Evidence Base for Large-scale Water Efficiency

Phase II Final Report

April 2011

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Acknowledgements

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Authorship

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About us

Waterwise is an independent, not-for-profit, nongovernmental organisation focused on decreasing water consumption in the UK, and on building the evidence base for large-scale water efficiency. In England, we sat on the Environment Minister's Water Saving Group, which came to a close in autumn 2008. We co-convene the Saving Water in Scotland Roundtable.

Our aim is to reverse the upward trend in how much water we all use at home and at work. We are developing a framework supported by a robust social, economic and environmental evidence base to demonstrate the benefits of water efficiency. To achieve our aims we work with water companies, governments, manufacturers, retailers, non-governmental organisations, regulators, academics, agricultural groups, businesses, domestic consumers, the media and other stakeholders. We conduct our own research and also undertake work as consultants.

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Foreword

I am delighted to introduce this final report of Phase II of the Evidence Base project. The Evidence Base represents the best current available knowledge of water efficiency in the UK. It has made a significant contribution to the development of water efficiency by gathering robust evidence from water company retrofitting projects and using innovative analysis methods to guide water company retrofitting activities in both homes and in schools. The original Evidence Base report – in October 2008 – for which I also Chaired the Steering Group, was widely acknowledged to have been extremely useful in plugging the information gaps, and was used by both water companies and Ofwat during the 2009 Price Review in England and Wales

However, the first report posed almost as many questions as it answered, which is why the Ministerial Water Saving Group agreed that it should be kept updated. As a result Phase II was specifically designed to best assist the water industry, regulators and policymakers in supporting the development of water demand management options as resource options – including in the context of carbon targets.

This report provides a single reference point for all that has been learned from Phase II of the Evidence Base. It summarises the outputs from the February 2010 and December 2010 reports. The report makes the case for large scale water efficiency in homes and schools, including through the first evidence on longevity of water savings.

This report will help companies start to build the case for their future water efficiency retrofitting projects in both price reviews and water resources management plan processes. The recommendations included in this report suggest ways in which water companies, manufacturers and retailers can help to make water efficiency a more viable option. Waterwise will release a separate paper setting out recommendations for water efficiency policy and regulation drawing specifically on this report. There are a number of areas where more work is required as the project moves into Phase III, but the results in this report should give water efficiency practitioners confidence that they can deliver water savings cost-effectively through retrofitting projects in both homes and in schools.

The Evidence Base Steering Group has approved a strategy for the development of the Evidence Base as the project moves into Phase III. In addition to continuing to improve the evidence base in domestic and schools retrofitting, this will further develop the evidence in areas including small and medium-sized enterprises, new build and grey/rain water recycling for non-domestic customers and metering, smart metering and tariff trials (when combined with retrofitting). One of the main aims of the Evidence Base will also be to help water companies and wider stakeholders to gain a greater understanding of how customer engagement, including where combined with retrofitting, can help to change customers' water-using behaviour. The aim is to integrate feedback from customers into analysis of water efficiency projects to achieve this.

Finally, I would like to thank the companies who have contributed to the Evidence Base project both through sharing their results of the projects and through the Steering Group. I would also like to thank the Evidence Base project funders during Phase II: Communities and Local Government, Defra, the Environment Agency and Ofwat, for their valued support over the last two years.

I once again commend Waterwise for an extremely useful piece of work, and look forward to continuing to work with Waterwise and the Steering Group on this important project.

Jean Spencer

Director of Regulation, Anglian Water

Chair, Waterwise *Evidence Base* Steering Group

1 Introduction

This final report of Phase II of the Evidence Base Project includes new data on the effectiveness of domestic and schools projects in addition to summarising what has been learnt from the two previous reports: on domestic water efficiency retrofitting (the February 2010 report)[1]; and water efficiency retrofitting in schools[2] (the December 2010 report).

Under further work in the February 2010 Phase II report, the following was described:

"Probably the biggest area of uncertainty in the cost-benefit analysis for water efficiency is how water savings are sustained over time. Further research is required that seeks to understand how well, over the medium- to long-term, water savings are sustained."

The reason for revisiting four of the nine trials originally analysed in the February 2010 report was to improve the industry's understanding of the extent that water savings from domestic water efficiency retrofitting trials are sustained (longevity of water savings). The trials for which further information is included are:

- ⇒ Severn Trent Water's Water Efficiency Trial
- ⇒ Sutton and East Surrey Water's Preston Water Efficiency
- ⇒ United Utilities' Home Audit Study
- ⇒ Yorkshire Water's Water Efficiency Trial

On the schools side data is presented from two new water efficiency retrofitting projects which will help to reinforce the data included in the December 2010 report. The following projects are included in this report:

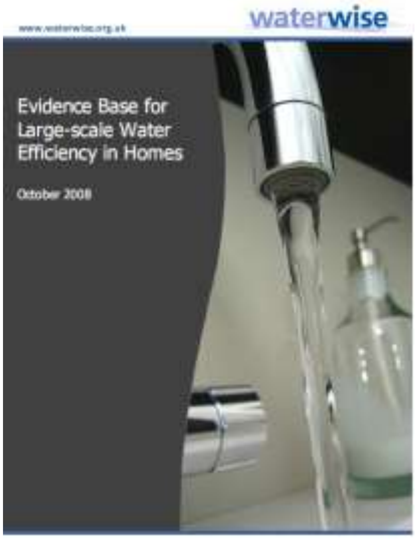
- ⇒ The Environment Agency's Schools Water Efficiency Grants Project
- ⇒ Essex & Suffolk Water's Schools Water Efficiency Programme

[1] Evidence Base for Large-scale Water Efficiency in Homes, Phase II Interim Report, February 2010, Available at: http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

[2] Evidence Base for Large-scale Water Efficiency, Phase II Second Report, Water Efficiency Retrofitting in Schools, December 2010, Available at: http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

1.1 Summary - The Evidence Base Project

1.1.1 Evidence Base Phase I

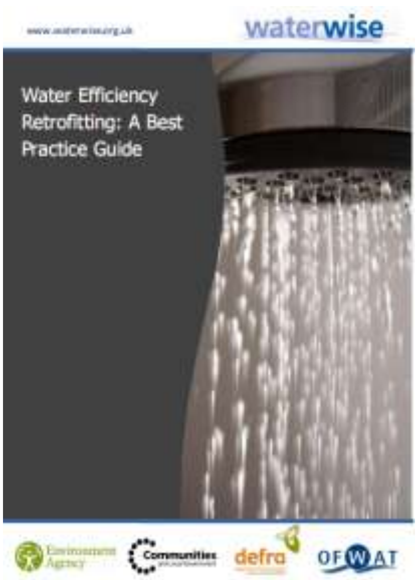


Waterwise produced the *Evidence Base for Large-Scale Water Efficiency in Homes* for the Water Saving Group in October 2008. The report was the first to collate the results of water company-led water efficiency retrofitting trials and it helped show the level of water savings that could be expected. It was used by water companies as they prepared their submissions for water efficiency programmes during the PR09 Price Review process and was praised by Ofwat for its role in the process. One part of this first report was scenarios which modelled how water efficiency delivered on a large scale in partnership with social housing providers and energy companies among others, could be cost effective.

The project was guided by the Evidence Base Steering Group, which meets quarterly and consists of members from several water companies, CLG, Consumer Council for Water, Defra, DECC, the Environment Agency, Ofwat and the Water Industry Commission for Scotland. The October 2008 report was one of the first reports to identify the link between water use and energy use. At its final meeting in November 2008, WSG colleagues "welcomed this useful report and agreed that it should be kept updated to reflect the evidence of future water efficiency projects as they became available in the future."

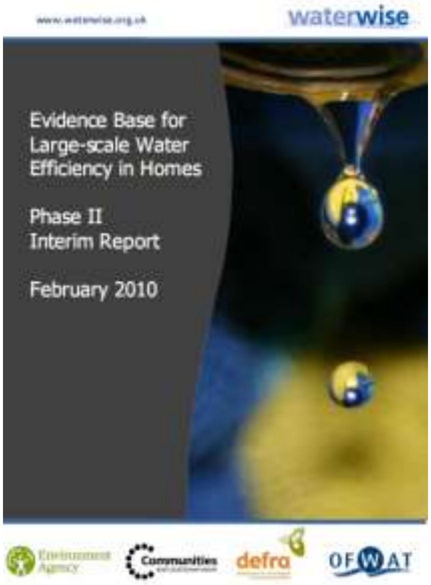
1.1.2 Evidence Base Phase II

1.1.2.1 Water Efficiency Retrofitting – A Best Practice Guide



Water Efficiency Retrofitting – A Best Practice Guide, published in December 2009, summarised best practice for water efficiency retrofitting, for those wishing to carry out large scale projects and for companies wishing to carry out water efficiency trials to contribute to the evidence base. The report included guidance on aspects of planning of water efficiency trials such as forming partnerships, recruiting customers, data collection, analysis and reporting, and also how to collect feedback from customers who participate in water efficiency projects to help improve future projects such as through questionnaires.

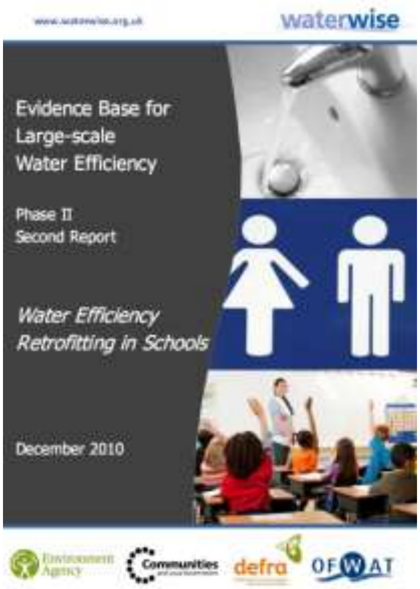
1.1.2.2 Phase II Interim Report on Domestic Retrofitting



This report was published in February 2010 and built on the October 2008 Phase I report. More demanding criteria on the data that was included and more robust analysis was used to gain a deeper understanding about how to target future water efficiency activities. The report presented results from the largest water efficiency retrofitting trials carried out by water companies in about 7000 properties across the UK and analysed them to understand the water savings achievable, the effectiveness of different products, the costs and benefits relating to water efficiency, and the carbon emissions and energy savings which result from reduced water consumption. In addition, this report only used measured consumption data.

The project was guided by the Evidence Base Steering Group, which met quarterly and consisted of members from several water companies, CLG, Consumer Council for Water, Defra, DECC, the Environment Agency, Ofwat and the Water Industry Commission for Scotland. This report showed that the savings from water efficiency retrofitting projects are significant and that by carrying out such projects in partnership with local councils, social housing providers, energy companies and piggybacking on government retrofitting schemes, further investment on large-scale water efficiency at the next round of Price Reviews and Water Resource Management Plans (WRMPs) may be cost beneficial.

1.1.2.3 Phase II Second Report on Water Efficiency Retrofitting in Schools



This report drew on evidence drawn from about 600 schools obtained from four water companies -including three from England and one from Scotland - and five water company school retrofitting programmes in order to show

- ⇒ what water savings are achievable from schools
- ⇒ what the savings cost to deliver
- ⇒ and what carbon emissions and energy savings can be obtained by reducing hot water consumption.

It also provided guidance to companies on the use of Department for Education and Schools' Water Benchmarking tool, which could be used to filter out schools which consume a lot of water relative to other schools on a per pupil basis and target these as a matter of priority. Again supported by the Evidence Base Steering Group, this report provides robust evidence that could support water company plans for carrying out water efficiency programmes in schools during the next round of price determinations. It also found that significant savings are achievable from the schools' point of view and that the benefits of retrofitting in schools accrue at a faster rate for schools than they do for water companies so this report is also useful for schools.

1.1.3 Evidence Base Achievements

The Evidence Base Project has been an important tool in helping to identify how water efficiency can be carried out on a large-scale, using approaches which are cost-effective compared to other demand-side and supply-side water resource options which the water companies have available. Although there are still gaps in the evidence base, this project has added to the development of water efficiency in the UK by providing a common baseline for assessing water efficiency projects.

The Evidence Base has focused attention on the formation of partnerships as a means to delivering cost-effective water efficiency programmes. This includes piggybacking on other activities such as gas safety visit for a Registered Social Landlord, home visits under the Carbon Emission Reduction Target (CERT) scheme in partnership with energy companies, or working within the framework of a government retrofitting programme.

The Evidence Base is the only such programme which draws conclusions from actual data from retrofitting projects covering thousands of homes (it is not a desk model). It was quoted extensively in the Walker Review for Household Charging and Sewerage Services. As a ministerially commissioned piece of work it has contributed to policymaking, and has been used to calculate potential payback times for the inclusion of water efficiency in the Green Deal.

1.1.4 Evidence Base Phase III

The Evidence Base is increasingly pertinent in the context of ensuring that robust evidence of the costs and benefits of water efficiency programmes, including how they can impact affordability and the benefits of hot water savings, are available to support water company proposals as part of the 2014 Periodic Review in England and Wales, plus Ofwat’s own comprehensive Sustainable Water programme on how it regulates to meet future long-term challenges. It is also useful for water companies and regulators in Scotland and Northern Ireland.

The Evidence Base strategy sets out how Phase III of the Evidence Base will broaden its scope to encompass other types of water efficiency project, namely:

⇒ continuing to refine the evidence base for domestic retrofitting.
⇒ understanding behaviour and attitudes to water use and providing guidance on how to influence behaviour change,
⇒ metering when linked with retrofitting,
⇒ schools,
⇒ small and medium-sized businesses,
⇒ rainwater harvesting and water re-use, working with manufacturers to understand what is possible for commercial customers and on a community scale.

Waterwise intends to undertake new research in partnership with universities in order to supplement the work being carried out as part of the Evidence Base project.

This programme will further develop the Evidence Base as robust, science-based research which advances understanding of how society can resolve the problems of reducing availability of water, increasing population and more water-intense lifestyles – as well as reduce carbon.

One of the key aims of Phase III of the Evidence Base project is to ensure that the best possible evidence is available to assist water companies with their regulatory submissions for water efficiency during the next round of price determinations and Water Resources Management Plans in England and Wales, Scotland and Northern Ireland. Figure 1 gives a Gantt chart which shows timescales for the various components of work which constitute Phase III of the Evidence Base project.

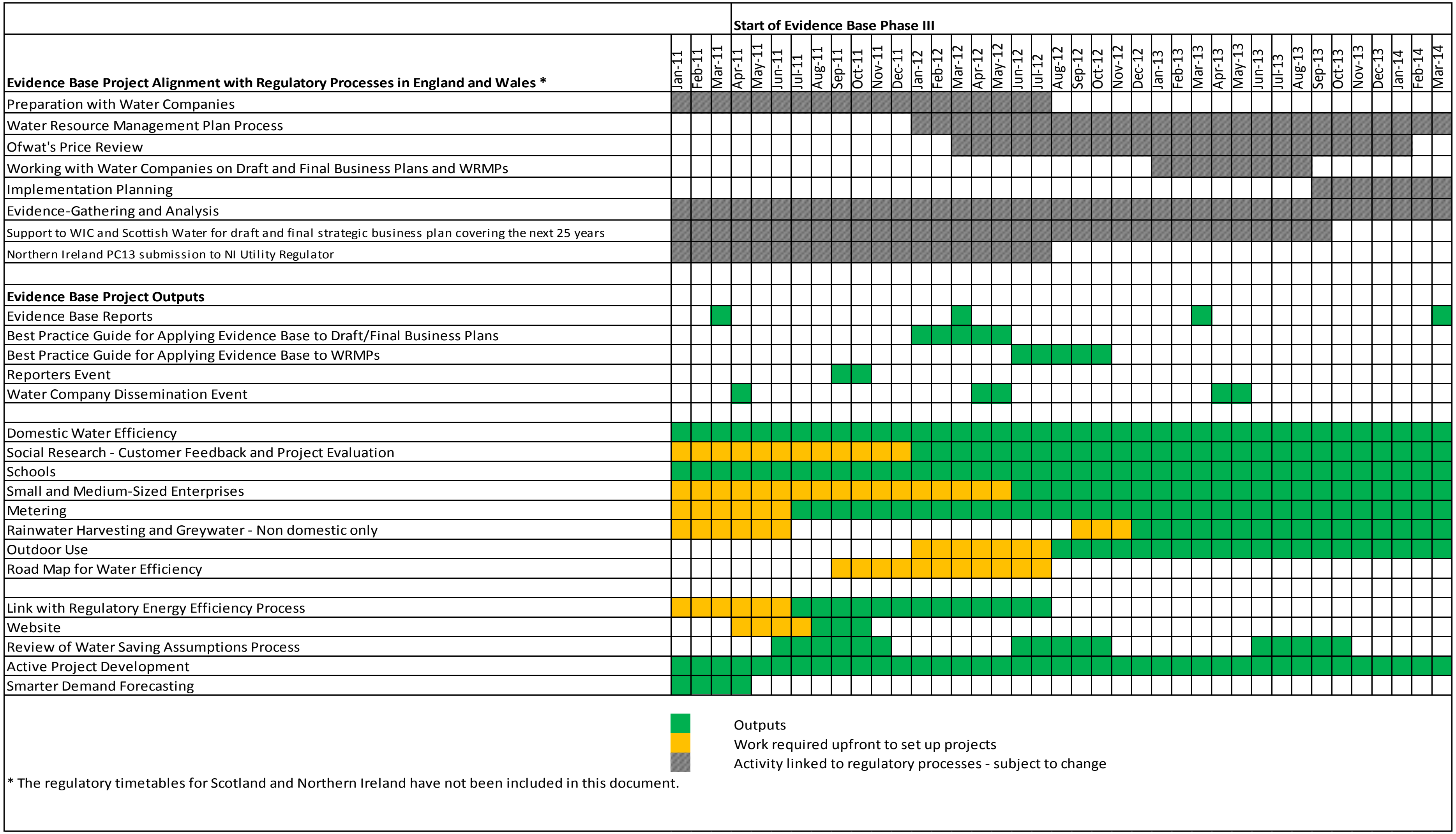


Figure 1 - Evidence Base Phase III Gantt Chart

The Evidence Base is a multi-layered process involving: detailed work with water companies to gather data; complex analysis and methodology; making the links with policy and regulatory frameworks; and, in turn, applying these outputs to influence the design of new projects both within the water sector and more widely. Specific drivers for the proposed three-year programme are listed below:

⇒ The remit for Phase III is far broader than that for Phase II (moving beyond domestic retrofit and schools to SMEs, tariffs and meters when linked with retrofit, social research and behaviour, and rainwater and greywater)

⇒ Water companies have told Waterwise that they would like the Evidence Base to focus on the sustainability of water savings. This has been a central concern of the Evidence Base Steering Group in Phases I and II, but the scale of the projects available for analysis has not been sufficient to address it.

⇒ During Phases I and II the role of the Evidence Base reached far beyond producing evidence and analysis, into working closely with individual companies to support design and implementation of projects which both contribute to the Evidence Base (a stated Ofwat aim of the Water Efficiency Targets) and deliver large-scale, cost-effective water savings. This Evidence Base work played an important role in the positive outcome for large-scale water efficiency in PR09, and a three-year programme up to the end of the price review processes across the UK, will maximise this impact. Water companies have told us that this would be useful. A three-year programme also enables added value for the Evidence Base from other Waterwise work, such as detailed social research beyond that outlined in the Evidence Base.

⇒ The UK Government is committed to reforming the water industry to ensure more efficient use of water (and the protection of poorer households), with legislation affecting England and Wales due in 2012. In Northern Ireland and Scotland changes to the policy and regulatory framework and industry structure will be starting to bed in towards the end of the proposed three-year timetable. It is important for these changes to be evidence-based, and Waterwise's Evidence Base is recognised as the best source of knowledge and analysis in this field.

As is clearly evidenced by public statements and citations by stakeholders across the public and private sector – including government, regulators, water companies and independent reviews the Evidence Base has to date played a significant role in helping the water industry identify the most cost-effective approaches by delivering water efficiency on a large scale. Increased challenges, such as climate change and population growth, and opportunities - such as Ofwat's review of regulation, Defra's Water White Paper and the developing policy and regulatory framework across Scotland and Northern Ireland - make the Evidence Base even more necessary in providing a robust foundation for policy and implementation.

2 Summary of Findings

Below the findings from the entire data collected and analysed during Phase II of the Evidence Base are summarised, firstly for domestic retrofitting and then for schools retrofitting.

2.1 Domestic Retrofitting – Summary

2.1.1 Overview

This section summarises the results of analysis carried out as part of domestic retrofitting stream of Phase II of the Evidence Base for Large-Scale Water Efficiency in Homes. It analyses nine water company projects. The results build upon the first phase of work, which was published in October 2008 (Phase I), and aimed to improve the evidence base for large-scale water efficiency by collating robust data and undertaking analysis to understand the achievable water savings, the longevity of water savings, uptake rates, carbon emissions and energy savings and the cost-effectiveness of different approaches. The results of seven scenarios, developed to assist with planning for price determinations and water resources management plans, are also summarised here.

2.1.2 Water Savings

Measured water savings of up to 34.0 litres per property per day (l/p/d) are possible from applying a multi-measure water efficiency retrofitting method in the traditional way, using current technology and means of engaging customers to encourage behaviour change. However, Anglian Water's Ipswich Area WEM trials resulted in savings of 41.5 l/p/d, which is the highest reduction in consumption of all the trials analysed in this report. There is a possibility that the fact that this WEM trial was carried out alongside a metering installation programme in the Ipswich area enhanced the results. Customers were made aware of their consumption and how much they could save by opting to be charged via a water meter, and this may have led to significant change in water-using behaviour.

2.1.3 Longevity of Water Savings

Table 1 below summarises the results of the analysis which was carried out in order to understand to what extent savings are sustained from four of the domestic retrofitting trials which were included in the February 2010 Evidence Base report.

	Preston Water Efficiency Initiative	UU Home Audit Study	Severn Trent Water WET	Yorkshire Water WET	Overall Results
Original no. of properties monitored	121	211	717	378	1427
Original water savings (l/prop/day)	50.0	20.6	28.4	18.1	26.4
Additional monitoring period (years)	3.0	3.0	2.6	2.6	2.8
No of properties monitored	79	208	680	337	1304
Revised mean water savings (l/prop/day)	31.5	28.7	20.3	14.9	20.9
Change in water savings (l/prop/day)	-18.5	8.1	-8.1	-3.2	-5.4
Percentage change in water savings (%)	-36.9	39.2	-28.6	-17.7	-20.6
Cost per property(£)	202	142	74	220	160
Cost per litre per day (£)	3.46	4.94	3.65	8.37	5.11
Revised energy indirect carbon emissions saved (kgCO2e/d)	6	5	10	11	32
Revised domestic hot water carbon emissions saved (kgCO2/d)	11	22	53	57	142
Revised Energy saving (kWh/d)	154	119	274	275	822
Revised cost of energy saved (£/year)	3595	6940	16023	16037	42596
Revised cost of energy saved (£/prop/year)	27	33	22	42	31

Table 1 - Summary Table from the additional monitoring of four domestic water efficiency retrofitting trials included in this report

Of the four trials for which additional meter data was available, the measured water savings fell in one trial and savings increased in three trials when the additional monitoring data was taken into account. The mean length of additional monitoring period was 2.8 years.

⇒ For Sutton and East Surrey Water's Preston Water Efficiency Initiative, three years' additional data was made available. Original savings of 50.0 l/p/d, from the retrofitting activities have been revised downward to 31.5 l/p/d taking into account the additional data. This is a reduction in savings of 36.9%.

⇒ For United Utilities' Home Audit Study, approximately three years' additional data was collected. Original water savings of 20.6 l/p/d have been revised upwards to 28.7 l/p/d after analysis of the extended dataset, which represents an increase of 39.2%

⇒ For Severn Trent Water's Water Efficiency Trial, the original water savings were 28.4 l/p/d. Following analysis of 2.6 years of additional consumption data, the savings have been revised downwards to 20.3 l/p/d, which is a decrease of 17.7%.

⇒ For Yorkshire Water's Water Efficiency Trial, 2.6 years of additional data was made available to evaluate the water savings. Analysis of 2.6 years' additional data resulted in the original water savings of 18.1 l/p/d being revised downwards to 14.9 l/p/d, which is a 17.7% reduction.

In order to understand what can be learnt from looking at the entirety of the results presented in Table 2, weighted average water savings were calculated (weighted based on the number of properties in each of the trials).

Weighted average original water savings (litres/prop/day)	**26.4**
Weighted average revised water savings (litres/prop/day)	**20.9**
Weighted average change in water savings over longer monitoring period (litres/prop/day)	**-5.4**
Percentage change in water savings over longer monitoring period (%)	**-20.6**

Table 2 – Weighted average water savings for original and extended dataset

This shows that across the four trials measured, water savings fell by 5.4 l/p/d following inclusion of extended datasets which included up to 3 years of additional data. This is equivalent to a percentage reduction of 20.6% over the period. This rate of decay of the water savings is slower than what has been assumed in the past.

However, taking into account the new evidence, with water savings reduced by 20.6% over a period of 2.8 years, the most likely half-life of the water savings (the rate at which they would decay to half their value) would be about 8.4 years. This result is a change from previous assumptions in the Evidence Base and more widely and leads to an improvement in the cost benefit analysis for retrofitting projects. This is shown in Figure 2 below.

