
    c. Collate and present the results clearly using a method agreed with the Steering Group.
    d. Present and discuss the results at a dissemination event.

2. Carry out a review of studies quantifying the impact of metering on demand. Using available data and information that water companies have gathered, in order to:
    a. Quantify the impacts of metering on demand from customers who live in different types of property and the impact of other factors if possible.

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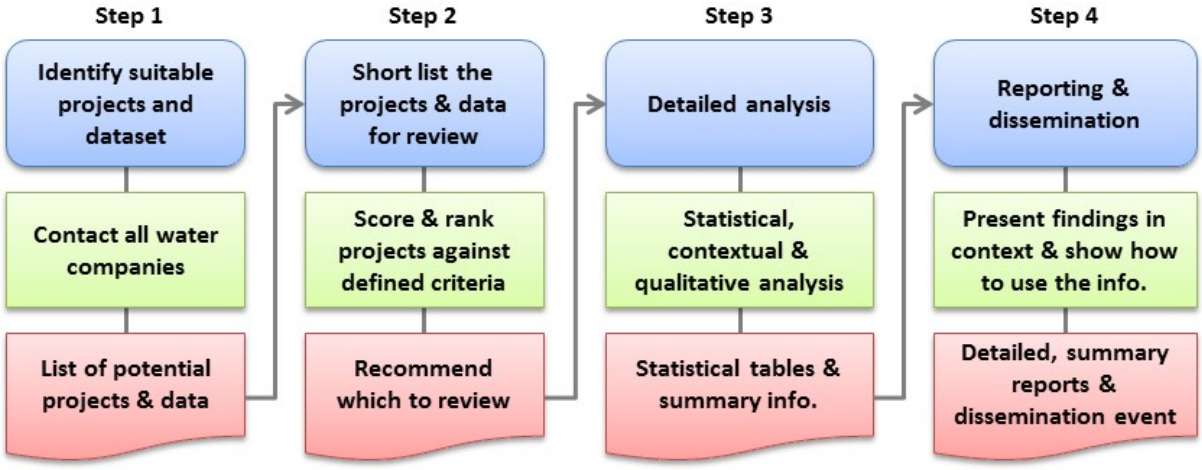
b. Quantify the impacts of metering on water use by meter optants to test if there is any difference in savings between 'optant' and 'progressive/compulsory metering'.
c. Determine the impact of metering on managing leakage, including leakage from customers' supply pipes.
d. Provide data on the expected changes in leakage levels that result from metering programmes over time.
e. Comment on the uptake of efficiency measures as a result of metering programmes.

3. Collation of information and results from rainwater and greywater harvesting system projects run by water companies. Use this information to:
   a. Quantify the water savings delivered by the systems.
   b. Review the effectiveness of the systems under drought and flood conditions.
   c. Examine the impacts the schemes could have on reducing demand, managing floods and droughts, improving resilience and addressing the impacts of climate change.
   d. Identify and document barriers to the use of these systems.

4. Present the results of the work in an easily accessible format to facilitate water companies and other organisations' use of the data.

1.3 Approach summary

The overall approach taken to deliver this project is set out in the four steps below:



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2 Project selection for analysis

2.1 Identify suitable projects for inclusion in the study

Every water company was contacted by an email (copy in Appendix 1) which asked for initial information on:

- Large-scale water efficiency projects completed since April 2010 and not included in Phases I or II of the Evidence Base;
- Studies and data for quantifying the impact of metering on demand; and
- Information and results from rainwater and grey water system trials and projects that they were involved in.

Twenty water companies were contacted of which eleven responded providing details of the projects they had undertaken which may be suitable for analysis. Five water companies responded to the initial information request but they did not have any projects to contribute and four companies did not respond at all. In total, information was given on about fifty water efficiency, metering and grey and rain water recycling projects. A full list of these candidate projects is presented in Appendix 2.

2.2 Short list of trials for analysis

Projects were selected for inclusion in the evidence base by applying a set of selection criteria on the projects supplied by the water companies. The selection criteria used is shown in Table 1.

Table 1 Selection criteria applied for project selection

Criteria	Why it was used
Is the raw data available?	Raw data was requested to allow consistent analysis in this report, rather than collating results analysed by the water company. It is important that access to the raw data was made available.
Will it deliver in time?	Some projects are ongoing and will provide data year by year and these can be included. Other projects have a definite beginning and end and if these do not end during this project then they cannot be included.
Is there a report?	Useful for background information and context setting.
Can it be used?	Must have permission from all stakeholders involved in the project that the data can be used and shared.
Domestic or Commercial?	This project is for domestic properties only.
Approximate size?	The size of the project, the quality and extent of measured data.
Approximate time period?	Over which AMP and how many years, the quality, length of time and detail/resolution of the measured data.
Data type and form	If the water savings were measured or assumed, etc.
The range of interventions	Ensuring a range intervention types, different methods of selection and implementation and different measurement recording strategies.

The criteria was applied to each project using the information supplied by the water company. The project team used professional judgement to decide whether the projects should proceed to further analysis. Rationale for inclusions and exclusions included:

- Larger data sets were chosen over small data sets for similar type projects.

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- If a project was based only on assumed water savings, then a similar project with measured reads, pre and post intervention would be chosen instead, if available.
- Projects including commercial properties were excluded, as this is beyond the scope of this project.
- Projects where it was likely to be difficult to demonstrate the effect of water efficiency activities (such as behaviour change studies or where the water savings are difficult to measure) were excluded.
- Projects where a project partner e.g. housing association or NGO has not given permission to share the data were generally excluded.

A good geographical spread of projects, was desirable, if possible. Many of the projects were located in the South East and so suitable projects in other areas of the country were sought where possible. Despite this, only two projects were located out of the South East area: these were, two projects run by Northumbrian Water. Northumbrian Water and Essex & Suffolk Water run the same water efficiency initiatives as they are part of the same organisation.

This screening process was presented to the project steering group and the final list of projects was agreed prior to analysis. In summary this consisted of: nine water efficiency projects, three domestic metering projects and one greywater recycling project. A summary of these projects are presented in Section 2.3.

2.3 Final selection for analysis

Using the screening criteria described in sections 2.1 and 2.2 the final water efficiency projects chosen for analysis in this phase of the evidence base are shown in Table 2 and the final list of metering projects in Table 3.

Table 2 Final list of water efficiency projects included in the evidence base analysis

Project title	Contributing water company	Comments
Water saving kits	Essex & Suffolk Water	Customers request a kit including a variety of water saving devices which is posted out.
Water saving kits	Northumbrian Water	This is the same as E&SW project above but in Northumbrian Water's area.
Bespoke water saving kits	Essex & Suffolk Water	This is the same as E&SW water kit project except that the customers chose specific items.
Challenge TWENTY:12	Essex & Suffolk Water	Behavioural change with devices.
ecoFIT – dual flush toilet retrofit	Northumbrian Water	Water efficiency with the installation of an ecoBETA and other multi device retrofits.
ecoFIT – dual flush toilet retrofit	Essex & Suffolk Water	This is the same as the above project but carried out in E&SW area.
Water efficiency measures programme	Anglian Water	Water efficiency home audit and retrofit of multiple water saving devices.
Ashford new homes project	South East Water	Water efficiency devices and seasonal tariff project.
H_2eco	Essex & Suffolk Water	Water efficiency domestic multi device retro-fit.

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H_2eco is a project run by Essex & Suffolk Water which is currently in its tenth phase with nine phases completed. It is a very large project which effectively is nine individual water efficiency projects carried out over an eight year period. The H_2eco programme is split into four separate projects for the purpose of this report because these four projects represent four different aspects of water efficiency which are analysed in different ways.

It was hoped to have received information about the Thames Water study 'Save Water Swindon' but unfortunately it did not deliver in time. In addition to the above list, the studies from the previous evidence base were revisited and reanalysed so that they are all consistent with the reporting in this document. This is explored in section 3.15.

Three metering projects have been analysed these are shown in Table 3.

Table 3 Final list of metering projects for inclusion in the evidence base

Project title	Contributing water company
Customer metering programme	South East Water
Universal metering programme	Southern Water
In home display project	Anglian Water

Southern Water began a programme to install nearly 500,000 meters to their customers by March 2015. This is the biggest 'universal' metering programme undertaken to date in the UK, and as such represents a very interesting case study. Our preference would have been to undertake analysis for this project on relevant metered consumption data, to investigate the effectiveness of this programme. Unfortunately this was not possible. Instead, this report summarises analysis undertaken by the University of Southampton on Southern Water's metering programme. This is a published report[1], which is summarised in this report.

Two water companies (Severn Trent and Bristol Water) responded to our information request have been investigating the effects of metering on change of occupier, but data from these programmes could not be provided to this project at this time.

[1] Ornaghi, C. & Tonin, M. (2015) The Effect of Metering on Water Consumption – Policy Note. University of Southampton February 2015. Accessed at http://www.water-soton.co.uk/ 15 May 2015.

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3 Analysis of water efficiency projects

3.1 Methodology

Two different types of statistical approach are used in this study: descriptive statistics and inferential statistics. These are described in the following sections.

3.1.1 Descriptive statistics

These are used initially to provide an indication of 'what the data looks like'. Simple measures such as the mean, median and standard deviation indicate the character of the dataset. Confidence intervals are also useful descriptive statistics which indicate the degree of uncertainty that can be associated with the mean value. These simple statistics reveal important information about data, and enables the most appropriate analysis to be selected.

If the mean and median are the same (or very similar) then the dataset will be distributed symmetrically, either side of these values. A large difference between the mean and median indicates that the data is 'skewed' – i.e. the peak in the distribution is off-centre. This is illustrated in Figure 1.

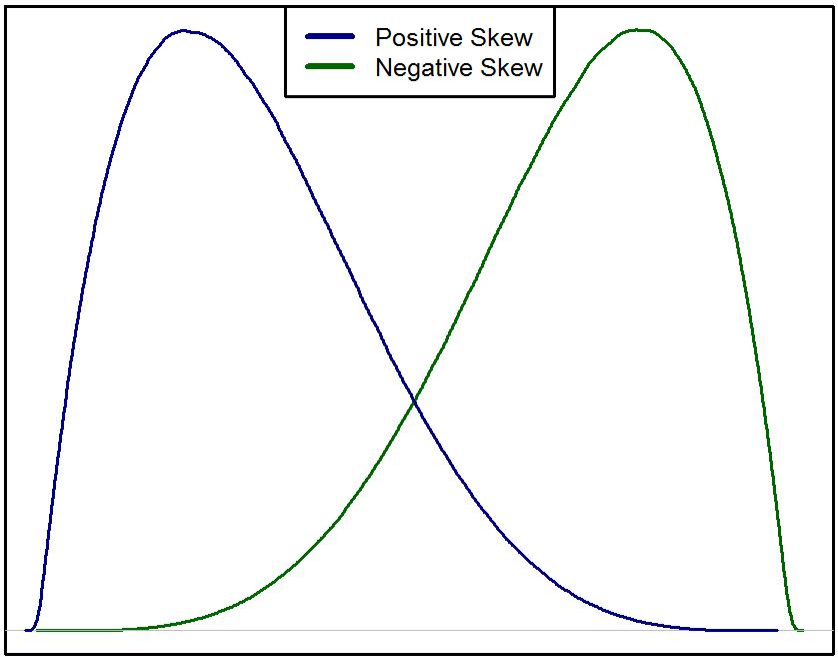

Figure 1 An illustration of skewed datasets

Standard deviation (SD) is a measure of how widely spread the data are around the mean. A large SD value indicates a wide scatter, whilst a small SD suggests a more narrow distribution. The inter-quartile range (between the 25th and 75th percentiles of the dataset when ranked in order of size) is also a good indicator of data spread. The spread of data will influence 'kurtosis' which is a measure of how peaky or flat data are distributed, as illustrated in Figure 2.

Skewness and kurtosis values can be calculated for any dataset, and these values are used to test if data are distributed 'normally'. A normal distribution will have low levels of skewness and kurtosis.

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The test for normality is important, as it will determine if it is valid to apply certain statistical tests (known as parametric tests) to the data.

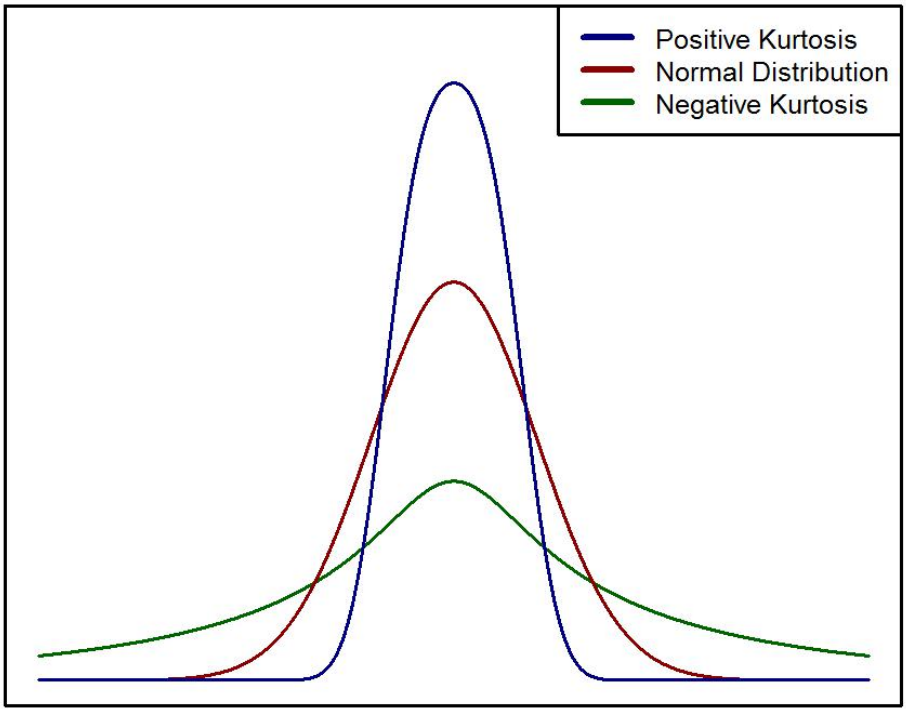

Figure 2 An illustration of kurtosis

Thresholds values of skewness and kurtosis were applied in this study to determine if the data being analysed are normally distributed, and results are classified as either 'acceptable', 'questionable' or 'unacceptable'. This classification is included in the description of data presented in sections 3.2 to 3.15. The normality of the data is assessed using the criteria presented in Table 4.

Table 4 Skewness and Kurtosis levels

Statistic	Acceptable	Questionable	Unacceptable
Skewness	>-0.5 and <0.5	+/- >0.5 and <1.0	< -1.0 or > 1.0
Kurtosis	>-3.0 and <3.0	+/- >8.0 and <8.0	< -8.0 or > 8.0

The project summaries presented in section 3.2 to 3.15 include key descriptive statistics.

3.1.2 Inferential statistics

All inferential statistics depend on the principle of hypothesis testing. Hypothesis tests are the tools used for assessing whether observed differences are real or down to chance. The correct process for hypothesis testing is:

- State the hypothesis being tested. The general convention is to assume initially that the intervention in question (i.e. water efficiency activity in this case) has no effect. This is the 'null hypothesis'. The analysis has to then prove or disprove the null hypothesis.
- Collect relevant data.

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- Select a test procedure and obtain a test result based upon assessing p-values. This is a measure of whether the data are consistent with the hypothesis.
- If the p-value is small enough, the data are not consistent with the hypothesis and the hypothesis is rejected and this is then described as statistically significant. If the p-value is large, the data are not judged inconsistent with the hypothesis and we fail to reject it; in this case the result is not statistically significant. For simplicity, and to avoid confusion, statistical results are reported as either 'statistically significant' or 'not statistically significant'.

A consistent analytical approach has been adopted for this study, except where stated in the individual project summaries. Firstly, the null hypothesis for all projects examined in this study is that the water efficiency intervention has no effect on consumption.

3.1.3 Study and control groups

Secondly, a set of control data and study data are identified. The principle of this 'case-control' approach is that cause and effect can be established by making an intervention in one group (or in the same group at a point in time). Any difference in the measured outcome (i.e. water consumption in this case) can be attributed to that intervention. Most of the projects examined in this project use a 'before and after' control where consumption is measured in the same 'study group' of properties before and after a water efficiency intervention is made. Exceptions to this are highlighted in the relevant projects.

The challenge with the before-and-after control approach is that the changes in consumption that result from the water efficiency intervention can be indistinguishable from the changes that would have occurred over time had no intervention taken place. A side-by-side control, using a separate 'control group' is able to account for these changes, but it can be difficult to select a suitably equivalent sample for such a control and ensure that changes in the control group's consumption does not influence the results. Side-by-side controls can also be generally more expensive to implement than a before-and-after control.

The concept of study and control groups are illustrated in Figure 3.

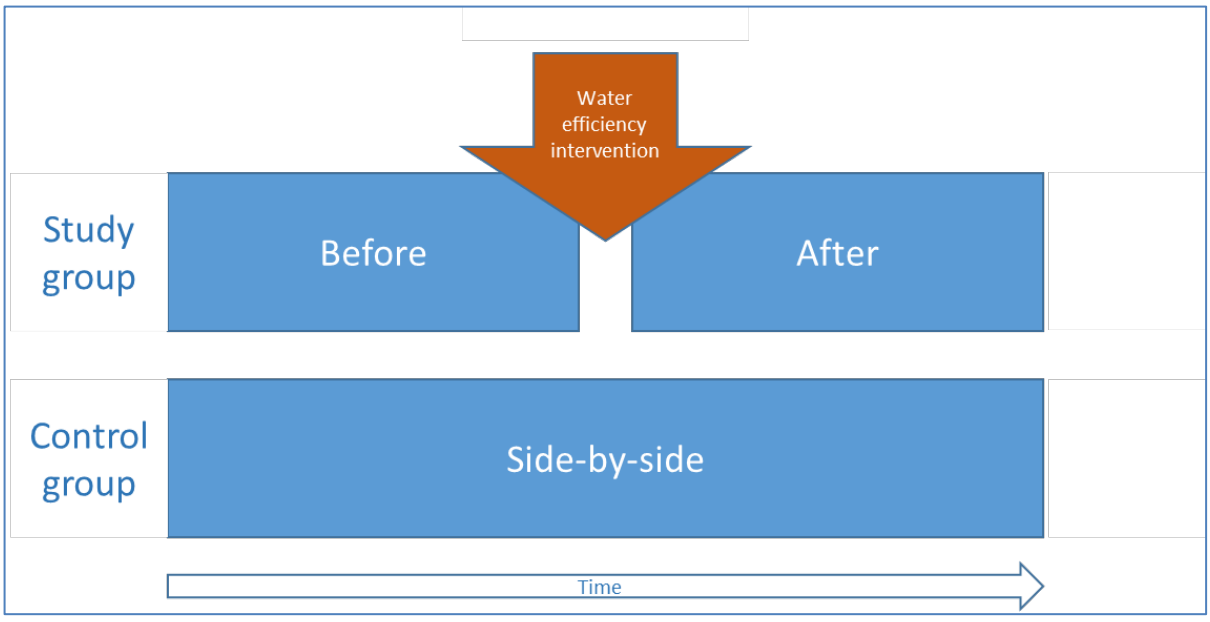

Figure 3 Illustration of the study and control group concept

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3.1.4 Applying a statistical test

Thirdly, a consistent statistical test has been used in this project, where possible. This is the t-test. The t-test is one of the commonest and most well-known statistical procedures. It is a 'parametric' test which means it should only be applied to close to normally distributed data. This is why tests for normality (based on skewness and kurtosis) are important. It was developed specifically for small samples, but can be used on any sample size.

The aim of the t-test is to determine the probability that the sample mean of one set of data is statistically different from the sample mean of another set of data. The test statistic considers the differences between the mean and variability of the data sets.

The analysis applied in this project calculates the difference between consumption before and after the water efficiency intervention (for all before-and-after control studies). A t-test is then applied to determine if this difference in consumption is statistically different from zero – in other words to test whether the null hypothesis (that there is no difference in consumption) should be rejected or not.

3.1.5 Evaluating the results

The decision whether or not to reject the null hypothesis is based on comparing the result of the t-test to a previously decided level of significance. This level of significance defines a p-value threshold. If the test result returns a value below the p-value threshold the null hypothesis can be rejected and the statistical significance is reported.

Having given consideration to sample sizes, the scale of daily variation in household consumption and the relatively small effect from water efficiency interventions a p-value threshold of 0.1 has been adopted as the most appropriate level.

The variation in household consumption and the relatively small effect size of water efficiency intervention also has implications for presenting project results. Figure 4 presents a box plot showing consumption before and after water efficiency intervention for Essex and Suffolk Water, water saving kits project. The graph illustrates that the two data sets are very similar, with only subtle differences observable, such as height of the whisker, illustrating the 95th percentile of the distribution.

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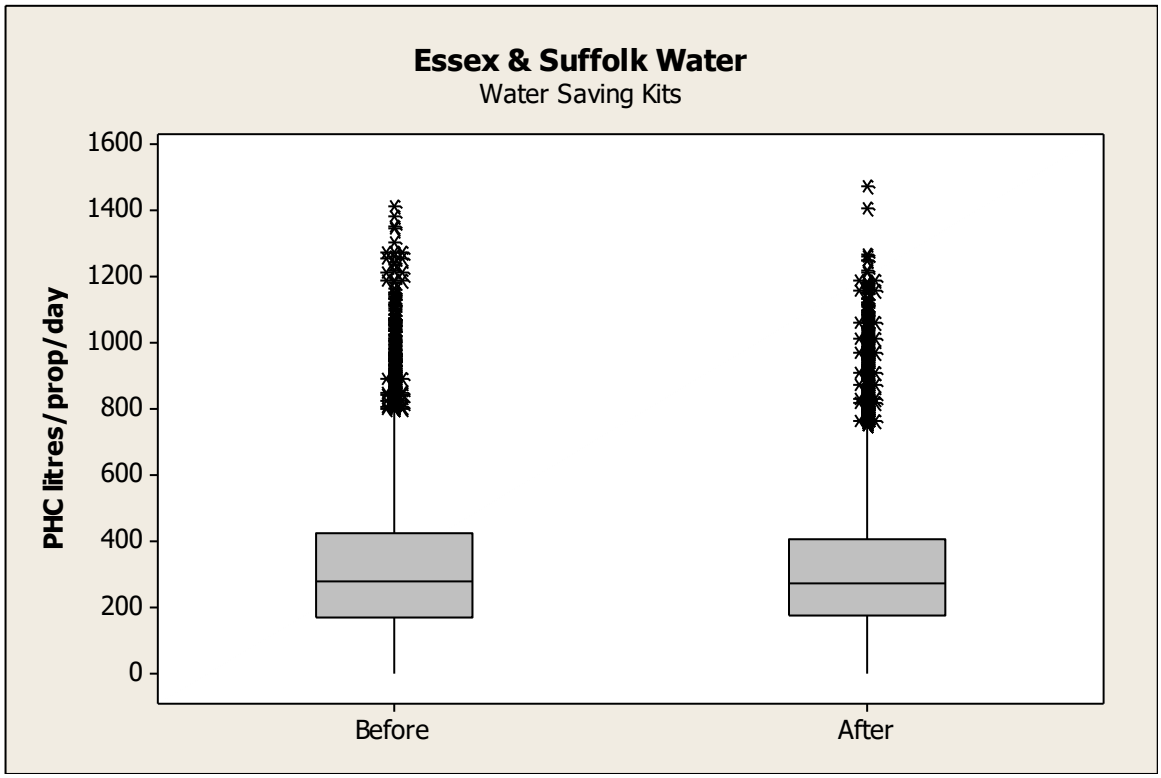

Figure 4 An illustration of the small differences in consumption resulting from water efficiency intervention

Figure 4 is typical of the results for the projects presented in this report. Alternative ways of presenting the data have been considered but, apart from Figure 15, further graphical presentation of these studies are not thought to bring additional insight to the results.

There is a relationship between the level of significance and confidence intervals. To calculate one from the other you subtract it from one. Therefore a 0.1 level of significance is equivalent to a confidence interval (C.I.) of 0.9. This is usually reported as a percentage number i.e. 90% C.I.

3.1.6 Measured meter reads

All the savings calculations are derived from actual measured meter reads. They are categorised as follows.

Short term reads - these are project-driven meter reads taken immediately prior to the time of an intervention and at a short time later. Typically these are 3 or 4 weeks before and again after any visit. Average daily consumptions are calculated from them using measured volumes over time elapsed.

Long term reads - these are also project-driven meter reads taken monthly, quarterly or annually before and after any intervention. Average daily consumptions are calculated from them using measured volumes over time elapsed.

Meter reads for billing - these are routinely captured meter reads taken principally for customer billing purposes, but used within this project in an opportunistic manner. These are typically six-monthly or annual reads. Average daily consumptions are calculated using measured volumes over time elapsed. In addition to this the pre and post period consumptions are derived by using the average daily consumption numbers for the appropriate period at each property. Also all the individual properties are synchronised based upon the intervention day. This process then allows for equivalent pre and post periods to be analysed, tested and compared.

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3.1.7 Data exclusions

All measured data is subject to exclusion testing. The principles of data exclusion are to minimise the removal of measured data whilst improving the calculated estimated savings. This is done by excluding data which is more likely to be generated from a measurement system error than actual consumption. Exclusions rules are equally applied to both ends of the distribution; that is to the largest and smallest calculated numbers. This ensures a balanced, symmetrical removal of data which maintains the underlying features of the distribution of data.

The data has been excluded when:

- Any negative consumptions;
- Pre and Post consumptions are outside the range 0 to 1,000 litres/prop/day; and
- The change in consumption is greater than ±70% of the mean consumption for the whole measurement period.

3.2 Essex & Suffolk Water – Water saving kits

3.2.1 Project summary

Essex & Suffolk Water offer their household customers water saving kits to help them reduce their water use. The water saving kit includes a variety of water saving devices (illustrated in Figure 5 and described in Table 5) that will help reduce water consumption. Customers request the kit via the Essex & Suffolk Water website, by phoning the billing team or whilst requesting a meter. As a result of this, it is more likely that the devices will actually be fitted than if the kits were sent out in an unsolicited manner.

Figure 5 Picture showing Essex & Suffolk Water's Water Saving Kit

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Essex & Suffolk Water have so far distributed over 52,700 water saving kits in the past five years across their whole geographical area. The kit and its contents has remained consistent over this period.

Table 5 Products offered in the Essex & Suffolk Water, water saving kit

Products offered
Shower aerator – to reduce the water used during a shower (claims to save 30 l/day)
Save a flush – to install in a toilet cistern saving water per flush (claims to save 12 l/day)
Tap insets – to reduce the flow from a tap during every use (claims to save 36 l/day)
Universal plug – universal plug size which fits to all sinks (claims to save 12 l/day)
Shower timer – to encourage a 4 minute shower by timing the duration (claims to save 5 l/day)

The properties in the following analysis requested water saving kits from 1st April 2011 until 31st March 2014.

3.2.2 Measurement method

The source data was six-monthly billed meter reads and the initial processing was in accordance with the **meter reads for billing** described in section 3.1.7. The savings have been calculated based on meter reads from metered properties, in two steps, using a before-and-after control, and then a side-by-side control. The before-and-after control is based on deriving:

- Average pre-installation consumption, calculated from meter data for the 12-month period immediately prior to the water saving kits being requested.
- A one-month period of post-request 'quarantine' is then allowed for, when it is assumed that devices will have been installed, but when consumption is not analysed.
- A 12-month post-installation average consumption is then calculated.

This before-and-after control will indicate how consumption has changed for the properties analysed from the period before the water saving kit was requested to a period after the items in the kit may have been installed.

It is possible that consumption would have changed over this period even without the kits being provided/installed. Therefore the second step of the analysis compares the changes in consumption before-and-after kit issue with the consumption of a control group of metered household customers over the same period who did not receive the kit.

A random sample of Essex & Suffolk Water metered billed customers were selected. An analysis target of 10,000 for side-by-side control customers was set and therefore 13,001 billing records for customers and Essex & Suffolk Water staff were extracted over an equivalent time period. Care was taken to ensure that the side-by-side control customers were not the subject of any targeted water efficiency drive in the period leading up to and during this study period. This means that any water saving messages they received during the period were typical of messages broadcast to all the Essex & Suffolk Water customers in general.

Both the water saving kit sample of customers and the side-by-side non-water saving kit customers were randomly selected to form two parallel random lists. The next part of the process was to pick the first water saving kit customer from the list and use its date of kit request as the 'ghost' start date for the non-saving kit which was first on that list. Next calculate the 12-month before, the 30-day quarantine and the 12-month post-intervention period for that property's meter read analysis. This same process continued all the way down the list using each household in the same position in each list to pair the non-water saving kit property with a ghost kit request date taken from the equivalent water saving kit request property.

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Once complete this process created a side-by-side control group which contained study control periods; these being 12-month pre and 12-month post following a ghost 30-day intervention period. This analysis (completed for this project) generated 11,447 properties with complete meter reads for the whole of the analysis period required and was done as part of this evidence base analysis.

3.2.3 Before-and-after control results

A total of 7,766 properties references were received, which had requested water saving kits and for which complete billed meter readings were also provided. Data exclusion resulted in a final sample number of 7,678 properties in the analysis. The descriptive statistics, the results of the normality tests, the 90% confidence interval, and results of the t-tests are shown in Table 6.

Table 6 Results of Essex & Suffolk Water's water saving kit analysis using a before-and after-control

Statistic	Value	Units
Measurements excluded	88	
Sample number used	7,678	
Mean	6.4	l/prop/day
90% Confidence interval	4.3, 8.5	l/prop/day
Lower quartile	-28.2	l/prop/day
Upper quartile	45.0	l/prop/day
Median	6.2	l/prop/day
Skewness	-0.1	Statistic
Kurtosis	3.3	Statistic
Statistically significant	Yes	Statistic

- 7,766 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 88 records.
- Skewness acceptable and close to normal.
- Kurtosis acceptable with median result close to the mean, this finding is robust.
- There was a statistical significant saving of **6.4 litres per property per day.**

A total of 7,678 properties which requested water saving kits experienced a water consumption mean reduction of 6.4 litres per property per day on average for one year after the kits were fitted.

However, the question remains whether this small but significant saving is entirely as a result of installation of the kits. This question is addressed by the use of a side-by-side control.

3.2.4 Side-by-side control group results

The side-by-side control group where no water saving kit was requested were analysed using a ghost kit request date and a before and after 12-month control and study approach in parallel to the kit request study analysis shown in section 3.2.3.

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Table 7 presents the descriptive and inferential statistics of the side-by-side analysis for the water saving kits.

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Table 7 Results of the Essex & Suffolk Water's water saving kit analysis using a side-by-side control

Statistic	Value	Units
Measurements excluded	98	
Sample number used	11,349	
Mean	2.8	l/prop/day
90% Confidence interval	1.9, 3.7	l/prop/day
Lower quartile	-18.9	l/prop/day
Upper quartile	27.1	l/prop/day
Median	2.9	l/prop/day
Skewness	-0.2	
Kurtosis	2.0	
Statistically significant	Yes	

- 11,447 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 98 records and therefore a final sample number of 11,349.
- Skewness acceptable and close to normal.
- Kurtosis acceptable with median result close to the mean, this finding is robust.
- There was a statistical significant mean saving of **2.8 litres per property per day.**

3.2.5 Final water saving kit results

The analysis of savings from the water savings kits has considered two approaches: a before-and-after control (with a statistically significant reduction in consumption of 6.4 litres per property per day) and a side-by-side control with before-and-after analysis (with a statistically significant reduction in consumption of 2.8 litres per property per day). These results are valid as stand-alone results, water savings were established for both groups. The first group that requested and (it is assumed) installed some or all of the water saving kit devices, whilst the second group did not. The reason for the second group's reduction in consumption is unknown but assuming that the water saving kit customers were exposed to similar circumstances the results can be combined.

This can be done by using the side-by-side control results and subtracting their 'non-water saving kits' water use reduction from the water saving kit numbers to establish the reduction in consumption that has occurred due to the request and installation of water saving kits.

The final results for the water saving kit, using a combined control are presented in Table 8.

Table 8 Results of the Essex & Suffolk Water's water saving kit analysis using a combined control

Statistic	Value	Units
Measurements excluded	88	
Sample number used	7,678	
Mean	3.6	l/prop/day
90% Confidence interval	1.7, 5.4	l/prop/day
Statistically significant	Yes	

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- There was a statistical significant mean saving of **3.6 litres per property per day.**

This water saving is the most likely amount of saving directly as a result of supplying the water saving kits.

The results of this project are discussed in section 3.5.

3.3 Essex & Suffolk Water – Bespoke water saving kits

3.3.1 Project summary

The water saving kits described in section 3.2 were a standard issue. Essex & Suffolk Water also give their customers the option of requesting water saving products individually: i.e. a bespoke water saving kit. When requesting a kit via the Essex & Suffolk Water website they have two options:

- Full water saving kit; or
- Select individual items.

When selecting the latter option, the customer has the opportunity to ask for individual products rather than a whole kit, and multiple items if required. Additional gardening products were also available to request as shown in Table 9. A total of 1,275 customers requested bespoke water saving kits, 1,042 in the Essex area and 233 in the Suffolk area.

Table 9 Additional products available in the bespoke water saving kit

Additional products
Trigger hose gun – a five dial trigger hose gun which attaches to the end of a garden hose using a hose end connector, allowing the flow of water to be stopped when required
SowPot – a collapsible plant pot containing wild flower seeds, expanding soil and an information booklet.
Water storing crystals - to mix with compost for hanging baskets or pots to retain water until needed.
Water stick – indicates when the plant needs watering so reduces overwatering and waste

Essex & Suffolk Water provided this data for analysis to determine whether there is a difference in water saving associated with standard and bespoke kits.

The properties who are the subject of the following analysis requested water saving kits from 1st April 2012 until 25th September 2014.

3.3.2 Measurement method

The source data was six-monthly billed meter reads and the initial processing was in accordance with the **meter reads for billing** described in section 3.1.7. The savings have been calculated based on meter reads from metered properties, in two steps, using a before-and-after control, and then a side-by-side control. The before-and-after control is based on deriving:

- Average pre-installation consumption, calculated from meter data for the 12-month period immediately prior to the water saving kits being requested.
- A one-month period of post-request 'quarantine' is then allowed for, when it is assumed that devices will have been installed, but when consumption is not analysed.
- A 12-month post-installation average consumption is then calculated.

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This before-and-after control will indicate how consumption has changed for the properties analysed from the period before the water saving kit was requested to a period after the items in the kit may have been installed.

It is possible that consumption would have changed over this period even without the kits being provided/installed. Therefore the second step of the analysis compares the changes in consumption before-and-after kit issue with the consumption of a control group of metered household customers over the same period who did not receive the kit.

A random sample of Essex and Suffolk Water metered billed customers were selected. An analysis target of 10,000 for side by side control customers was set, and therefore it was initially decided to select 13,001 customers and Essex & Suffolk Water staff and extract meter billed reads over an equivalent time period. Care was taken to ensure that the side-by-side control customers were not the subject of any targeted water efficiency drive in the period leading up to and during this study period. This means that any water saving messages they received during the period were typical of messages broadcast to all the Essex & Suffolk Water customers in general.

Both the bespoke water saving kit sample of customers and the side-by-side non-bespoke water saving kit customers were randomly selected to form two parallel random lists. The next part of the process was to pick the first bespoke water saving kit customer from the list and use its date of kit request as the 'ghost' start date for the non-saving kit which was first on that list. Next calculate the 12-month before, the 30-day quarantine and the 12-month post-intervention period for that property's meter read analysis. This same process continued all the way down the list using each household in the same position in each list to pair the non-bespoke water saving kit property with a ghost kit request date taken from the equivalent bespoke water saving kit request property.

Once complete this process created a side by side control group which contained study control periods these being 12-month pre and 12-month post from a ghost 30 day intervention period. This process generated 8,786 properties with complete meter reads for the whole of the analysis period required.

3.3.3 Before-and-after control results

A total of 631 properties references were received which had requested water saving kits and for which complete billed meter readings were also provided. Data exclusion resulted in a final sample number of 610 properties in the analysis. The descriptive statistics, the results of the normality tests, the 90% confidence interval, and results of the t-tests are shown in Table 10 Results of Essex & Suffolk Water bespoke water saving kit analysis using a before-and after-control

Table 10 Results of Essex & Suffolk Water bespoke water saving kit analysis using a before-and after-control

Statistic	Value	Units
Measurements excluded	21	
Sample number used	610	
Mean water saving	6.2	l/prop/day
90% Confidence interval	2.3, 10.1	l/prop/day
Lower quartile	-22.2	l/prop/day
Upper quartile	28.1	l/prop/day
Median	2.8	l/prop/day
Skewness	0.5	Statistic
Kurtosis	2.9	Statistic

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Statistically significant	Yes	Statistic

- 610 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 31 records.
- Skewness acceptable and close to normal.
- Kurtosis acceptable.
- There was a statistical significant mean saving of **6.2 litres per property per day.**

A total of 610 properties which requested bespoke water saving kits experienced a water consumption mean reduction of 6.2 litres per property per day on average for one year after the kits were fitted.

However, the question remains whether this small but significant saving is entirely as a result of installation of the kits. This question is addressed by the use of side-by-side controls.

3.3.4 Side-by-side control group results

The side-by-side control group where no water saving kit was requested were analysed using a ghost kit request date and a before and after 12-month control and study approach in parallel to the kit request study analysis shown in section 3.3.3. The results are shown in Table 11.

Table 11 Results of the Essex & Suffolk Water bespoke water saving kit analysis using a side-by-side control

Statistic	Value	Units
Measurements excluded	302	
Sample number used	8484	
Mean water saving	0.65	l/prop/day
90% Confidence interval	-0.4, 1.7	l/prop/day
Lower quartile	-23.1	l/prop/day
Upper quartile	23.9	l/prop/day
Median	0.4	l/prop/day
Skewness	0.0	Statistic
Kurtosis	1.8	Statistic
Statistically significant	No	Statistic

- 8,786 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 302 records and therefore a final sample number of 8,484.
- Skewness acceptable equal to zero.
- Kurtosis acceptable this finding is robust.
- There wasn't a statistical significant saving established**.**

A larger number of nearly 8,500 properties were included in this sample. A mean reduction of 0.65 l/prop/day was observed in this sample but this value is not statistically significant and so therefore it is not possible to state that this group saved any water during the period.

This analysis of the side-by-side control has demonstrated that the results from the before-and-after control (presented in section 3.3.3) are valid. These are summarised in Table 12.

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Table 12 Final results from statistical analysis from bespoke water saving kit data

Statistic	Value	Units
Measurements excluded	21	
Sample number used	610	
Mean water saving	6.2	l/prop/day
90% Confidence interval	2.3, 10.1	l/prop/day
Statistically significant	Yes	

- There was a statistically significant mean saving of **6.2 litres per property per day.**

This water saving is the most likely amount of saving directly as a result of supplying the water saving kits.

The results of this project are discussed in section 3.5.