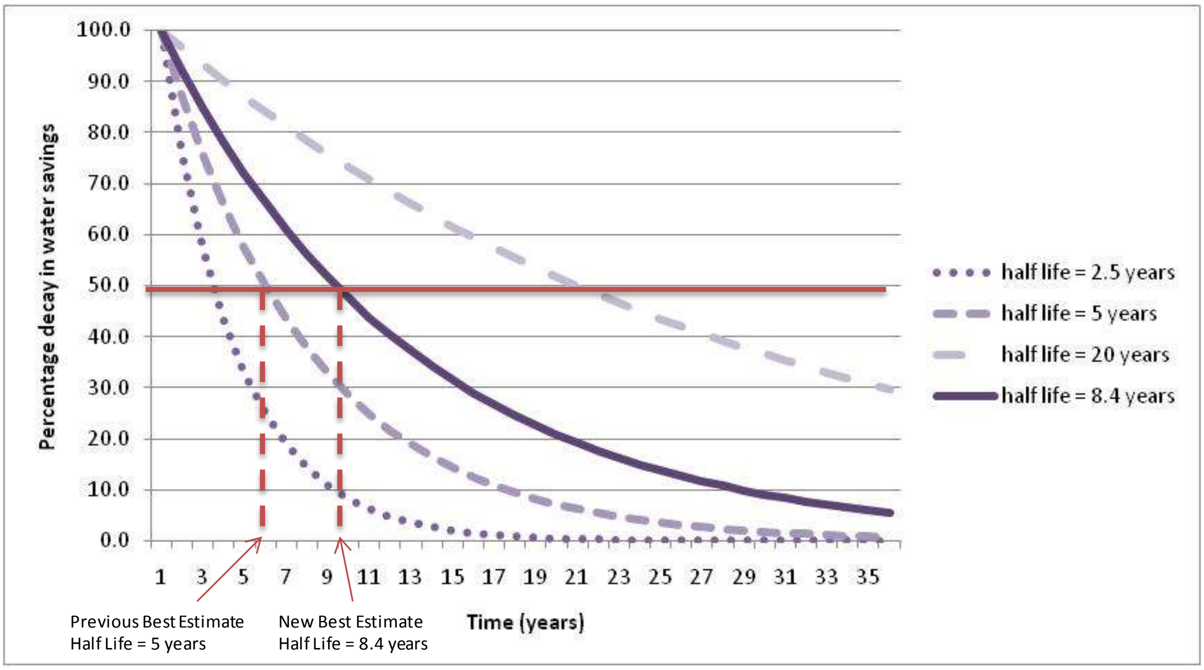


Figure 2. Half-life of water savings from retrofitting trials and projects.

2.1.4 Uptake rates

The results show a range of uptake between 6% and 60% has been achieved. Further work is required to determine the optimal uptake/investment ratio which is the level that should be aimed for when the cost of the tools to achieve uptake (letters, telephone calls and door-knocking) are considered.

2.1.5 Carbon Emissions and Energy Savings

Analysis of the nine water company-led water efficiency retrofitting trials in this report shows a range of between 0.031 and 0.187 kgCO_2e per property per day of carbon emissions saving as a result of the water efficiency retrofitting projects included in this report. It also shows that the average cost of energy saved in the trials ranges from £1.3 to £44.3 per property per year. Both carbon emissions and energy savings were dependent on the extent to which hot water was targeted during a trial. Trials which did not target showering or bath use showed relatively low energy savings. However, this assessment illustrates that there are significant carbon and energy benefits to be gained from water efficiency retrofitting.

2.1.6 Understanding the Costs of Water Efficiency Retrofitting

There is a wide variation in the cost of retrofitting per property, which ranges from £41 to £240 per property. Anglian Water's Ipswich Area WEM trial achieved the lowest cost per property and one of the reasons for this was that the trial was carried out alongside the Ipswich area metering programme. Similarly, Wessex Water's Water Efficiency Trial (WET), carried out in partnership with a social housing provider, achieved a cost of £49 per property.

2.1.7 Innovative Analysis

Use of linear regression in the analysis of the trials in the February 2010 Evidence Base report shows that, using our current methods alone, it is unlikely that households consuming 400 litres per day or more will be able to reduce their consumption sufficiently to meet the long-term government ambition of 130 litres per person per day. The main assumption made in this analysis is that the occupancy of the trial properties is similar to the national average occupancy. More effective methods of encouraging customers to reduce their consumption alongside retrofitting will have to be found in particular, targeting higher consumers. New water-using technologies could play a part in helping to drive down consumption, but it is likely that significant behaviour change will also be necessary, whichever technologies are employed. This ties in with the Final Report of the Walker Review[3] which recommends a multi-stakeholder education campaign on water efficiency for England and Wales.

2.1.8 Scenarios

Seven new scenarios for delivering water efficiency on a large-scale through partnership are presented in this report (see Table 3). The scenarios are the following:

- ⇒ Scenario 1: Social Housing
- ⇒ Scenario 2: Energy company
- ⇒ Scenario 3: Whole Town
- ⇒ Scenario 4: Retail Led Retrofit
- ⇒ Scenario 5: Piggybacking on Water Company Metering Programmes
- ⇒ Scenario 6: Toilet Amnesty
- ⇒ Scenario 7: Piggybacking on Government Retrofitting Schemes

Scenarios 1 to 4 show that partnership is an increasingly attractive option for stakeholders who want to deliver water efficiency. The partnership scenarios offer realistic options for water companies, social housing providers, energy companies, local councils, NGOs and retailers to work together to deliver water efficiency on a large-scale and in the most cost-effective way. The most cost-effective of the partnership options is Scenario 2 which describes the opportunity that currently exists for water companies and energy companies to take advantage of the fact that a few water efficiency measures are currently[4] included under the Great Britain-wide Carbon Emission Reduction Target (CERT)[5] scheme and could potentially be included under CERT's successor, ECO, and therefore, receive a credit for carbon emissions saved through reducing household water consumption.

[3] Defra website - http://www.defra.gov.uk/environment/quality/water/industry/walkerreview/final-report.htm

[4] At the time of print, although an announcement is imminent from the Coalition Government on whether this will remain the case to the end of CERT, in 2012, and there are barriers to joint working in certain cases, in this context.

[5] DECC website - http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cert/cert.aspx

Scenario 5 also provides a cost effective way of delivering water savings through a water company integrating its activities to carry out metering on a zonal basis and piggyback on this activity to carry out retrofits in the same properties. Scenarios 6 and 7 are built around the possibility of the updating of the Decent Homes Standard[6] to include water efficiency, an additional government action on toilets, and the inclusion of water efficiency retrofitting in existing government energy efficiency programmes: for example through the GB-wide Green Deal[7] or Community Energy Saving Programme[8] (CESP) or the Scottish Home Insulation Scheme[9].

Combinations of the scenarios in Table 3 could result in even more cost effective water efficiency retrofitting projects, for example, combining scenario 1 (social housing partnership) with scenario 2 (energy company partnership) or even scenario 2 with scenario 3 (whole town retrofit).

Partnership Options		Best Estimate	Best Case	Worst Case
Scenario 1: Social Housing	AIC (p/m^3)	26.7	3.6	172.6
	AISC (p/m3)	24.3	1.2	170.2
Scenario 2: Energy company	AIC (p/m^3)	5.6	1.5	106.7
	AISC (p/m3)	-15.0	-19.0	86.1
Scenario 3: Whole Town	AIC (p/m^3)	73.1	16.0	571.4
	AISC (p/m3)	52.5	-4.6	550.8
Scenario 4: Retail-Led Retrofit	AIC (p/m^3)	17.2	-4.0	232.5
	AISC (p/m3)	14.9	-6.4	230.1

Company-Driven		Best Estimate	Best Case	Worst Case
Scenario 5: Piggybacking on Metering	AIC (p/m^3)	29.3	10.6	153.8
	AISC (p/m3)	6.5	-12.2	131.0

Government-Led		Best Estimate	Best Case	Worst Case
Scenario 6: Toilet Amnesty	AIC (p/m^3)	1.8	-4.0	26.0
	AISC (p/m3)	-18.8	-24.6	5.4
Scenario 7: Piggybacking on Government Retrofitting Schemes	AIC (p/m^3)	5.9	-4.0	71.0
	AISC (p/m3)	-14.6	-24.6	50.4

Table 3– Summary of AIC and AISC results for each of the scenarios

[6] http://www.decenthomesstandard.co.uk/index.php

[7] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/green_deal/green_deal.aspx

[8] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cesp/cesp.aspx

[9] http://www.scotland.gov.uk/Topics/Built-Environment/Housing/privateowners/his

2.2 School Retrofitting – Summary

2.2.1 Overview

The evidence presented here is drawn from 633 schools resulting from four water companies and five school retrofitting programmes in order to show what water savings are achievable from schools, what the savings cost to deliver and what carbon emissions and energy savings can be obtained by reducing hot water consumption. Table 4 provides the summary of the key outcomes from the school programmes and case studies included in this report.

	Severn Trent Water Schools Programme - Logged Schools	Severn Trent Water Schools Programme - Metered Schools	Thames Water Liquid Assets - Metered Schools	Thames Water Water Makeover Project - Logged Schools	EA School Water Efficiency Grants Project	Essex & Suffolk Water Schools Programme - Phase 2	Overall
No of schools monitored	43	439	95	13	4	39	633
Mean number of pupils per school	433	368	330	640	818	-	497
Mean water savings (m3/pupil/year)	1.00	1.76	0.58	1.78	1.61	-	1.34
Mean water savings (m3/day)	1.18	1.78	0.52	3.13	3.60	0.78	1.83
Percentage change of water savings	14.52	23.07	1.85	23.41	18.92	11.69	19.67
Probability of water savings	81%	90%	65%	93%	100%	72%	84%
Cost per litre per day (£)	0.72	0.42	-	0.41	0.48	-	0.51
Mean energy indirect carbon emissions saved (kgCO2e/annum)	272	485	142	853	78	-	420
Mean site hot water carbon emissions saved (kgCO2/annum)	294	836	246	1470	839	-	716
Mean energy saved (kWh/annum)	1429	4058	1193	7137	4075	-	3477

Table 4 - Summary Table from some of the school retrofitting projects which are included in this report

2.2.2 Water Savings

Analysis of the data shows that mean water savings of between 0.58 and 1.78 m^3 per pupil per year are achievable through retrofitting in schools. This is equivalent to between 0.52 and 3.13 m^3 per day per school. Linear regression is used to enable the results from the 633 schools to be grouped together and then guide future school activities.

Table 5 provides a look-up table which can be used by water companies when planning water efficiency retrofitting programmes in schools. The table is derived from the equation below which is produced using linear regression.

$$\text{Post PCC} = 0.611 * \text{Pre PCC} + 1.008$$

(where Post PCC is the post-intervention consumption in m^3 per pupil per year and Pre PCC is the pre-intervention consumption in m^3 per pupil per year).

A percentage reduction in water consumption of about 23% was achieved in two separate school programmes and in both instances this coincided with a high proportion of schools saving water: 90% and 93% of schools in each programme reduced their consumption.

However, one programme achieved a reduction of 1.85% and across the 95 schools to which this applied there was only a 65% probability of saving water. A number of the schools saw significant increases in consumption, which is unusual. The reason for this is unclear, but it may be because the audits identified works necessary under the water fittings regulations[10] which required certain flow which had been shut off to be restored. It could also be that there were leakage issues during the post-intervention monitoring period.

School Pre PCC (m3/pupil/year)	School Post PCC (m3/pupil/year)	Percentage reduction in consumption
1.00	1.62	-61.90
2.00	2.23	-11.50
3.00	2.84	5.30
4.00	3.45	13.70
5.00	4.06	18.74
6.00	4.67	22.10
7.00	5.29	24.50
8.00	5.90	26.30
9.00	6.51	27.70
10.00	7.12	28.82
11.00	7.73	29.74
12.00	8.34	30.50
13.00	8.95	31.15
14.00	9.56	31.70
15.00	10.17	32.18

Table 5- Use of linear regression derived relationship to determine post-intervention consumption for an input pre-intervention consumption in m3/pupil per year

10 The Water Supply (Water Fittings) Regulations 1999, available at: http://www.legislation.gov.uk/uksi/1999/1148/contents/made

2.2.3 Cost-Effectiveness of Retrofitting

The cost of the water savings from the schools programmes included in this report are given in Table 4. **The cost ranges from £0.41 to £0.72 per litre per day based on cost data from about 500 schools. This compares very favourably to the cost of water savings achievable through domestic retrofit.** The February 2010 Evidence Base Phase II report[11] showed that the most cost-effective saving achieved through domestic retrofit to date was £1 per litre per day and could be as high as £21 per litre per day.

2.2.4 Hot Water, Carbon Emissions and Energy Savings

As far as the 633 schools analysed in this report are concerned, there were few showers fitted so the main means of targeting hot water was through hot taps: either via retrofit or replacement, or using in-line flow regulators. **The single most significant source of hot water savings in schools comes from reduced consumption through use of more efficient use of hot taps.**

Table 4 gives the mean energy indirect carbon emissions saved (kgCO2e/annum) (i.e. the calculated savings to the water company from reduced supply and treatment of water), the mean domestic hot water carbon emissions saved (kgCO2/annum) by the school and the mean energy saved (kWh/annum) by the school, which were calculated using the above assumptions on hot water savings and then applying Waterwise's Water-Energy Calculator (for further explanation see the Evidence Base Phase II interim report – February 2010) .[13] Significant carbon emissions and energy savings are achievable from retrofitting schools, evidenced from the programmes included in this report:

⇒ **Mean energy indirect carbon emission savings (from supply and treatment) ranging from 142 to 853 kgCO_2e per annum**

⇒ **Mean site hot water carbon emission savings of between 246 and 1470 kgCO_2 per annum**

⇒ **Mean energy savings of between 1193 and 7137 kWh per annum.**

The energy indirect carbon emissions savings result from less cold water needing to be treated and pumped through water company networks. The level of site hot water carbon emissions savings from these schools projects depends on the extent to which hot water is targeted.

Where data is not available to allow the calculation of hot water savings to be carried out for a school, the mean hot water savings from the 43-logged school sample from Severn Trent Water's school water efficiency retrofitting programme is applied (16%).

11 The Evidence Base Phase II interim report, February 2010. Available at:
http://www.waterwise.org.uk/images/site/Policy/evidence_base/evidence%20base%20for%20large-scale%20water%20efficiency%20in%20homes%20-%20phase%20ii%20interim%20report.pdf

2.2.5 Payback

The benefits of retrofitting in schools accrue at a faster rate for schools than they do for water companies. This is shown by the proportion of schools that payback within five years (see section 4.5.1) from the water company's and the school's different perspectives. Reasons for the quicker accrual of benefits to the schools are:

⇒ schools see the benefit of water savings at the price of water (e.g. £2.25 per m3) compared to water companies who realise only the marginal cost of water (e.g. £0.40 per m3), which is about significant lower and includes the benefit of indirect energy savings

⇒ schools benefit from site energy savings where hot water consumption is reduced whereas this benefit does not accrue to the water company

⇒ The fact that the benefits of retrofitting accrue significantly faster to the school than they are likely to do to the water company is an argument in favour of using spend-to-save schemes as a means to finance water efficiency in schools.

There is also significant scope for improving the proportion of schools which pay back within five years. This could be achieved if activities are targeted better, such as by using benchmarking. This is discussed further in section 4.5.2.

2.2.6 Spend-to-save schemes in schools

Retrofitting water saving devices in schools is very cost-effective and offers a relatively quick payback. However, there are a number of barriers that discourage schools from undertaking these works independently: uncertainty over the level of savings for any specific school; a difficulty in securing capital funding for operational savings even if the payback is two years; and a lack of awareness and ownership of the issue.

The combination of these potential benefits and barriers means that there is an opportunity to devise a targeted spend-to-save scheme for schools. Such an approach would involve an assessment of a group of schools within a specific locality: the data would then be analysed to provide a ranking to prioritise retrofits and retrofit work undertaken for specific schools under a payback agreement which fixed the current level of bills until the cost of retrofit and finance had been recovered. Schools would be taken out of the water company's tariff basket and a bilateral agreement would need to be negotiated. Additional measures would need to be put in place to cover lower than expected savings, changes to the fabric of the school or make-up of the student body during the agreement, and issues such as leakage.

Waterwise and some water companies are currently developing spend-to-save trials.

2.2.7 Targeting Water Efficiency Retrofitting Programmes in Schools

Three different methods have been used in this report to analyse the evidence from the 633 schools to determine what insight might be gained into how to target school water efficiency retrofitting programmes to make them more cost-effective

- ⇒ The results from this linear regression modelling demonstrate that **there is value in benchmarking of schools to help prioritise water company activities**

- ⇒ Section 4.5.2 shows that using the DfES water consumption benchmarking tool and focusing on bottom quartile schools in place of randomly choosing schools, can significantly improve water savings. A **78% improvement in water savings was achieved: 1.65 m^3 per pupil per year for all schools becomes 2.94 m^3 per pupil per year when activities are focused on bottom quartile schools.** Targeting activities at bottom quartile schools also results in the cost of water savings reducing from £0.716 per litre per day (including all schools) to £0.273 per litre per day(targeting bottom quartile schools). **This is equivalent to a 62% reduction in the cost of water savings through a targeted approach using the DfES water consumption benchmarking tool. These are encouraging results and would seem to justify the use of benchmarking in targeting future activities**

- ⇒ Comparison of the water savings achieved in primary schools versus secondary schools show that the savings in secondary schools are obtained at a cost of £0.36 per litre per day, which is about 23% cheaper than was achieved for primary schools. Secondary schools yield more cost-effective savings even considering that on average more was spent retrofitting secondary schools (£1092 was spent on each secondary school compared to £680 per school for primary schools). **This indicates strongly that economies of scale are achievable from targeting secondary schools compared to primary schools.**

2.2.8 Estimates of water savings from devices in schools

The derived estimates in Table 6 have been developed through comparison of the assumptions initially derived in section 4.5.3 with the measured savings from 43 schools logged as part of Severn Trent's Schools Water Efficiency Programme. **These derived estimates of water savings could be used by water companies to plan for future school retrofitting projects such as in future price reviews or the Water Resources Management Plan process.**

In order to ensure that these assumptions are updated with the results of future trials, **details of the stock of water-using devices such as showers, taps, toilet cisterns and urinals need to be collected as part of future school retrofitting projects.** This could be undertaken as part of an initial audit carried out by water companies, prior to installation of measures, to assess what measures are needed in schools.

Category	Device	Derived Water Savings	Units for savings
Toilets	Dual-flush valve conversion	-	-
	EcoBETA dual flush siphon	0.174*y	litres/pupil/day
	Cistern Dams	-	-
	Cistern Displacement Devices	0.068*y	litres/pupil/day
Taps	Push Taps - Retrofit	0.105*x	litres/pupil/day
	Push Taps - Complete tap	0.105*x	litres/pupil/day
	In-line flow regulators	0.211*z	litres/pupil/day
	Outlet aerators regulator	-	-
	Re-time existing tap	-	-
Urinals	Service UCD	40	litres/day
	Hydromate - Mains 240v	80	litres/day
	Hydrocell - Battery 6v	80	litres/day
	Hydrocell Ultra - Battery 6v	80	litres/day
	Isolation valve	-	-

Table 6 – Revised water savings assumptions for 43 schools which were part of the Severn Trent School Water Efficiency Programme.

2.2.9 Data collection

The following observations can be made on the data collected for monitoring the school retrofitting projects

- ⇒ Datasets are generally of short duration (for example 1 to 6 months) and monitored periods inevitably cover half terms, Christmas, Easter or summer holidays
- ⇒ Most schools consume significantly less water on weekends and during holidays but some may consume more depending on whether the school is used as a sports facility or for community events
- ⇒ The before and after retrofit monitoring periods invariably include vastly different proportions of time when the school is open and closed.

There is a need for a consistent approach to collecting data to assess the savings from school retrofitting programmes. If meter readings are used to measure the school's consumption, monitoring should ideally take place for an entire year before and after the intervention in order to understand the effect on the school's water bills. This would also ensure an equal proportion of days when the school is open and closed in the pre and post-intervention monitoring periods. Continued monitoring of the school's consumption in subsequent years is also extremely useful in order to understand how savings are maintained. However, account must also be taken of whether or not the amount of water used when the school is closed is highly variable.

The use of logger data enables a more accurate determination of the consumption when the school is open and enables the short-term effect on consumption of the water efficiency retrofitting programme to be determined. **To understand how savings are sustained over time it would be useful to monitor school consumption using data loggers for a school-term period per year over the course of three or more years after the intervention.**

3 Domestic Retrofitting – The Evidence

3.1 Introduction

In Phase II of the Evidence Base Waterwise collated and analysed the costs and benefits of nine water company-led domestic water efficiency retrofitting projects carried out in the UK. The water savings are derived by measuring and comparing the consumption before and after the installation of devices is carried out in 7000 homes. The monitoring period ranges from a few weeks to a year. The fact that the savings are evaluated over the short term means that there is significant uncertainty when applying these savings to cost benefit analysis such as the calculation average incremental cost (AIC) which are a key part of regulatory price reviews and water resource management plans. A cost benefit analysis of this type would assume a lifetime of ten years for retrofit devices such as water-efficient showerheads, dual-flush conversion devices and tap inserts. It is important to gather evidence to help to improve the robustness of cost benefit analyses carried out over the long term.

This section starts by presenting up to three years of additional consumption data which has been collected from four trials which were included in the first report of Phase II. The aim is to provide evidence as to what extent savings from the trials have been sustained. The limitations of the data will then be discussed and following this a summary of the results from domestic retrofitting projects included in Phase II of the Evidence Base project will be given.

3.2 The Methodology

Waterwise has developed a methodology for the Evidence Base project which is the basis of the analysis of the domestic and schools retrofitting projects which is presented in this report. Part of what has been developed is a water-energy model which has enabled carbon emissions and energy savings to be estimated. The methodology for Phase II of this project draws much from the following three pieces of water industry work:

- UKWIR (2007) "A framework for valuing the options for managing water demand," 073/WR/25/3, referred to as WR25B, from which the cost/benefit analysis procedure and spreadsheet tool have been used;
- UKWIR (2006) "Sustainability of water efficiency measures," 06/WR/25/2, referred to as WR25A; and,
- UKWIR (2002) "Economics of balancing supply and demand," 02/WR/27/3, referred to as EBSD, which is ultimately used to develop the optimum mix of resource and demand interventions to balance supply/demand. The outputs generated from the WR25B spreadsheet tool are designed to be used in the EBSD process.

The method used in this project for calculating average incremental social cost (AISC) is consistent with the WR25B approach, the EBSD and the Water Resource Planning Guidelines. A discount rate of 4.5% has been used as this was the value used by Ofwat within their financial model for PR09. In addition, a 25-year planning horizon has been used, as this is common practice for water companies (in practical terms, this means assigning a zero value to all figures after 25 years up to 60 years when calculating the AISC values).

The methodology was applied in five steps:

1. Consult stakeholders to understand the gaps in the current evidence and how these can be filled;

2. Collect evidence from water companies and other water efficiency practitioners, and then assess the quality of the evidence;

3. Analyse the data to extract the following:
    - → Water savings in litres per property per day saved and percentage reduction in consumption
    - → 90% confidence intervals in terms of litres per property per day saved and percentage reduction in consumption
    - → The distribution of water savings
    - → Cost per property of retrofitting and the cost per litre per day of water saved
    - → The probability of a property taking part in the trial and consequently reducing their water consumption
    - → Customer response to the company initiative as described by a percentage uptake rate (i.e. the percentage of customers initially contacted to take part who actually took part in the trial or project)
    - → Carbon emissions and energy savings, calculated by applying a model and methodology that will be presented later in this section

4. Assess the background trend in demand as described by water company per capita consumption data presented in 2010 June Return submissions.

5. Construct scenarios and analyse the costs and benefits, in terms of water savings, for these scenarios using the spreadsheet tool developed under the UKWIR WR25B project.

The application of this methodology has yielded useful evidence which should improve the quality of the evidence base (an explicit aim of Ofwat's Water Efficiency Targets for England and Wales) and help to provide stakeholders with more confidence when planning water efficiency retrofitting schemes. Phase II of the Evidence Base has also provided a standard methodology and an output format that are flexible enough to enable water companies to develop their own scenarios, with existing and standard tools, for the EBSD process that are consistent with Ofwat's guidance on cost benefit analysis.

3.2.1 Data Collection

Information was gathered from UK water companies through written data requests, desk study and personal communications. These efforts were followed up by visits to the water companies. Specific project reports and raw data were obtained from the companies. The information was then collated and analysed.

When reviewing the range of water efficiency trials and project reports, a great deal of time was spent trying to obtain the data in its raw form. The water companies were keen to contribute and very helpful in providing raw data, by and large promptly after it was requested. However, there were occasions when a large amount of work was required by companies in order to make the data fit to share, as customer privacy was a key consideration. A good deal of time was spent, in particular, reviewing survey feedback from customers as there were a broad range of approaches to questions that were asked and the storing and management of this data.

3.2.2 Data Analysis

3.2.2.1 Water Savings and Monitoring

The measurement of both pre-installation and post-installation water consumption was required so that water savings in terms of litres saved and percentage reduction in consumption could be calculated. Each of the companies that contributed to this report provided data for properties that had been monitored for at least three months before and after retrofitting. However, four companies provided additional meter data for four trials which enabled consumption of retrofitted properties to be monitored for a further period of between two and a half and three years after the initial monitoring period. This additional data has been analysed in this report to determine to what extent savings have been sustained over the extended period.

The intention was to maintain as many of the original properties as possible in the dataset so that a true comparison can be made between the previously reported savings and those from the extended monitoring period. However, there are a few reasons that the number of properties in the follow-up dataset may not be the same as in the original dataset:

- Negative consumption values were removed from the dataset.
- Consumption values were removed after visual inspection of the datasets if it was deemed likely that excessive consumption was due to either leakage or inaccurate meter reads or data input.

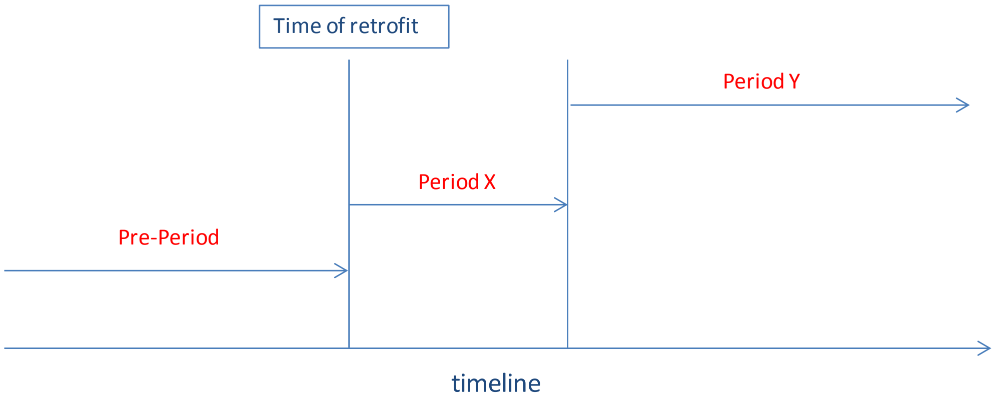


Figure 3 - Timeline Illustrating Consumption Monitoring Periods for Trials included in this report.

Figure 3 illustrates the different periods over which water consumption is monitored.

- Pre-Period represents the monitoring period before the retrofit is carried out, which is generally a period of at least three months.
- Period X represents the monitoring period from immediately after the retrofit for a period of six months to a year.
- Period Y represents the monitoring period from the end of Period X for a period of two and half and three years

In this report the change in consumption is to be evaluated for the following periods:

1. Change in consumption between Pre-Period and Period X
2. Change in consumption between Pre-Period and Period Y

The consumption changes defined in 1 and 2 refer to two different periods and in order to understand the consumption change over the combined period included in both Period X and Period Y. The overall consumption change at the end of Period Y will be defined by:

$$Overall\ Consumption\ Change = \frac{(P_X \times MD_X) + (P_Y \times MD_Y)}{(MD_X + MD_Y)}$$

where

P_X - change in consumption between Pre-Period and Period X

P_Y - change in consumption between Pre-Period and Period Y

MD_X - number of monitoring days in Period X

MD_Y - number of monitoring days in Period Y

3.2.2.2 Carbon Emission and Energy Savings

Waterwise has developed a means of determining the carbon emissions and energy savings which result from hot and cold water savings from more efficient use of water. This method has been used in Phase II to apply carbon emissions savings and energy savings to the included trials.

This section gives a summary of the method used to calculate the energy and carbon emissions saved when water consumption is reduced due to a water efficiency retrofitting project. The process, illustrated in Figure 4, starts at Step 1 with estimating the temperatures at which water is supplied to the property, the temperature that it leaves the boiler and the use temperature in baths, taps and showers. Defining these temperatures allows the ratio of hot to cold water which is necessary to deliver water at the required temperature. There are different ratios for baths as opposed to showers and taps because the use temperature is usually higher in baths.

In Step 2, knowing the ratio of hot to cold water allows the calculation of the amount of hot water required and the amount of energy necessary to heat a litre of water to be used in the home. This required energy assumes 100% efficiency so heat source efficiencies are applied in Step 3 to determine the actual amount of energy required. In Step 4 the energy required is then expressed in kilowatt hours and carbon factors (which convert kWh to $kgCO_2$) can be applied which help determine the carbon emissions created as a result of production of that energy.

At the next stage (Step 5), the per-litre energy requirement (for heating water) and carbon emissions can be calculated. The results of these calculations are presented in Table 7. The final step involves using disaggregation of the water savings to determine how much of the measured savings from a trial are hot water savings (e.g. from showers) as opposed to cold water (e.g. from toilets). The energy and carbon emissions saved are determined by multiplying the per-litre values in Table 7 by the disaggregated water savings.

FOR GAS HOT WATER SYSTEMS

Litre type	Domestic hot water energy consumption (kWh)	Domestic hot water carbon emissions (Kg CO_2)	Indirect carbon emissions (Kg CO_2eq)
1 litre of hot water for taps and showers	0.039	0.0081	7.47×10^{-4}
1 litre of hot water for a bath	0.044	0.0097	7.47×10^{-4}
1 litre of cold water for indoor use	0.000	0.0000	7.47×10^{-4}
1 litre of cold water for outdoor use	0.000	0.0000	2.71×10^{-4}

FOR ELECTRICAL HOT WATER SYSTEMS

Litre type	Domestic hot water energy consumption (kWh)	Domestic hot water carbon emissions (Kg CO_2)	Indirect carbon emissions (Kg CO_2eq)
1 litre of hot water for taps and showers	0.031	0.0171	7.47×10^{-4}
1 litre of hot water for a bath	0.034	0.0191	7.47×10^{-4}
1 litre of cold water for indoor use	0.000	0.0000	7.47×10^{-4}
1 litre of cold water for outdoor use	0.000	0.0000	2.71×10^{-4}

Table 7 - Per-litre values for energy and direct and embedded carbon emissions saving for both gas and electricity hot water systems

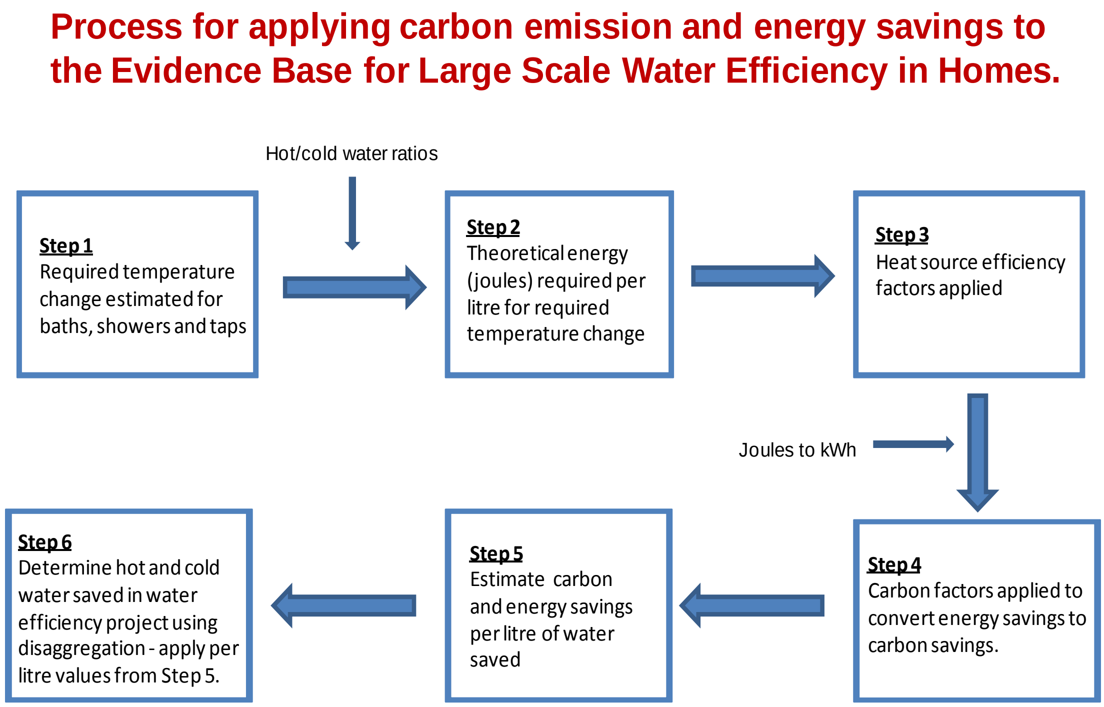


Figure 4 - Diagram of the modelling process

3.2.2.3 Confidence Intervals

The trials included in the October 2008 Evidence Base report were subject to an assessment of uncertainty as defined in the UKWIR Sustainability of Water Efficiency Measures report (Report Ref. No. 06/WR/25/2)[12]. This method places the data into one of three bands with regard to both accuracy and reliability. However, in Phase II of the Evidence Base 90% confidence intervals will be applied to the water savings. The aim is to make the uncertainty involved in the water efficiency trials as easily comprehensible as possible. One argument in favour of confidence intervals is that they allow uncertainty in the data to be taken into account in models to which Evidence Base data may be applied such as in UKWIR's EBSD framework.[13] It would be difficult to take uncertainty into account in such models if reliability and accuracy bands were used.

3.2.2.4 Distribution of Savings

The inclusion of water saving histograms in this report has given us further insight into how customers respond to being engaged by companies through water efficiency retrofitting. It will also show us that there is a fairly predictable structure to the distribution of savings obtained from water efficiency retrofitting projects.

[12] UKWIR Sustainability of Water Efficiency Measures report (Report Ref. No. 06/WR/25/2)

[13] UKWIR, The Economics of Balancing Supply & Demand (EBSD) Guidelines (02/WR/27/4)

3.2.2.5 Understanding Costs

It is essential that the Evidence Base presents data that allows the cost of implementation of water efficiency trials to be evaluated. The cost of water savings is something which is clearly defined in each of the water efficiency retrofitting trials in this report. Including cost analysis of the trials in the Evidence Base will help harness the experience gained from budgeting for different sizes and types of water efficiency trial. This will be invaluable when upscaling to large-scale water efficiency projects.

3.2.2.6 Uptake Rates

Data was available for each of the trials included in Phase II to allow the level of customer interest, as expressed by the uptake rate, to be included for each of the retrofitting trials. The uptake rate simply describes the proportion of customers invited to benefit from the trial who actually end up taking part. This is a useful reference for stakeholders who are planning to carry out water efficiency projects, as it has previously been difficult to date to gauge how many customers need to be invited in order to ensure a certain level of participation in a trial or project.

3.2.2.7 Background Changes in Demand

Water company 2010 June Return submissions to Ofwat (Chapter 10)[14] were used in order to obtain the per capita consumption (measured household – excluding supply pipe leakage) for 2002-03, 2007-08, 2008-09 and 2009-10. The per capita measured consumption figures were converted into per household measured consumption figures (an occupancy of 2.4 was assumed) and, for the trials for which an extended dataset is available, this is plotted alongside the mean per household consumption for trial properties between 2007 and 2009. This comparison helps to show whether similarities exist between the consumption of the samples of properties involved in the trials and the average consumption of measured properties across the water company area.

[14] http://www.ofwat.gov.uk/regulating/junereturn/jrlatestdata/

3.3 New Evidence from Domestic Retrofit in Phase II

Additional data is collated from three water companies who carried water efficiency retrofitting projects, the results of which were included in the February 2010 Evidence Base report. These projects for which further data has been collected are:

- Severn Trent Water's Water Efficiency Trial
- Sutton and East Surrey Water's Preston Water Efficiency
- United Utilities' Home Audit Study
- Yorkshire Water's Water Efficiency Trial

The results from each of the trials are presented in turn below.

3.3.1 Sutton and East Surrey Water's Preston Water Efficiency

3.3.1.1 Summary

The project was initiated and coordinated by Reigate and Banstead Borough Council with funding from the Government's New Growth Points Programme, and was delivered in partnership with Raven Housing Trust, Sutton and East Surrey Water, the Environment Agency, Surrey County Council and Waterwise. The initiative was undertaken in Preston, Surrey, and had a number of components. Firstly, refurbishment was carried out on 160 dwellings within social housing as part of an enhanced Decent Homes programme. This included the installation of:

⇒ Dual-flush toilets: the toilet flushed with 4 litres for the full flush and 2.6 litres for the short flush

⇒ Water-efficient showers and shower curtains: where houses or flats had a combination boiler, a mixer shower was installed

⇒ Water butts: tenants with gardens were also offered a water butt kit. The kit that was selected was manufactured by Blackwall from recycled materials

Secondly, retrofitting of water efficiency devices was carried out on 205 properties within social housing that was not part of the Decent Homes programme. The package of retrofitted measures included toilets, taps, wasted water and leakage and garden watering.

It was originally estimated that 340 dwellings would receive a retrofit; however, at the end of the trial 205 properties had received a retrofit. This was mainly due to difficulties in contacting and accessing these properties rather than the residents refusing to have the devices fitted. Other activities included the installation of a pilot rainwater harvesting system to a block of twelve flats, which also received a bathroom refurbishment. This part of the project did not produce the expected water savings and was costly due to problems with equipment. Hence the water savings from this part of the project have not been presented here. In addition water efficiency devices were fitted in a school and leisure centre, including urinal controls, push taps and new dual-flush toilets. A promotional and awareness campaign, including outreach work, information leaflets, giveaways and discount vouchers was also part of the project.

3.3.1.2 New Data

Table 8 gives a comparison of some of the key results from the February 2010 Evidence Base report and the results taking into account the most recently gathered monitoring data. After the original six month monitoring period overall water savings of 64.4 litres per property per day were measured. Work on retrofitting and refurbishment was finalised in March 2008 and Sutton and East Surrey Water made data available which measured consumption in properties for further periods as follows:

- For properties in blocks of flats up to August 2009
- For properties in small area metered zones up to February 2010
- For individual properties up to February 2011

Therefore, monitoring data for a further period of up to three years is available for some of the properties.

3.3.1.3 Water Savings

Taking into consideration the additional meter data which measures the post-retrofit consumption over a further mean period of 962 days, a reduction in consumption of 42.6 litres per property per day was calculated across 134 properties. In addition, the cost of retrofitting, which was £2.24 per litre, becomes £3.46 per litre with revised water savings. The cost of refurbishment is also revised upward from £27.72 per litre to £43.94 per litre.

Preston Water Efficiency Initiative	After 6 months			After 3 years		
	Retrofit	Refurbishment	Overall	Retrofit	Refurbishment	Overall
No. of properties	121	68	189	79	55	134
Water savings (l/prop/day)	50.00	90.00	64.4	31.54	58.40	42.6
Water savings (% reduction)	12.6	15.3	13.9	9.0	9.9	9.4
	Max	Min		Max	Min	
90% Confidence interval (% water saved)	43	-17		40	-10	
90% Confidence interval (litres/prop/day saved)	185	-80		212	-62	
	Retrofit	Refurbishment		Retrofit	Refurbishment	
Cost per property(£)	202	1386		202	1386	
Cost per litre per day (£)	2.24	27.72		3.46	43.94	
	Retrofit	Refurbishment	Overall	Retrofit	Refurbishment	Overall
Energy indirect carbon emissions saved (kgCO2e/d)	4.5	4.6	9.1	2.9	3.0	5.8
Domestic hot water carbon emissions saved (kgCO2/d)	0.7	16.0	16.7	0.5	10.4	10.8
Energy saving (kWh/d)	3.6	234.6	238.2	2.3	152.2	154.5
Cost of energy saved (£/year)	209.7	5336.8	5546.5	132.3	3463.0	3595.3
Cost of energy saved (£/prop/year)	2	78	29	2	63	27

Table 8 – Summary of key results from the Preston Water Efficiency Initiative

In order to help put the results from this trial into context, information was sought as to how background domestic demand has varied over the period since the project commenced. Figure 5 shows the comparison of Sutton and East Surrey Water's measured household consumption data for 2002-03, 2007-08, 2008-09 and 2009-10 with the household consumption of properties which took part in the trial. This data is taken from Sutton and East Surrey Water's 2010 June Return submission.[15] The training, retrofitting and refurbishment stages of the Preston Water Efficiency Initiative commenced in April 2007 and were completed in May 2008. It is evident from Figure 5 that the mean consumption of properties involved in the Preston Project was similar to that of measured properties in the Sutton and East Surrey Water area. During 2008 and 2009 the consumption of the trial properties falls markedly compared to SESW's measured consumption figures.

[15] Sutton and East Surrey Water's 2010 annual data submission, available at: http://www.ofwat.gov.uk/regulating/junereturn/jrlatestdata/

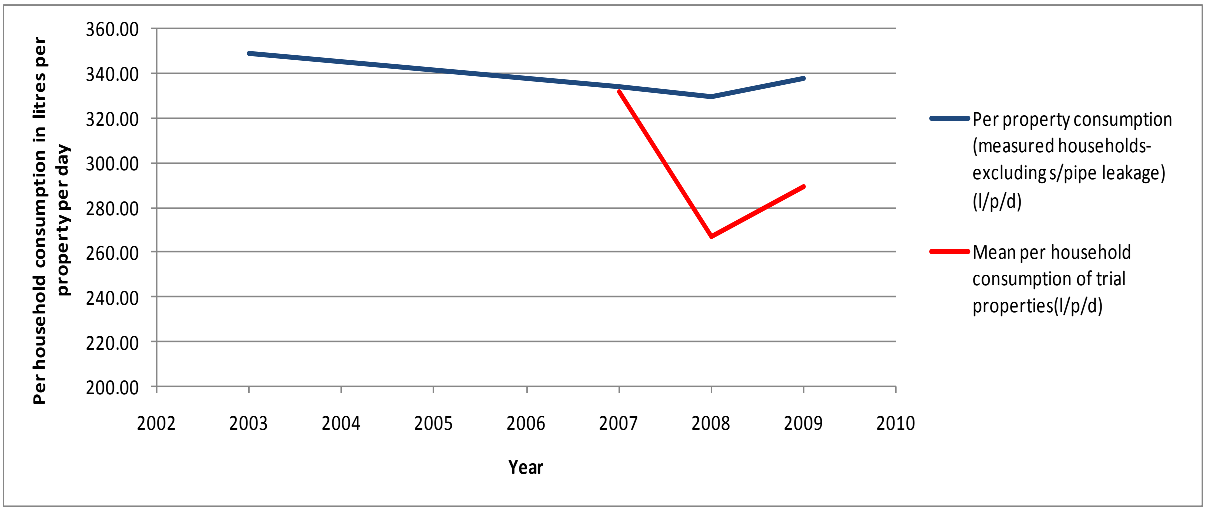


Figure 5 – Comparison of Sutton and East Surrey Water's Measured Per Household Consumption Data with Per Household Consumption Data from Trial Properties – Source: Sutton and East Surrey Water June Return 2010

3.3.1.4 Carbon Emissions and Energy Savings

As a result of the observed reduction in the level of water savings there is also a decrease in the level of carbon emissions and energy savings which result from lower levels of hot water savings. Energy indirect carbon savings of 5.8 kgCO2e/day, domestic hot water carbon emissions of 10.8 kgCO2/day and energy savings of 155 kWh/day are estimated to result from water efficiency retrofitting of the 189 properties (The new savings are calculated on the basis of the original number of properties).

3.3.2 Severn Trent Water – Water Efficiency Trial

3.3.2.1 Summary

The data included represents all properties with a valid set of at least three meter readings. In total, 911 properties were used in the analysis. The primary source of data used was gathered through the meter readings. In May of 2007, information was collected from the Severn Trent Water (STW) accounting database. The records that were obtained included all the properties within the Nottingham (District #11) and Worcester (District #06) areas that were metered. This generated a list of some 220,000 accounts.

A wide range of water efficiency devices was retrofitted in the properties which opted to be part of the trial. Dual-flush conversion devices, cistern displacement devices, tap inserts and showerheads were offered.

The selection of the areas in which to conduct the trial programme used a DMA map as the primary reference to select areas that were geographically adjacent, yet diverse enough to satisfy the requirements for ACORN groupings. The DMAs selected from each area were assembled to form 10 groups of approximately 1000 properties. Out of these, 120 properties in each group were to be surveyed. Based on information from previous projects involving the contacting of customers, a 1 in 10 success rate was adopted. In other words, for every ten customers that were contacted by phone, one would actively participate. From October 2007 to December 2007, 9446 letters were mailed. From the same source, a call list was produced for each group, and was provided to the call centre staff.

In January 2008, it started to become apparent that recruitment rates were falling from the predicted 10:1 ratio to 8.5:1. The forecast was that target numbers were not going to be met, and an additional 2,500 addresses were released, all in the Worcester area.

3.3.2.2 New Data

Severn Trent Water provided Waterwise with follow-up meter data for the properties which originally took part in the project from their billing database. Of the original 717 properties, data is included here for 689. Table 9 shows the number of days that consumption was monitored before the retrofit, immediately after the retrofit was carried out and also in the most recent follow-up period. There was a mean pre-installation monitoring period of approximately 180 days, a mean initial post-installation monitoring period of 100 days and the most recent follow-up included a mean 962 days of monitoring.

Mean No. of Pre- installation Monitoring Days	960*
Mean No. of Post-Installation Monitoring Days	90*
Mean No. of Follow- up Monitoring Days	963

* Estimated Monitoring Period

Table 9 – Monitoring Periods for Severn Trent Water's Water Efficiency Trial

3.3.2.3 Water Savings

Table 10 gives a comparison of some of the key results originally presented in the February 2010 Evidence Base report and the new analysis which takes into account the most recently gathered monitoring data. After the original three month monitoring period, savings of 28.4 litres per property per day were measured. However, taking into consideration the additional meter data which measures the post-retrofit consumption over a further mean period of 962 days, a reduction in consumption of 20.3 litres per property per day was calculated across 680 properties. In addition, the cost of water savings which was £2.61 per litre becomes £3.65 per litre with revised water savings.

The 90% confidence interval for water savings is also broader, as would be expected, with the inclusion of a longer dataset and increased variability in consumption.

Severn Trent Domestic Water Efficiency Trial	After 3 months		After 2.6 years	
	Overall		Overall	
No. of properties	717		680	
Water savings (l/prop/day)	28.4		20.3	
Percentage reduction in water savings (%)	11.4		8.2	
	Max	Min	Max	Min
90% Confidence interval (litres saved/prop/day)	149.8	-92.9	247.4	-206.8
	Overall		Overall	
Probability of water savings	0.65		0.56	
Cost per property(£)	74.06		74.06	
Cost per litre per day (£)	2.61		3.65	
Energy indirect carbon emissions saved (kgCO2e/d)	15.3		10.9	
Domestic hot water carbon emissions saved (kgCO2/d)	76.7		54.7	
Energy saving (kWh/d)	400.0		285.6	
Cost of energy saved (£/year)	23360		16681	
Cost of energy saved (£/prop/year)	33		23	

Table 10 – Summary of key results from the Severn Trent Water's Water Efficiency Trial

Figure 6 shows that, even though there is clearly a large degree of variability, there is structure to the distribution in the water savings. It cannot quite be stated that the water savings are normally distributed, but the water savings distribution alongside the curve of a normal distribution reveals more than a passing resemblance. There has also been a reduction in the proportion of properties which show water savings. From the latest data 56% of the 680 properties included in assessment made savings in their water consumption where this was previously 65%.

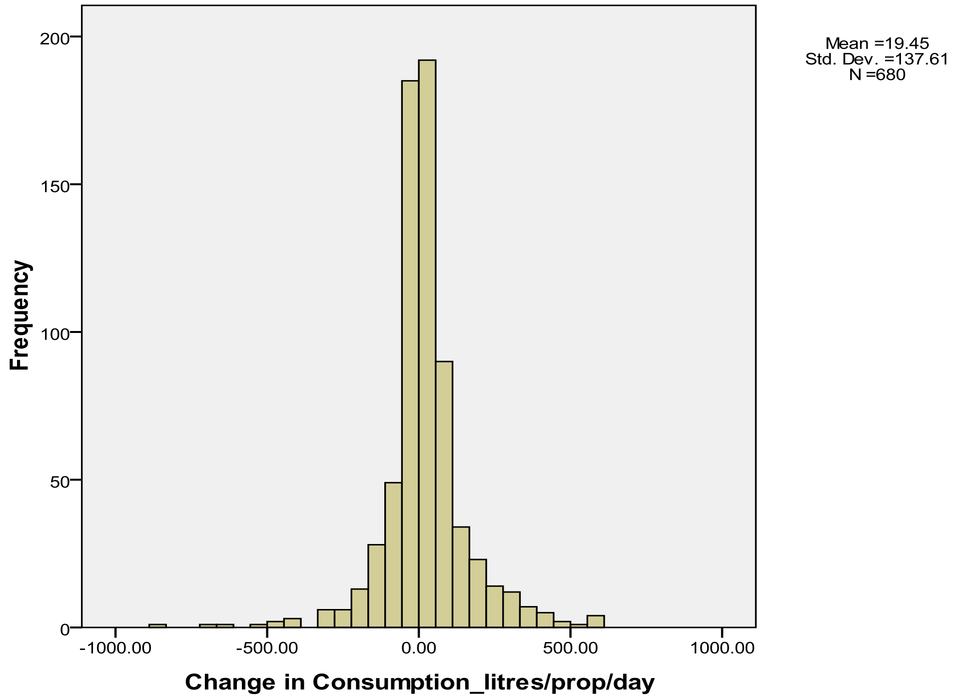


Figure 6 - Distribution of Water Savings from the Severn Trent Water's Water Efficiency Trial

Figure 7 has been included in order to help to show how background domestic demand has varied over the period since the project commenced. It shows the comparison of Severn Trent Water's measured household consumption data for 2002-03, 2007-08, 2008-09 and 2009-10 with the household consumption of properties which took part in the trial. This measured household data is taken from Severn Trent Water's 2010 June Return submission.[16] Severn Trent Water's Water Efficiency Trial commenced in 2007 and looking at Figure 7, it seems that there has been a general decline in consumption across Severn Trent Water's measured customers since at least 2002.

The plot also shows that the consumption of properties which took part in the trial is much lower (about 30 l/p/d) than the mean consumption of measured properties within Severn Trent's area. The trial was offered to all customers in the Nottingham and Worcester districts (about 22,000 customers). One reason the trial group of properties is not representative of the company's area may be due to a selection bias such that customers who agree to take part are likely to be more conscious of their water-use.

[16] Severn Trent Water's 2010 annual data submission, available at: http://www.ofwat.gov.uk/regulating/junereturn/jrlatestdata/

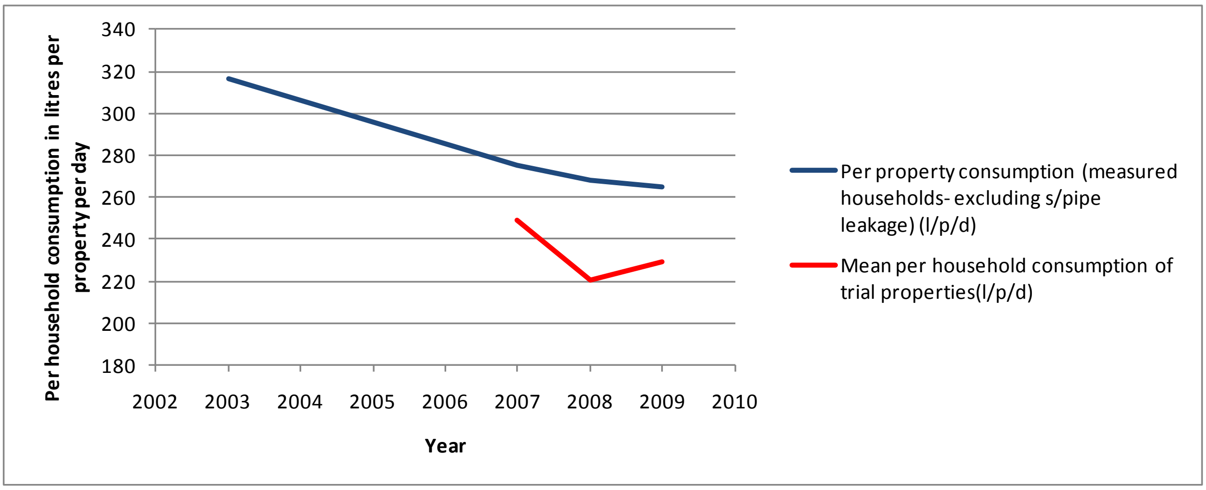


Figure 7– Comparison of Severn Trent Water's Measured Per Household Consumption Data with Per Household Consumption Data from Trial Properties – Source: Severn Trent Water June Return 2010

3.3.2.4 Carbon Emissions and Energy Savings

As a result of the observed reduction in the level of water savings there is also a decrease in the level of carbon emissions and energy savings which result from lower levels of hot water savings. Energy indirect carbon savings of 10.9 kgCO2e/day, domestic hot water carbon emissions of 54.7 kgCO2/day and energy savings of 285.6 kWh/day are estimated to result from water efficiency retrofitting of the 717 properties (The new savings are calculated on the basis of the original number of properties).