3.4 Northumbrian Water – water saving kits

3.4.1 Project summary

Northumbrian Water (NW) and Essex & Suffolk Water are part of Northumbrian Water Limited, which is a member of Northumbrian Water Group (NWG). As a result Northumbrian Water and Essex & Suffolk Water often run the same water efficiency initiatives.

Northumbrian Water has also offered its customers water saving kits to help them reduce their water use in the home. The water saving kit is exactly the same as the Essex & Suffolk Water kit as described in section 3.2, Table 5. The kit and its contents has remained consistent between 2011 and 2013 during which period 637 water saving kits have been distributed in total in the Northumbrian Water company area.

The properties who are the subject of the following analysis requested water saving kits from 7th April 2011 until 13th February 2013.

3.4.2 Measurement method

The source data was six-monthly billed meter reads and the initial processing was in accordance with the **meter reads for billing** described in section 3.1.7. The savings have been calculated based on meter reads from metered properties, in two steps, using a before-and-after control, and then a side-by-side control. The before-and-after control is based on deriving:

- Average pre-installation consumption, calculated from meter data for the 12-month period immediately prior to the water saving kits being requested.
- A one-month period of post-request 'quarantine' is then allowed for, when it is assumed that devices will have been installed, but when consumption is not analysed.
- A 12-month post-installation average consumption is then calculated.

This before-and-after control will indicate how consumption has changed for the properties analysed from the period before the water saving kit was requested to a period after the items in the kit may have been installed.

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It is possible that consumption would have changed over this period even without the kits being provided/installed. Therefore the second step of the analysis compares the changes in consumption before-and-after kit issue with the consumption of a control group of metered household customers over the same period who did not receive the kit.

A random sample of Northumbrian Water metered billed customers were selected. An analysis target of 10,000 for side-by-side control customers was chosen, and therefore initially 12,489 customers and Northumbrian Water staff were selected and meter billed reads were extracted over an equivalent time period. Care was taken to ensure that the side-by-side control customers were not the subject of any targeted water efficiency drive in the period leading up to and during this study period. This means that any water saving messages they received during the period were typical of messages broadcast to all the Northumbrian Water customers.

Both the water saving kit sample of customers and the side-by-side non-water saving kit customers were randomly selected to form two parallel random lists. The next part of the process was to pick the first water saving kit customer from the list and use its date of kit request as the 'ghost' start date for the non-saving kit which was first on that list. Next calculate the 12-month before, the 30-day quarantine and the 12-month post intervention period for that property's meter read analysis. This same process continued all the way down the list using each household in the same position in each list to pair the non-water saving kit property with a ghost kit request date taken from the equivalent water saving kit request property.

Once complete this process created a side-by-side control group which contained study control periods these being 12-month pre and 12-month post either side of a ghost 30-day intervention period. This process generated 9,426 properties with complete meter reads for the whole of the analysis period required.

3.4.3 Before and-after control results

A total of 431 properties references were received which had requested water saving kits and for which complete billed meter readings were also provided. Data exclusion resulted in a final sample number of 423 properties in the analysis. The descriptive statistics, the results of the normality tests, the 90% confidence interval, and results of the t-tests are shown in Table 13.

Table 13 Results of the Northumbrian Water's water saving kit analysis using a before and after control

Statistic	Value	Units
Measurements excluded	9	
Sample number used	423	
Mean water saving	1.7	l/prop/day
90% Confidence interval	-3.7, 7.1	l/prop/day
Lower quartile	-17.6	l/prop/day
Upper quartile	31.0	l/prop/day
Median	4.1	l/prop/day
Skewness	-0.5	Statistic
Kurtosis	3.1	Statistic
Statistically significant	No	Statistic

- 431 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 9 records.

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- Skewness acceptable and close to normal.
- Kurtosis acceptable/borderline.
- There wasn't a statistical significant saving.

A total of 431 properties which requested water saving kits experienced no statistically significant reduction in water used in the after request period.

3.4.4 Side-by-side control group results

The side-by-side control group where no water saving kit was requested were analysed using a 'ghost' kit request date and a before-and-after 12-month approach in parallel to the kit request study analysis shown in section 3.4.3. The before-and-after control showed no statistically significant saving.

Table 14 presents the descriptive and inferential statistics of the side-by-side analysis for the water saving kits.

Table 14 Results of the Northumbrian Water's water saving kit analysis using a side-by-side control

Statistic	Value	Units
Measurements excluded	241	
Sample number used	9185	
Mean water saving	3.4	l/prop/day
90% Confidence interval	2.9, 4.6	l/prop/day
Lower quartile	-16.8	l/prop/day
Upper quartile	25.2	l/prop/day
Median	3.6	l/prop/day
Skewness	-0.1	Statistic
Kurtosis	2.7	Statistic
Statistically significant	Yes	Statistic

- 9,426 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 241 records and therefore a final sample number of 9,185.
- Skewness acceptable and very close to normal.
- Kurtosis acceptable with median result close to the mean, this finding is robust.
- There was a statistical significant mean saving of 3.4 **litres per property per day.**

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3.4.5 Final Results

Table 15 Final results from Northumbrian Water's water saving kit analysis.

Statistic	Value	Units
Sample number used	423	
Mean water saving	0	l/prop/day
90% Confidence interval	N/A	l/prop/day
Statistically significant	No	Statistic

There was no statistical significant water saving in this group. The results of this project are discussed in section 3.5.

3.5 Comparison of ESW and NWL and bespoke water saving kits

The three water saving kit projects returned different before and after changes in consumption once the side by side control had been taken into account.

Essex & Suffolk Water's water savings kits comprised a very large sample (in excess of 7,500) and returned a statistically significant but small saving of 3.6 litres per property per day. The Essex & Suffolk Water bespoke water savings kits had a much sample size (600 or so) and returned a statistically significant, and larger saving of 6.2 litres per property per day. There are two different possible reasons for this. The first is that people requesting bespoke kits do actually reduce their consumption to a greater extent than people who request a standard water saving kit. The other possibility is that the 600 or so bespoke kit customers are different in some way (e.g. more pre-disposed to being water efficient) than the 7,500 or so standard kit customers. Customers were not allowed to choose both the bespoke and standard kit.

Northumbrian Water's water saving kit project didn't return any statistical significant savings. There are, once again, two possible reasons for this. The first is that the customers in this sample behave differently than those in the Essex & Suffolk samples, with regard to requested water saving kits. The second possible explanation is that the relatively small sample size of Northumbrian Water customers (just over 400) meant that it was not possible to identify a statistically significant saving.

If the provision of water saving kits continues, and the recording of the same information is maintained continues, then further analysis should determine which of these possibilities is likely to be true.

3.6 Essex & Suffolk Water – Challenge TWENTY:12

3.6.1 Project summary

Essex & Suffolk Water (ESW) has conducted a behavioural change campaign called Challenge TWENTY:12 (C2012). The aim of C2012 was to use a range of range of innovative stimulus and participation incentives to change behaviour in order to achieve a measured saving of 20 litres per property per day. The project was undertaken over a 12-month period between September 2012 and August 2013 and it was restricted to Chafford Hundred in Essex, which is a new development built in the 1990s and as a result 100% of the houses are metered. The presence of meters allows a robust data set to be obtained which can be converted into reliable and accurate information on water savings.

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Engagement was done through the use of monthly postal letters. Each month a different set of water efficiency facts and messages were used and these were themed around events, topics or time of the year e.g. a Halloween themed letter in October and a Christmas themed letter in December. At the bottom of each fact sheet each customer has a bespoke consumption chart showing their use for the previous two months as well as the average for the whole sample. This was to bring the customers' consumption to their attention and to allow benchmarking with their neighbours which might stimulate a competitive drive through social norms.

To incentivise participation and to ensure interest for the project was sustained over the 12-month period, customers were given the opportunity to request a series of different water saving products as shown in
Table 16. By asking the customers to request the product rather than sending out products unsolicited this ensures minimal wastage due to the fact that the devices are more likely to be installed.

Table 16 Range of products offered during the Challenge TWENTY:12 campaign

Products offered
Shower aerator – to reduce the water used during a shower without compromising the experience
Tap insets – to reduce the flow from a tap during every use
Washing machine magnet – as an aid memoir to remind customers to always fill the washing machine
Water stick – is a product which indicates to customers when to water their plants
Water saving crystals - water crystals are super absorbent and reduces the frequency of watering
Trigger hose gun - it attaches to a garden hose allowing the flow of water to be stopped when required
Universal plug – universal plug size which fits to all sinks
Shower timer – to encourage a 4 minute shower by getting out of the shower when the sand runs out
Beaker – to use when brushing teeth instead of leaving the tap running
Children's kit – a range of child friendly products to engage with children
Water butt voucher – a discount voucher for customers to buy a water butt for the garden

3.6.2 Measurement method

In order to obtain the best data possible, a stringent meter reading programme was developed and implemented. Each of the 1,000 participants on the project had their meter manually read during the last week of each month. These monthly readings at each property were averaged across all properties each month. There was no visible trend in the data during the period, as illustrated in Figure 6.

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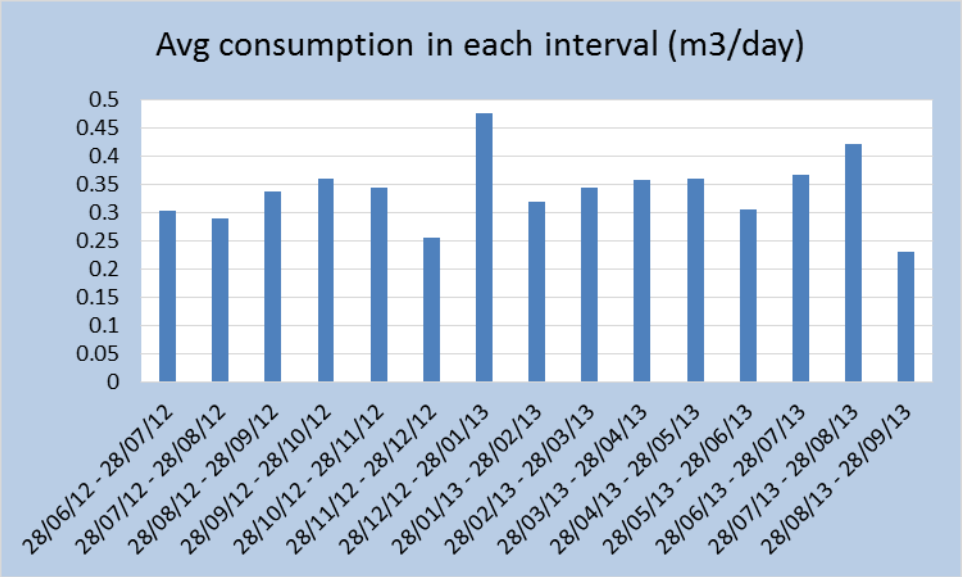

Figure 6 Average monthly consumption for the 1,000 properties in the C2012 project

Weather data was sent to us by ESW and the monthly average maximum daily temperature was regressed against the monthly demand but there is no correlation found (R^2 <1.5%). This suggests that any further analysis to remove weather effects from the change in consumption would be unproductive.

3.6.3 Statistical analysis

Due to the confusing picture above a more straightforward approach was adopted based on the principal of a before-and-after control.

The first one third of the period (first five months) and the last one third of the period (last five months) was analysed as a before-and-after control. The results are shown in Table 17.

Table 17 Headline results from statistical analysis from Challenge TWENTY:12 project

Statistic	Value	Units
Measurements excluded	12	
Sample number used	914	
Mean water saving	-2.9	l/prop/day
90% Confidence interval	[-11.0, 4.4]	l/prop/day
Lower quartile	-52.5	l/prop/day
Upper quartile	32.5	l/prop/day
Median	-6.8	l/prop/day
Skewness	0.5	Statistic
Kurtosis	2.4	Statistic
Statistically significant	No	Statistic

- 926 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 12 records.

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- Skewness acceptable.
- Kurtosis acceptable.
- There was no statistically significant saving.

Therefore it is not possible to conclude whether or not the Challenge Twenty:12 project resulted in any water savings.

3.7 Essex & Suffolk Water – ecoFIT

3.7.1 Project summary

Essex & Suffolk Water was a leader in the design and development of the ecoBETA device, which converts single flush toilets to dual flush. The ecoFIT water saving project targeted properties which could have an ecoBETA installed in the home. The customers were also offered a comprehensive home audit and offered a range of water saving devices throughout the house and garden as shown in Table 18. In addition to this, the participants were given information and advice to help promote water saving behavioural changes.

The ecoFIT project targeted 15,260 customers and successfully conducted 2,552 audits. Due to the pre-screening questions, all properties which were visited were assumed to have at least one suitable toilet for conversion for a single flush to a dual flush. Of the 2,552 properties 3,776 toilets were inspected and 3,251 (86%) of toilets were suitable for a retrofit device. Of these considered to be suitable, 2,598 (80%) were successfully converted. The remaining 1,178 were not converted or had an alternative device fitted, as follows:

- 629 (53%) were unchanged as they were already considered to be efficient; and
- 549 (47%) had a save-a-flush fitted as they were unable to have an ecoBETA fitted due to slim cisterns, siphon problems or areas on concealed pipework.

Table 18 Water saving products offered during the ecoFIT project

Products offered
Children's activity pack – to educate children about the importance of water saving in the home
Water saving crystals - water crystals are super-absorbent and reduces the frequency of watering
Water butt – two sizes available, 200 or 95 litres to save rainwater for garden watering
Trigger hose gun - it attaches to a garden hose allowing the flow of water to be stopped when required
ecoBETA – retrofit device to convert a single flush cistern into a dual flush
Save-a-flush – cistern displacement device to save a litre per toilet flush
Eco-flow tap adaptor – multi directional tap aerator for kitchen taps to alter the flow
Tap inserts – a range of tap inserts offered to reduce the flow of water through the tap
Tap re-washering – a tap re-washering service was offered to repair any leaking taps in the home
Aerated showerhead – to reduce the water used during a shower without compromising the experience
Shower regulator – an inline regulator to reduce the water flow of water delivered to the shower head
Shower timer – to encourage a 4 minute shower by getting out of the shower when the sand runs out

Table 19 Number of products installed during the ecoFIT water audits in Essex & Suffolk Water

Products / repairs	Fitments inspected	Quantity fitted	Quantity of suitable fitments	% of suitable fitments	% plumber success rate on fitments
Basin plug	5971	9	5971	100%	0%

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Crystals	2552	2517	2552	100%	99%
Hose gun	2552	2366	2400	94%	99%
Shower adjustments	2301	870	2301	100%	38%
Shower aerator	2301	830	899	39%	92%
Shower timer	2552	2347	2552	100%	92%
Tap aerator	8185	5198	7151	87%	73%
Tap repair	8185	360	8185	100%	4%
Toilet dual flush (ecoBETA)	3776	2598	3251	86%	80%
Toilet repair	3776	103	3776	100%	3%

3.7.2 Measurement method

The source data was short term project-based meter reads, typically four weeks before and four weeks after installation. The savings have been calculated based on these short term meter reads. Each property has the average daily consumption calculated from the meter read volumes over the intervening time periods. The savings are calculated on a before-consumption minus after-consumption which means that positive numbers are water savings and negative numbers represent increased water use.

The ecoFIT installations took place over the period 1st December 2012 to February 2013.

3.7.3 The before-and-after control results

Table 20 Results of the Essex & Suffolk Water's water ecoFIT project

Statistic	Value	Units
Measurements excluded	7	
Sample number used	330	
Mean water saving	33.8	l/prop/day
90% Confidence interval	29.0, 38.6	l/prop/day
Lower quartile	3.4	l/prop/day
Upper quartile	55.5	l/prop/day
Median	24.9	l/prop/day
Skewness	0	Statistic
Kurtosis	3.0	Statistic
Statistically significant	Yes	Statistic

- 337 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulted in the exclusion of seven records.
- Skewness questionable and borderline.
- Kurtosis questionable.

A total of 330 properties were involved in the ecoFIT study and had complete meter reads. The normality tests carried presented in the table above are borderline, therefore to estimate the most likely water saving for this project, the average (arithmetic mean) of the mean and median water

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savings has been taken (this value is taken to be representative of the parametric and non-parametric mean). This explains why the figure below is different from those in the table.

The most likely saving from this project is 29.4 litres/property/day.

3.8 Northumbrian Water – ecoFIT

3.8.1 Project summary

Northumbrian Water and Essex & Suffolk Water are part of the Northumbrian Water Group and they often run the same water efficiency initiatives in both companies. Northumbrian Water has built on the success of ESW ecoFIT water saving project and has conducted an identical project in the Northumbrian Water area.

Through the recruitment process, ecoFIT specifically targeted properties which were suitable for the ecoBETA dual flush conversion. The customers were also offered a comprehensive home audit and offered a range of water saving devices throughout the house and garden as described in section 3.7.1 and listed in Table 18. The customers were also given information and advice to help promote key water saving behavioural changes.

The Northumbrian Water ecoFIT project targeted 15,134 customers and successfully conducted 2,003 audits. Due to the pre-screening questions, all properties which were visited were assumed to have at least one suitable toilet for conversion for a single flush to a dual flush. Of the 2,003 properties 3,032 toilets were inspected and 2,537 (86%) of toilets were suitable for a retrofit device. Of these considered to be suitable, 2,250 (74%) were successfully converted. The remaining 782 were not converted or had an alternative device fitted, as follows:

- 568 (73%) were unchanged as they were already considered to be efficient; and
- 214 (27%) had a save-a-flush fitted as they were unable to have an ecoBETA fitted due to slim cisterns, siphon problems or areas of concealed pipework.

Table 21 Number of products installed during the ecoFIT water audits in Northumbrian Water

Products / repairs	Fitments inspected	Quantity fitted	Quantity of suitable fitments	% of suitable fitments	% plumber success rate on fitments
Basin plug	4881	27	4881	100%	1%
Crystals	2003	1810	2003	100%	90%
Hose gun	2003	1936	1951	97%	99%
Shower adjustments	1956	209	1956	100%	11%
Shower aerator	1956	649	715	37%	91%
Shower timer	2003	1705	2003	100%	85%
Tap aerator	7000	4119	5673	81%	73%
Tap repair	7000	531	7000	100%	8%
Toilet dual flush (ecoBETA)	3032	2250	2537	84%	89%
Toilet repair	3032	47	3032	100%	2%

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3.8.2 Measurement method

The source data was short-term project-based meter reads, typically four weeks before and four weeks after installation. The savings have been calculated based on these short-term meter reads. Each property has the average daily consumption calculated from the meter read volumes over the intervening time periods. The savings are calculated on a before consumption minus after consumptions which means that positive numbers are water savings and negative numbers are water increases.

3.8.3 The before-and-after control results

Table 22 Results of Northumbrian Water's water ecoFIT project

Statistic	Value	Units
Measurements excluded	7	
Sample number used	177	
Mean water saving	35.6	l/prop/day
90% Confidence interval	27.3, 43.8	l/prop/day
Lower quartile	4.7	l/prop/day
Upper quartile	63.0	l/prop/day
Median	33.3	l/prop/day
Skewness	0.9	Statistic
Kurtosis	4.4	Statistic
Statistically significant	Yes	Statistic

Although 2003 ecoFIT interventions were completed only 184 sets of meter reads were provided to this project.

- 184 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of seven records.
- Skewness questionable and borderline.
- Kurtosis questionable.

A total of 177 properties were involved in the ecoFIT study and had complete meter reads. The normality tests carried presented in the table above are borderline, therefore to estimate the most likely water saving for this project, the average (arithmetic mean) of the mean and median water savings has been taken (this value is taken to be representative of the parametric and non-parametric mean). This explains why the figure below is different from those in the table.

The most likely saving from this project is 34.4 litres/property/day.