3.3.3 United Utilities Home Audit Study

3.3.3.1 Summary

This trial investigated the effectiveness of domestic water efficiency devices. Specifically it was designed to:

1. Determine the practicality of fitting and promoting a range of water-saving devices;

2. Gain a better understanding of the likely costs of fitting these devices;

3. Determine associated savings of these devices through property and District Metering Area (DMA) metering.

4,642 domestic properties in the Greater Sankey area of Warrington were sent an invitation to take part in this study. Customers were asked to respond by filling out a form to confirm they would be willing to take part in the trial.

The target population can be described as financially stable, and living in homes predominantly built since 1990, making them likely to have a water meter installed. Over 95% of the target properties were in ACORN category 1 (Wealthy achievers) or 2 (Comfortably off). The population targeted by the study is therefore not representative of the United Utilities (UU) customer base; however there are a large number of similar areas within the UU region. Once the completed application form had been received, customers were contacted by telephone to arrange a suitable time for a qualified plumber to visit the property and install water-efficient-devices. UU offered only a limited number of Saturday appointments for audits, and it is thought this could have contributed to a lower than expected uptake rate. Overall 23% of the customers who agreed to participate ultimately dropped out of the trial.

Of the 393 customers who underwent an audit, 313 were metered customers and 80 were unmetered. For metered customers, several meter readings were taken during the course of the trial. Initially the customers were asked to provide a meter reading when they responded to the invitation to take part in the trial. Subsequent meter readings were taken when the water audit was carried out, and at one-month intervals for three months following the trial. The post-installation meter readings have been used to calculate a post-trial average daily consumption for each household. Meter readings from the UU billing database from before the trial began were also collated (from as early as December 2006) and used to calculate a pre-trial average daily consumption for each household.

Device Fitted	Number fitted (Percentage of homes)
Showerheads	212 (48%)
Ecobeta dual flush retrofits	193 (34%)
Save-a-flush bags	384 (58%)

Table 11- Water saving devices installed during the United Utilities Home Audit Project

All customers who had a water audit carried out were given a 'water savers pack' which included a basic shower timer and information on saving water. Further devices were installed where appropriate, including water-efficient showerheads (Challis aerated showerheads), dual-flush retrofit (EcoBETA dual-flush devices) and save-a-flush cistern displacement devices. Customers were given the option of requesting the removal or repair of water-efficient devices for up to three months after they were fitted. Devices were installed by 3 qualified plumbers, who each completed up to 5 appointments per day during the installation window. During the water audit, information was gathered on the types and number of water-using appliances installed in the home, and behaviour on water use. In addition, information on occupancy was confirmed. Where showerheads were installed, pre-installation and post-installation flow rate readings were measured using a 'shower bag'.

3.3.3.2 New Data

United Utilities provided Waterwise with follow-up meter data for the properties which originally took part in the project from their billing database. Of the original 211 properties, data is included here for 208. Figure 8 shows the number of days that consumption was monitored before the retrofit, immediately after the retrofit was carried out and also in the most recent follow-up period. There was a mean pre-installation monitoring period of 3080 days, a mean post-installation monitoring period of 197 days and the most recent follow-up included a mean 951 days of monitoring.

Mean No. of Pre- installation Monitoring Days	3080
Mean No. of Post-Installation Monitoring Days	197
Mean No. of Follow- up Monitoring Days	951

Figure 8 – Monitoring Periods for United Utilities Home Audit Study

3.3.3.3 Water Savings

Table 12 gives a comparison of some of the key results from the original results presented in the February 2010 Evidence Base report and the results taking into account the most recently gathered monitoring data. After the original 6 month monitoring period savings of 20.6 litres per property per day were measured. However, taking into consideration the additional meter data which measures the post-retrofit consumption over a period of a mean period of 957 days, a reduction in consumption of 28.7 litres per property per day was calculated across 208 properties. In addition, the cost of water savings which was £6.88 per litre becomes £4.94 per litre with revised water savings.

The 90% confidence interval for water savings is also broader, as would be expected, with the inclusion of a longer dataset.

United Utilities Home Audit Study	After 6 months		After 3 years	
	Overall		Overall	
No. of properties	211		208	
Water savings (l/prop/day)	20.6		28.7	
Water savings (% reduction)	6.8		9.2	
	Max	Min	Max	Min
90% Confidence interval (litres saved/prop/day)	169.4	-128.1	195.7	-138.3
	Overall		Overall	
Probability of water savings	0.67		0.67	
Cost per property(£)	141.92		141.92	
Cost per litre per day (£)	6.88		4.94	
Energy indirect carbon emissions saved (kgCO2e/d)	3.3		4.5	
Domestic hot water carbon emissions saved (kgCO2/d)	16.1		22.4	
Energy saving (kWh/d)	85.4		118.8	
Cost of energy saved (£/year)	4985		6940	
Cost of energy saved (£/prop/year)	24		33	

Table 12 – Summary of key results from the United Utilities Home Audit Study

The 90% confidence interval covers a wide band of percentage savings: it is 90% certain that between 195.7 litres per property per day reduction and a 138.3 litres per property per day increase in water consumption. For any individual property there is a large amount of uncertainty. However, looking across the entire sample gives greater confidence that the majority of properties will actually save water during a trial such as United Utilities'. Figure 9 shows the distribution of the per litre water-use reduction achieved for the 208 properties for which data has continued to be collected since the trial. The histograms show that the majority - 141 customers out of the 211 (about 67%) - reduced their water usage after retrofitting as part of the UU study.

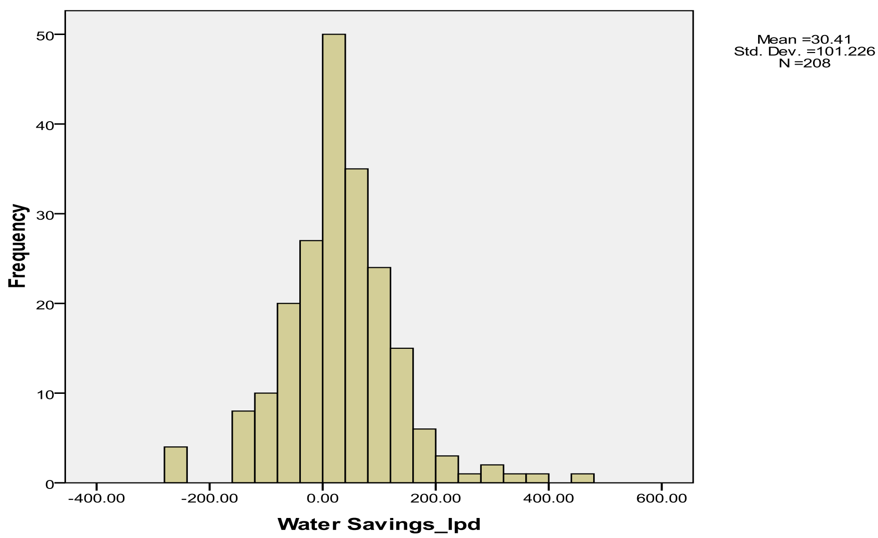


Figure 9 - Distribution of Water Savings from the United Utilities Home Audit Study

Figure 10 has been included in order to help to show how background domestic demand has varied over the period since the project commenced. It compares United Utilities' measured household consumption data for 2002-03, 2007-08, 2008-09 and 2009-10 with the household consumption of properties which took part in the trial. The measured household data is taken from United Utilities' 2010 June Return submission.[17] The trial data has been plotted excluding the effect of the control group demand on the trial properties. United Utilities' Home Audit Study commenced in 2007.

The offer to participate in the trial was mainly made to United Utilities customers in more wealthy socio-economic groups. This explains why the consumption of the trial group is different (about 40 l/p/d) from the mean measured consumption in the United Utilities' area. Figure 10 shows that there has been a steady decline in the consumption of measured customers in United Utilities' area from at least 2002, with the exception of between 2008 and 2009 when there was an increase in consumption.

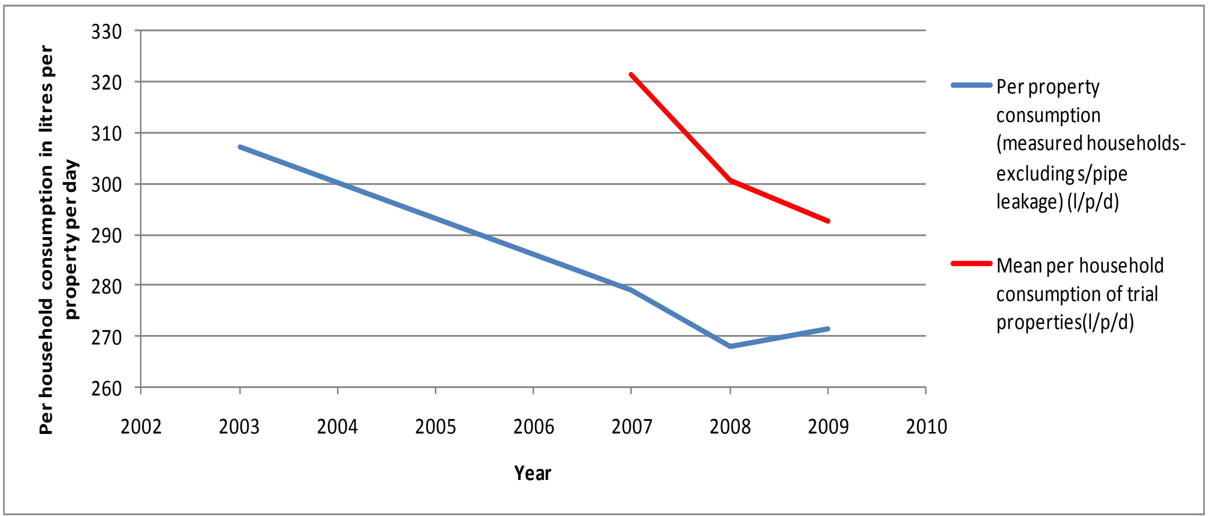


Figure 10 – Comparison of United Utilities' Measured Per Household Consumption Data with Per Household Consumption Data from Trial Properties – Source: United Utilities June Return 2010

3.3.3.4 Carbon Emissions and Energy Savings

As a result of the observed increase in the level of water savings there is also an increase in the level of carbon emissions and energy savings which result from higher levels of hot water savings. Energy indirect carbon savings of 4.5 kgCO2e/day, domestic hot water carbon emissions of 22.4 kgCO2/day and energy savings of 118.8 kWh/day are estimated to result from water efficiency retrofitting of the 211 properties (The new savings are calculated on the basis of the original number of properties).

[17] United Utilities 2010 annual data submission, available at: http://www.ofwat.gov.uk/regulating/junereturn/jrlatestdata/

3.3.4 Yorkshire Water – Water Saving Trial

3.3.4.1 Summary

The Water Saving Trial (WST) was carried out to assess the feasibility of reducing water into supply through installing retrofit devices into customers' properties. Data was obtained from householders who agreed to have a selection of water saving devices installed in their properties. The objectives of the trial were to establish:

- the performance of a selection of water saving devices
- the acceptability of water-efficient products to customers
- customers' attitudes to water efficiency
- the volume of water saved through installing water-efficient devices
- the cost of installing water-efficient devices
- the cost-effectiveness of installing water-efficient products on a larger scale.

The project aimed to include 500 properties in the Water Saving Trial. Two areas of the Yorkshire Water supply system were included to provide some variation in the types of households that were participating. The areas chosen were Scarborough and Wakefield.

Wakefield was selected to represent an urban area in the Grid Surface Water Zone with customers connected to the grid system. The grid supplies 96% of Yorkshire Water's customers. Scarborough is part of the East Ground Water Zone and represents a demand area supplied by local groundwater resources that is currently not supported by the grid system. However, a pipeline connecting the two zones will be completed in 2011 and the East Ground Water Zone will become part of the Grid Surface Water Zone. A letter was sent to 5,000 properties in total, 2,500 in each area, to recruit households willing to take part in the Water Saving Trial. The letter included a questionnaire requesting information on occupancy rate, age of occupants, council tax band and type of house.

All of the properties sent the recruitment letter were metered. This meant water savings could be measured from existing meters and no cost was incurred through installing meters. Additionally, metered households had an incentive to take part as the installation of water-efficient products had the potential to reduce their bills. In response to the recruitment letter sent to 5,000 properties, a total of 986 households agreed to take part in the trial. The 500 properties to take part in the trial were selected using the information provided in the questionnaires, with 250 selected from each of the two areas. The 19.72% return rate provided a good variation in property types, occupancy rates and age groups.

As there was a good return rate sufficient information was available to collect meter reads from a control sample and a reserve group in addition to those selected to participate in the trial. One hundred properties were included in the control group: 50 in each of the two areas. The control sample was not made aware that they were part of the trial. Meter readings were also collected from an additional 20 properties in each area to provide a reserve group to replace any selected properties that no longer wished to take part. The reserve group were only made aware they were part of the trial if they were selected to replace a selected property.

3.3.4.2 New Data

Yorkshire Water provided Waterwise with follow-up meter data for the properties which originally took part in the project from their billing database. Of the original 378 properties, data is included here for 337. Figure 11 shows the number of days that consumption was monitored before the retrofit, immediately after the retrofit was carried out and also in the most recent follow-up period. There was an estimated mean pre-installation monitoring period of 90 days, an estimated mean post-installation monitoring period of 180 days and the most recent follow-up included a mean 780 days of monitoring.

Mean No. of Pre- installation Monitoring Days	90*
Mean No. of Post-Installation Monitoring Days	180*
Mean No. of Follow- up Monitoring Days	780

* Estimated Monitoring Period

Figure 11 – Monitoring Periods for Yorkshire Water's Water Efficiency Trial

3.3.4.3 Water Savings

Table 13 gives a comparison of some of the key results from the original results presented in the February 2010 Evidence Base report and the results taking into account the most recently gathered monitoring data. After the original six month monitoring period savings of 18.1 litres per property per day were measured. However, taking into consideration the additional meter data which measures the post-retrofit consumption over a period of a mean period of 780 days, a reduction in consumption of 14.9 litres per property per day was calculated across 337 properties. In addition, the cost of water savings which was £7.98 per litre becomes £8.37 per litre with revised water savings.

The 90% confidence interval for water savings is also broader, which would be expected to a certain extent, because of the inclusion of over two years of additional data. As part of this trial a control group of 88 properties was monitored and the consumption of these properties was monitored over the same period as the main group. This showed that the water consumption of the control group fell by 11.4 litres per property per day over the most recent 780-day monitoring period and 9.5 litres per property per day for the initial 6-month period. The net water saving figures in Table 13 take into account the background movement in demand measured through the control group.

Yorkshire Water - Water Efficiency Trial	After 6 months		After 2.6 years	
	Overall		Overall	
No. of properties	378		337	
Water savings (l/prop/day)	27.6		26.3	
Control group water savings (l/prop/day) - 88 properties	9.5		11.4	
Net water savings (l/prop/day)	18.1		14.9	
	Max	Min	Max	Min
90% Confidence interval (litres saved/prop/day)	124.2	-69.0	348.4	-295.8
	Overall		Overall	
Probability of water savings	0.74		0.62	
Cost per property(£)	220.24		220.24	
Cost per litre per day (£)	7.98		8.37	
Energy indirect carbon emissions saved (kgCO2e/d)	8.0		7.6	
Domestic hot water carbon emissions saved (kgCO2/d)	39.2		37.4	
Energy saving (kWh/d)	190.5		181.5	
Cost of energy saved (£/year)	11125		10601	
Cost of energy saved (£/prop/year)	29		28	

Table 13 – Summary of key results from the Yorkshire Water Water Efficiency Trial

Figure 12 shows the distribution of water savings in terms of litre reduction in use per property per day. This histograms show how much of the overall sample is saving water in such a trial. After 6 months' monitoring 74% of properties involved in this trial reduced their water consumption after analysis of before and after monitoring data. But after 2.6 years' monitoring, this had reduced to 62%.

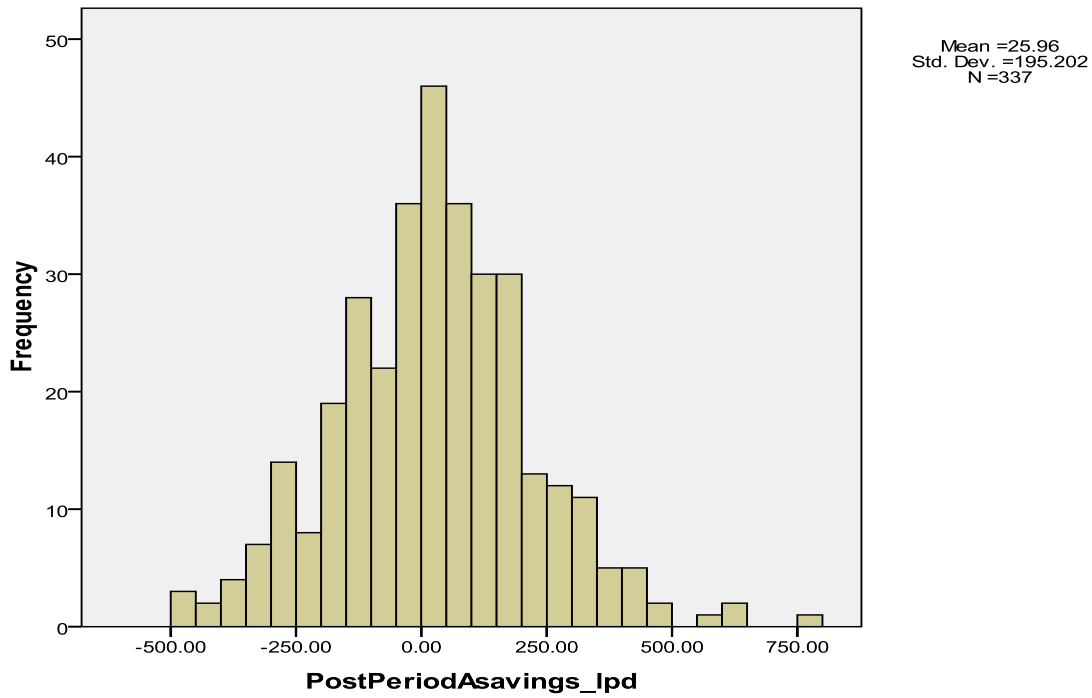


Figure 12 – Distribution of Water Savings from the Yorkshire Water Water Efficiency Trial

Figure 13 has been included in order to help show how background domestic demand has varied over the period since the project commenced. It compares Yorkshire Water's measured household consumption data for 2002-03, 2007-08, 2008-09 and 2009-10 with the household consumption of properties which took part in the water efficiency trial. This data is taken from Yorkshire Water's 2010 June Return submission.[18] Yorkshire Water's Water Efficiency Trial commenced in June 2007.

The plot also shows that the consumption of properties which took part in the trial is much lower (about 40 l/p/d) than the mean consumption of measured properties within Yorkshire Water's area. The trial was offered to 5000 customers split equally between Scarborough and Wakefield to try to ensure that a broad range of customers were included. However, one reason the trial group of properties is not representative of the company's area in terms of water consumption may be due to a selection bias, such that customers who agree to take part are likely to be more conscious of their water-use.

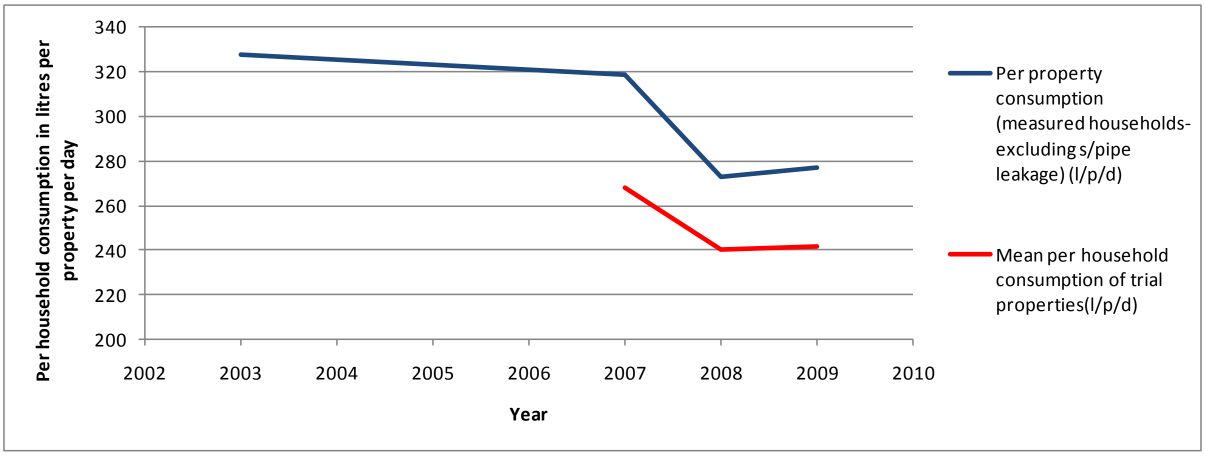


Figure 13 – Yorkshire Water's Measured Per Household Consumption Data with Per Household Consumption Data from Trial Properties – Source: Yorkshire Water June Return 2010

3.3.4.4 Carbon Emissions and Energy Savings

As a result of the observed increase in the level of water savings there is also an increase in the level of carbon emissions and energy savings which result from higher levels of hot water savings. Energy indirect carbon savings of 7.6 kgCO2e/day, domestic hot water carbon emissions of 37.4 kgCO2/day and energy savings of 181.5 kWh/day are estimated to result from water efficiency retrofitting of the 378 properties (The new savings are calculated on the basis of the original number of properties).

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[18] Yorkshire Water's 2010 annual data submission, available at: http://www.ofwat.gov.uk/regulating/junereturn/jrlatestdata/

3.4 Limitations

The additional data which has been analysed for four trials in this report is derived from water company billing systems which are used to collect meter readings every six months. It is possible to understand from this data how much water is consumed in a property but it is impossible to be certain from this information alone whether factors other than the technological changes that have been carried out in the home or the behaviour of the original householders who occupied the property when devices were originally installed have influenced the consumption over the extended monitoring period. Three areas of uncertainty are described below:

- Background changes in consumption
- Occupancy changes
- Supply pipe leakage
- Uninstalled products

3.4.1 Background changes in consumption

One of the four trials for which further consumption data is analysed in this report has a control property which is monitored simultaneously to the main group of properties. Having a control group of properties, in which there are no changes made to water using devices but which is monitored in parallel with the properties in which devices are installed (the study group) is a useful means of assessing the extent to which background changes influence the consumption changes which are observed as part of the trial.

In the February 2010 Evidence Base report four trials monitored control groups and two trials increased saw the background trend in consumption rise and in two trials it fell. There is no way to be certain of the magnitude or direction of the background influence on water consumption so this makes it essential to include a control group in water efficiency trials. Furthermore it is important to ensure that a meaningful comparison is being made between the control and study groups.[19] That is to say, certain characteristics should be similar between the two groups:

- Consumption profile
- Types of dwelling (flat, house, bungalow, cottage, etc.)
- Homes with gardens
- Occupancy
- Customer profile distribution using a suitable segmentation tool.

[19] Waterwise, 'Water Efficiency Retrofitting: A Best Practice Guide', November 2009, http://www.waterwise.org.uk/images/site/Research/water%20efficiency%20retrofitting%20best%20practice_final.pdf

3.4.2 Occupancy changes

There is evidence from within water companies that turnover of property tenancy can be as high as 20% per year in some areas. In trying to assess whether water efficient devices and how customers use them, are responsible for reduction in consumption in a group of properties, it is important that the number of people who live in the properties does not change drastically over the monitoring period, to the extent that this masks the effect of the product installation. This means that a major challenge when assessing the change in water consumption in properties over the long term are to

- be aware that a change of occupancy has taken place
- understand how occupancy has changed (number of tenants)
- account for the change in occupancy in the evaluation

Data is not currently available to enable the above factors to be taken into account in the analysis of the results from the current trials. Therefore it was not been possible to assess how significant a influence change in occupancy may have on the results of a water efficiency retrofitting trial which is evaluated over the long term. As such this remains a source of uncertainty in the results of water efficiency trials which are evaluated over the long term.

3.4.3 Supply pipe leakage

Supply pipe leakage is another potential source of uncertainty in the results of domestic water efficiency retrofitting trials. Where monthly meter reads are used to evaluate savings, it is impossible to determine whether an increase in consumption is due to a change in customer behaviour or simply due to a leak downstream of the meter. One way to be able to identify when leakage is an issue could be to use higher resolution data but this is expensive, as it would require a data logger to be installed on a standard meter or otherwise to use smart metering technology to identify and then arrange to repair leaks at properties during a trial.

3.4.4 Uninstalled products

There is a possibility that retrofit devices such as for dual flush conversion, cistern displacement, tap and shower inserts or showerheads may be uninstalled by customers who take part in water efficiency trials. This means that where there is an observed reduction over time in the water savings, this may be due to the fact that the changes made in the home at the time of the audit which have since been reversed. One way to understand how widespread a phenomenon this is would be to carry out follow-up surveys with customers who took part in trials. This could also provide useful feedback on customer satisfaction with products that are offered through water efficiency projects.

3.5 Scenarios for Domestic Retrofitting

The Water Saving Group identified problems of transferability as a key barrier to large-scale water efficiency. As a result, the October 2008 Evidence Base report presented scenarios which were extremely well received by the water companies and other stakeholders planning water efficiency projects and trials. Therefore, new scenarios have been updated from previous reports using the range of savings values identified from the evidence and apply them to a set of possible water efficiency programmes. In particular, new evidence in this report has been applied to produce new assumptions of the rate of decay of water savings. The new half-life assumptions are as follows:

⇒ Best estimate half life: 8.4 years (based on data presented in section 3.3)
⇒ Best case half life: 25 years
⇒ Worst case half life: 2.5 years

The scenarios chosen in order to illustrate how the evidence in this report can be used for water resources planning are as follows:

⇒ Scenario 1: Social Housing
⇒ Scenario 2: Energy company
⇒ Scenario 3: Whole Town
⇒ Scenario 4: Retail Led Retrofit
⇒ Scenario 5: Piggybacking on Water Company Metering Programmes
⇒ Scenario 6: Toilet Amnesty
⇒ Scenario 7: Piggybacking on Government Retrofitting Schemes

Each scenario is described in detail below, with the input data used in the AISC spreadsheet tool provided. Results from the analyses are displayed for the best estimate, best case and worst case variations of each scenario.

3.5.1 Scenario 1 – Social Housing

A social housing provider and a water company form a partnership brokered by the local council or Waterwise. They carry out retrofitting of toilets and taps in social housing along with engagement to encourage tenants to change their behaviour with regard to water use.

Scenario 1 - Social Housing Partnership with Water Company		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	10,000	Based on the number of homes managed by a relatively small housing association
Max expected	20,000	
Min expected	8,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	55%	Captive market; best case based on Sutton and East Surrey Preston estate project
Best case	60%	
Worst case	40%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£15.00	Waterwise estimate; toilet and tap retrofit; one toilet per home; water company pays full cost of devices
Best case	£10.00	
Worst case	£25.00	
Installation costs (per property)		
Best estimate	£15.00	Installation costs shared 50:50 between social housing provide and the water company
Best case	£5.00	
Worst case	£20.00	
Administration costs (per property)		
Best estimate	£0.10	Procurement of dual flush devices and tap inserts
Best case	£0.00	
Worst case	£0.50	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants, which may be done by the housing association
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	34.00	Wessex Water - Water Efficiency Trial
Best case	45.00	Sutton and East Surrey Preston project
Worst case	20.00	South West Water - Water Efficiency Trial (dual flush conversion element of trial)

Table 14 - Data input into the AISC spreadsheet tool for scenario 1

The AIC, AISC and NPV values for Scenario 1 are given in Table 15 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

		Best Estimate	Best Case	Worst Case
	AIC (p/m3)	26.70	3.58	172.58
	AISC (p/m3)	24.33	1.20	170.20
NPV values				
	WAFU*(Ml)	440.29	2137.52	59.53
	Capex (£M)	0	0	0
	Opex (£M)	0.13519	0.162	0.10512
	Social & Env Costs (£M)	-0.010	-0.051	-0.001

Table 15 - AIC, AISC and NPV results for Scenario 1

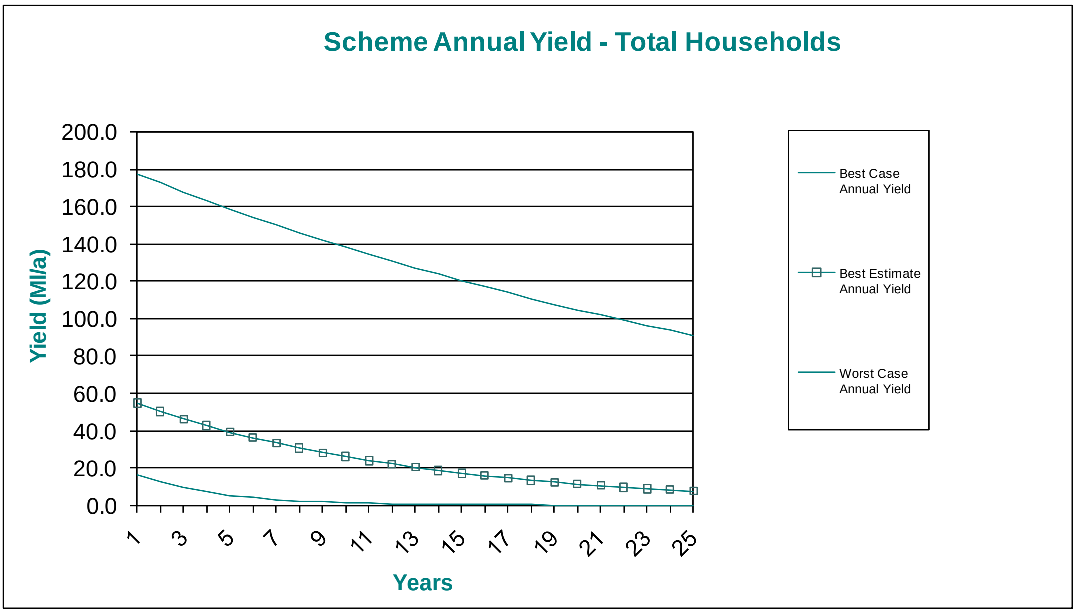

Figure 14 - Annual yield for scenario 1

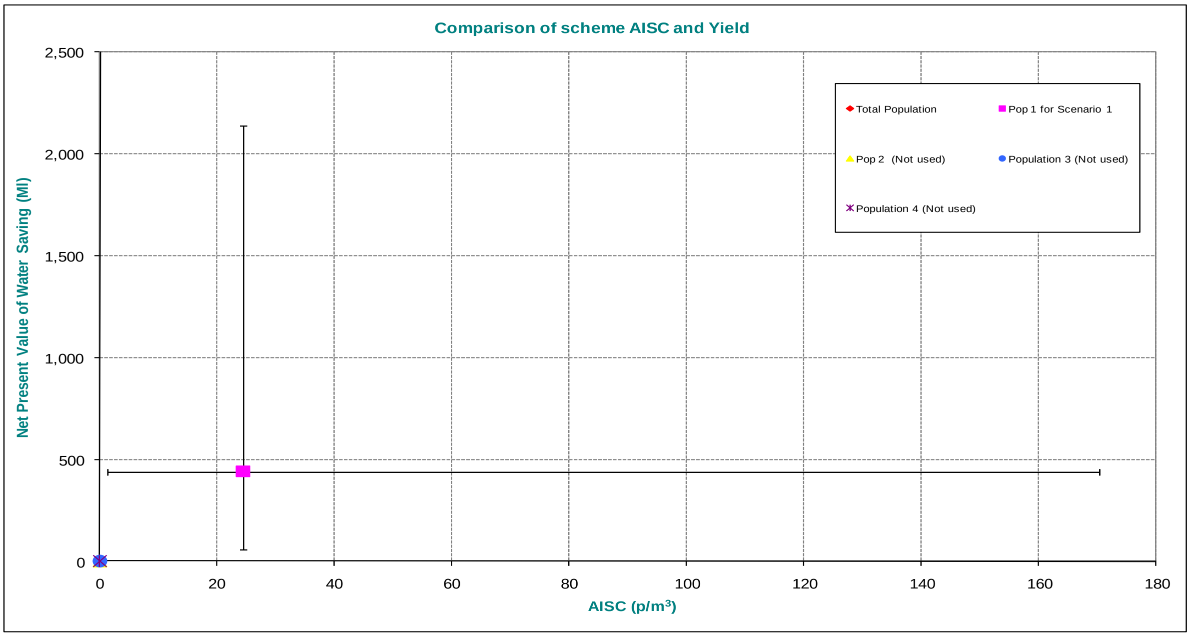

Figure 15 - Comparison of scheme AIC and yield for scenario 1

3.5.2 Scenario 2 - Energy Company

A water company and an energy company work together to carry out simultaneous water and energy retrofitting in private housing including the installation of water-efficient showerheads, converting toilets to dual-flush and installing inserts and fixing leaking taps. Use is made of the Great Britain-wide CERT[20] scheme to gain credit for hot water savings made as a result of their planned collaboration. In addition combined water and energy engagement is organised to run alongside the retrofitting to encourage behaviour change with regard to water and energy use.

Scenario 2 - Energy Company		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	15,000	Waterwise estimate
Max expected	20,000	
Min expected	10,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	15%	Enhanced uptake rates because of involvement of energy company and a coordinated campaign to generate interest.
Best case	20%	
Worst case	10%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£5.00	Waterwise estimate; water company claims cold water savings and energy company claims hot water savings. The result is that the energy company is able to claim credit for carbon savings through the Carbon Emission Reduction Target Programme and uses some of this to pay for the products.
Best case	£0.00	
Worst case	£7.50	
Installation costs (per property)		
Best estimate	£5.00	Installation costs shared 50:50 between the water company and the energy company. This includes customer engagement to help ensure that positive water using behaviours are encouraged.
Best case	£10.00	
Worst case	£20.00	
Administration costs (per property)		
Best estimate	£0.10	Procurement of dual flush devices, showerheads and tap inserts
Best case	£0.00	
Worst case	£0.50	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	38.00	Thames Water Measured Visit and Fix Trial
Best case	41.00	Anglian Water Ipswich Area WEM Trial
Worst case	20.00	South West Water - Water Efficiency Trial (results for ecobeta installation)

Table 16 - Data input into the AISC spreadsheet tool for scenario 2

[20] Joint water and energy schemes using CERT have been successful, but there are barriers to this, not least through the interpretation of the "additionality" principle in CERT. Furthermore, at time of print a Coalition Government decision was pending on whether water efficiency products would remain in CERT to its conclusion in December 2012.

The AIC, AISC and NPV values for Scenario 2 are given in Table 17 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

		Best Estimate	Best Case	Worst Case
	AIC (p/m³)	5.59	1.55	106.73
	AISC (p/m³)	-15.00	-19.05	86.14
NPV values				
	WAFU*(Ml)	201.31	649.17	18.60
	Capex (£M)	0	0	0
	Opex (£M)	0.019305	0.036	0.0206
	Social & Env Costs (£M)	-0.041	-0.134	-0.004

Table 17 - AIC, AISC and NPV results for Scenario 2

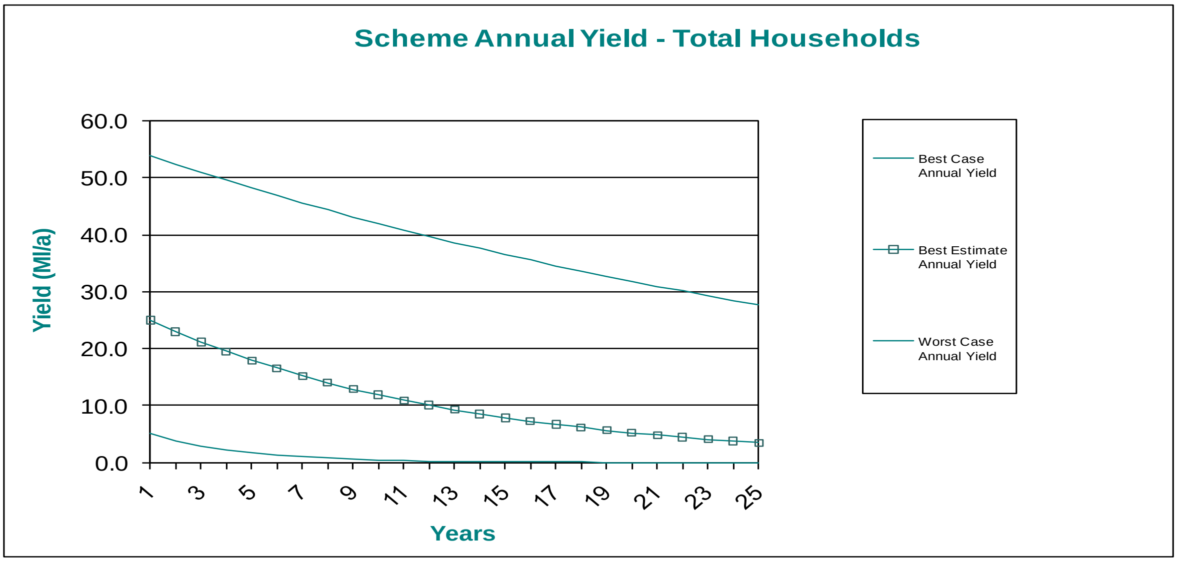

Figure 16- Annual yield for scenario 2

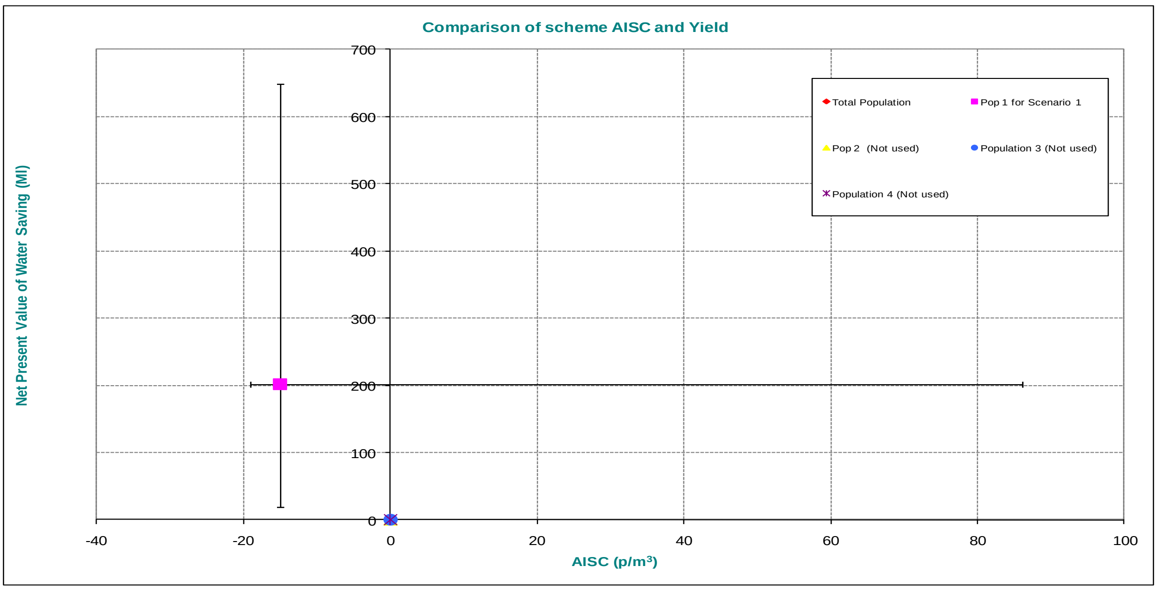

Figure 17- Comparison of scheme AIC and yield for scenario 2

3.5.3 Scenario 3 – Whole Town

A water company retrofits a whole town to install water-efficient showers and tap inserts in addition to converting toilets to dual-flush.

Scenario 3 - Whole Town		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	35,000	Based on a plan to retrofit the whole of a medium sized town by a water company in partnership witih local government and non-governmental organisations.
Max expected	70,000	
Min expected	15,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	15%	Enhanced uptake rates because of involvement of local government and a coordinated campaign to generate interest.
Best case	20%	
Worst case	10%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£25.00	Waterwise estimate; Could be lower if used CERT credits as in Scenario 2.
Best case	£18.00	
Worst case	£30.00	
Installation costs (per property)		
Best estimate	£60.00	Estimate from Evidence Base Phase II - Severn Trent Domestic WET, United Utilities Home Audit Trial
Best case	£20.00	
Worst case	£120.00	
Administration costs (per property)		
Best estimate	£0.10	Procurement of dual flush devices, showerheads and tap inserts
Best case	£0.00	
Worst case	£0.50	
Recruitment costs (per propoerty)		
Best estimate	£1.00	Letter to participants
Best case	£1.50	
Worst case	£2.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	38.00	Thames Water Measured Visit and Fix Trial
Best case	45.00	Sutton and East Surrey Preston project
Worst case	20.00	South West Water - Water Efficiency Trial (results for ecobeta installation)

Table 18- Data input into the AISC spreadsheet tool for scenario 3

The AIC, AISC and NPV values for Scenario 3 are given in Table 19 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	73.10	15.96	571.43
	AISC (p/m^3)	52.50	-4.64	550.83
NPV values				
	WAFU*(Ml)	469.72	2493.77	27.91
	Capex (£M)	0	0	0
	Opex (£M)	0.362145	0.4977	0.160575
	Social & Env Costs (£M)	-0.097	-0.514	-0.006

Table 19 - AIC, AISC and NPV results for Scenario 3

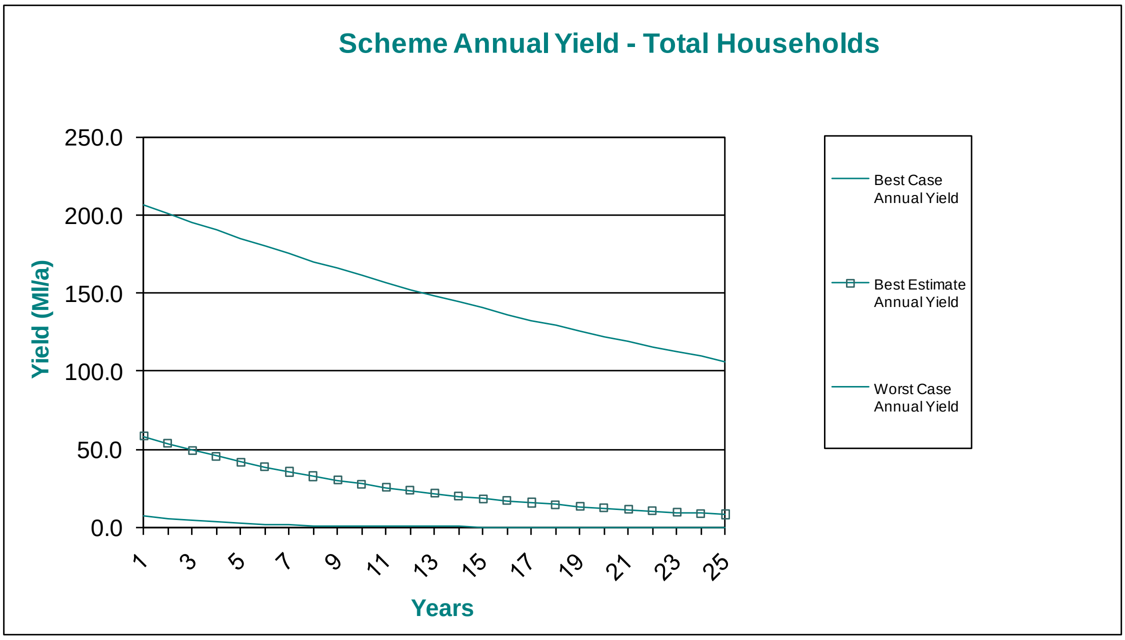

Figure 18 - Annual yield for scenario 3

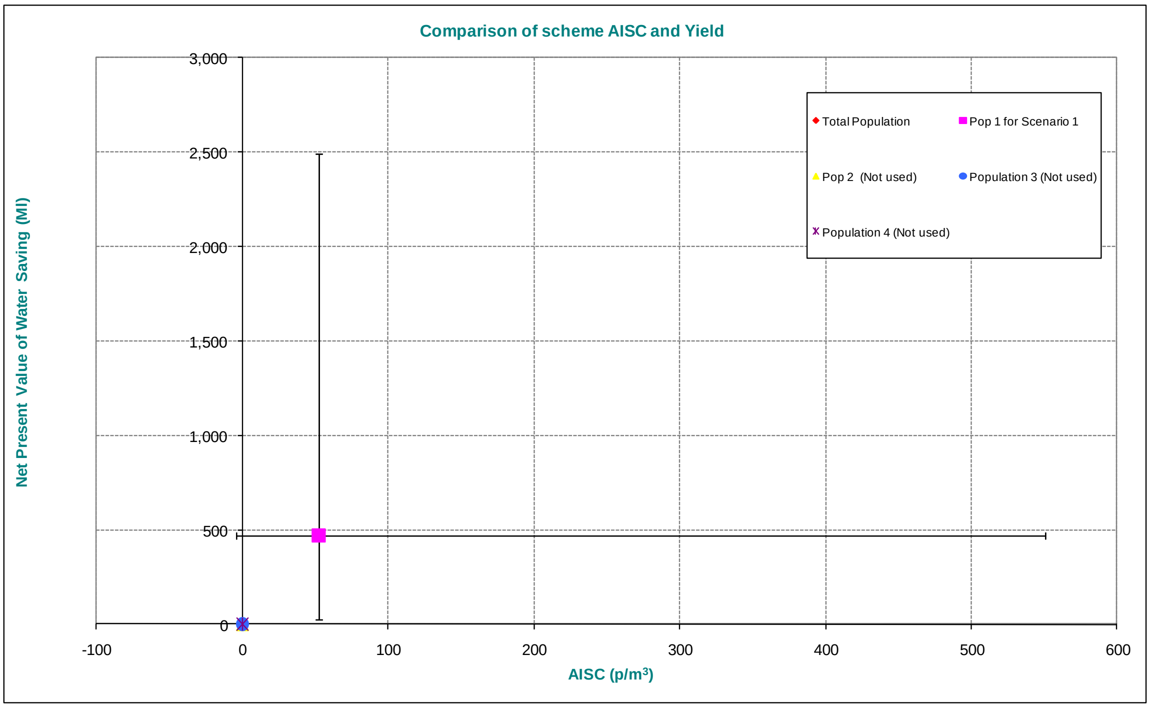

Figure 19 - Comparison of scheme AIC and yield for scenario 3

3.5.4 Scenario 4 – Retail-Led Retrofit

A retailer partners with a water company to make products which are water-efficient or increase water efficiency available to the public in their stores in a specific town at a discounted price.

Scenario 4 - Retail-Led Retrofit		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	25,000	Waterwise estimate - based on likely number visitor to the water efficient products section of a large retailer's store in a medium sized town over the course of a year.
Max expected	30,000	
Min expected	20,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	10%	Waterwise estimate
Best case	15%	
Worst case	5%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£15.00	The water company contributes £15 to the cost of equipment to be installed in the home, the remainder is paid for by the customer but the retailer may also contribute.
Best case	£0.00	
Worst case	£30.00	
Installation costs (per property)		
Best estimate	£0.00	Installation costs are paid for by the customer but the retailer organises for installation to be carried out by an approved plumber and may choose to contribute towards this.
Best case	£0.00	
Worst case	£0.00	
Administration costs (per property)		
Best estimate	£0.00	Procurement of dual flush devices, showerheads and tap inserts
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants. Part paid by the retailer
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants. Part paid by the retailer
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	25.00	Waterwise estimate
Best case	30.00	Waterwise estimate
Worst case	10.00	Waterwise estimate

Table 20 - Data input into the AISC spreadsheet tool for scenario 4

The AIC, AISC and NPV values for Scenario 4 are given in the Table 21 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	17.24	-4.00	232.51
	AISC (p/m^3)	14.86	-6.38	230.14
NPV values				
	WAFU*(Ml)	147.16	534.38	9.30
	Capex (£M)	0	0	0
	Opex (£M)	0.03125	0	0.022
	Social & Env Costs (£M)	-0.003	-0.013	0.000

Table 21 - AIC, AISC and NPV results for Scenario 4

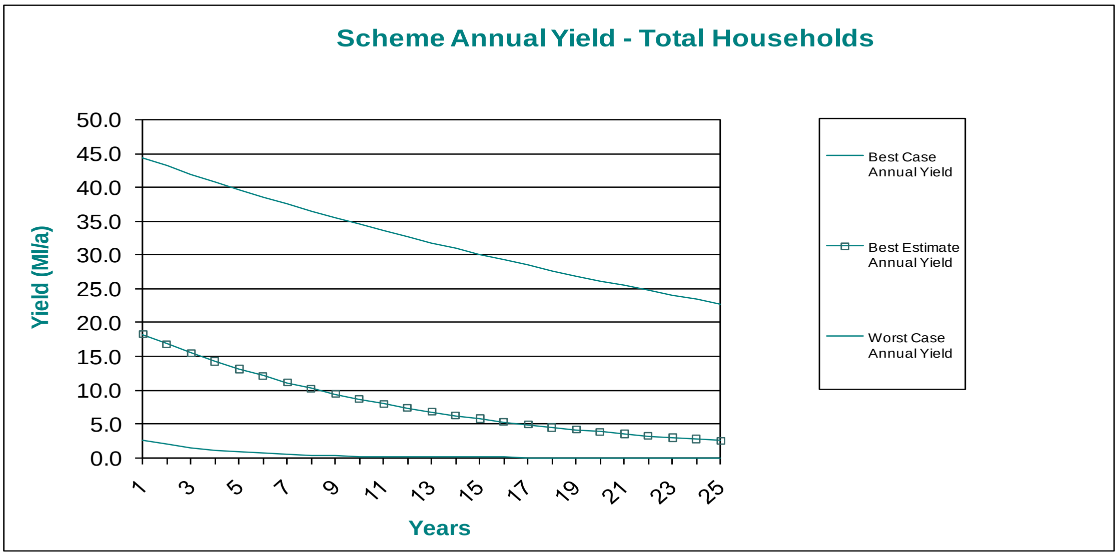

Figure 20 - Annual yield for scenario 4

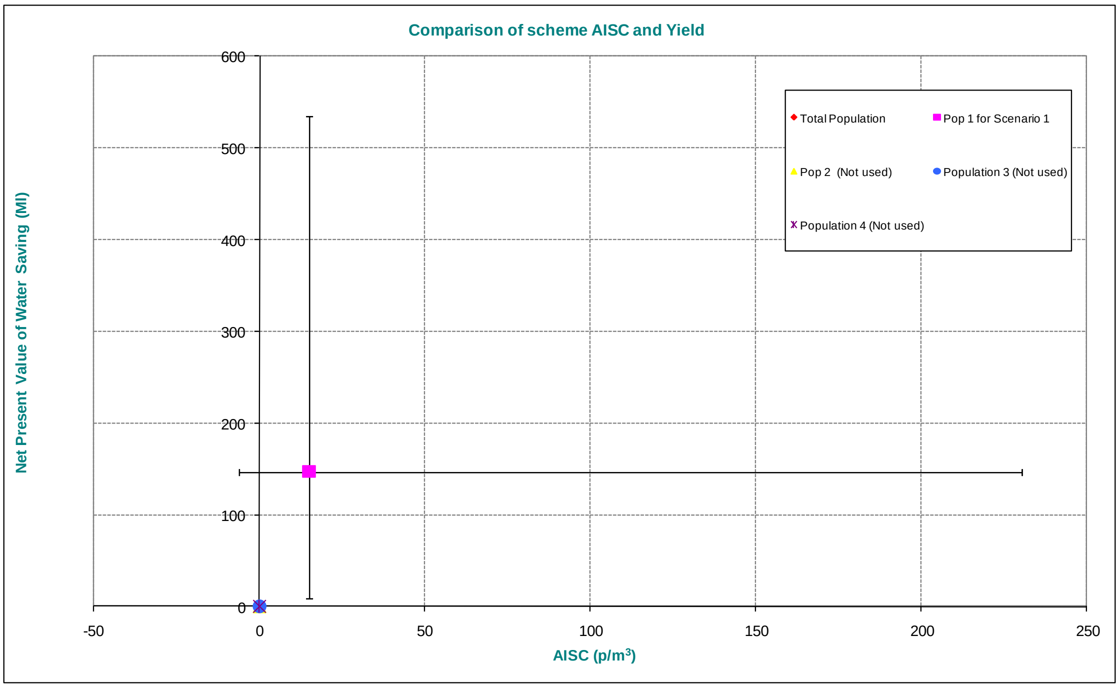

Figure 21 - Comparison of scheme AISC and yield for scenario 4

3.5.5 Scenario 5 – Piggybacking on Water Company Metering Programmes

A water company carries out an integrated demand management programme consisting of an enhanced zonal metering programme which includes water efficiency retrofitting of showers, taps and toilets in the area chosen to be metered.