3.9 Anglian Water – Water efficiency measures programme

3.9.1 Project summary

Anglian Water has an ongoing companywide campaign called "Love every drop" which aims for everyone, everywhere, every day to save 20 litres of water. As part of this it has the "bits and bobs

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giveaway" which encourages their customers to *'…do your bit to save water which could save you a bob or to...'*

'Bits and bobs' is a water efficiency measures programme which involves a free household visit to carry out a water audit and retrofit of a number of products combined (listed in Table 23). During the visit water saving tips and advice is also given to the customer to help save water around the home. A questionnaire was also filled out to gain information about: bathing habits, number of showers and baths, number of toilets, water using appliances etc. Additional information such as occupancy, ACORN group and property type were also collated.

Anglian water has conducted 2,006 home visits in 2013-14 and 20,628 in 2014-15, questionnaires were conducted during most of these visits.

Table 23 Water efficient products offered during Anglian Water home audit visits

Water efficient products
Bath Buoy – to remind customers not to overfill their bath
ecoBETA – retrofit device to change a single flush toilet into a dual flush
Fat Trap – a pot to collect fat in from the kitchen to prevent it from going down the sink
Garden Kit – various devices to use in the garden to reduce water
Hose Gun - attaches to a garden hose allowing the flow of water to be stopped when required
Cistern displacement device – either a hippo or a save a flush to save water per flush
Tap magic (A, B, C or D) - a range of tap inserts offered to reduce the flow of water through the tap
Shower restrictor – to reduce the flow delivered to the shower head
Shower aerator – to aerate the flow of water from the shower to use less water
Shower timer – to encourage customers to have a 4 minute shower
Other plumbing correction – including replacing washers or adjustment of ball valve

3.9.2 Measurement method

The source data was six-monthly billed meter reads and the initial processing was in accordance with the **meter reads for billing** described in section 3.1.7. The savings have been calculated based on meter reads from metered properties using a before-and-after control. The before-and-after control is based on deriving:

- Average pre-installation consumption, calculated from meter data for the 12-month period immediately prior to the date of the water efficiency intervention.
- A 12-month post-installation average consumption is then calculated.

This before-and-after control will indicate how consumption has changed for the properties analysed from the period before the water efficiency intervention to a period after the intervention. Parallel testing was not possible for this project due to the nature of the data provided.

3.9.3 Before and after control results

Table 24 Results of Anglian Water's 'Love every drop' campaign

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Statistic	Value	Units
Measurements excluded	277	
Sample number used	12,231	
Mean water saving	13.1	l/prop/day
90% Confidence interval	12.4, 13.9	l/prop/day
Lower quartile	-2.8	l/prop/day
Upper quartile	25.2	l/prop/day
Median	6.6	l/prop/day
Skewness	1.1	
Kurtosis	6.9	
Statistically significant	Yes	

- 12,508 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 277 records.
- Skewness questionable and borderline.
- Kurtosis questionable and borderline.

A total of 12,231 properties were involved in the retrofit water efficiency intervention project and had complete meter reads. The normality tests carried presented in the table above are borderline, therefore to estimate the most likely water saving for this project, the average (arithmetic mean) of the mean and median water savings has been taken (this value is taken to be representative of the parametric and non-parametric mean). This explains why the figure below is different from those in the table.

The most likely saving from this project is 9.9 litres/property/day.

There are very many properties included in this project and around ten devices installed/supplied per property and these have been recorded. Therefore there is an opportunity to undertake much more analysis on this data, similar in part at least to H_2eco analysis (Section 3.11.3).

3.10 South East Water – Ashford new homes project

All properties on the Highland Park development in Ashford have been built since 2007. Therefore all the properties on this development are metered. One hundred of the homes in this development had water efficient devices installed including:

- Aerated shower heads (max 10l/min flow);
- Flow restrictors in taps (max 5 l/min indoors and max 10 l/min outdoors);
- Dual low flush toilets (3/4 litres);
- A+ rated washing machines (39 l/cycle or 7.8 l/kg on economy wash); and
- Rain water butts.

One hundred other properties were billed on a seasonal tariff basis. The properties also had the same water efficient products installed as the above group. The seasonal tariff involves charging a different rate for water during the peak summer months, when the unit costs of water is almost double the price of water in the winter period. This is shown in Table 25. A control group in the Highland Park

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development consisting of 60 properties, was also identified and used for the baseline consumption of typical houses.

Table 25 Seasonal tariffs applied in the Ashford Homes project (2009-2010 prices)

	Standing charge	Low tariff (September – April)	Summer tariff (May – August)
Standard measured tariff	£25.20	108.20 p	108.20 p
Seasonal tariff	£25.20	51.00 p	204.00 p

3.10.1 Initial results

As of September 1st 2011 there were 88 seasonal tariff properties on the billing system, with only two of these unoccupied. South East Water analysed some of the initial results. The data for 2008-2010 has been used, as the data for 2007 and 2011 is very limited due to a small number of properties occupied in 2007 and only a partial year for 2011. The apparent annual average savings for that period for all groups are shown in Table 26 as a percentage saving.

Table 26 Initial estimates of savings from the Ashford Homes project

	2008	2009	2010	Average
Control group	7 %	13 %	14 %	**11 %**
Water efficiency only	17 %	11 %	9 %	**12 %**
Water efficiency and seasonal tariff	28 %	22 %	17 %	**23 %**

3.10.2 Measurement method

Meter reads averaged annually at each property and aggregated for each group.

3.10.3 Statistical analysis

Although there appears to be some savings the sample numbers are very low particularly when comparing properties with complete meter reads within a specific year. For example, the results of a t-test between the control group and the water efficiency group, for the year 2010 shows no statistically significant results. The results are presented in Table 28.

Table 27 South East Water Ashford Homes - Difference in consumption between the control and water efficiency group

Statistic	Value	Units
Measurements excluded	2	
Sample number used	50	
Mean water saving	12.1	l/prop/day
90% Confidence interval	[-16.9,41.1]	l/prop/day
Lower quartile	-65.1	l/prop/day
Upper quartile	85.2	l/prop/day
Median	9.9	l/prop/day
Skewness	0.23	Statistic

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Kurtosis	1.9	Statistic
Statistically significant	No	Statistic

- 52 properties were available with complete sets of meter reads.
- Data exclusion rules stated resulting in the exclusion of 2 records.
- Skewness acceptable.
- Kurtosis acceptable.
- There are no statistically significant savings.

Table 29 presents statistics on the differences between the tariff group and the control group.

Table 28 South East Water Ashford Homes - Difference in consumption between the control and seasonal tariff group

Statistic	Value	Units
Measurements excluded	0	
Sample number used	32	
Mean water saving	22.5	l/prop/day
90% Confidence interval	[-10.9,55.9]	l/prop/day
Lower quartile	-33.4	l/prop/day
Upper quartile	81.1	l/prop/day
Median	15.4	l/prop/day
Skewness	0.35	Statistic
Kurtosis	2.7	Statistic
Statistically significant	No	Statistic

- 32 properties were available with complete sets of meter reads.
- Data exclusion rules stated resulting in the exclusion of 0 records.
- Skewness acceptable.
- Kurtosis acceptable.
- There are no statistically significant savings.

The exploratory data analysis undertaken for this project suggests that this result is likely to be repeated for every year, and therefore there are unlikely to be any statistically significant savings for any year in this study. The small sample size and the large within and between year variations in demand are likely to be the main reasons for this.

3.11 Essex & Suffolk Water – H_2eco Phases 1-9 as a collective

3.11.1 Project summary

The H_2eco project is a water efficiency domestic retro-fit multi-device home audit project undertaken by Essex & Suffolk Water. The project has been carries out over the past eight years and consists of nine phases, which are almost like nine individual water efficiency projects. During analysis for this

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project all of the data was consolidated into one database and the water savings were analysed as well as analysing the data for each phase individually.

During the H_2eco project plumbers installed over 20,500 water saving products free-of-charge and also offered advice about simple ways to save on water consumption. The nine phases of the H_2eco project are listed in Table 29. All phases of the study used similar approaches to recruiting properties for an audit, the audit itself and the devices offered for fitting. A total of 102,000 properties were approached and invited to take part in the audit phases and of these 18,008 properties had an audit and 7,296 of these provided short valid pre and post meter reads.

Additional information about socio-economic groups was also collected and analysed to determine if any correlation with Acorn group and water savings.

Table 29 Water efficiency studies included under the H_2eco project

Name	Type	Approximate dates	Location
H_2eco Phase 1	Domestic retrofit	01-12-07 to 31-03-08	Chelmsford, Essex
H_2eco Phase 2	Domestic retrofit	01-02-08 to 30-09-08	Chelmsford, Essex
H_2eco Phase 3	Domestic retrofit	01-03-09 to 31-03-09	Chelmsford, Essex
H_2eco Phase 4	Domestic retrofit	01-09-09 to 31-01-10	Chelmsford, Essex
H_2eco Phase 5	Domestic retrofit	07-10-10 to 01-04-10	Wickford, Essex
H_2eco Phase 6	Domestic retrofit	15-07-11 to 23-12-11	Basildon, Essex
H_2eco Phase 7	Domestic retrofit	01-05-12 to 01-10-12	Basildon, Essex
H_2eco Phase 8	Domestic retrofit	01-05-13 to 01-10-13	South Benfleet, Essex
H_2eco Phase 9	Domestic retrofit	01-06-14 to 01-12-14	Billericay, Essex

3.11.2 Measurement method

The source meter data was short-term meter reads typically four weeks before and four weeks after the water efficiency intervention. ESW supplied extensive amounts of data for analysis. The potential water savings were derived for both measured and unmeasured houses using the data on devices fitted and device flow rate measurements taken during the audits. The study has then used pre and post-audit meter reading data from the measured properties to quantify the savings made per property in the short term and long term.

All of these results have been used to carry out further statistical analysis on the total dataset to derive further insights into the savings per device, the factors driving the water savings and the persistence of water saving over time.

3.11.3 Essex & Suffolk Water – H_2eco overall savings

Essex & Suffolk Water (ESW) has routinely carried out water efficiency retrofit projects for the last 15 years. As part of these schemes the Company has installed thousands of water efficiency devices and encouraged customers to embrace water saving habits through behavioural change campaigns. These initiatives are monitored through the collection of three separate meter reads; these are used to calculate overall study savings. Through this process ESW has produced a measurable decrease in its customers' consumption.

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In a continued effort to improve the understanding of the effects of their endeavours the analysis was initiated to further integrate study data and look at some new areas of analysis.

ESW completed H_2eco home audit project phase 9 in November 2014. This section contains analysis using data from all nine phases.

The studies involve selecting an area to target, inviting domestic customers to participate (currently 15,000 per year), then arranging home visits (approximately 3,000 which is 20% of invitees), and installing a range of water efficiency devices appropriate for each setting. In addition to this, a number of instruction and behaviour changing messages are delivered to maximise the effect of the process.

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Table 30 Overall results from the H2eco phases – short term meter reads results

Statistic	Value	Units
Measurements excluded	217	
Sample number used	7296	
Mean	21.5	l/prop/day
90% Confidence interval	19.3, 23.7	l/prop/day
Lower quartile	-18.2	l/prop/day
Upper quartile	59.6	l/prop/day
Median	19.3	l/prop/day
Skewness	0.0	Statistic
Kurtosis	3.5	Statistic
Statistically significant	Yes	Statistic

- 7,513 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 217 records.
- Skewness acceptable.
- Kurtosis borderline acceptable.

A total of 7,296 properties were involved in all the retrofit water efficiency intervention projects and had complete meter reads. The normality tests are acceptable.

The most likely saving from these projects as a collective is 21.5 litres/property/day.

The individual study results for each phase is shown in Table 31.

Table 31 H2eco results for individual phases and overall

H2eco	Mean	Statistically significant water saving	90% CI	N° of measured properties
Phase 1	17.1		[10.4, 23.8]	663
Phase 2	6.3		[-0.2, 12.8]	626
Phase 3	8.2		[0.0, 16.4]	146
Phase 4	29.1		[19.3, 38.8]	361
Phase 5	19.7		[8.1, 31.4]	748
Phase 6	44.6		[39.8, 49.4]	1042
Phase 7	28.9		[21.8, 36.0]	545
Phase 8	28.2		[24.0, 32.4]	1507
Phase 9	6.1		[1.5, 10.7]	1658
All studies	**21.5**		**[19.3, 23.7]**	**7296**

Although each study was similar in nature, contained similar types of interventions and broadly similar water saving messages, they returned very different short-term results. However, the overall "All

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Studies" value represents the most likely savings achieved overall. The number of audits completed varied greatly in Phases 1 to 5. Later Phases (5 to 9) are very consistent in scale completing audits of just over 3,000 domestic properties in each case.

There is an indication that the water savings per property are increasing in later phases with the exception of Phase 9 and possibly Phase 5. Whilst the learning process has generally improved the amount of water saving there is clearly more to learn from the low value returned in Phase 9.

3.12 Essex & Suffolk Water – H_2eco Phases 1-5 longevity of savings

3.12.1 Project summary

As previously described, the H_2eco project is a water efficiency domestic retro-fit programme consisting of nine phases. The longevity of water savings were analysed as part of a separate piece of work commissioned by Essex & Suffolk.

3.12.2 Measurement method

The source data was six-monthly billed meter reads and the initial processing was in accordance with the **meter reads for billing** described in section 3.1.7. The savings have been calculated based on meter reads from metered properties using a before-and-after control. The before-and-after control is based on deriving:

- Average pre-installation consumption, calculated from meter data for up to four years in units of years immediately prior to the date of the water efficiency intervention; and,
- Average post-installation consumption, calculated from meter data for up to four years in units of years immediately after the water efficiency intervention.

This before-and-after control will indicate how consumption has changed for the properties analysed from the period before the water efficiency intervention to a period after the intervention.

3.12.3 Before-and-after control results

The comparison of the short term and long term results for 1 and 2 years post intervention are shown in

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Table 32.

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Table 32 Water Efficiency Studies - comparison of short term and long term savings

	Water savings (l/property/day)			
Phase	**Measured water savings**	**90% confidence limits [lower, upper]**	**Number of measured properties**	**Measure type**
Phases 1 to 5	18.8	[12.4, 25.2]	2853	Short term
Phases 1 to 5	15.2	[12.9, 17.5]	3909	Long term average one-year post
Phases 1 to 4	16.2	[12.5, 19.8]	1787	Short term
Phases 1 to 4	14.8	[12.2, 17.3]	2419	Long term average two-years post

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Table 32 shows the difference between short and long-term savings for two sets of results: Phases 1 to 5 as a group and Phases 1 to 4 as a group. The table presents the long-term savings over one year for both groups and over two years for the Phase 1 to 4 group (the savings are calculated using the same period before as after, i.e. 'one year' is one year before and one year after and so on).

Using the 'one-year' Phase 1 to 5 comparisons, the water savings show that there is a 19% decrease in water savings from short to long term. When the Phase 1 to 4 group is analysed the equivalent reduction water savings from the short-term to the long-term is 8.5%. Furthermore there is no further reduction in savings throughout year two for phases 1 to 4. This suggests that the savings seen during the first year persist throughout the second year, after a period of settling in.

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Table 32 presents the results for groups of studies as described above. The long-term pre and post intervention water consumptions for each of the individual Phases (1 to 5) are shown in Figure 7.

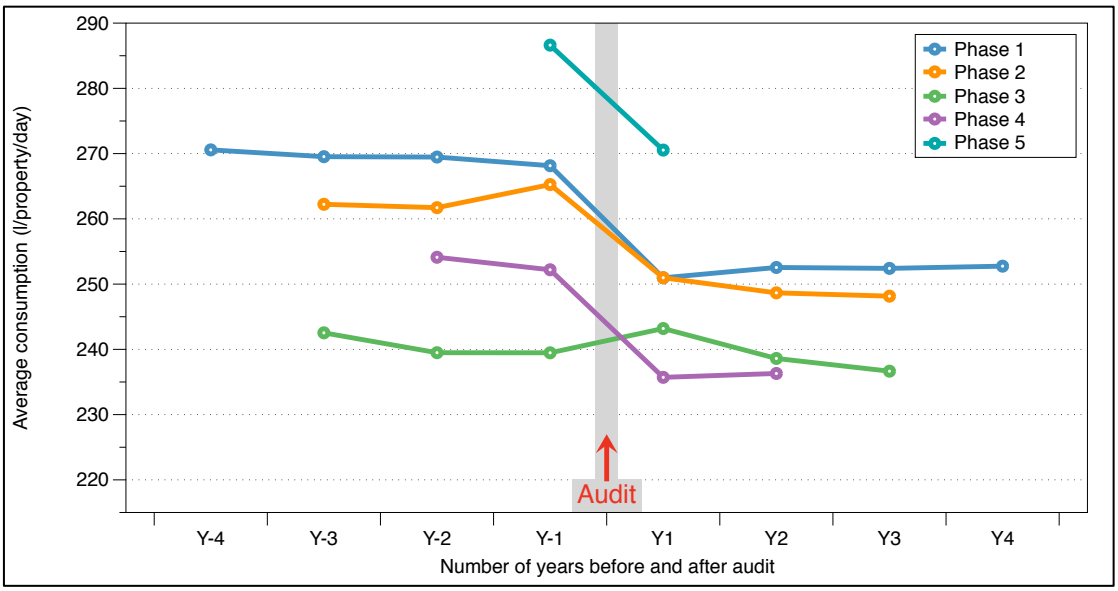

Figure 7 Average consumption before and after the audits over time for Phases 1 to 5

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Table 32 shows the resulting long term water savings for five phases of H_2eco, and compares them with the short term savings.

For Phases 1 to 4 collectively, short term savings drop by less than 10% by the end of year one. Thereafter savings hold up surprisingly well for a 3 to 4 year period with no further decay.

Additional work is required over time to further illuminate the longer term savings, but these initial findings are very encouraging.

3.13 Essex & Suffolk Water – H_2eco Phases 1-9 device savings

3.13.1 Project summary

The H_2eco project is a water efficiency domestic retro-fit multi-device home audit project undertaken by Essex & Suffolk Water. Phases 1 to 9 were analysed as a collective using short term reads. This is described in section 3.12. Although there are a large mix and combination of devices fitted to homes in each phase the analysis employed here attempts to disaggregate the savings attributable to as many devices as possible.

3.13.2 Measurement method

The source data were short term meter reads, using the short-term change in consumption at each individual property. A number of techniques have been used to extract the individual device contributions within the H_2eco projects. The techniques used include generalised linear multi-regression models, correspondence analysis, cluster analysis and other multi-variate techniques. This analysis is more extensive than that undertaken for other projects in this study, but as the results are available it is considered appropriate to present them. The summary results are shown below.

3.13.3 Summary of the multi-variate analysis

The statistical results are summarised in Table 33, which compares the short term savings from installed devices for all phases.

Table 33 Comparison of short-term water savings from installed devices

Device	Water savings l/device/day	Number of measured properties
ecoBETA	22.6	7,296
Save-a-flush	6.4	7,296
Showerhead	10.5	7,296
Tap Insert	6.7	7,296

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3.14 Essex & Suffolk Water – H_2eco Phases 1-9 additional insight

3.14.1 Project summary

The H_2eco project is a water efficiency domestic retro-fit multi-device home audit project undertaken by Essex & Suffolk Water. Phases one to nine were analysed as a collective using short term reads. This is described in section 3.12. Additional insight was sought to further inform the water efficiency story.

3.14.2 Measurement method

Two different fundamental measurements were used. The first were short-term meter reads and the before-consumption minus the after-consumption are labelled actual water savings at each property. The second set of measurements were taken in the home at the time of the audit. These are typically cistern sizes, volume of flushes, flow rates, occupancy and customer survey information. From these measurements a bi-proxy potential savings value is calculated after making some estimates about frequency of use.