Scenario 5 - Piggybacking on Water Company Metering Programmes		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	55,000	Based on zonal, compulsory metering of an entire town and offering customers the opportunity to have their homes retrofitted.
Max expected	85,000	
Min expected	35,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	10%	Enhanced uptake rates because of because of the compulsory nature of the metering programme, and with the surveyors interacting with customers there is likely to be significant opportunity to convince customers to switch to meter charging and to take part in the water efficiency part of the project.
Best case	15%	
Worst case	10%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£19.00	Waterwise estimate; toilets to dual flush, taps and showerheads included.
Best case	£17.00	
Worst case	£25.00	
Installation costs (per property)		
Best estimate	£20.00	Waterwise estimate; Reduced costs due to the fact that metering work is going ahead and hence can share resources to make water efficiency a seamless part of the enhanced metering programme.
Best case	£15.00	
Worst case	£25.00	
Administration costs (per property)		
Best estimate	£0.50	Procurement of dual flush devices, showerheads and tap inserts
Best case	£0.00	
Worst case	£1.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	41.00	Anglian Water Ipswich Trial
Best case	50.00	Waterwise estimate
Worst case	25.00	Waterwise estimate

Table 22 - Data input into the AISC spreadsheet tool for scenario 5

The AIC, AISC and NPV values for Scenario 5 are given in Table 23 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	29.25	10.55	153.82
	AISC (p/m^3)	6.47	-12.23	131.03
NPV values				
	WAFU*(Ml)	530.94	2523.46	81.39
	Capex (£M)	0	0	0
	Opex (£M)	0.17655	0.3672	0.12845
	Social & Env Costs (£M)	-0.121	-0.575	-0.019

Table 23 - AIC, AISC and NPV results for Scenario 5

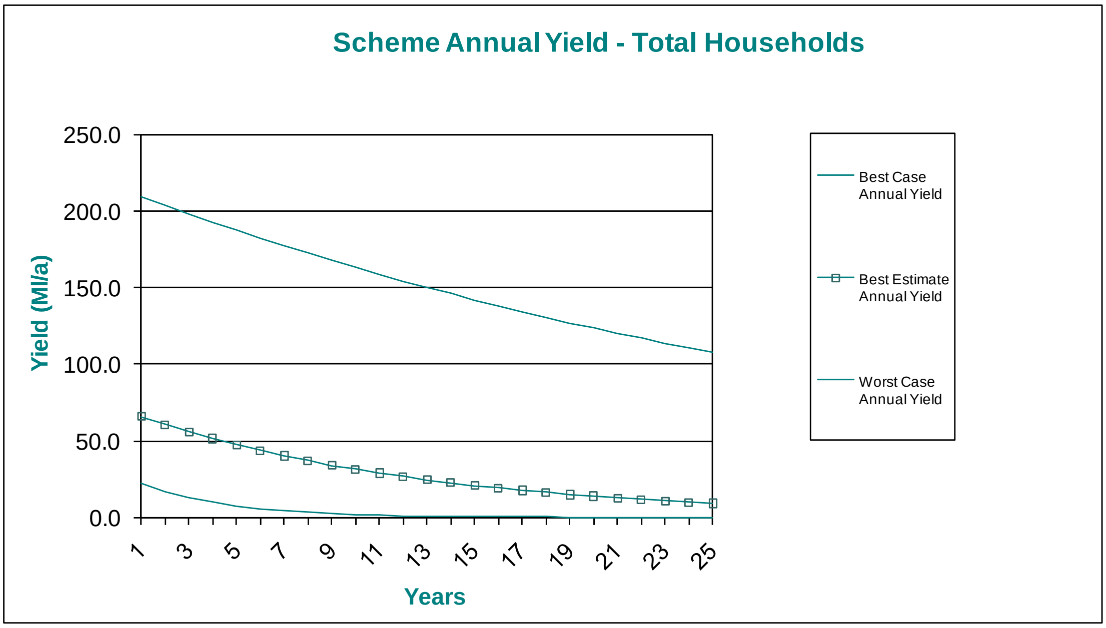

Figure 22 - Annual yield for scenario 5

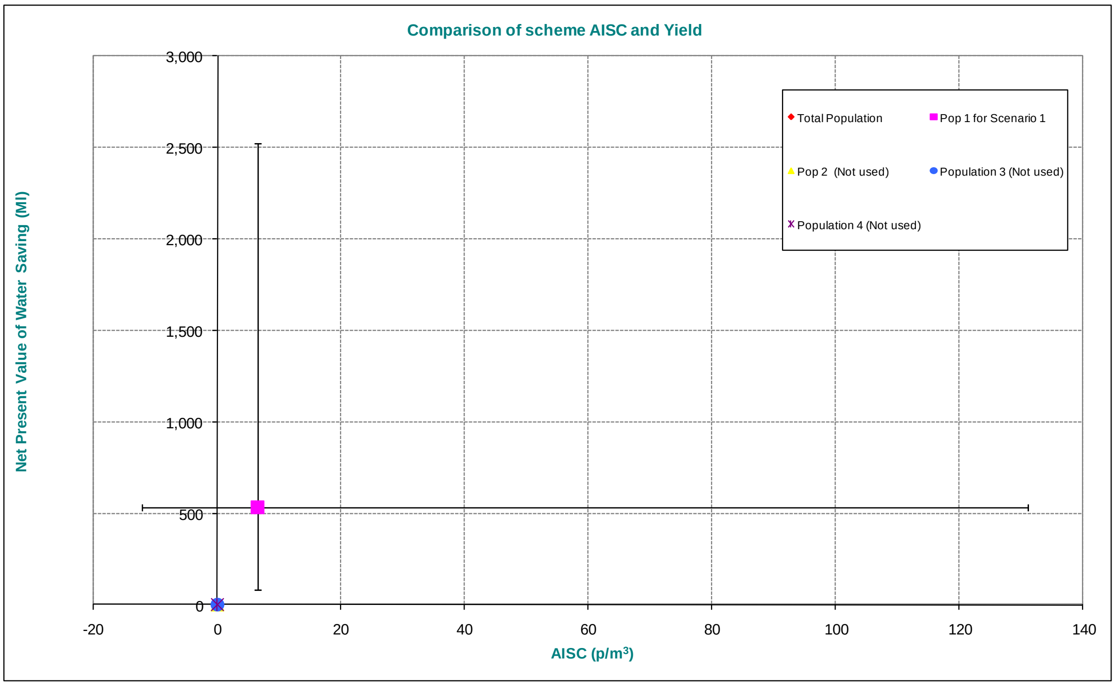

Figure 23 - Comparison of scheme AISC and yield for scenario 5

3.5.6 Scenario 6 – Toilet Amnesty

A toilet scrappage scheme is introduced which would allows replacement of old, single-flush toilets with new dual-flush toilets, and is combined with a revised Decent Homes Programme, which allows for the installation of showers as part of refurbishment work in social housing. Social housing providers would work with water companies to secure funding for the proposed refurbishment work.

Scenario 6 - Toilet Amnesty		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	5,000	A government sponsored initiative through which water company partners with a social housing providers to deliver refurbishment of water using devices in the home under the Decent Homes Scheme. This includes a toilet amnesty scheme to ensure all toilets are dual flush, installation of a
Max expected	7,500	
Min expected	3,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	90%	Enhanced uptake rates due to the involvment of the Decent Homes Initiative and of the social housing provider.
Best case	100%	
Worst case	80%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£5.00	Waterwise estimate; Refurbishment paid for through the Decent Homes Programme. But further equipment such as shower timers may be supplied by the company to encourage behaviour change.
Best case	£0.00	
Worst case	£7.50	
Installation costs (per property)		
Best estimate	£5.00	Waterwise estimate; Installation paid for through the Decent Homes Programme, though the water company may choose to carry out surveys or engage customers to encourage behaviour change.
Best case	£0.00	
Worst case	£10.00	
Administration costs (per property)		
Best estimate	£0.50	Procurement of toilets, showerheads and tap inserts
Best case	£0.00	
Worst case	£1.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	65.00	
Best case	75.00	Preston Water Efficiency Initiative
Worst case	50.00	

Table 24 - Data input into the AISC spreadsheet tool for scenario 6

The AIC, AISC and NPV values for Scenario 6 are given in Table 25 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	1.82	-4.00	25.99
	AISC (p/m^3)	-18.78	-24.59	5.40
NPV values				
	WAFU*(Ml)	688.69	2226.58	111.62
	Capex (£M)	0	0	0
	Opex (£M)	0.04005	0	0.03348
	Social & Env Costs (£M)	-0.142	-0.459	-0.023

Table 25 - AIC, AISC and NPV results for Scenario 6

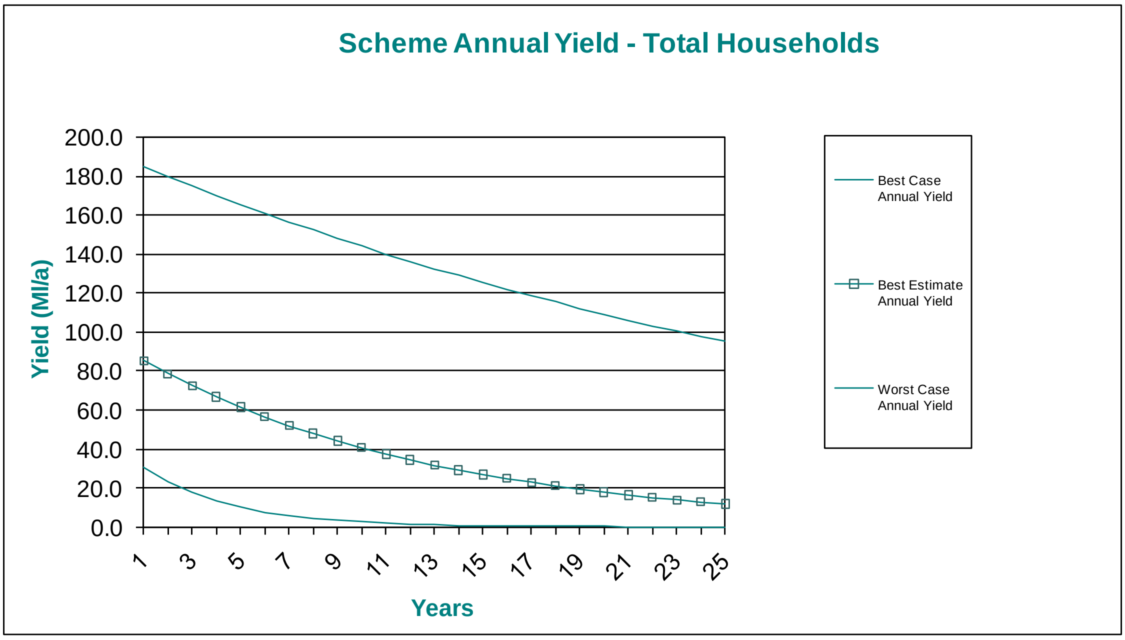

Figure 24 - Annual yield for scenario 6

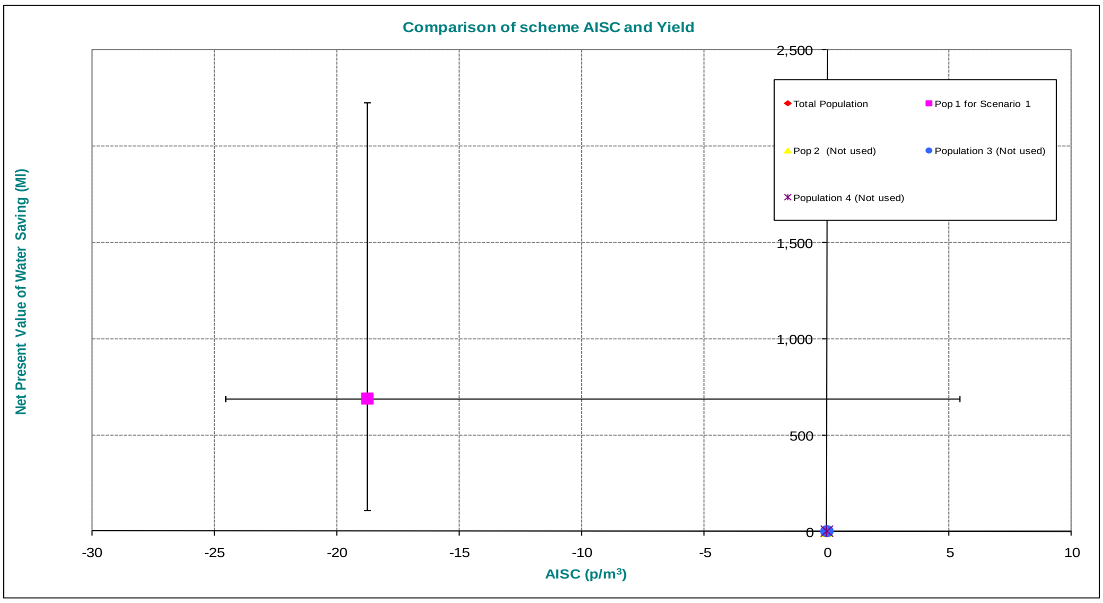

Figure 25 - Comparison of scheme AISC and yield for scenario 6

3.5.7 Scenario 7 – Piggybacking on Government Retrofitting Schemes

Water companies can deliver cost-effective water efficiency retrofitting by piggybacking on various government-led energy efficiency retrofitting schemes across the United Kingdom.

Scenario 7 - Piggybacking on Government Retrofit Schemes		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	50,000	Water companies can collaborate with local councils, NGOs and energy companies to carry out house-to-house calls under CESP and to offer water saving measures for taps and showers alongside energy saving measures in some of the most deprived areas of the UK.
Max expected	75,000	
Min expected	25,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	45%	Enhanced uptake rates due to the involvment of the local government, inclusion of energy efficiency measures and a joint recruitment campaign
Best case	60%	
Worst case	25%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£5.00	Waterwise estimate;
Best case	£0.00	
Worst case	£7.50	
Installation costs (per property)		
Best estimate	£5.00	Waterwise estimate; Installation paid for through the CESP as carried out at the same time as insulation installation programmes. However, the water company may choose to carry out surveys or engage customers to encourage behaviour change.
Best case	£0.00	
Worst case	£10.00	
Administration costs (per property)		
Best estimate	£0.50	Procurement of dual flush devices, showerheads and tap inserts
Best case	£0.00	
Worst case	£1.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	38.00	
Best case	45.00	Preston Water Efficiency Initiative
Worst case	20.00	

Table 26 - Data input into the AISC spreadsheet tool for scenario 7

The AIC, AISC and NPV values for Scenario 7 are given in Table 27 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	5.95	-4.00	70.99
	AISC (p/m^3)	-14.65	-24.59	50.39
NPV values				
	WAFU*(Ml)	2013.08	8015.69	116.27
	Capex (£M)	0	0	0
	Opex (£M)	0.2003	0	0.0872
	Social & Env Costs (£M)	-0.415	-1.651	-0.024

Table 27 - AIC, AISC and NPV results for Scenario 7

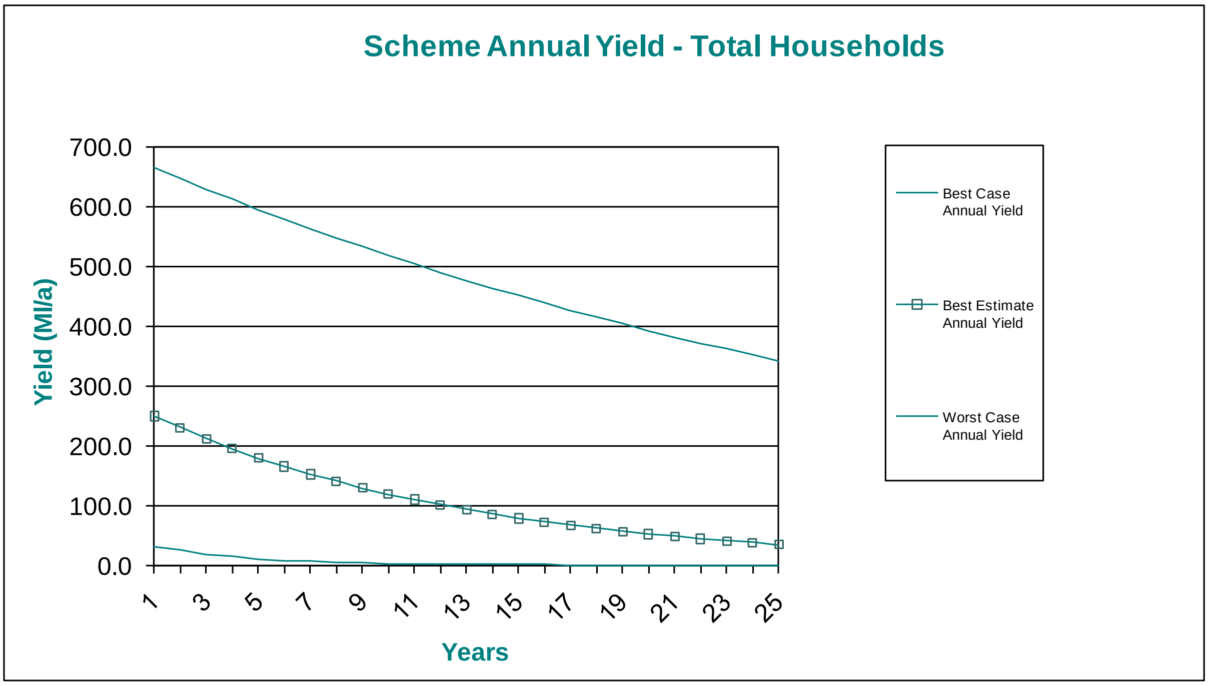

Figure 26 - Annual yield for scenario 7

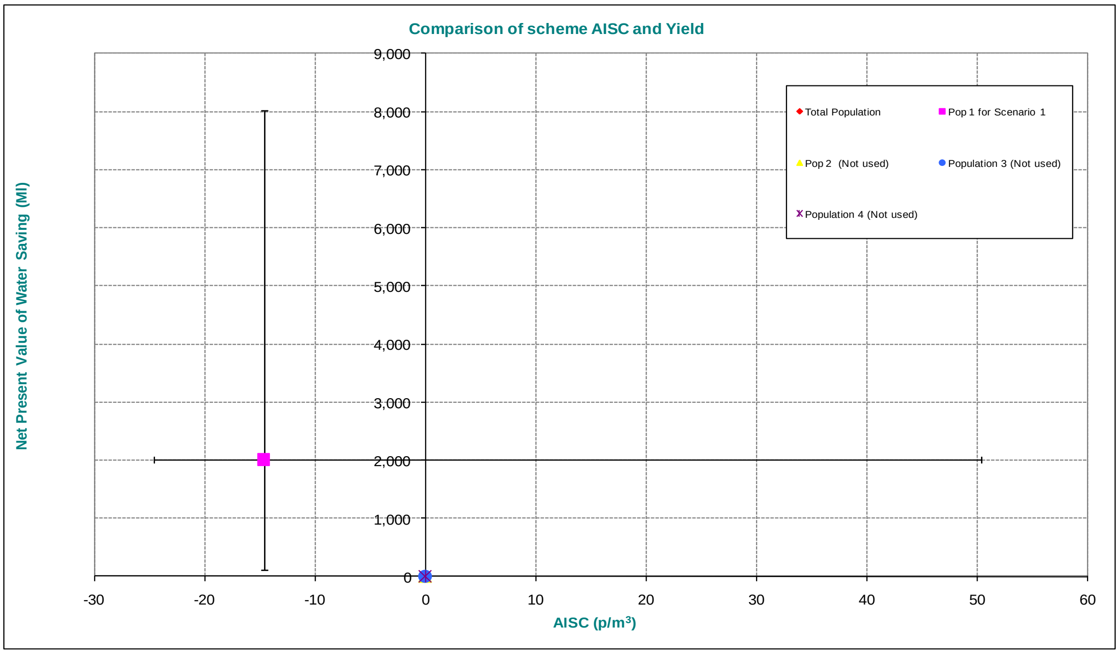

Figure 27 - Comparison of scheme AISC and yield for scenario 7

3.6 Sensitivity of Scenarios to Changes in Discount Rate

The summary of results in Table 28 includes sensitivity to water savings, uptake rates, and costs of equipment and installation. It also includes analysis of sensitivity of results to the discount rate used in the calculation of AIC and AISC. Understanding how changes in discount rate affect the cost-benefit analysis for water efficiency is extremely important for water company investment plans. The discount rate was varied from its original 4.5% to high and low levels of 6% and 3% respectively.

3.7 Scenario Conclusions

Table 28 below summarises the results from the scenarios presented in this chapter. The scenarios have been categorised into 3 different types:

- ⇒ Partnership options
- ⇒ Company-Driven
- ⇒ Government-Led

Partnership options describe ways that various stakeholders, including water companies, social housing providers, local councils and NGOs can work together to deliver cost-effective water savings by retrofitting on a large-scale.

The company-driven option relates to a water company which makes use of the fact that it is carrying out meter installation in a particular area to offer its customers and is able to offer an integrated demand management solution by simultaneously carrying out water efficiency retrofitting in the same homes. In effect the company piggybacks on other internal activities to install devices and engage with customers.

The government-led scenarios require government intervention such as new legislation or funding streams to facilitate novel partnerships and to allow fresh ways for stakeholders to deliver water efficiency in partnership and on a large-scale.

Scenarios 1 to 4 show that partnership is an increasingly attractive option for stakeholders who want to deliver water efficiency. The partnership scenarios offer realistic options for water companies, social housing providers, energy companies, local councils, NGOs and retailers to work together to deliver water efficiency on a large-scale and in the most cost-effective way. The most cost-effective of the partnership options is Scenario 2 which describes the opportunity that currently exists for water companies and energy companies to take advantage of the fact that water efficiency measures are currently[21] included under the Great Britain-wide Carbon Emission Reduction Target (CERT)[22] scheme and could potentially be included under CERT's successor, ECO, and therefore, receive a credit for carbon emissions saved through reducing household water consumption.

However, Scenario 5 also provides a cost effective way of delivering water savings through a water company integrating its activities to carry out metering on a zonal basis and piggyback on this activity to carry out retrofitting in the same properties. Partnership with a social housing provider remains a good option particularly because of the high uptake rates which are achievable and the potential for housing providers to facilitate customer engagement to encourage behaviour change. The retail-led scenario (Scenario 4) provides a means of working with retailers of water-efficient products, harnesses their close relationships with customers and involves them formally in a retrofitting project. The whole-town approach (Scenario 3) involves several stakeholders including local government and non-governmental organisations who can tailor engagement methods to the particular needs of the town to generate interest and boost participation.

Scenarios 6 looks forward to the updating of the Decent Homes Standard[23] to include the installation of showers over baths, and combines this with a government incentive scheme to replace old toilets in social housing with new ones. Scenario 7 gives a view of what could be possible were existing government energy efficiency programmes extended to include water efficiency, for example through the Community Energy Saving Programme[24] (CESP). It should be highlighted that by working in partnership in a way which combines 2 or more of these scenarios this could lead to further cost savings in large-scale water efficiency projects. For example, Scenarios 2 and 5, integrated demand management in partnership with an energy company, could result in improved cost effectiveness.

[21] At the time of print, although an announcement is imminent from the Coalition Government on whether this will remain the case to the end of CERT, in 2012, and there are barriers to joint working in certain cases, in this context.

[22] DECC website - http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cert/cert.aspx

[23] http://www.decenthomesstandard.co.uk/index.php

[24] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cesp/cesp.aspx

		Best Estimate			Best Case			Worst Case		
Partnership Options		3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate
Scenario 1: Social Housing	AIC (p/m^3)	23.93	26.70	29.48	2.67	3.58	172.58	165.82	172.58	179.16
	AISC (p/m3)	21.55	24.33	27.11	0.30	1.20	170.20	163.44	170.20	176.78
Scenario 2: Energy company	AIC (p/m^3)	4.72	5.59	6.46	0.88	1.55	2.23	102.49	106.73	110.86
	AISC (p/m3)	-15.87	-15.00	-14.14	-19.71	-19.05	-18.37	81.90	86.14	90.26
Scenario 3: Whole Town	AIC (p/m^3)	66.12	73.10	80.07	13.58	15.96	18.41	549.39	571.43	592.86
	AISC (p/m3)	45.53	52.50	59.48	-7.02	-4.64	-2.18	528.79	550.83	572.26
Scenario 4: Retail-Led Retrofit	AIC (p/m^3)	15.31	17.24	19.16	-4.00	-4.00	-4.00	223.45	232.51	241.32
	AISC (p/m3)	12.94	14.86	16.78	-6.38	-6.38	-6.38	221.08	230.14	238.95
Company-Driven		3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate
Scenario 5: Piggybacking on Metering	AIC (p/m^3)	26.24	29.25	32.26	8.82	10.55	12.34	147.77	172.58	159.70
	AISC (p/m3)	3.46	6.47	9.48	-13.97	-12.23	-10.44	124.99	170.20	136.91
Government-Led		3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate
Scenario 6: Toilet Amnesty	AIC (p/m^3)	1.29	1.82	2.34	-4.00	-4.00	-4.00	24.85	25.99	27.11
	AISC (p/m3)	-19.31	-18.78	-18.25	-24.59	-24.59	-24.59	4.25	5.40	6.52
Scenario 7: Piggybacking on Government Retrofitting Schemes	AIC (p/m^3)	5.05	5.95	6.85	-4.00	-4.00	4.51	165.82	172.58	179.16
	AISC (p/m3)	21.55	24.33	27.11	0.30	1.20	2.14	163.44	170.20	176.78

Table 28- Variation of AIC and AISC with discount rate

3.8 Summary of the Findings on Domestic Retrofit – Phase II of the Evidence Base Project

The Evidence Base report published in February 2010 presented the results from nine water company-led domestic water efficiency retrofitting projects carried out in the UK. These results are updated in this report with the latest results from four trials for which additional monitoring data has been collected. The updated findings from all the domestic retrofitting project data analysis which has been carried out in Phase II of the Evidence Base are summarised in Table 29 (new data is shown in red).

3.8.1 Description of contents of results table.

Uptake rate – the proportion of customers initially invited to take part in the project who participated in the project.

No of properties included in the trial/project – the total number of properties which were retrofitted or engaged as part of the trial or project.

No. of properties for which data used in analysis – not all the properties included in the trials yielded consumption data which could be used to determine their pre-and post-trial consumption. This may have been due to faulty meters or another possibility is that during the analysis of the data that some properties were removed because they were considered to be outliers.

Mean reduction in water consumption (litres/property/day) – the water savings, in litres per property per day, attributed to the longest monitoring period included in the trial.

Mean percentage reduction in water consumption (%) – the percentage reduction in water consumption attributed to the longest monitoring period included in the trial.

Mean reduction in control group's consumption (l/prop/d) – if a control group was monitored as part of the trial the litre per property per day reduction in water consumption over the same period as the study group is shown in this column.

Mean percentage reduction in control group's consumption (%) – if a control group was monitored as part of the trial the percentage reduction in water consumption over the same period as the study group is shown in this column.

Reduction in consumption incl background effects(lpd) – if a control group was monitored this is taken into account in this column by subtracting the change in background consumption in litres per property per day from the litre consumption change results from the main group.

Percentage reduction in consumption incl background effects (%) – if a control group was monitored this is taken into account in this column by subtracting the percentage change in background consumption from the percentage change in consumption results from the main group.

Probability of water saving (-) – the proportion of all the customers who participated in the trial/project who contributed to the savings. The higher the probability of saving water the less likely it is that a few erroneously large savings have distorted the results.

Linear Regression - R2 values – the R^2 value represents the percentage of the variation in the outcome that can be explained by the model. This provides us with a good way of assessing whether there is a substantive relationship between the pre and post-trial consumption. This means that if R^2 is found to be 0.6, then the line of best fit describes 60% of the relationship between the two variables.

Cost per property (£) – this is the cost of retrofitting per property which includes only the costs that would be applicable to a large-scale retrofitting project. Hence costs, such as for monitoring, database upkeep and other aspects which would not apply if the trial was scaled up, have been removed before reporting this figure.

Cost per litre/ day (£) – the cost per property divided by the water savings in litres per property per day. This is not comparable with the average incremental cost but can be used as a simple measure to compare different approaches to trials/projects.

Energy indirect - carbon savings (kgCO2e/day) – this describes the greenhouse gas emissions saved from reduced water consumption, converted into a carbon dioxide equivalent quantity, that is sourced from outside the home for water and waste treatment and pumping.

Domestic hot water - carbon savings (kgCO2/day) – this is the carbon dioxide emissions sourced from inside the home for water heating, which are saved due to reduced water consumption due to retrofitting.

Average carbon savings per property (kgCO2/day) – The combined amount of energy indirect and domestic hot water carbon dioxide emissions which are saved per property as a result of water savings.

Domestic energy saving (kWh/day) – the energy saved due to reduced hot water consumption in the home as a result of the water efficiency trial.

Cost of energy saved (£/prop/yr) – the domestic energy saving is monetised for each trial using the cost of energy production per kWh.

Weighted central value of carbon saved (£/tCO2e) – the value of carbon which are applied to cost benefit analysis in a water efficiency trial depends on the proportion of carbon emissions which fall into the energy indirect carbon savings (traded) and the domestic hot water carbon savings (non-traded), as these are valued differently (i.e. for 2010 traded carbon emissions are valued at 22 pounds per tCO_2e and non-traded carbon emissions are valued at 52 pounds per tCO_2e).

Project Name	Project Type	Type of device installed	Uptake rate (%)	No. of properties included in the trial/project	No. of properties for which data used in analysis	Mean reduciton in water consumption (l/prop/d)	Mean percentage reduction in water consumption (%)	Mean reduction in control group's consumption (l/prop/d)	Mean percentage reduction in control group's consumption (%)	Reduction in consumption incl background effects(lpd)	Percentage reduction in consumption incl background effects(%)	Probability of water saving (-)	Linear Regression - R^2 values	Cost per property (£)	Cost per litre/property/day (£)	Energy indirect - carbon savings ($kgCO_2/day$)	Domestic hot water - carbon savings ($kgCO_2/day$)	Average carbon savings per property (kgCO2/day)	Domestic energy saving (kWh/day)	Cost of energy saved (£/prop/yr)	Weighted central value of carbon saved (£/tCO2e)
Preston Water Effiiciency Initiative	SH Rtr, Rfb	T, D, L	60	205	134	42.6	12.3	NM	NM	-	-	0.78	N/A	202.0	3.5	5.8	10.8	0.124	154.5	26.8	41.5
Wessex Water WET	SH Rtr	D	45	156	103	33.9	6.6	0.9	0.3	33.0	6.3	0.77	N/A	49.0	1.6	2.7	0.4	0.031	2.3	1.3	26.2
South West WET ***	Gen Rtr	D,C, S, R	22	430	198	-10.8	-4.2	-16.7	-6.5	5.9	2.3	0.58	0.77	197.8	21.8	1.6	8.0	0.049	41.8	13.8	47.0
United Utilities Home Audit Trial	Gen Rtr	D,C, S	9	393	208	28.7	9.2	NM	NM	-	-	0.67	0.67	141.9	4.9	4.5	22.4	0.129	118.8	32.9	46.9
Anglian Water Ipswich Area WEM Trial	Gen Rtr	D, C, S, R	10	1000	552	41.5	14.2	NM	NM	-	-	0.78	0.69	40.8	1.0	17.1	86.2	0.187	418.3	44.3	47.0
Thames Water MVF Trial	Gen Rtr	D, C, S, R	9	1274	727	29.1	7.9	-1.8	-2.2	30.9	10.1	0.69	0.70	240.0	8.2	15.5	78.1	0.129	415.2	33.3	47.0
Yorkshire Water WET	Gen Rtr	D, C, S, R	20	500	337	26.3	14.9	11.5	4.4	14.8	10.5	0.62	0.80	220.2	8.4	7.6	37.4	0.133	181.5	28.0	46.9
Severn Trent Domestic WET	Gen Rtr	D, C, S, R	9	933	680	20.3	8.2	NM	NM	-	-	0.56	0.75	74.1	3.6	10.9	54.7	0.097	285.6	23.3	47.0
Thames Water Self-Audit	SA Rtr	C,S,R	6	980	525	21.9	1.2	NM	NM	-	-	0.54	0.64	110.0	5.0	9.9	13.1	0.044	76.0	8.4	39.1

Key - SH - Social Housing; Rtr - Retrofit; Rfb - Refurbishment; Gen - General; Rtr - Retrofit; SA - self audit; T - New toilets; D - Dual flush conversion device; C - Cistern displacement device; S - Showers; R - Tap inserts, regulators, restrictors and spray taps; L - repair of leaky taps; NM - not measured, N/A - not applicable;
*** This trial was carried out at a time of drought which may have significantly affected the water savings achieved (see section 7.3 for fuller account of SWW WET)

Table 29- Summary of results from the water efficiency projects in the Evidence Base Phase II report

3.8.2 Water Savings

Measured water savings of up to 34 litres per property per day are possible from applying a multi-measure water efficiency retrofitting method in the traditional way, using current technology and means of engaging customers to encourage behaviour change. However, Anglian Water's Ipswich Area WEM trials resulted in savings of 41.5 lpd, which is the highest reduction in consumption of all the trials analysed in this report. There is a possibility that the fact that this WEM trial was carried out alongside a metering installation programme in the Ipswich area enhanced the results. Customers were made aware of their consumption and how much they could save by opting to be charged via a water meter, and this may have led to a significant change in water-using behaviour.

3.8.3 Longevity of Water Savings

Table 30 below summarises the results of the analysis which was carried out in order to understand to what extent savings are sustained from four of the domestic retrofitting trials which were included in the February 2010 Evidence Base report.

	Preston Water Efficiency Initiative	UU Home Audit Study	Severn Trent Water WET	Yorkshire Water WET	Overall Results
Original no. of properties monitored	121	211	717	378	1427
Original water savings (l/prop/day)	50.0	20.6	28.4	18.1	26.4
Additional monitoring period (years)	3.0	3.0	2.6	2.6	2.8
No of properties monitored	79	208	680	337	1304
Revised mean water savings (l/prop/day)	31.5	28.7	20.3	14.9	20.9
Change in water savings (l/prop/day)	-18.5	8.1	-8.1	-3.2	-5.4
Percentage change in water savings (%)	-36.9	39.2	-28.6	-17.7	-20.6
Cost per property(£)	202	142	74	220	160
Cost per litre per day (£)	3.46	4.94	3.65	8.37	5.11
Revised energy indirect carbon emissions saved (kgCO2e/d)	6	5	10	11	32
Revised domestic hot water carbon emissions saved (kgCO2/d)	11	22	53	57	142
Revised Energy saving (kWh/d)	154	119	274	275	822
Revised cost of energy saved (£/year)	3595	6940	16023	16037	42596
Revised cost of energy saved (£/prop/year)	27	33	22	42	31

Table 30 - Summary Table from the additional monitoring of four domestic water efficiency retrofitting trials included in this report

Of the four trials for which additional meter data was available the measured water savings fell in two trials, and savings increased in two trials when the additional monitoring data was taken into account. The mean length of additional monitoring period was 2.8 years.

- For Sutton and East Surrey Water's Preston Water Efficiency Initiative, three years' additional data was made available. Original savings of 50 litres per property per day (lpd), from the retrofitting activities have been revised downward to 31.5 lpd taking into account the additional data. This is a reduction in savings of 36.9%.
- For United Utilities' Home Audit Study, approximately three years' additional data was collected. Original water savings of 20.6 lpd have been revised upwards to 28.7 lpd after analysis of the extended dataset, which represents an increase of 39.2%.
- For Severn Trent Water 's Water Efficiency Trial, the original water savings were 28.4 lpd. Following analysis of 2.6 years of additional consumption data, the savings have been revised downwards to 20.3 lpd, which is a decrease of 17.7%.
- For Yorkshire Water's Water Efficiency Trial, 2.6 years of additional data was made available to evaluate the water savings. Analysis of 2.6 years' additional data resulted in the original water savings of 18.1 lpd being revised downwards to 14.9 lpd, which is a 17.7% reduction.

In order to understand what can be learnt from looking at the entirety of the results presented in Table 31, weighted average water savings were calculated (weighted based on the number of properties in each of the trials).

Weighted average original water savings (litres/prop/day)	**26.4**
Weighted average revised water savings (litres/prop/day)	**20.9**
Weighted average change in water savings over longer monitoring period (litres/prop/day)	**-5.4**
Percentage change in water savings over longer monitoring period (%)	**-20.6**

Table 31– Weighted average water savings for original and extended dataset

This shows that across the four trials measured water savings fell by 5.4 litres per property per day following inclusion of extended datasets which included up to 3 years of additional data. This is equivalent to a percentage reduction of 20.6% over the period. This rate of decay of the water savings is significantly slower than what has been assumed in the past.

It has been assumed since the first Evidence Base report in October 2008 that the water savings resulting from the installation of water efficiency measures (WEM) in a home deteriorate significantly over time. The WEM was assigned a 'half-life' distribution: the years from time of peak savings until only half peak savings are delivered. A half-life is the period of time it takes for a substance (usually a radioactive substance) undergoing decay to decrease by half. In this instance, water savings are assumed to decrease exponentially with time.

If water savings are said to have a half-life of X years, this is simply a means of describing the rate at which water savings are expected to decay: in x years water savings will be half of the initial level. Half-life is also independent of the product lifespan. It is therefore quite feasible for a water efficiency device to have a lifespan of ten years and for the water savings to decay with a half-life of 20 years. The following equation describes how water savings are assumed to decrease over time:

$$WS(t) = WS_o \times \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$$

where,

t – time in years
$WS(t)$ - water savings which vary with time
WS_o – the original water savings
$t_{1/2}$ – the half life in years with which the water savings decay

Using this approach, a range of projected water savings was made as best estimate, best case and worst case. The half-life was estimated for each of these cases. Guidance was developed and applied as follows in previous scenarios for water efficiency programmes in Evidence Base reports:

⇒ the best estimate (i.e. most likely) value is given by a half-life equal to 5 years;
⇒ the best case is given by a half-life equal to 20 years; and,
⇒ the worst case is given by a half-life equal to 2.5 years.

However, taking into account the new evidence, with water savings reduced by 20.6% over a period of 2.8 years, the most likely decay rate for the water savings would be about 8.4 years. This is shown in Figure 28 below.

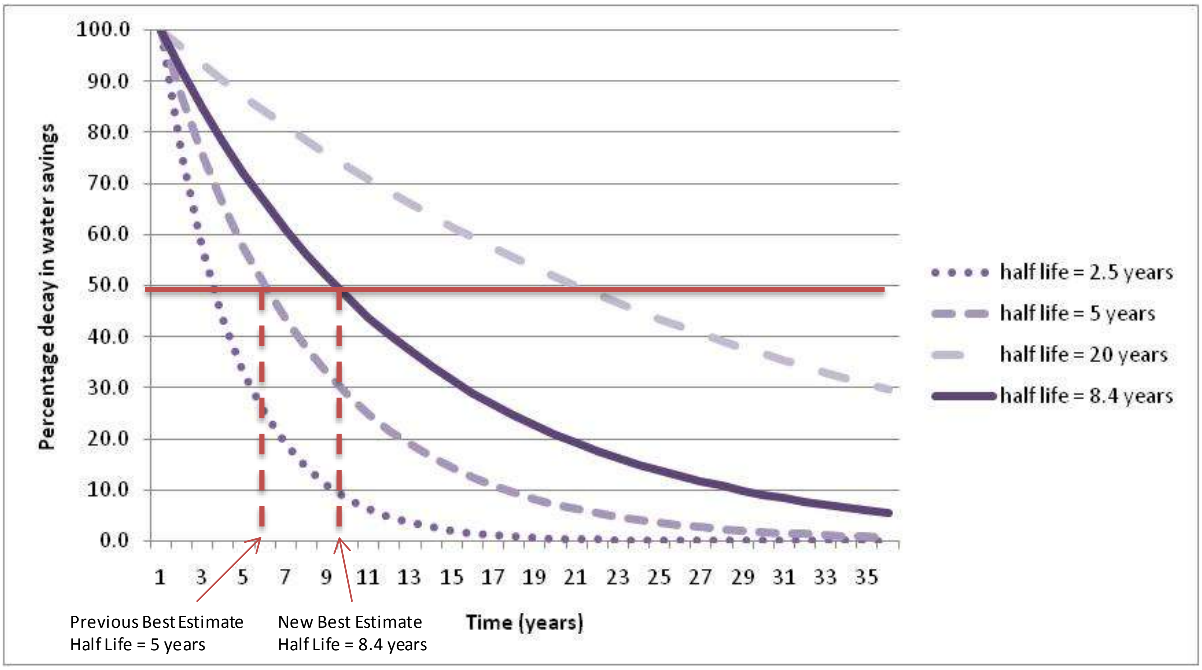

Figure 28. Half-life of water savings from retrofitting trials and projects.

In addition, the weighted average carbon emissions and energy savings for the four trials with extended datasets are given in Table 32. The evidence suggests, just as with the water savings, that carbon savings are sustained to a greater extent than previously thought over the lifetime of water efficient devices which are properly installed as part of a retrofitting programme.

Weighted average energy indirect carbon emissions saved (kgCO2e/d)	**9.5**
Weighted average domestic hot water carbon emissions saved (kgCO2/d)	**45.6**
Weighted average energy saving (kWh/d)	**241.3**

Table 32– Weighted average carbon emissions and energy savings across four water efficiency trials with extended dataset

3.8.4 Uptake rates

The results show a range of between 6% and 60% have been achieved. Further work is required to determine the optimal uptake/investment ratio which is the optimal level of uptake that should be aimed for when the cost of the tools to achieve uptake (letters, telephone calls and door-knocking) are considered.

3.8.5 Carbon Emissions and Energy Savings

Analysis of the nine water company-led water efficiency retrofitting trials in this report shows a range of between 0.031 and 0.187 $kgCO_2e$ per property per day of carbon emissions saving as a result of the water efficiency retrofitting projects included in this report. It also shows that the cost of energy saved in the trials ranges from 1.3 to 44.3 pounds per property per year. Both carbon emissions and energy savings were dependent on the extent to which hot water was targeted during a trial. Trials which did not target showering or bath-use showed relatively low energy savings. However, this assessment illustrates that there are significant carbon and energy benefits to be gained from water efficiency retrofitting.

3.8.6 Understanding the Costs of Water Efficiency Retrofitting

There is a wide variation in the cost of retrofitting per property, which ranges from £41 to £240 per property. Anglian Water's Ipswich Area WEM trial achieved the lowest cost per property and one of the reasons for this was that the trial was carried out alongside the Ipswich area metering programme. Similarly, Wessex Water's WET, carried out in partnership with a social housing provider, achieved a cost of £49 per property.

3.8.7 Innovative Analysis

Use of linear regression in the analysis of the trials in the February 2010 Evidence Base report shows that, using current methods alone, it is unlikely that households consuming 400 litres per day or more will be able to reduce their consumption sufficiently to meet the government ambition of 130 litres per person per day. The main assumption made in this analysis is that the occupancy of the trial properties is similar to the national average occupancy. More effective methods of encouraging customers to reduce their consumption alongside retrofitting will have to be found - in particular, targeting higher consumers. New water-using technologies could play a part in helping to drive down consumption, but it is likely that significant behaviour change will also be necessary, whichever technologies are employed. This ties in with the Final Report of the Walker Review[25] which recommends a multi-stakeholder education campaign on water efficiency for England and Wales.

3.8.8 Scenarios

Seven new scenarios for delivering water efficiency on a large-scale through partnership are presented in this report (see Table 33). Scenarios 1 to 4 show that partnership is an increasingly attractive option for stakeholders who want to deliver water efficiency. The partnership scenarios offer realistic options for water companies, social housing providers, energy companies, local councils, NGOs and retailers to work together to deliver water efficiency on a large-scale and in the most cost-effective way. The most cost-effective of the partnership options is Scenario 2 which describes the opportunity that currently exists for water companies and energy companies to take

[25] Defra website - http://www.defra.gov.uk/environment/quality/water/industry/walkerreview/final-report.htm

advantage of the fact that water efficiency measures are currently[26] included under the Great Britain-wide Carbon Emission Reduction Target (CERT)[27] scheme and could potentially be included under CERT's successor, ECO, and therefore, receive a credit for carbon emissions saved through reducing household water consumption.

Scenario 5 also provides a cost effective way of delivering water savings through a water company integrating its activities to carry out metering on a zonal basis and piggyback on this activity to carry out retrofitting in the same properties. Scenarios 6 and 7 are built around the possibility of the updating of the Decent Homes Standard[28] to include water efficiency, an additional government action on toilets, and the inclusion of water efficiency retrofitting in existing government energy efficiency programmes: for example through the GB-wide Green Deal[29] or Community Energy Saving Programme[30] (CESP) or the Scottish Home Insulation Scheme[31].

Combinations of the scenarios in Table 33 could result in even more cost effective water efficiency retrofitting projects, for example, combining scenario 1 (social housing partnership) with scenario 2 (energy company partnership) or even scenario 2 with scenario 3 (whole town retrofit).

Partnership Options		Best Estimate	Best Case	Worst Case
Scenario 1: Social Housing	AIC (p/m^3)	26.7	3.6	172.6
	AISC (p/m3)	24.3	1.2	170.2
Scenario 2: Energy company	AIC (p/m^3)	5.6	1.5	106.7
	AISC (p/m3)	-15.0	-19.0	86.1
Scenario 3: Whole Town	AIC (p/m^3)	73.1	16.0	571.4
	AISC (p/m3)	52.5	-4.6	550.8
Scenario 4: Retail-Led Retrofit	AIC (p/m^3)	17.2	-4.0	232.5
	AISC (p/m3)	14.9	-6.4	230.1

Company-Driven		Best Estimate	Best Case	Worst Case
Scenario 5: Piggybacking on Metering	AIC (p/m^3)	29.3	10.6	153.8
	AISC (p/m3)	6.5	-12.2	131.0

Government-Led		Best Estimate	Best Case	Worst Case
Scenario 6: Toilet Amnesty	AIC (p/m^3)	1.8	-4.0	26.0
	AISC (p/m3)	-18.8	-24.6	5.4
Scenario 7: Piggybacking on Government Retrofitting Schemes	AIC (p/m^3)	5.9	-4.0	71.0
	AISC (p/m3)	-14.6	-24.6	50.4

Table 33 – Summary of AIC and AISC results for each of the scenarios

[26] At the time of print, although an announcement is imminent from the Coalition Government on whether this will remain the case to the end of CERT, in 2012, and there are barriers to joint working in certain cases, in this context.

[27] DECC website - http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cert/cert.aspx

[28] http://www.decenthomesstandard.co.uk/index.php

[29] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/green_deal/green_deal.aspx

[30] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cesp/cesp.aspx

[31] http://www.scotland.gov.uk/Topics/Built-Environment/Housing/privateowners/his

4 Schools Retrofitting – The Evidence

4.1 Introduction

This final report of Evidence Base Phase II summarises the evidence which has been gathered to improve our understanding of the water savings which are achievable from water efficiency retrofitting in schools. The evidence in this report owes greatly to work to improve water efficiency in schools undertaken over the last few years by The Environment Agency, Essex and Suffolk Water, Severn Trent Water, Thames Water, Business Stream and Southern Water. As a result, this report includes data from about 633 school retrofit projects in five English regions and Scotland:

⇒ This Environment Agency Southern Region project took advantage of an opportunity to support the schools water efficiency initiatives being promoted by Southern Region Water Companies. The Environment Agency offered grants to schools in the region to help them improve their water efficiency. 65 schools received a grant and spent approximately £120,700 on their water efficiency projects across the region. Data was collected from four of the schools for further analysis and to investigate the benefits of installing water efficient fittings in schools.

⇒ As part of Essex & Suffolk Water's Schools Water Efficiency Programme carried out during 2010, 80 schools were retrofitted, in order to help them to reduce their water consumption and lower their water bills. The results from Phase 2 of the project which included 39 schools are included in this report. A pre audit survey was carried out following which a recommendation report was written and then sent to the school. The school was then given the option to either opt out or schedule a date for the installation of a range of water efficient measures based on the recommendations.

⇒ As part of Severn Trent Water's water efficiency programme during 2008-09, data was collected from 482 out of 600 school water efficiency retrofitting projects carried out in partnership with six local councils. Recommendations were made on equipment and use which were then implemented. Where it was deemed to be cost-effective in terms of the water savings this would yield, these schools were then offered a retrofit of urinal water supply systems, taps, toilets and showers.

⇒ Thames Water retrofitted about 200 schools over two programmes: the Liquid Assets Project (2006/7) and the Water Makeover Project (2008). The 247 sites visited as part of the Liquid Assets Project included 154 schools with high water consumption within their respective geographical areas. Thames Water partnered with Aqualogic and ech2o for the Schools Water Makeover which consisted of an audit, retrofit and education programme for 22 primary and 10 secondary schools in the Thames Water area.

⇒ Two case studies are also included:

→ Business Stream's work with a local council in Scotland to identify where the largest savings could be made and to reduce water consumption levels in schools

→ The joint initiative between Southern Water, the Environment Agency and West Sussex County Council, which set out to demonstrate the water and cost savings achievable in a practical school environment and to provide information and know-how which could be applied more widely.

In this report Waterwise analyses data collected by the water companies from their activities in order to understand the effectiveness of the retrofitting in helping the schools to reduce their water consumption.

Schools in the UK spend at least £70 million annually on the provision of fresh water and the disposal of wastewater. The average annual water and sewerage bill for primary schools in the UK is £1,600 and for secondary schools between £3,200 and £8,600, although a large secondary school might spend up to £20,000. Improving water efficiency in schools will also help meet the UK's legally binding goals of a reduction in greenhouse gas emissions of 34% by 2020 and 80% by 2050, through reduced energy use in schools and by water companies.

This part of the report contains the following sections:

⇒ Section 4.2 describes some of the water-efficient products which are commonly installed in schools
⇒ Section 4.3 explains the methodology for benchmarking of water use in schools and the calculations in this report
⇒ Section 4.4 presents the evidence and the detailed outcomes of the analysis
⇒ Section 4.5 presents a 'Retrofit in Schools' scenario, including calculation of average incremental cost (AIC) and average incremental social cost (AISC), to assist water companies with planning school retrofitting programmes.