3.14.3 Summary results of ACORN and occupancy analysis

The comparison of actual savings achieved versus the bi-proxy potential produces a result which indicates the percentage of potential saving that is actually achieved. These are calculated for each of the top level Acorn category. The group which actually reaches the greatest percentage of its potential saving is the 'Urban Adversity' group. This is shown in Table 34 and in Figure 8.

Table 34 Water Savings versus potential Acorn Category level groupings

Acorn Category	Counts	Actual Savings l/prop/day	By-proxy potential savings l/prop/day	% meet potential
Affluent Achievers	2,120	16.5	37.8	43.7%
Rising Prosperity	259	18.7	40.4	46.2%
Comfortable Communities	2,578	19.6	39.8	49.4%
Financially Stretched	789	23.9	43.6	54.9%
Urban Adversity	1,310	37.4	58.8	63.7%

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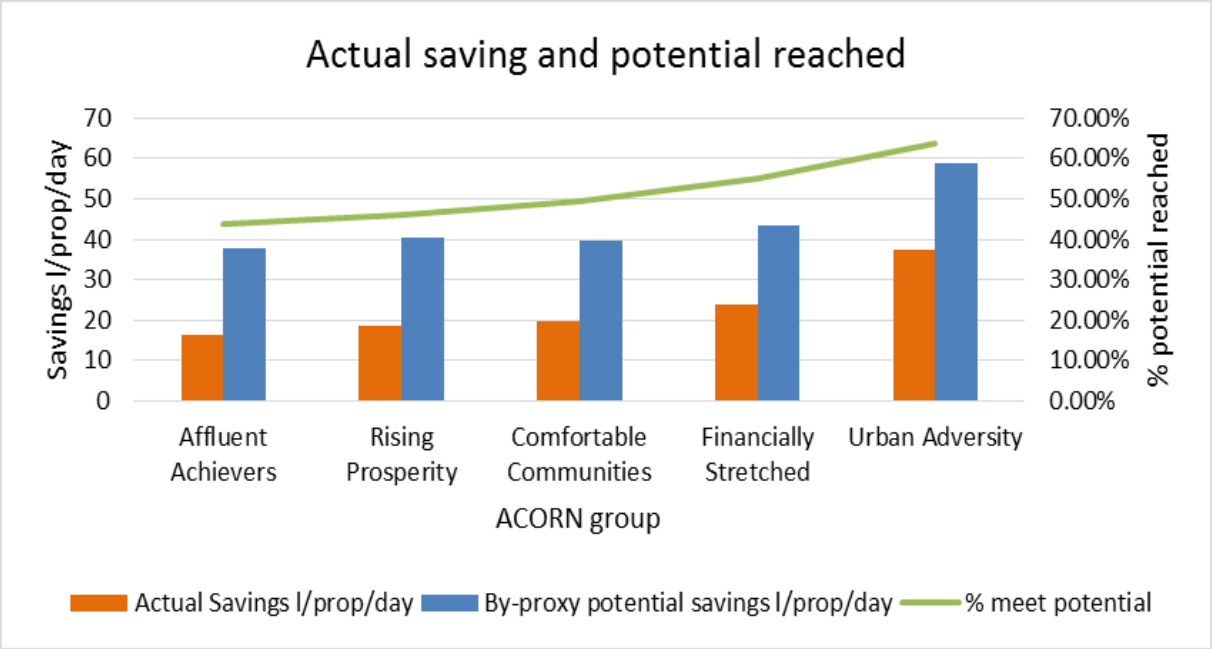

Figure 8 Actual and potential water saving based on Acorn category

Level 5 (Urban adversity) return the greatest savings which are statistically significant and they are also the group which achieves the highest percentage of their potential saving.

Undertaking a similar analysis based on occupancy also shows differences. Properties with one and three occupants meet the highest proportion of their potential and homes with an occupancy of three save the most water per property. This is shown in Table 36 and Figure 9.

Table 35 Water Savings versus potential Occupancy Groupings

Occupancy	Counts	Actual Savings l/prop/day	Potential Savings l/prop/day	% meet potential
1	2,120	16.7	23.6	70.8%
2	259	22.9	41.0	55.4%
3	2,578	47.3	69.6	67.9%
4	789	40.2	87.3	46.0%
=>5	1,310	38.1	119.9	31.8%

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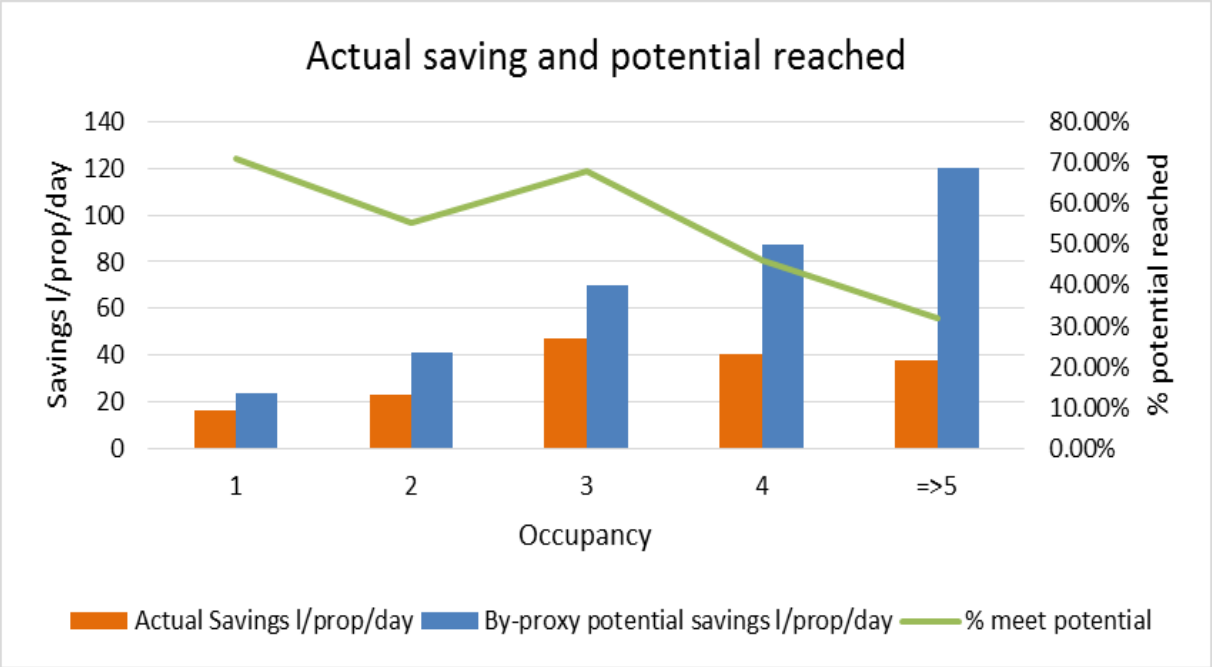

Figure 9 Actual and potential water saving based on occupancy

3.15 Summary and update of Environment Agency Evidence Base Phase 1

Seven studies were reported in the previous water efficiency evidence review, but not exactly in the same way, so it was agreed to revisit these studies. All seven studies were re-analysed to produce a standard output tables which ensures all the studies reported within this project are consistent and can be directly compared. For any details of these studies please refer back to the previous study report[2].

3.15.1 Severn Trent Water domestic water efficiency project

This project selected a number of metered households in Worcester and Nottingham. 11,946 houses were contacted, from which 932 households took part representing an uptake rate of 7.8%. Meter readings were taken pre and post intervention. The water savings devices offered included; dual flush toilets, shower heads and tap inserts.

The source of data is short-term meter reads.

Table 36 Results of Severn Trent Water's domestic water efficiency project

Statistic	Value	Units
Measurements excluded	93	
Sample number used	717	
Mean	25.8	l/prop/day
90% Confidence interval	21.4, 30.2	l/prop/day

[2] Environment Agency (2012) Water Efficiency Evidence Base - Review and Enhancement. Report – EPBLW 12032/5 Final Version, 21 June 2012

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Lower quartile	-17.1	l/prop/day
Upper quartile	60.5	l/prop/day
Median	18.5	l/prop/day
Skewness	0.2	Statistic
Kurtosis	2.4	Statistic
Statistically significant	Yes	Statistic

- 810 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 93 records.
- Skewness acceptable.
- Kurtosis acceptable.

There was a statistical significant saving of **25.8 litres per property per day**

3.15.2 Thames Water measured visit and fix project

This project targeted metered households in Wiltshire and Bromley which was aimed to evaluate the effectiveness of the retrofit-style water efficiency devices in houses from the two areas. Trained plumbers were used to install the devices within the property which included; dual flush toilets, showers, aerated shower heads, tap and tap inserts.

The source of data is short-term meter reads.

Table 37 Results of Thames Water's measured visit and fix project

Measurements excluded	Value	Units
Measurements excluded	62	
Sample number used	823	
Mean	16.0	l/prop/day
90% Confidence interval	11.7, 20.2	l/prop/day
Lower quartile	-17.1	l/prop/day
Upper quartile	50.5	l/prop/day
Median	13.5	l/prop/day
Skewness	-0.1	Statistic
Kurtosis	2.4	Statistic
Statistically significant	Yes	Statistic

- 885 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 62 records.
- Skewness acceptable.
- Kurtosis acceptable.

There was a statistical significant saving of **16.0 litres per property per day**

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3.15.3 Thames Water self-audit rateable value project

During this project Thames Water distributed 1,754 water saving packs to households in London between December 2007 and March 2008. They were water efficiency packs designed to help domestic properties reduce their water consumption. The customers were billed by the rateable value method, but may had 'sleeping' meters installed which were read and available for analysis.

The source of data is short term meter reads.

Table 38 Results of Thames Water's self- audit rateable value project

Statistic	Value	Units
Measurements excluded	110	
Sample number used	525	
Mean	0.3	l/prop/day
90% Confidence interval	-7.7, 8.4	l/prop/day
Lower quartile	-53.0	l/prop/day
Upper quartile	52.4	l/prop/day
Median	-2.6	l/prop/day
Skewness	0.36	Statistic
Kurtosis	1.4	Statistic
Statistically significant	No	Statistic

- 635 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 110 records.
- Skewness acceptable.
- Kurtosis acceptable.

There was no statistically significant water saving from this study.

3.15.4 Yorkshire Water's water saving project

This water saving project was designed to assess the reduction in water supply through the installation of retro-fit devices into customers' properties. Specifically the project wanted to establish; the performance of devices, the acceptability of devices from customers, volume of water saved, the cost and therefore cost effectiveness of water efficient products and finally, customers' attitudes to and acceptance of water efficiency.

The source of data is short-term meter reads.

Table 39 Results of Yorkshire Water's water saving project

Statistic	Value	Units
Measurements excluded	11	
Sample number used	359	
Mean	34.5	l/prop/day
90% Confidence interval	25.2, 43.7	l/prop/day
Lower quartile	-10.1	l/prop/day

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Upper quartile	65.3	l/prop/day
Median	31.1	l/prop/day
Skewness	0.24	Statistic
Kurtosis	3.6	Statistic
Statistically significant	Yes	Statistic

- 370 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 11 records.
- Skewness acceptable.
- Kurtosis borderline acceptable.

There was a statistical significant saving of **34.5 litres per property per day**

3.15.5 United Utilities Home audit study

The objectives of this project were to determine the practicality of fitting and promoting a selection of water efficiency measures to gain a better understanding of the likely costs of fitting these devices and to determine associated savings of these devices through property and DMA metering. Water efficiency devices fitted included; dual flush toilets, cistern displacement devices, aerated shower heads.

The source of data is short-term meter reads.

Table 40 Results of United Utilities home audit project

Measurements excluded	Value	Units
Measurements excluded	14	
Sample number used	246	
Mean	20.4	l/prop/day
90% Confidence interval	13.0, 27.9	l/prop/day
Lower quartile	-14.2	l/prop/day
Upper quartile	52.9	l/prop/day
Median	21.8	l/prop/day
Skewness	-0.3	Statistic
Kurtosis	3.1	Statistic
Statistically significant	Yes	Statistic

- 260 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 14 records.
- Skewness acceptable.
- Kurtosis borderline acceptable.

There was a statistical significant saving of **20.4 litres per property per day**

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3.15.6 South West Water's water efficiency trial

During this project households were offered a variety of devices and most households opted for a combination of different devices. Only a small number of houses only had a single water efficiency measure. South West Water's trial aimed to; assess the acceptability of water saving devices to its customers, to quantify the volume of water saved, make an assessment of how well the devices performed, cost effectiveness and how viable the devices tested are for a programme of wide scale installation.

The source of data is short term meter reads.

Table 41 Results of South West Water's water efficiency project

Statistic	Value	Units
Measurements excluded	7	
Sample number used	341	
Mean	16.6	l/prop/day
90% Confidence interval	3,5, 29.7	l/prop/day
Lower quartile	-21.8	l/prop/day
Upper quartile	54.6	l/prop/day
Median	17.2	l/prop/day
Skewness	-0.22	Statistic
Kurtosis	5.9	Statistic
Statistically significant	Yes	Statistic

- 348 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of 7 records.
- Skewness acceptable.
- Kurtosis questionable.

The median and mean are very similar. There was a statistical significant saving of **16.6 litres per property per day.**

3.15.7 ESW Ecobeta only water efficiency project

The source of data is short-term meter reads.

Table 42 Headline results from statistical analysis

Statistic	Value	Units
Measurements excluded	7	
Sample number used	238	
Mean	40.0	l/prop/day
90% Confidence interval	34.4, 45.7	l/prop/day
Lower quartile	-1.9	l/prop/day
Upper quartile	81.1	l/prop/day

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Median	36.6	l/prop/day
Skewness	-0.2	Statistic
Kurtosis	2.4	Statistic
Statistically significant	Yes	Statistic

- 245 properties were available with complete sets of pre and post meter reads.
- Data exclusion rules stated resulting in the exclusion of seven records.
- Skewness acceptable.
- Kurtosis acceptable.

There was a statistical significant saving of **40.0 litres per property per day**

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4 Metering projects

4.1 Final list

This project aimed to analyse a number of metering projects but after the request for information was returned it showed that very few metering projects had been undertaken, and of those that were the projects were either ongoing and so data was not available, or the water company was not able to provide the data to us for inclusion in this evidence base. The final list of projects included are shown in Table 44.

Table 43 Metering projects included in this study

Project title	Contributing water company
Customer metering programme	South East Water
Universal metering programme	Southern Water
In home display project	Anglian Water

4.2 Overall Methodology

Metering projects generally are more difficult to interpret than water efficiency projects. This is because it is usually it has not been possible to measure an RV billed property's consumption before a meter is installed. In these cases therefore an assumed 'pre' metering consumption volume is used, based on other data. Not knowing the pre-meter installation consumption will introduce some uncertainty into the effect metering has on consumption and if this is the case then allowances will be included in the confidence intervals of the data to reflect the estimate in the pre consumption data.

Another factor that often influences the application of findings from metering studies is the characteristic of the property or occupier moving to a meter. The clearest example is those properties that opt for a meter under the free meter option; in these properties it can be the case that pre-intervention consumption is already lower than the mean or median of unmetered consumption for all households. So for metering studies, it is be important to gain as much detail as possible about the socio-demographic characteristics and the method by which the property moves to a meter.

Finally, if 'consumption' is shown to decrease as a result of metering, it is necessary to try and determine which element of this is due to customers using less water in the home and which is due to the identification and fixing of leaks on the customer supply pipes.

4.3 Anglian Water in-house displays

Anglian Water has 1.3 million active domestic meters and approximately eighty percent meter penetration. The company's new water meters provide the possibility of 'in house displays', and Anglian Water has carried out a trial of these units, using internal meters. The in house display:

- Shows water use in real time;
- Relays volume information from meter;
- Calculates price of water used;

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- Learns use profiles;
- Forecasts use against budget set by customer; and
- Relays leak alerts immediately.

A total of 23,000 customers were invited to apply for a free 'water display' device and 3,300 devices were issued to customers who requested the device.

4.3.1 Measurement method

A representative sample of 450 properties were selected for analysis based on ACORN category. Of these, it was possible to obtain 12 months consumption data prior to issue of the water display, and 12 months consumption data after the device was provided at 441 properties (as of September 2014).

4.3.2 Results

Table 44 Anglian Water in-house display statistical analysis results

Statistic	Value	Units
Measurements excluded	14	
Sample number used	427	
Mean	5.7	l/prop/day
90% Confidence interval	2.5, 8.9	l/prop/day
Lower quartile	11.9	l/prop/day
Upper quartile	24.1	l/prop/day
Median	6.2	l/prop/day
Skewness	-0.4	Statistic
Kurtosis	1.8	Statistic
Statistically significant	Yes	Statistic

- 184 properties were available with complete sets of pre and post meter read;
- Data exclusion rules stated resulting in the exclusion of 7 records;
- Skewness acceptable; and
- Kurtosis acceptable.

The most likely saving from this project is 5.7 litres/property/day.

4.3.3 Discussion

This project looked at the effect of the provision of an in home display on consumption at properties that were already metered. The analysis presented here indicates that the provision of such a device can result in a statistically significant reduction in household consumption – of 5.7 litres per property per day on average.

The results from this study could provide an indication of the benefit of smart metering, over and above the effect of 'dumb' metering.

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4.4 Southern Water Universal Metering Programme

4.4.1 Project Summary

This section reports estimated savings from Ornaghi & Tonin (2015)[1].

Southern Water's Universal Metering Programme (UMP) will result in the installation of nearly 500,000 domestic water meters by March 2015, when more than 90% of households in the company area will be metered – compared to a rate of approximately 40% before the metering programme.

4.4.2 Measurement method

The Southern Water UMP is delivered in a number of stages, which enables the different effects associated with the programme to be measured and analysed, as shown in Figure 10.

Customers get information about the UMP before meter installation. Customers continue to be charged on the same rateable value basis in the period between meter installation and contract switch. Water charges are then based on metered consumption between contract switch and the 3-month letter, but customers do not receive any information about consumption in this period. The 3-month letter contains information about customers' water usage and a projection of the first metered bill. Customers then receive a bill every six months based on their actual consumption.

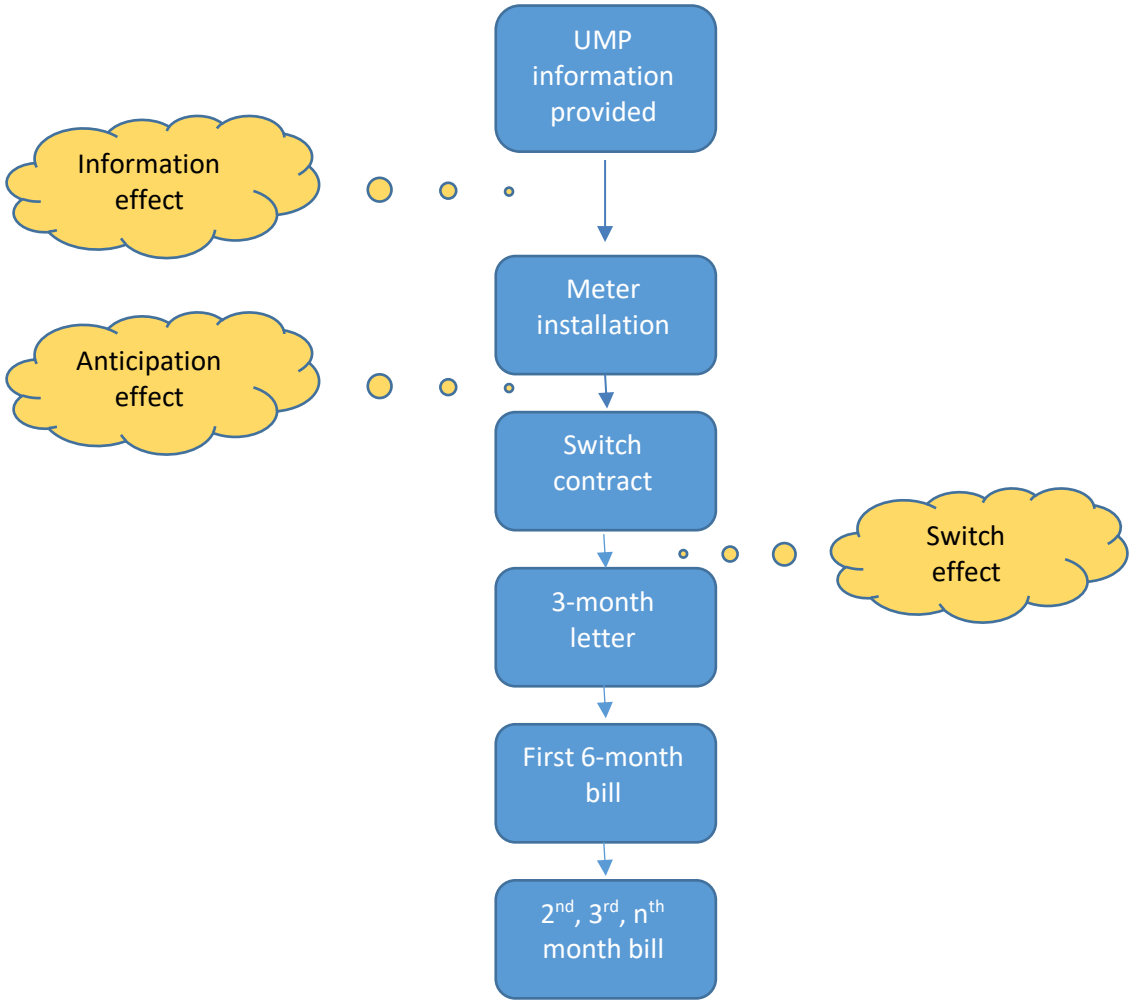

Figure 10 Southern Water universal metering programme

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The UMP is a rolling process, so that households go through this process at different points in time. The study also observes consumption at households that are not part of the UMP programme. This enables the effects of the UMP to be separated from other effects such as seasonality and geographical variations in consumption.

Data for this study were collected between January 2011 and September 2014. In this time there are over 220,000 properties in the UMP metered during the pre-switch period, approximately 230,000 metered between switch and the three-month letter, and 226,000 properties which have received a first bill. The number of properties then decreases for each subsequent stage, because fewer properties have proceeded to 2nd, 3rd bills, and so on. The study also included 280,000 households which are already metered but are not part of the UMP programme.

Three types of analyses are undertaken. Firstly, water consumption can only be measured once the meter is installed. Therefore this study has to assume that pre-switch consumption is a good proxy for unmetered consumption, and consequently there is no anticipation effect.

Secondly, a sub-sample of 200,000 properties have several observations of pre-switch consumption, to enable the analysis of when water use starts to change.

Thirdly, information effect can be determined by comparing of non-UMP property consumption with those properties being targeted as part of the UMP.

4.4.3 Results

A typical UMP household consumes 13.5 percent less water than non-UMP households after 2.5 years on a metered bill (falling from 373 litres per household per day to 323 l/hhd-d).

The sub-sample of properties which has multiple observations of pre-switch consumption show that households start changing the water use before their contract is switched to billed consumption. The report suggests that consumption falls by 12.5% during this period, due to the 'anticipation effect'.

The observation of this additional anticipation effect (which cannot be seen using the first data set) suggests that the total reduction in consumption due to the UMP is 16.5%, and that a large part of this reduction occurs before the contract switch.

The presence/magnitude of the information effect was analysed by comparing consumption at non-UMP properties subject to information campaigns, with those outside campaign areas. Preliminary results do not show any significant effect of information campaigns.

4.4.4 Discussion

The Southampton Water study results indicate that the UMP has had a significant effect on water consumption – in the region of a 16.5% reduction. The report recognizes that these are preliminary results that need to be investigated further, particularly to derive better estimates of the longer-term effects of the UMP, as more properties on the UMP are metered for longer.

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4.5 South East Water Customer Metering Programme

4.5.1 Project Summary

South East Water (SEW) started its customer metering programme (CMP) in 2011 to help address the challenges of population growth, climate change and increased pressures on water availability and manage water supplies. Metering is also considered to be a fairer way for customers to pay for their water.

The CMP will result in more than 175,000 domestic properties being metered by 2015 and a further 180,000 homes to be metered by 2020. In total, 90 per cent of customers will be metered by 2020. South East Water is building on previous research which shows installing water meters in customers' homes reduces water consumption by an average of 15 per cent per household.

4.5.2 Measurement method

SEW provided data for the reporting years 2012-13 and 2013-14 for consumption by the following groups of customers:

- Un-measured customers. The data came from the Company's control area monitor.
- Non-CMP metered customers. These are customers who were metered outside of the CMP, i.e. mostly meter optants and new builds. The data came from billing records.
- CMP metered customers. These are customers who were metered as part of the current customer metering programme. The data came from billing records.

Exploratory data analysis showed that data was most complete for the 2012-13 dataset, and therefore this has been used for the analysis in this project.

The objective is to determine the most likely water saving for the group of customers moving from an un-metered bill onto a metered bill. The challenge in doing this is that no information is available for each property's occupant's consumption prior to moving to a metered bill. Therefore the approach taken has been to subtract the mean consumption from the metered set of customers from the mean consumption from the un-metered set of customers (non-CMP and CMP).

4.5.3 Results

Mean consumption of the un-metered customers

By their very nature, the consumption of the un-metered households is not known. Therefore SEW use a control area monitor to determine the un-metered household consumption for a sample of properties and then extrapolate this to the larger population of un-metered households. The control area monitor currently consisted of 30 small areas in the year 2012-13. Each small area consists of um-metered households, metered households, and some contain a small number of non-households.

The flow is measured into each small area at 15-minute periods. Leakage is estimated from the night flow, metered household and non-household consumption is determined from the billing system, and then un-metered household consumption is determined by subtracting these estimated consumption figures from the daily flow into each area. These calculations are carried out in a bespoke software package used by SEW called CAMMS. The per property consumption results for each control area are exported to a spreadsheet where the control area per property consumption is extrapolated to company level based on a defined distribution of high, medium and low consumption properties.

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The summary details of the 30 control areas are shown in Table 45.

Table 45 Characteristics for the 30 control areas

Characteristic	Minimum	Maximum	Mean	Total
Number of umHHs	46	1192	280	8388
Number of mHHs	20	500	123	3683
Number of nonHHs	0	44	7	204

The property weighted unmetered household consumption from the SEW analysis process for the total unmeasured population is 378 l/property/day. The uncertainty around this value is estimated to be ± 20 l/property/day.

Mean consumption of the CMP metered customers

In 2012-13 there were 83,382 CMP metered households in SEW. The billing system data provided meter readings taken between 1st April 2012 and 31st March 2013, resulting in 44,576 meter readings. The household consumption was determined from the meter readings. Outliers in the dataset were determined and excluded using a modified Grubbs test. The resulting statistics for the CMP mHH consumption are shown in **Error! Reference source not found.**.

Table 46 Statistics for the CMP mHH consumption

Statistic	Value	Units
Measurements excluded	645	
Sample number used	44576	
Mean	308.0	l/prop/day
90% Confidence interval	306.6, 309.4	l/prop/day
Median	278.7	l/prop/day
Skewness	1.09	
Kurtosis	2.33	
Statistically significant	Yes	

Mean consumption of the non-CMP metered customers

In 2012-13 there were 379,883 non-CMP metered households in SEW. The billing system data provided contained meter readings taken between 1st April 2012 and 31st March 2013 resulting in 390,530 meter readings. The household consumption was determined from the meter readings. Outliers in the dataset were determined and excluded using a modified Grubbs test. The resulting statistics for the non-CMP mHH consumption are shown in Table 47.

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Table 47 Statistics for the non-CMP mHH consumption

Statistic	Value	Units
Measurements excluded	5489	
Sample number used	390530	
Mean	261.1	l/prop/day
90% Confidence interval	260.6, 361.6	l/prop/day
Median	230.4	l/prop/day
Skewness	1.15	
Kurtosis	3.58	
Statistically significant	Yes	

The summary results for this project are presented in Table 49.

Table 48 Statistics for the CMP metered household (mHH) consumption

SEW household group	Mean consumption (l/prop/day)	Difference in consumption (l/prop/day)
Mean unmeasured consumption estimate	378.0 ± 20	
Mean CMP measured household consumption	308.0 ± 1.4	70.0 ± 18.6
Mean non CMP measured household consumption	261.1 ± 0.5	116.9 ± 19.5

In common with many studies of metered consumption, there is no data tracking the consumption of individual households pre and post-meter installation. This means that in order to estimate the difference in consumption between the unmetered and metered properties it is necessary to estimate the mean unmetered household consumption from elsewhere (e.g. domestic consumption monitors or district metered areas). These data can then be compared the mean metered household consumption derived from individual properties. This problem also prevents detailed investigation of the effect of metering on different parts of the customer base (e.g. different property types, socio-economic groups or household compositions). This type is study is planned in South East Water, but the data is not yet available.

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5 Grey water reuse and rain water harvesting systems

5.1 Methodology

Rainwater harvesting (RWH) and greywater recycling (GWR) are systems which have had limited uptake in the UK. Consequently, water company studies with robust datasets were not available. A few water companies have conducted studies, but these have been very small scale and with limited data (Section 5.4). Any old data is likely to be outdated given ongoing advances in RWH and GWR technology and so evidence from historic trials may not therefore be indicative of future RWH and GWR system effectiveness.

A thorough literature review has been conducted to assess any relevant information in order to address this lack of empirical research in the UK. Sources included:

- Reports and data from UK water companies Information and data from RWH and GWR industry groups and manufacturers;
- Other relevant UK research undertaken or collated by UKWIR, Waterwise, Environment Agency, CIRIA, BRE;
- Other sources such as BSI, WRAS, Defra (MTP, WTL), CLG (Building Regulations), trade bodies and associations, NGO's (Green Building Council, AECB, Green Alliance, etc);
- Relevant overseas studies and data e.g. from Germany, Spain (and other European countries), Israel, Australia, New Zealand; and
- Thorough search of published papers and articles on the internet.

A logical and thorough search of the internet was conducted by using a standard set of pre-agreed search terms. Papers were selected that described studies of, and standards covering, water savings and other externalities from rainwater harvesting and grey water recycling systems in the UK and other developed countries until no further relevant results were identified. Having gathered and reviewed those papers, papers were identified that gave quantitative data for water savings, cost and any other interesting or useful information, based on empirical research. The results of this literature review are presented in sections 5.2 and 5.3.

5.2 Literature Review – rainwater harvesting

According to the Environment Agency each person in the UK uses on average approximately 150 litres of potable water per day[3]. Some of this water is used for activities not requiring high-quality supply such as toilet flushing (26%), washing clothes (12%) and outdoor activities (7%) and could therefore be replaced with harvested water. These figures are based on average data on likely consumption and the split into water using activities.

Many different valuation methods have been used for the financial assessment of RWH in terms of cost benefit analysis and whole life costs. To date, the financial performance of RWH systems has been carried out in an unplanned and simplistic way by attempting to predict the cost of harvested supply and then comparing it against an equivalent volume from the mains supply[4]. The barriers to implementation, adoption and maintenance have cost implications, which at the local level may be

[3] Environment Agency (2010) Harvesting rainwater for domestic uses: An information guide, p 31.

[4] Roebuck, R. (2007) A whole life costing approach for rainwater harvesting systems: An investigation into the whole life cost implications of using rainwater harvesting systems for non-potable applications in new-build developments in the UK. PhD Thesis, Bradford University.

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balanced by benefits but an estimation of the benefits is not always possible[5]. The experience of RWH users in Barcelona, Spain was that all of their toilet flushing needs were met by using a relatively small tank[6]. The long payback period of the RWH installations was seen as a drawback. Even if discount rates were applied to the water used, payback was around sixty years. Another study looked at the cost effectiveness of RWH in Granollers, eastern Spain[7]. The result of this study concluded that at current prices for water RWH was not cost-effective given the price of water. However levels of cost effectiveness were associated with the sale of installation. At the individual building scale RWH was 'unrewarding' but at the neighbourhood scale applied to new-build housing RWH had a more favourable payback period.

Australia is a dry continent with high water consumption but low and variable rainfall[8]. The use of RWH by tank storage is encouraged by state legislation, development control plans and various subsidies. As a result, RWH is popular even though it was found to be financially non-viable at the single dwelling scale but at the catchment scale the wider benefits associated with RWH increased their viability[9].

A study by the EA assessed the energy and carbon implications of RWH compared to main supply water. As part of that assessment the paper contains modelled water savings for RWH systems of different tank size, property size, occupancy and predicted rainfall[10]. The savings ranged from 7m^3 (18% of non-potable water supply, 6% in total) for a 375 litre tank, in a low rainfall area, for a 70m^2 flat in a four-storey block of ten flats each with two occupants. For a 2,500 litre tank in a high rainfall area for a 120m^2 two-storey house with four occupants a saving of 43m^3 was estimated (or 57% of non-potable water supply, or 20% of total).

The Environment Agency also collated examples of rainwater harvesting examples in the UK housing developments, the outline information is given in Table 49[11].

Another academic study showed a comparison of two methods used when conducting a life-cycle analysis of rainwater harvesting systems using a rainwater harvesting system on a campus building at the University of Exeter and a new housing development as examples[12]. Table 50 contains some monthly figures for water collected by the RWH system. It should be noted that 1500m^2 is a large catchment areas, therefore the results are likely to be site specific and not transferrable to other sites and buildings.

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[5] Gordon-Walker, S et.al. (2007) Cost-benefits of SUDS retrofit in urban areas. Environment Agency Science Report SC060024.

[6] Domenech, L and Sauri, D. (2011) A comparative appraisal of the use of rainwater harvesting in single and multi-family buildings of the Metropolitan Area of Barcelona (Spain): social experience, drinking water savings and economic costs. Journal of Cleaner Production, 19, 598-608.

[7] Farreny, R et al. (2011) Cost efficiency of rainwater harvesting strategies in dense Mediterranean neighbourhoods. Resources Conservation and Recycling, 5, 686-694.

[8] Khouri, G. (2006) Integrated water cycle management, an Australian perspective. European Water, 15/16, 23-32.

[9] Van der Sterren et.al. (2012) Rainwater harvesting systems in Australia. Ecological water quality – water treatment and reuse.

[10] Environment Agency (DATE) Energy and carbon implications of rainwater harvesting and greywater recycling

[11] Sarah Ward, Environment Agency. Rainwater harvesting in the UK, current practice and future trends

[12] Ward, Butler and Memon: Benchmarking energy consumption and CO2 emissions from rainwater-harvesting systems: an improved method by proxy

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Table 49 Rainwater harvesting in current UK housing developments

Name	Location	Size of development	RWH/ annum	Payback period (yrs)	Usage
Great Bow Yard	Somerset	12 houses	28 m^3	24	WC, GT
Millennium Green	Nottinghamshire	24 houses, 1 office block	84 m^3	Unknown	WC, WM, GT
Barn Park	Devon	37 houses, 11 systems	194 m^3	4.6	WC, WM, GT
Upton Green	Northamptonshire (new development)	Starting with 120 houses	Unknown	Unknown	WC, GT

[Key: WC = toilet flushing, WM = Washing machine, GT = Garden taps]

Table 50 Rainwater volumes supplied by the innovation center rain water harvesting system at Exeter University

Month	Volume (m^3)
January	25.02
February	29.89
March	38.84
April	2.77
May	14.25
June	38.16
Total volume supplied	148.93

The paper simulated rainwater harvesting schemes at two sites: a campus building ("The Innovation Centre") at the University of Exeter and a new-build housing development at Bude, with a view to optimising tank size. It uses three methods, the first two of which are taken from a 1999 paper by Fewkes. Method one uses a yield after spill model using a time series of daily rainfall and demand. Method two simply uses the annual rainfall over the catchment area divided by the demand. Method 3, is based on a different approach recommended by the Environment Agency (EA). This is a simple 'rule-of-thumb' method, which sizes the tank based on a user-defined percentage of average annual rainfall or demand (whichever is the lower).

As stated, this is simulated data but the paper does not conclude which model produced the best results and if the simulated data was ever verified with measurements.

5.3 Literature Review – greywater recycling

Simply moving greywater from one place to another without undergoing any treatment processes it is called greywater 'reuse'. Processing greywater and improving its water quality before it is used again is termed greywater 'recycling'. There is great potential for greywater recycling (GWR) especially in densely populated areas and areas of growing water demand. GWR is an alternative to using high-quality water to flush the toilet or irrigate the garden. Reuse and recycling of water would also prevent

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overloading of the sewers, reduce the volume of wastewater treated, decreased processing costs and reduced energy consumption[13].

Systems that recycle water have been installed in domestic housing as an individual systems although communal systems are considered to be more cost effective[14]. The cost-benefit of GWR systems has not been successfully demonstrated because payback periods have a high range of variants due to: number of system users, volume of greywater produced, and initial and operational running costs and the current and future price of water. The cost of retrofitting a property with GWR is higher than installation in a new build because a system of dual pipes is required, in addition to tanks and pumps. The Environment Agency calculated the payback period of a GWR system based on installation costs of £3,000. In areas of high water charges payback period was between 30 and 40 years, but in areas of lower water charges the payback period was as much as 83 to 113 years[15]. Payback periods for GWR are longer than their lifespan because tap water is inexpensive[16]. This is dependent on occupancy however and with a minimum of three people in a household this can be reduced.

A study by the EA assessed the energy and carbon implications of GWR compared to main supply water. As part of that assessment the paper contains modelled water savings for GWR systems ranging from 16m^3 to 76m^3 of mains water being offset. Again, these are modelled saving and very little has been verified.

Case study: Whichelo Place, Brighton
Whichelo Place is a privately owned bungalow built in 2007. The building was designed and built to an Eco-homes 'excellent' standard and the GWR installed in the building contributed to this rating. The greywater is supplied from the bath and shower. In terms of water savings six months water use at the bungalow totalled 22.10m^3 equating to ~60 litres/person/day.

5.3.1 Summary

What is clear from reviewing the literature, is that there are many studies which have simulated results from models, but the simulations have not been verified by looking at observed data.

5.4 Water company studies: Final list

Project title	Contributing water company
Domestic grey water reuse trial	Severn Trent Water

With only one water company conducting grey water or rainwater harvesting projects data is very limited. The Severn Trent trial is still ongoing and the raw data was not available but some headline

[13] Eriksson, E. et.al. (2002) Characteristics of grey wastewater. Urban Water, 4 (1) 85-104

[14] Jefferson, B. et.al. (2000) Technologies for urban water recycling. Urban Water, 1 (4) 285-292

[15] Environment Agency (2008) Greywater: an information guide

[16] Leggett, D. et.al. (2001b) Rainwater and greywater use in buildings: Decision making for water conservation. Construction Industry Research and Information Association (CIRIA)

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figures have been supplied which is reported on in section 5.5. Scottish Water also has started a grey water retrofit project but this project is yet to deliver in time for inclusion in this evidence base.

5.5 Severn Trent Water – domestic grey water reuse trial

5.5.1 Project summary

Severn Trent launched a two year collaborative grey water reuse project in January 2014. This was in partnership with the supplier (ReAqua Systems Ltd), a housing association (the Accord Group), and customers (Tenants) of the Accord Group.

The specific aims of the project are:

- To understand the long term reliability of the system;
- The customers' attitudes and perceptions to the system; and
- An accurate volume-based analysis of the system's performance.

Grey water reuse systems were installed in ten homes at Bushbury a suburb of Wolverhampton in partnership with Accord Housing Association. The ReAqua system collects all of the grey water from the showers and baths and treats this water so it can be reused for toilet flushing. The water is treated by filtering it and a disinfectant is added before it is stored ready for it to be used to fill up toilet cisterns in place of mains potable water.

5.5.2 Project summary

Property Number	Total water used in first 11 months	% of reused water in toilet flush	% of mains water used to flush toilet*	% of mains water recycled	Savings off the annual water bill	Number of flushed/day (7 litre flush)
Minimum	22	27	4	2	£13.58	2
Maximum	473	100	59	22	£67.16	17
Average	**87**	**63.4**	**21.7**	**11.2**	**£31.07**	**5.9**
Median	71	63	17	11.5	£24.08	5

[* predicted volume of mains water used to flush toilets is 30%]

Three properties had an annual bill saving of £47.46 which covers the annual cost of consumables for operating costs (cleaning, maintenance, filters and disinfectant). Four properties however had an annual saving of just £18.78 which does not cover the operating costs. Data was not available for the remaining three properties.

The study has revealed that occupancy is a big factor in the cost effectiveness of grey water reuse systems. In most low occupancy homes (one adult and one child), it is unlikely that any real savings will be seen. Not enough water is generated via bathing in these homes and consequently the average volume of water used in these homes is 63% grey water. The remaining top up water comes from the mains which will affect the overall cost benefit of these systems.

This data will inform further work on the economics of grey water reuse.

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5.6 Water and energy recycling in a residential Passive House

Due to the limited amount of examples of rainwater and grey water recycling projects in the UK, one of the team for this study attended a 'WATEF' fact-finding trip to Berlin. The objective was to visit examples of grey water reuse and rainwater recycling projects and report back any useful or relevant information for the UK context.

5.6.1 Project summary

A passive house (*Passivhaus* in German) is a voluntary standard for energy efficiency in a building, with the aim to reducing its ecological footprint. It results in ultra-low energy buildings that require little energy for space heating or cooling. The standard is not confined to residential properties: office buildings, schools and supermarkets may also be built to this standard. Passive design is not an attachment or supplement but a process integrated within architectural design. The vast majority of passive structures have been built in German-speaking countries and Scandinavia.

Die Projekt am Arnimplatz is a residential housing project which has 41 apartments in total built to the Passiv-haus standards. As part of the design, a grey water recycling system was included as water and energy are closely linked and so by saving water also results in an energy saving.

Figure 11 **Multistory passive house at Arnimplatz, Berlin-Prenzlauer Berg containing 41 dwellings and covering an area of 4,600m^2**

A greywater recycling system and heat recovery (from the grey water) was included in the design. Greywater from showers and bathtubs is collected and then treated for use later to flush toilets. The water undergoes an advanced physical-biological treatment followed by UV disinfection without the use of chemicals. The heat energy recovered from greywater is used to pre-heat the cold water for the building's combined heat and power plant (CHP) as shown in the photos below. The combined system is placed in the basement and occupies an area of 9m^2 which equates to 0.1m^2 per person.

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Figure 12 Greywater recycling combined with heat recovery

A total of 41 flats with 123 tenants occupying an area of 4,600 m² and 4 commercial units (600 m²) are connected to the greywater and heat recovery system. About 3,000 litres of low load greywater are treated daily to produce high quality water which is reused for toilet flushing.

The energy gains are dependent on the amount of generated greywater and freshwater demand. The orange line shows the thermal energy which can be recovered from the system which can be more than 40 kWh/d. The yellow line shows the electric energy demand for the entire system, which is about 4 kWh/d. Comparing the primary energy gains, this approach achieves a relatively higher degree of efficiency due to withdrawing energy from municipal wastewater.

5.6.2 Results and discussion

Figure 13 shows that the amount of greywater (black line), originating in this case only from showers and bathtubs, is not sufficient to cover all of the demand for toilet flushing (green line). Consequently it was recommended that future developments included additional greywater sources (e.g. laundry, kitchen), which will reduce the need for top up water from mains supply and thus and improve the system's efficiency.

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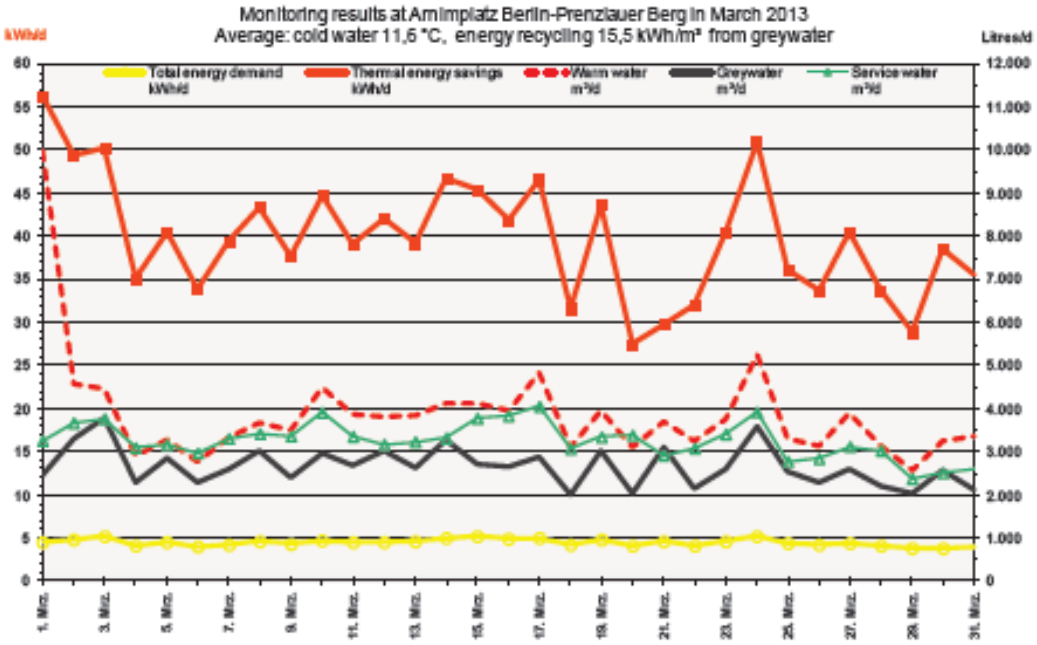

Figure 13 Monitoring results from the combined system

The additional investment costs for the combined recycling system of 10 €/m² of floor space (excluding second pipe network) is around 400 €/person, compared to the real estate costs (3,500 - 4,000 €/m²), are very low (< 0.3%). The total electrical demand for heat recovery, greywater treatment and service water distribution is less than 1.5 kWh/m³. The annual savings on water and energy were 5,000 € and 1,000 €, respectively. Energy recycling shows best performance during the cold winter months, when thermal solar plants are not productive. The yearly energy recovered by this plant is equivalent to the energy delivered by a thermal solar energy system of 35 m². The yearly total electric energy demand for greywater recycling and heat recovery of 1,800 kWh can be covered by 18 m² of the building's 145 m² installed PV-Modules. The results are summarised in the Table 52.

Table 51 Summary of energy and water demand and costs of greywater provision

	Specific demand	Yearly demand	Price per unit	Yearly costs (euros)
Space heating	15 kWh/m²/a	69.00	0.07 € kWh/a	4,830
Warm water heating	760 kWh/P/a	93.48	0.07 € kWh/a	6,543
Electricity	875 kWh/P/a	107.62	0.25 € kWh/a	26,906
Water	122 L/P/d	5.477	5.0 € m³/a	27,385
			Total	65,665

5.6.3 Conclusion

The Passive House was shown to have yielded benefits to the home owner. The apartments have benefited from innovative design which have reduced energy and water consumption and costs, and has proved that greywater can be a renewable and safe resource.

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This was an exemplar project and the design of the greywater system had been incorporated from start of the design of the whole building. It is hard to know how transferrable this type of housing development would be in the UK. Currently the majority of passive houses have been built in Germany and the uptake of these homes in the UK has been small. It is clear that the technology does work and is effective in saving water and energy but convincing developers to incorporate this technology may prove a challenge without new regulation.

As a new development, the technology can be fitted into a building easily. It would be very difficult and costly to retrofit this into an existing building, but without data or evidence to prove or disprove this then this is an anecdotal statement.

5.7 Summary of findings

It is clear that rainwater harvesting and greywater recycling can yield water savings. What is still undetermined is the uncertainty of these savings as effectiveness in terms of cost and water varies greatly. The theoretical water savings often are not realised for a variety of reasons including climatic variations, system reliability and occupancy.

5.7.1 Water-savings (Rainwater Harvesting)

Systems are sized based upon the smaller value of the harvesting potential of the roof (often a function of area) and the potential use of non-potable water within the building concerned. This results in a size of water storage tank that is around 5% of this calculation. The theoretical annual mains-water saving is therefore twenty times the size of the tank on the particular system. Storage tanks vary in size from around 2,000 litres on a small house, up to hundreds of thousands of litres on large commercial projects.

The theoretical annual mains-water savings will be reduced in practice by uneven patterns of rainfall and usage. If, for example, there is a long dry spell then the harvested rainwater will need to be supplemented by mains-water. Conversely, during long or heavy spells of rain the storage tank will overflow, in the process losing some of the harvested water.

The impact on the theoretical savings of these practical effects will vary from project to project, geographically and from year-to-year. A reasonable assumption of the general impact would be that only 80% of the theoretical savings are on average achieved[17].

5.7.2 Water-savings (Greywater Recycling)

GWR systems are much more costly than their RWH counterparts, making GWR the system of choice where the roof-area to occupancy ratio is too low for RWH to make a significant contribution to mains water savings.

They therefore work best in high-density buildings (e.g. blocks of flats, hotels, student accommodation) where there can be expected to be a very good match between the source of the greywater and the potential non-potable water usage as shown in the Die Projekt am Arnimplatz residential housing project. Under these circumstances, it should be possible to substitute recycled greywater for mains water for all the non-potable water used.

[17] From UK Rainwater Management Association – communication with Director, Terry Nash, 01/04/2015

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The Severn Trent project however highlights that when this technology is retrofitted into single dwellings then the effectiveness of the greywater recycling is a function of occupancy.

5.7.3 Impact on SuDS

Greywater recycling and rainwater harvesting will certainly have a directly beneficial impact on foul drain capacities where sewerage systems are under stress. Generally, a RWH system designed for that sole purpose is assumed not to make a contribution to SuDS as the storage tank may already be full when a storm event occurs.

For maximum benefits, an integrated system can be developed where a SuDS contribution is designed into the RWH system. This can be achieved in a number of ways and an example is shown in Figure 14.

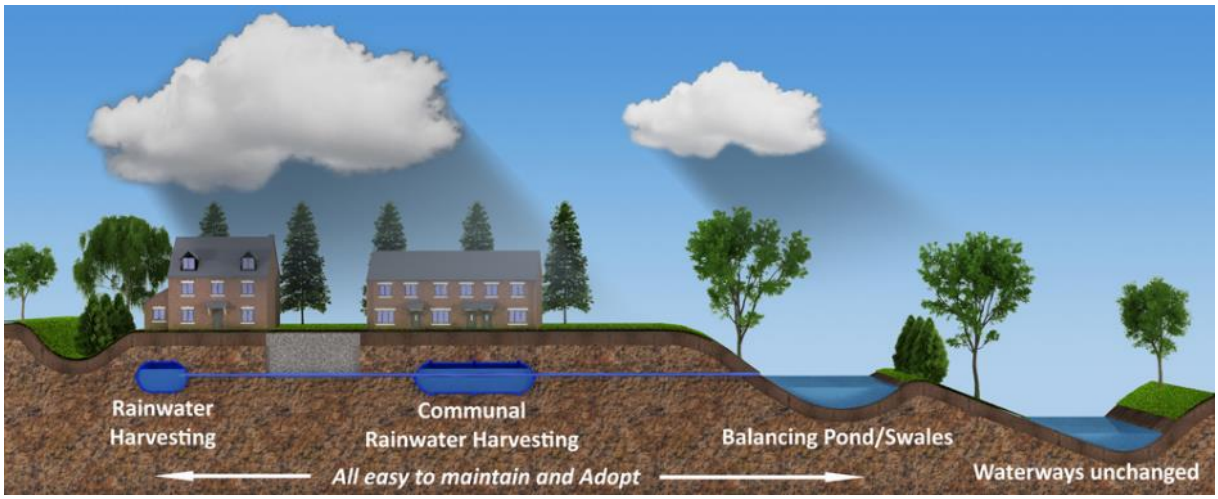

Figure 14 Integrated system combining rainwater harvesting and SUDS

This also raises interesting questions from a SuDS Adoption point of view and where a SuDS system starts. It would be much more straightforward to adopt if it starts at the overflow from the communal RWH system as illustrated, upstream of which, the maintenance would fall into the schedules of the properties being served.

5.7.4 Drivers to Adoption

The initial driver for RWH adoption occurred around the turn of the century due to:

- the self-build new homes market;
- one or two niche house-builders; and
- the sustainability policies of commercial clients.

Adoption accelerated modestly from 2004 onwards, driven marginally by the Code for Sustainable Housing (new homes) and BREEAM (commercial new-build). This progress however was modest (compared to Germany) and it stalled completely in 2007 with the financial crisis, and has subsequently regressed.

Commercial client-driven schemes are recovering, but the new-homes market is less so due to the abandonment of the Code for Sustainable Homes. There is hope that the idea of integrated SuDS and

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RWH designs, (principally to avoid floods) may slowly gain traction and facilitate adoption. This is the Welsh Government's preferred option, very unlike the UK Government's position.

5.7.5 Barriers to Adoption

In Germany, "green" drivers are greater (e.g. the Green Party is more prominent at a local, regional and national level), water scarcity and water costs are very much higher and so RWH systems are a more attractive proposition in terms of payback. In addition Germany has over 20 year's productive experience of these systems. In the UK water is still very cheap and for the economics to stack up, subsidies may be required. A similar model would be the photo voltaic solar scheme which was a Government led subsidy.

There are no perceived water shortages in the UK. The fact that supplies are already under stress, and are forecast to become increasingly so is neither publicised nor widely appreciated or understood. Using mains water to flush toilets is a wasteful practice, and most would agree RWH or GWR to be preferable, however, not if that involves costs that the individual can easily avoid.

Government policy is to encourage reducing consumption, which is a sensible starting point. It is not known however if this in isolation will be sufficient to address the uncertainties of future water supplies, given climate-change and population growth. The evidence shows that RWH/GWH is most cost effective when built into housing plans for new builds rather than retrofit. From a policy point of view, encouraging investment in RWH/GWR now, to build-up capacity to address the uncertainties of the future, is not currently done.

In addition, house-builders tend to be strongly against RWH as it adds (a small amount of) complexity to their projects, plus un-recoverable costs as these are the home occupiers in terms of reduced bills. The UK sector, again unlike Germany, is stalled in a position where the technology is new to users, installers and maintainers alike, leading to lack of capacity and too many bad experiences which affects the uptake of these systems.

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6 Summary results

Figure 15 is a meta-analysis chart which allows the comparison of the results from all of the water efficiency projects presented in this report, alongside previously reported projects and metering projects. Firstly just by comparing the means (centre dots) it is possible to use this graph to provide the most likely saving value for different types of study. It is also possible to look at likely ranges of savings for any given type of study because these are denoted by the left and right hinges on each bar.

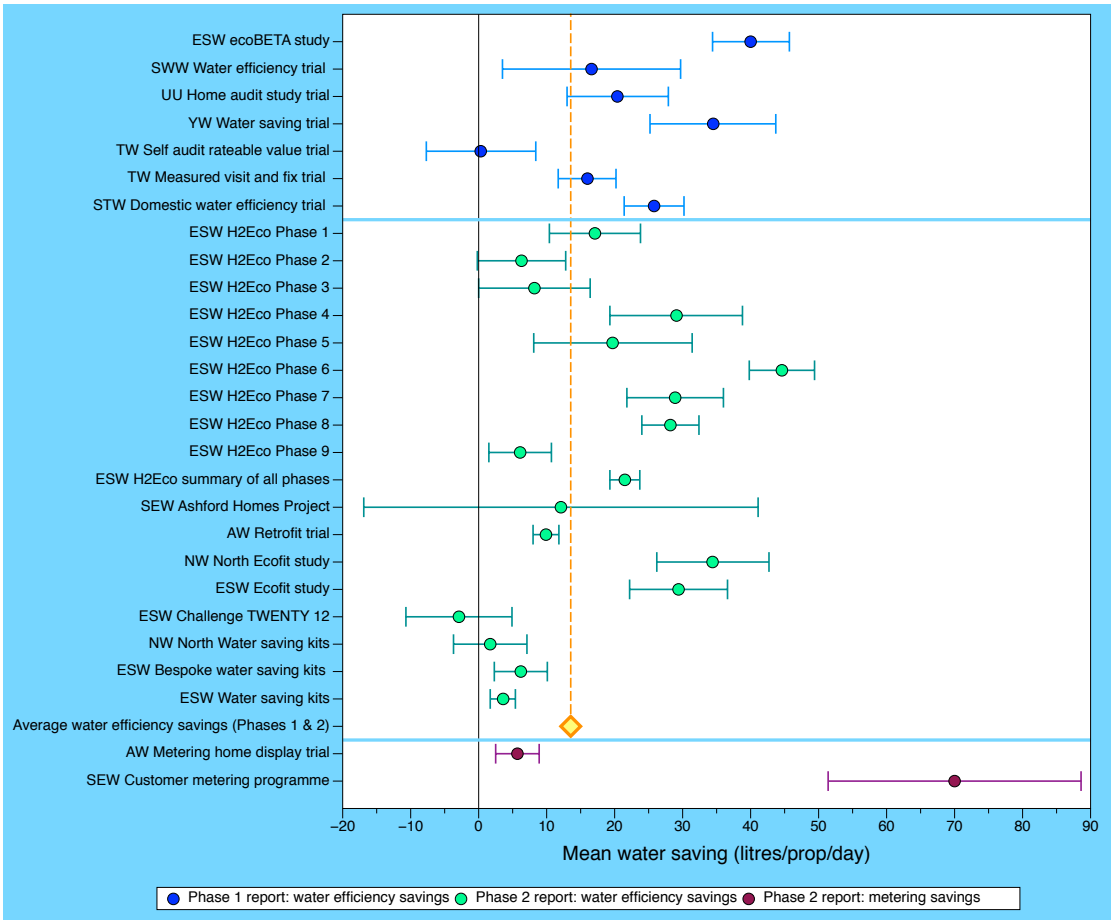

Figure 15 Meta-analysis of Phase 1 and Phase 2 water efficiency and metering projects

In addition, this graph can be used to infer statistical significance. Any project with bars that cross the zero line (e.g. SEW Ashford Homes) are not statistically significant. In addition, any project result whose bars and hinges are completely clear of another has returned statistically significantly different results. An example of this is H_2eco Phase 6 which has returned statistically significantly higher savings than all the other H_2eco phases.

The yellow diamond on Figure 15 denotes the weighted mean saving for all the water efficiency projects included in this analysis, and indicates that the overall mean saving from the 25 projects analysed is 13.5 litres/property/day.

These results are also presented in tabular form in Table 53.

Table 52 Summary of results

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Project title	Sample size	Sample mean (l/h/d)	Lower CI (l/h/d)	upper CI (l/h/d)
ESW Water saving kits	7,678	3.6	1.7	5.4
ESW Bespoke water saving kits	610	6.2	2.3	10.1
NW North Water saving kits	423	1.7	-3.7	7.1
ESW Challenge TWENTY 12	902	-2.9	-10.7	4.9
ESW Ecofit study	330	29.4	22.2	36.6
NW North Ecofit study	177	34.4	26.2	42.7
AW Retrofit trial	12,231	9.9	8	11.8
SEW Ashford Homes Project	52	12.1	-16.9	41.1
ESW H2Eco summary of all phases	7,296	21.5	19.3	23.7
ESW H2Eco Phase 1	663	17.1	10.4	23.8
ESW H2Eco Phase 2	626	6.3	-0.2	12.8
ESW H2Eco Phase 3	146	8.2	0	16.4
ESW H2Eco Phase 4	361	29.1	19.3	38.8
ESW H2Eco Phase 5	748	19.7	8.1	31.4
ESW H2Eco Phase 6	1,042	44.6	39.8	49.4
ESW H2Eco Phase 7	545	28.9	21.8	36
ESW H2Eco Phase 8	1,507	28.2	24	32.4
ESW H2Eco Phase 9	1,658	6.1	1.5	10.7
STW Domestic water efficiency trial	717	25.8	21.4	30.2
TW Measured visit and fix trial	823	16	11.7	20.2
TW Self audit rateable value trial	525	0.3	-7.7	8.4
YW Water saving trial	359	34.5	25.2	43.7
UU Home audit study trial	246	20.4	13	27.9
SWW Water efficiency trial	341	16.6	3.5	29.7
ESW ecoBETA study	238	40	34.4	45.7
AW Metering home display trial	427	5.7	2.5	8.9
SEW Customer metering programme	44,576	70	51.4	88.6

The results of the Southern Water metering study are not shown on Figure 15 because it was not possible to obtain the raw data used in the Southampton University study, and therefore confidence intervals cannot be presented. However the initial savings reported in this study, of approximately 61 litres per property per day are consistent with the results presented in Figure 15.

The SEW customer metering project saved statistically significantly more water (measured in litres/property/day) than any of the water efficiency programmes.

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7 Conclusions and recommendations

7.1 Summary results

This project has presented statistical analyses for 25 water efficiency projects three metering projects and one greywater recycling project. The water efficiency projects include nine studies completed by various water companies; the nine phases of the Essex & Suffolk Water H2Eco project (reported as four sections here); and seven projects analysed and presented previously. This is the most extensive and comprehensive analysis of water efficiency projects undertaken in the UK to date.

The body of evidence presented in this report indicates that reductions in consumption are likely to occur as a result of water efficiency activity, and that overall, an average saving of 13.5 litres per property per day can be achieved. This is equivalent to around 3.5 per cent of consumption (assuming 150 litres per head per day average per capita consumption and an average occupancy of 2.5).

This is an important finding from this project, which confirms that suitably designed water efficiency programmes will reduce household water consumption.

The H2Eco work undertaken by Essex & Suffolk Water provides a very useful, large and long-duration dataset on water efficiency. There are many useful findings from this work, including:

- There is a reduction in savings from water efficiency programmes from year one to year two after implementation, of between 9 and 19%, but savings then stabilize, and then appear to be maintained.
- The opportunity to save water varies between households. For example, properties in the 'Urban Adversity' ACORN group save more in absolute volume, and achieve more of their potential savings, than any other group
- Properties with an occupancy of three save the most water per property and save a large proportion of their potential savings (second only to single occupancy properties).

Essex & Suffolk's water efficiency work continues to be of great benefit to the water industry. It would be valuable if other organisations could implement similar water efficiency programmes and research studies to increase the evidence base to include other customer groups and areas of the country.

7.2 Effective design of water efficiency programmes

The actual saving that will result from any individual water efficiency activity will depend on how the intervention was implemented, which customers were targeted, and the nature of the intervention itself. The reported saving for a given intervention will also depend on study design and analysis. The results of the H2Eco ecoBETA studies presented in this report illustrate that the main reason for the variation in water efficiency savings is due to the customers targeted (all other things being equal).

Based on these findings it is recommend water efficiency programmes should:

- Identify the most effective water saving device;
- Target households that will use it most; and
- Install it as cost-effectively as possible.

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A long-term, targeted strategy is likely to deliver greater total savings than a programme that delivers short-term successes but cannot be replicated over several years.

However, every plan is different and it is recommended that anyone designing a water efficiency programme discusses their plans with colleagues and peers in the water industry, in order to achieve the best savings possible. The engagement and sharing of ideas that already occurs within the water industry should continue, and this will ensure that over time, water efficiency programmes become increasingly effective.

7.3 Effective estimation of water efficiency savings

This report provides guidance on study design to assess the savings from water efficiency projects. The analyses presented in section 3 demonstrate that a before-and-after control, possibly combined with a side-by-side control can be a very effective method of quantifying the savings from water efficiency activity. These approaches can also be cost-effective. It is recommended that water efficiency research should use this study design where possible and appropriate. Practitioners will always need to consider study design carefully, especially where before-and-after controls are not possible.

This report also sets out a simple and consistent approach to statistical analysis that can be adopted by practitioners, to accompany the study-control research method. The use of t-tests to determine whether the savings resulting from water efficiency interventions are statistically significant (measured against a standard p-value of 0.1) can be applied readily in common tools such as Excel. This report also provides simple rules on testing for normality and data exclusion.

These methods are effective for 'snap-shot' or cross-sectional studies of a group of customers. However, these kinds of studies do only provide a view of water efficiency at a given point in time. The H2Eco work indicates that savings from this water efficiency campaign can be maintained, but it is recommended that more work is done to demonstrate the longevity of water efficiency savings. This can be done in a number of ways, including longditudinal studies which follow a cohort of households over a prolonged period of time. This kind of study is possible with routinely collected meter billing data.

7.4 Estimating savings due to metering

Whilst the evidence base for water efficiency is now large and broadly conclusive, there is more work required on metering. The two studies completed on large-scale 'universal' metering programmes suggest broadly similar results, with short-term reductions in consumption of approximately 16 to 18 percent. However our confidence in these results has to be limited because neither study is able to accurately estimate consumption at the household level, prior to pre-meter installation.

It is likely that there will be more large-scale meter installation programmes over the next few years. These offer a unique chance to determine the effect of metering (of this type) on consumption. It is recommended that companies delivering these programmes develop approaches to monitor consumption at the individual household level prior to meter installation, and then implement ongoing monitoring to track how consumption changes over the first few years of metered billing. This will enable a more accurate estimate of the savings due to metering to be estimated. There are likely to be challenges in achieving this, but these can be overcome if the industry works together.

7.5 Rainwater and greywater conclusions

This project aimed to collate information and results from rainwater and greywater harvesting system projects run by water companies. Only one valid household-scale study was identified, with water

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company involvement, with limited data available (at the time of writing). This study indicated that GWR could save 11% of potable water supplied to households.

Several water companies have investigated RWH and GWR systems, but the literature review indicated that relatively little of this research has been published, or is available. The literature review also highlighted the relative scarcity of any empirical research on household RWH or GWR systems anywhere.

The Berlin field trip reported in section 5.6 shows that greywater systems that are included in the development plans for apartment buildings can deliver benefits to households. The systems installed in the Arnimplatz building in Berlin uses water from showers and baths. This is insufficient to meet demand from toilets, and it is recommended that further greywater should be generated from laundry and kitchen sources.

The following conclusions can be made from this part of the study:

- The water efficiency of RWH and GWR systems remains unproven, and therefore it is not possible to make any firm conclusions about their cost-effectiveness, or other pros and cons.
- RWH and GWR remain marginal technologies that are unlikely to become mainstream under current policy, regulation and legislation in the UK.
- The limited evidence available also suggests that retro-fitting RWH or GWR is not viable.
- The evidence from the Berlin field trip presented in this report, and from other anecdotal evidence suggests that RWH and GWR systems are likely to be more cost-effective in communal residential buildings such as apartment blocks, halls of residence, or military barracks.

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Appendix 1: Text from email sent to water companies requesting information

Artesia has been commissioned to update the Water Efficiency Evidence Base (see more details below). We want to hear from you if your company has undertaken any water efficiency projects, metering/enhanced metering projects, or rainwater harvesting / greywater trials since 2010.

We just need some summary information at the moment to help us start this project, so would be grateful if you could answer the following quick questions.

- What was the topic of your trial/study (e.g. dual flush retrofits, self-audits, behaviour change, change of occupier metering, compulsory metering, rainwater harvesting, etc)?
- Are you able to access the raw data for this study (and if so how quickly)?
- Did you write a report (either internal or published) for this study?
- Would you be happy for us to use your data/information to help improve the water efficiency evidence base (subject to appropriate confidentiality/security provisions)?

Please respond to me at your earliest convenience, and by the 23 January at the latest.

Please forward to anyone else in your company who might be able to contribute. We will review the information available and where necessary undertake a screening exercise to select the most useful studies for more detailed analysis.

Thanks in anticipation for your help in this project.
Kind Regards

The Water Efficiency Evidence Base
The Water Efficiency Evidence Base was created to help water companies identify the most effective approaches to water efficiency retrofit programmes. The Environment Agency review of the of the water efficiency evidence base (published in 2012) provided valuable, industry-wide summary statistics on the savings that could be achieved by a range of water efficiency measures.

A number of new water efficiency studies have been completed by water companies since the review was published. In addition, companies have increased levels of metering and have also run projects to test grey and rainwater harvesting systems. This means that recent information on the water savings and network management that result from these activities is available. It is now proposed to incorporate the outcomes of this greater range of projects into the Evidence Base, so that they can be shared more widely and inform future Water Resources Management Plans and Business Plans.

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Appendix 2: Full list of potential projects for review

Nº	Water Company	Project
1	Anglian Water	Water efficiency measures programme - water audit and retrofit
2	Bristol Water	Water efficiency in student halls
3	Bristol Water	Change of occupier metering
4	Bristol Water	Compulsory metering of cattle troughs and commercial properties
5	Dŵr Cymru Welsh Water	'Wrap Up Wales' - Winter Campaign Report
6	Dŵr Cymru Welsh Water	Sustainable Economic Level of Water Efficiency (SELWE) - Tywyn and Aberdyfi Project
7	Dŵr Cymru Welsh Water	Hydrocell Maintenance Project - urinal optimisation
8	Essex and Suffolk Water	Flagship retrofits
9	Essex and Suffolk Water	Swan Housing retrofits
10	Essex and Suffolk Water	Challenge TWENTY:12
11	Essex and Suffolk Water	Little Green Riding Hood
12	Essex and Suffolk Water	Water Saving Kits
13	Essex and Suffolk Water	Leaking WC's (E&S internal)
14	Essex and Suffolk Water	Shopping centre events
15	Essex and Suffolk Water	ecoFIT
16	Essex and Suffolk Water	RE:NEW
17	Essex and Suffolk Water	Shower 'n' save
18	Essex and Suffolk Water	Waterpebble
19	Essex and Suffolk Water	Greywater Recycling
20	Essex and Suffolk Water	Holiday park
21	Essex and Suffolk Water	H2eco 1
22	Essex and Suffolk Water	H2eco 2
23	Essex and Suffolk Water	H2eco 3
24	Northumbrian Water	Dual flush retrofit trial with behaviour change in 2011.
25	Northumbrian Water	Dual flush retrofit with behaviour change in 2012 .
26	Northumbrian Water	Water cycle retrofit with behaviour change in 2013.
27	Northumbrian Water	Every Drop Count whole town campaign 2014.
28	Severn Trent Water	Domestic grey water reuse trial
29	Severn Trent Water	Tracking of behaviour change impact of our education programme
30	Severn Trent Water	Rainwater Harvesting EngD
31	Severn Trent Water	Change of occupier metering trial
32	South East Water	Customer metering programme
33	South East Water	Leaking toilets data (internal water company)
34	South East Water	Water efficiency retro fit project
35	South East Water	Ashford new homes project (since 2006)
36	South East Water	Free devices offered to our metered customers in CMP
37	South Staffs Water	Change of occupier metering

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38	South Staffs Water	AMR fixed area network
39	South Staffs Water	District metering
40	South Staffs Water	Frequent logging trials
41	South Staffs Water	Grey water reuse
42	Southern Water	School Case Study
43	Thames Water	Save water Swindon summary
44	Thames Water	Fixed network trial and measured savings
45	Thames Water	Leaky loo (internal)
46	Thames Water	Multifaith water use analysis
47	Thames Water	At home with water 2
48	Wessex Water	Combismart boiler device
49	Collaborative	Leaky loo's collaborative project
50	Collaborative	Showering project partnership - collaborative fund

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Water Company	N°	Project	Raw data available?	Will it deliver in time?	Is there a report?	Can it be used?	Progress to 1st proforma screening?	WE/Metering or GWRW	Domestic or Commercial	Requested to be included in project	Type of project	Approx size	Approx time period	data type and form	Selected Y / N
Anglian Water	1	Water efficiency measures programme - water audit and retrofit	Y	ongoing	N	Y	Y	W	D	N	Water audit, retrofit and behavioural	? Info requested	ongoing	? Info requested	Y
Bristol Water	2	Water efficiency in student halls	limited	ongoing	Y	Y	Y	W	D	N	Water audit, retrofit and behavioural change	155 rooms in 24 flats	ongoing	Bulk meter reads	N
	3	Change of occupier metering	Y	ongoing	N	Y	Y	M	D	N	Metering	1500/year	ongoing	Meter reads	Y
	4	Compulsory metering of cattle troughs and commercial properties	Y	ongoing	N	Y	Y	M	C	N	Metering and leak detection		AMP5 - AMP6	Meter reads	N
Dŵr Cymru Welsh Water	5	'Wrap Up Wales' - Winter Campaign Report	Y	Y	Y	Y	Y	W	D	N	Leak prevention	1537	Winter of 2013	Questionnaire responses	N
	6	Sustainable Economic Level of Water Efficiency (SELWE) - Tywyn and Aberdyfi Project	Y	Y	Y	Y	Y	W	D	N	Water audit and retrofit	21 homes	2014	Assumed	R
	7	Hydrocell Maintenance Project - urinal optimisation	Y	Y	Y	Y	Y	W	C	N	waste reduction	1920	AMP5	Assumed	N
Essex and Suffolk Water	8	Flagship retrofits	Y	Y	Y	Y	Y	W	D	N	Full retrofit, visit and fix and behaviour.	90 properties	AMP5	measured	R
	9	Swan Housing retrofits	Y	Y	Y	Y	Y	W	D	N	Full retrofit, visit and fix and behaviour.	91 properties	AMP6	measured	R
	10	Challenge TWENTY:12	Y	Y	Y	Y	Y	W	D	N	behaviour change	1000 metered customers	12 months over 2012	meter reads	Y
	11	Little Green Riding Hood	limited	Y	N	limited	N	W	D	N	behaviour change	Exposure to 140,000 pupils	since 2010	assumed	N
	12	Water Saving Kits	Y	Y	Not yet analysed	Y	Y	W	D	Y	water saving kits, self installed	60,000 kits distributed	?	metered and assumed	Y
	13	Leaking WC's (E&S internal)	Y	Y	N	Y	Y	W	D	N	Leak detection and fix	approx 50	?	meter reads and questionnaires	N
	14	Shopping centre events	Y	Y	N	Y	Y	W	D	N	Distribution of water saving kits	?	?	Assumed	N
	15	ecoFIT	Y	Y	Y	Y	Y	W	D	N	Full domestic retrofit	3,200	?	Same methodology as H2eco	Y
	16	RE:NEW	Y	Y	Y	Y	Y	W	D	N	retrofit visit and fix as part of energy retrofit	3,000	?	metered and assumed	N
	17	Shower 'n' save	Y	Y	Y	Y	Y	W	D	N	water saving device	?	?	meter reads	N
	18	Waterpebble	Y	Y	Y	Y	Y	W	D	N	water saving device	?	?	meter reads	N
	19	Greywater Recycling	Y	Y	Y	Y	Y	G	D	N	greywater	a housing estate	since 90's	?	N
	20	Holiday park	Y	Y	Y	Y	Y	W	D	N	retrofit	250 caravans	?	metered control area	N
	21	H2eco 1	Y	Y		Y	Y	W	D						Y
	22	H2eco 2	Y	Y		Y	Y	W	D		TBC!				Y
	23	H2eco 3	Y	Y		Y	Y	W	D						Y
Northumbrian Water	24	Dual flush retrofit trial with behaviour change in 2011.	Y	Y	N	Y	Y	W	D	N	retrofit and behaviour	?	2011	?	
	25	Dual flush retrofit with behaviour change in 2012 .	Y	Y	Y	Y	Y	W	D	N	retrofit and behaviour	2,000	2012	metered	Y
	26	Water cycle retrofit with behaviour change in 2013.	Y	Y	N	Y	Y	W	D	N	retrofit and behaviour	230	2013	?	N
	27	Every Drop Count whole town campaign 2014.	Y	Y	N	Y	Y	W	D	N	retrofit and behaviour	500	2014	?	R

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Severn Trent Water	28	Domestic grey water reuse trial	limited	Y	N	Y	Y	G	D	N	grey water reuse trial	10 properties	only in year 1 of 3	metered	Y
	29	Tracking of behaviour change impact of our education programme	Y	Y	N	Y	Y	W	D	N	behaviour change	?	?	?	N
	30	Rainwater Harvesting EngD	limited	ongoing	some papers but not final	Y	N	R	D	N	Rainwater harvesting	?	ongoing	?	N
	31	Change of occupier metering trial	Y	1 month for data	N	maybe	Y	M	D	N	change of occupier metering	?	ongoing	meter reads	Y
South East Water	32	Compulsory metering programme	Y	Y	N	Y	Y	M	D	Y	Compulsory metering programme	~83,000	ongoing since 2011	meter reads	Y
	33	Leaking toilets data (internal water company)	Y	Y	N	Y	Y	W	D	N	Leak detection and fix	?	?	?	N
	34	Water efficiency retro fit project	Y	Y	N	Y	Y	W	D		retrofit project	?	?	?	R
	35	Ashford new homes project (since 2006)	Y	ongoing	N	Y	Y	W	D	Y	water efficiency and tariff trials	?	2006	meter reads	Y
	36	Free devices offered to our metered customers in CMP	Y	ongoing	N	Y	Y	W	D	N	Compulsory metering and water efficiency distribution kits.	linked to CMP	ongoing	meter reads	N
South Staffs Water	37	Change of occupier metering	not done with water efficiency in mind				Y	M	D						N
	38	AMR fixed area network	not done with water efficiency in mind				Y	M	D						N
	39	District metering	not done with water efficiency in mind				N	M	D						N
	40	Frequent logging trials	not done with water efficiency in mind				N	M	D						N
	41	Grey water reuse	limited	Y		N	N	G	D						N
Southern Water	42	School Case Study	Y	Y	Y	Y	Y	W	C	N	schools education	?	?	?	N
Thames Water	43	Save water Swindon summary	Y	Y	Y	Y	Y	W	D	N	water efficiency	Town wide	Apr-15		Y
	44	Fixed network trial and measured savings	Y	Y	No due March 2015	Y	Y	W	D	N	water saving devices and smart metering	4 areas	?	metered	Y
	45	Leaky loo (internal)	Y	Y	No due March 2016	Y	Y	W	D	N	Leak detection and fix	?	?	metered	N
	46	Multifaith water use analysis	Y	N (April 2015)	N	N	N	W	D	N	behaviour change	?	?	?	N
	47	At home with water 2	Y	N (March 2015)	N	N	N	W	D	N	behaviour change	70 homes	?	metered and questionnaire	N
Wessex Water	48	Combismart boiler device	N	N	N	N	N	W	D	N	water efficient device	4 homes!	due mid 2015	meter reads	N
Collaborative	49	Leaky loo's collaborative project	not yet	N	N	N	N	W	D	N	Leak detection	?	?	?	N
	50	Showering project partnership - collaborative fund	not yet	N	N	N	N	W	D	N	water efficiency	?	?	?	N

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