4.2 Water-Efficient Devices in Schools

The water-efficient products used in the school retrofitting projects analysed in this report differ from those products fitted in domestic dwellings. Whilst some of these products are the same or very similar to those installed in a domestic property (for example, toilet retrofit devices), the other products are designed for more frequent use. It is worth noting that not all of these devices were taken up within the trials. In the case of the products in the 'showers' category, none were installed in these projects, and as a result they are not included in this list.

4.2.1 Toilets

There were several different types of toilet retrofit device considered for installation in the schools:

4.2.1.1 Dual-Flush Valve Conversion

This is a piece of kit which is installed into the existing siphon-operated toilet cistern to convert it from a single-flush into a dual-flush system. The kit is attached to the existing flushing mechanism, allowing a 'short flush' or a 'long flush', as required. It is relatively easy to install but does require a trained installer. The flush valve incorporates a unique bayonet-type joint which enables the unit to be removed from the cistern for future maintenance without the need to disconnect the cistern. The valve is not suitable for any cisterns fitted with levers which are not mounted in a circular hole.

4.2.1.2 Dual-flush Siphon Retrofit Device

This is installed within the existing cistern and replaces the single-flush siphon. When the user holds the handle down it provides a full flush, but when the handle is released promptly it provides a smaller flush, pre-set by the installer. The volume of water in the small flush can also be adjusted to suit system requirements: the dual-flush siphon retrofit insert could be adjusted to provide a single-flush of 4 ½ litres which should be enough to dispose of all waste.

On some occasions clear instructions on how to use the product are necessary, for example via a sticker on the cistern to show that the lever should be held down for a long flush or released quickly for a short flush. Dual-flush siphon retrofit devices can only be installed in siphon-flush toilets and those that are not already dual-flush.

4.2.1.3 Cistern Dam

This is an easy-to-install water displacement device which creates a barrier within the toilet tank to restrict the water released when the flush lever is activated. Water is saved through the overall volume of the flush being reduced. Sometimes the toilet will need flushing more than once to clear the pan.

4.2.1.4 Cistern Displacement Device (CDD)

This is another category of water displacement device, installed into the cistern to displace typically 1 to 3 litres of water. These devices can easily be placed in the cistern and removed at any time, should there be any difficulties. There are instances when CDDs should not be installed, such as when the toilet is already at a low-flush volume (6 litres per flush or less).

4.2.2 Taps

There were five different types of tap fittings installed in the schools:

4.2.2.1 Retrofit Push Tap

This is a conversion kit which is installed onto the existing tap, converting it to a push tap. The benefit of the push tap is that the water supply is cut off automatically after a given time or volume. This prevents water wastage when taps are left running and is more hygienic as once hands have been washed there is no need to turn the tap off again. The time delay can be adjusted if it is found that the tap is being pressed more than once to dispense a more satisfactory flow of water, or if the taps are running for too long and dispensing water long after required. The benefit of the retrofit push tap is that there is no need to remove the existing tap in order to fit it.

4.2.2.2 Push Tap

This uses the same technology as the retrofit push tap, with the exception that this is a whole-tap kit, replacing the entire existing tap instead of just the mechanism. It follows the same water-saving approach, by restricting flow to a designated length of time.

4.2.2.3 In-Line Flow Regulator

An in-line flow regulator saves water by limiting flow in the supply pipe. Regulators are available for a range of pipe and tap diameters and have a cartridge which limits the maximum flow to a set number of litres per minute. An in-line flow regulator can be easily fitted to the existing tap by screwing it into the existing pipe work or onto the end of the tap. It helps to reduce the volume of water flowing out of the taps if the taps are used correctly. For areas with low water pressure it may be found that an in-line flow regulator makes very little difference at all.

4.2.2.4 Outlet Aerator Regulator

A tap aerator is designed to mix air with water, giving the effect of the same flow rate but using a lower volume of water to achieve it. It is simply screwed onto the outside of the tap, but cannot always be easily installed if it is the wrong size or where there is threading on the outside or the inside of the tap (where male/female threading is present).

4.2.2.5 Re-Time Existing Tap

Where a push tap or other flow or time-controlled tap is already installed, but the flow is too high or low for the designated use, the tap can be adjusted so that the flow is more suitable.

4.2.3 Urinals

Five different types of urinal device were used in the schools trials:

4.2.3.1 Service Urinal Control Device

In this instance the existing urinal control device is serviced to make sure that the flush rate is in keeping with the volume of people using the urinals and is in good working order.

4.2.3.2 Urinal Control Device 1 - Mains 240v

This is a urinal control which uses sensors to detect presence of users at the urinal and flushes accordingly after a set time. The first person to use the urinals is detected and then the urinals are flushed after a given time from the moment of this detection. Flush frequency can be set between 10 and 40 minutes. When no one has used the urinals, a hygienic flush will go off every 12 hours. It is also possible to have lighting control installed with this device so that the washroom lighting will remain on for a required time, but be automatically switched off. The only problem these urinal devices may have is that, if there are a large number of people using the urinals within a short period of time, lack of flushing can mean the urinals begin to smell.

4.2.3.3 Urinal Control Device 2 - Battery 6v

This allows the flush frequency to be set so that the urinals are not flushed automatically if no one has used them. The product detects the first user of the urinals and then flushes after a set period of time (this ranges from 10 minutes to 40 minutes). When no one has used the urinals, the hydrocell will produce a hygiene flush after a given interval (between 6 and 12 hours usually). Using a battery instead of mains power means there is no programming required or disruption from installation. As with the previous urinal device, if there are a high volume of users in a given period of time, lack of flushing can mean the urinals begin to smell.

4.2.3.4 Urinal Control Device 3 – Battery 6v

This is very similar to the above Hydrocell kit, but the frequency of the flush is dependent on the volume of users. The flush can be set at 10, 20, 30 or 40 minutes after detecting the first user, but the time will be reduced through frequent usage and high ambient temperature. This device will deliver a hygiene flush if necessary, but will reduce the time between hygiene flushes if ambient temperature is high.

4.2.3.5 Isolation Valve

Isolation valves are fitted to stop or reduce the water supply to a given area. They are installed in the pipe-line to restrict flow, and are used to ensure that when the urinals are flushed this is at a lower volume. They do not control the flushing in any way.

4.3 The Methodology

The methodology applied in this report owes much to that developed as part of Chapters 4 and 5 of the February 2010 Evidence Base report[32]. The same broad approach to data analysis, calculation of carbon emissions and energy savings is applied here as has been previously employed. However, a further schools-specific methodology has been developed and this chapter explains the approach taken with regard to:

- ⇒ Water use in schools
- ⇒ Estimating savings from schools water efficiency projects in schools
- ⇒ Estimating hot water savings from water efficiency projects in schools
- ⇒ Cost benefit analysis from the water company perspective, including payback time and average incremental cost (AIC) and average incremental social cost (AISC) calculations, and from the school perspective including payback time calculations
- ⇒ The weighted central value of carbon saved

4.3.1 Water use in schools

This section presents some general information which will provide a reference to help assess levels of water consumption in different types of school. Tables 34 and 35 present national-level data for all types of school. Results are presented separately for schools with and then schools without swimming pools and also categorised by the following school types:

- ⇒ Secondary (Including Middle Schools deemed Secondary)
- ⇒ Primary (Including Middle Schools deemed Primary)
- ⇒ Nursery
- ⇒ Other

32 The Evidence Base Phase II interim report, February 2010. Available at: http://www.waterwise.org.uk/images/site/Policy/evidence_base/evidence%20base%20for%20large-scale%20water%20efficiency%20in%20homes%20-%20phase%20ii%20interim%20report.pdf

	WATER CONSUMPTION						WATER COST					
	M3 /m2 floor area			M3 /pupil			£/m2 floor area			£/pupil		
	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
Secondary												
Mean	0.98	0.55	0.49	8.18	4.45	4.41	0.81	0.87	0.99	7.29	7.81	8.91
% change		-43.94	-10.77		-45.61	-0.86		6.99	13.16		7.14	14.09
Performance Bands												
Decile: 10	0.23	0.23	0.20	2.10	2.15	1.87	0.35	0.37	0.38	3.10	3.36	3.35
%change		0.91	-13.42		2.16	-13.03		4.58	4.87		8.51	-0.31
(Q1) 25	0.30	0.31	0.28	2.79	2.84	2.60	0.49	0.54	0.58	4.54	4.72	5.29
%change		2.42	-8.53		1.96	-8.68		8.62	8.00		4.07	12.11
(Median) 50	0.43	0.43	0.42	3.70	3.75	3.75	0.71	0.75	0.84	6.60	6.85	7.66
%change		-1.55	-1.73		1.47	0.03		4.97	12.24		3.72	10.37
(Q3) 75	0.63	0.61	0.59	5.60	5.35	4.92	1.01	1.05	1.34	9.36	9.83	12.20
%change		-3.60	-3.55		-4.49	-8.03		4.34	27.05		4.95	24.14
90	1.04	0.91	0.72	8.89	7.83	6.34	1.45	1.53	1.99	12.35	12.90	17.10
%change		-12.41	-21.03		-11.89	-19.11		5.53	30.24		4.46	32.53
Primary												
Mean	0.89	0.92	0.90	5.11	5.17	5.18	1.30	1.46	1.60	7.49	8.42	9.41
% change		3.73	-2.53		1.06	0.24		12.19	10.17		12.45	11.80
Performance Bands												
Decile: 10	0.33	0.33	0.32	2.18	2.19	2.16	0.51	0.55	0.60	3.43	3.71	4.07
%change		-1.15	-1.87		0.32	-1.49		8.01	8.92		7.98	9.78
(Q1) 25	0.46	0.47	0.47	2.96	2.91	2.96	0.75	0.84	0.89	4.78	5.18	5.67
%change		0.76	0.94		-1.52	1.71		12.33	6.48		8.28	9.46
(Median) 50	0.66	0.66	0.67	3.99	4.08	4.11	1.03	1.20	1.30	6.52	7.37	8.12
%change		1.76	1.48		2.33	0.74		16.11	8.60		13.02	10.18
(Q3) 75	0.99	1.04	0.99	5.86	6.05	5.97	1.49	1.69	1.93	9.14	10.43	11.51
%change		4.49	-4.83		3.18	-1.24		13.49	14.68		14.15	10.33
90	1.59	1.66	1.58	9.51	9.38	9.26	2.14	2.41	2.71	12.72	14.23	16.02
%change		4.43	-4.06		-1.38	-1.27		12.75	12.65		11.92	12.55
Nursery												
Mean	0.89	0.99	0.95	4.29	4.70	5.02	1.49	1.82	1.83	7.49	8.42	9.41
% change		10.63	-4.42		9.59	6.91		22.02	0.62		12.45	11.80
Performance Bands												
Decile: 10	0.44	0.45	0.45	1.94	1.82	1.94	0.64	0.79	0.80	3.43	3.71	4.07
%change		1.86	-0.31		-6.25	6.47		23.37	0.85		7.98	9.78
(Q1) 25	0.62	0.57	0.59	2.59	2.40	2.35	0.91	0.96	1.16	4.78	5.18	5.67
%change		-7.76	2.89		-7.33	-2.03		6.01	20.89		8.28	9.46
(Median) 50	0.91	0.84	0.77	3.50	3.52	3.71	1.43	1.46	1.54	6.52	7.37	8.12
%change		-8.52	-8.07		0.53	5.50		1.90	5.70		13.02	10.18
(Q3) 75	1.14	1.09	1.19	5.59	5.40	6.04	1.82	2.22	2.13	9.14	10.43	11.51
%change		-3.95	8.69		-3.52	12.00		21.46	-3.84		14.15	10.33
90	1.31	1.43	1.60	7.02	7.99	9.31	2.42	3.45	3.23	12.72	14.23	16.02
%change		8.96	11.77		13.81	16.46		42.73	-6.41		11.92	12.55
Other												
Mean	0.68	0.84	0.62	27.81	36.47	33.54	1.12	1.16	1.16	42.24	51.00	51.77
% change		22.06	-25.98		31.14	-8.04		3.47	-0.01		20.73	1.52
Performance Bands												
Decile: 10	0.26	0.35	0.25	5.72	7.61	6.62	0.38	0.47	0.45	9.92	13.55	12.74
%change		32.05	-27.83		33.03	-12.91		22.06	-5.47		36.56	-5.95
(Q1) 25	0.41	0.46	0.45	8.92	10.54	9.80	0.64	0.76	0.84	15.05	17.57	17.79
%change		11.93	-1.51		18.16	-6.98		19.94	9.40		16.72	1.26
(Median) 50	0.53	0.59	0.57	13.46	16.94	15.93	0.98	1.10	1.14	22.89	26.16	28.84
%change		11.05	-2.01		25.81	-5.94		12.25	3.54		14.26	10.26
(Q3) 75	0.74	0.77	0.77	22.75	26.77	23.77	1.23	1.29	1.43	40.29	46.78	48.19
%change		3.39	-0.06		17.66	-11.20		5.11	10.96		16.12	3.00
90	1.12	0.98	0.91	40.01	61.70	63.04	2.20	1.60	1.82	64.38	86.01	80.61
%change		-12.47	-7.59		54.22	2.17		-27.10	14.00		33.60	-6.28

Table 34: Water Consumption Performance Benchmarks for Schools without Swimming Pools – Source: Department for Education and Schools

Tables 34 and 35 and Figure 29 help to illustrate the distribution of water use across secondary, primary and nursery schools. The headline figures for schools with no swimming pools (Table 34) are a mean consumption of 4.41 m^3/pupil for secondary schools, 5.18 m^3/pupil for primary schools and 5.02 m^3/pupil for nursery schools.

Table 34 shows that 10% of schools have water consumption of equal to or less than:

⇒ 1.87 m^3/pupil in secondary schools

⇒ 2.16 m^3/pupil in primary schools

⇒ 1.94 m^3/pupil in nursery schools.

Table 34 also shows that 10% of schools have water consumption of greater than or equal to:

⇒ 6.34 m^3/pupil in secondary schools

⇒ 9.26 m^3/pupil in primary schools

⇒ 9.31 m^3/pupil in nursery schools.

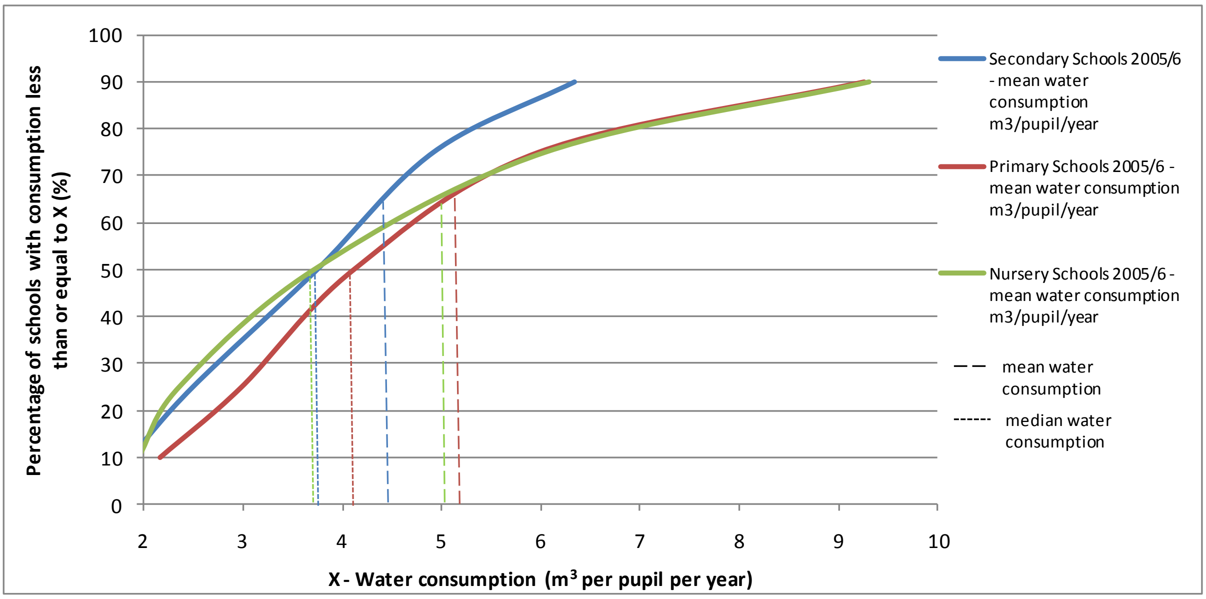

Figure 29 - Distribution of Nursery, Primary and Secondary school water consumption from DfES benchmarking data

	WATER CONSUMPTION						WATER COST					
	M3 /m2 floor area			M3 /pupil			£/m2 floor area			£/pupil		
	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06	2003-04	2004-05	2005-06
Secondary												
Mean	1.12	0.61	0.67	9.99	5.61	6.03	1.12	1.00	1.15	9.08	9.45	10.39
% change		-45.61	9.92		-43.84	7.45		-10.89	14.91		4.07	9.97
Performance Bands												
Decile: 10	0.31	0.27	0.31	2.73	2.20	2.92	0.48	0.46	0.55	3.97	4.10	4.70
%change		-13.82	15.48		-19.57	32.79		-3.08	17.80		3.26	14.63
(Q1) 25	0.41	0.38	0.43	3.42	3.20	4.12	0.61	0.65	0.71	6.01	6.24	6.62
%change		-8.85	14.23		-6.60	28.97		5.66	8.92		3.82	6.18
(Median) 50	0.58	0.58	0.58	5.08	4.89	5.39	0.98	0.92	0.98	9.04	9.01	9.70
%change		0.22	0.19		-3.66	10.19		-5.88	6.36		-0.33	7.66
(Q3) 75	0.83	0.72	0.78	7.41	6.88	7.68	1.24	1.21	1.40	11.76	12.37	13.22
%change		-12.80	8.16		-7.14	11.70		-2.47	16.08		5.22	6.86
90	1.38	1.04	1.15	11.37	9.98	9.00	1.68	1.67	1.92	15.29	15.70	17.98
%change		-24.81	10.49		-12.27	-9.83		-0.96	15.46		2.65	14.52
Primary												
Mean	0.98	0.96	0.90	6.83	7.05	5.76	1.21	1.25	1.54	8.45	9.16	9.96
% change		-2.28	-6.01		3.22	-18.41		2.99	23.50		8.49	8.73
Performance Bands												
Decile: 10	0.37	0.35	0.31	2.74	3.03	2.98	0.56	0.57	0.66	4.02	4.33	5.57
%change		-5.49	-12.74		10.61	-1.53		0.71	16.87		7.67	28.74
(Q1) 25	0.53	0.48	0.54	3.71	3.96	3.77	0.81	0.81	0.95	5.89	6.23	6.54
%change		-7.89	11.74		6.71	-4.76		-0.03	17.00		5.73	4.92
(Median) 50	0.66	0.68	0.73	5.16	4.95	4.91	1.04	1.13	1.30	7.76	9.22	8.88
%change		2.30	7.64		-4.07	-0.81		8.59	15.56		18.89	-3.74
(Q3) 75	0.96	1.07	1.00	7.03	6.99	6.89	1.50	1.49	1.77	9.98	11.74	11.98
%change		10.96	-6.90		-0.62	-1.47		-0.52	18.74		17.63	2.04
90	1.44	1.75	1.38	9.05	13.56	8.74	1.84	2.13	2.31	12.50	14.02	14.91
Other												
Mean	5.95	1.06	1.05	34.00	29.45	31.43	1.38	1.82	2.18	43.62	51.83	62.82
% change		-82.25	-0.28		-13.39	6.73		32.66	19.40		18.82	21.20
Performance Bands												
Decile: 10	0.56	0.42	0.63	18.48	17.58	15.84	0.69	0.95	1.23	17.98	26.26	27.84
%change		-24.73	50.27		-3.33	-9.89		37.16	29.75		46.02	6.00
(Q1) 25	0.79	0.69	0.75	19.97	20.18	20.75	0.90	1.22	1.37	29.75	29.20	34.25
%change		-12.46	9.42		1.04	2.83		34.73	12.46		-1.84	17.31
(Median) 50	1.09	0.93	0.83	23.38	26.38	23.70	1.23	1.42	1.99	32.79	51.06	57.41
%change		-15.28	-9.96		12.86	-10.16		16.06	39.48		55.72	12.43
(Q3) 75	1.67	1.43	1.20	46.15	37.51	41.28	1.62	2.45	2.64	55.53	63.70	80.22
%change		-14.78	-15.90		-18.72	10.05		50.79	7.68		14.71	25.92
90	17.63	1.86	1.80	62.57	49.07	56.46	2.28	2.76	3.32	76.15	93.81	121.64
%change		-89.43	-3.57		-21.57	15.05		20.83	20.43		23.20	29.66

Table 35: Water Consumption Performance Benchmarks for Schools with Swimming Pools. Source: Department for Education and Schools

This can be seen from Figure 29 which shows the distribution of water consumption in primary, secondary and nursery schools in the DfES benchmarking tools. It also shows the median and mean for each type of school. The blue line in Figure 29 shows the distribution of secondary schools. Overall, this category of school uses significantly less water than nursery and primary schools, which are shown in the green and red lines respectively. However, Figure 29 also shows that the most efficient nursery schools are more efficient than the most efficient secondary schools, although the most inefficient nursery schools are as inefficient as primary schools.

The following common themes can be seen in the three different distributions shown in Figure 29:

⇒ The median consumption levels for the three types of schools are significantly less than mean levels of consumption. This shows that the majority of schools perform better than the mean level. The distribution therefore exhibits positive skew with the majority of schools estimated to have relatively low consumption.

⇒ The gradients of the three lines reduce at higher consumptions. Broadly there is a point at about 70% of schools (5.5 m^3/pupil/year) for nursery and primary schools (see the y-axis on Figure 29) and at about 75% of schools (5.0 m^3/pupil/year) for secondary schools where the school consumption levels start to increase at a rate faster than seen at lower consumption levels. In short, there is a minority of schools which consume very high levels of water compared to other schools.

The data from the Department for Education and Schools therefore makes it clear that there is a minority of very poorly-performing schools which could be helped to reduce their water bills and be the source of very large water savings for the water companies.

Savings to date and the range in the quantities of water consumed in schools point to a huge amount of water which could be saved through installation of appropriate technology such as urinal control systems, as well as retrofitting taps, toilets and showers, and, equally importantly, through educating and encouraging pupils and teachers to take on water-efficient behaviours.

4.3.2 Estimating Savings From Water Efficiency Projects in Schools

Part of the established Evidence Base methodology was further developed in producing this report, because of the different nature of water consumption and water-using devices in schools and homes. In planning for water efficiency projects it is important to have a means, based on assumptions, of assessing the level of water savings which are achievable from water efficiency retrofitting. The following general assumptions (Figure 30) which relate to water-using behaviour in schools were taken from the Market Transformation Programme report 'BNWAT22: Domestic water consumption in domestic and non -domestic properties' (2008)[33].

General assumptions

Assume two uses per day of facilities, and seven uses for boarding pupils (ie equal to WC usage in households).
Ratio of WC to urinal use suggested in BS 6465 is 2:1, therefore the ratio of use, in the same way as for shopping malls, will be assumed to be one
Occupancy assumed to be 50% male pupils and 50% female.
Number of days in school year assumed to be 195 for day pupils and 252 for boarding pupils.

Figure 30 - General Assumption for Quantification of Theoretical Water Savings in Schools - Source: MTP (2008)

The assumptions for calculating theoretical savings for the following water efficiency measures are described in Figures 31 to 39.

Taps

- ⇒ Push tap retrofit
- ⇒ Push tap – replace complete tap

Toilets

- ⇒ Dual-flush retrofit
- ⇒ Cistern displacement devices

Flow regulators

- ⇒ In-line flow regulators without retrofitting push taps
- ⇒ In-line flow regulator with push tap retrofit.

A major difference between domestic retrofitting and projects carried out in schools is that there are multiple toilets, urinals and taps in toilet areas. Therefore, when evaluating the likely impact of retrofitting in schools, account must be taken of the extent to which retrofitting has been carried

33 Market Transformation Programme report 'BNWAT22: Domestic water consumption in domestic and non -domestic properties' (2008), http://efficient-products.defra.gov.uk/cms/market-transformation-programme/

out. To illustrate this it is useful to consider the following example: if there are 20 sinks in a school toilet with 40 twist taps installed, and only 8 taps are replaced with push taps, then it would be difficult to justify claiming savings associated with reduced tap use for every pupil in that school. This is not relevant to urinal control systems as one of these is assumed to control flow of water into all the urinals in a toilet area.

In order to take account of this in the savings estimates the following factors have been created:

$$x = Proportion\ of\ total\ push\ taps\ retrofitted = \frac{Number\ of\ push\ taps\ retrofitted}{Total\ number\ of\ taps\ in\ the\ school}$$

$$y = Proportion\ of\ total\ WCs\ retrofitted = \frac{Number\ of\ WCs\ retrofitted}{Total\ number\ of\ WCs\ in\ the\ school}$$

$$z = Proportion\ of\ total\ push\ taps\ retrofitted = \frac{Number\ of\ in-line\ regulators\ installed}{Total\ number\ of\ taps\ in\ the\ school}$$

Figure 31 - Equations defining the factors x, y and z

<u>Push Taps - Retrofit</u>

For twist taps assume flowrate of	10	litres/min
Number of uses	4	per day per pupil
On average a screw head tap is left on for	15	seconds
Daily water use per pupil	10	litres/pupil/day
After push tap retrofit		
Assume flowrate of	10	litres/min
Number of uses	8	per day per pupil
On average a screw head tap is left on for	6	seconds
Daily water use per pupil	8	litres/pupil/day
Proportion of total push taps retrofitted (x) =	number of push taps retrofitted/ total number of push taps in school	
Savings from push tap retrofit	**2.0*x**	**litres/pupil/day**

Figure 32 - Assumptions for Estimating Water Savings in Schools from Push-Tap Retrofit

Push Taps - Complete tap

For twist taps assume flowrate of	10	litres/min
Number of uses	4	per day per pupil
On average a screw head tap is left on for	15	seconds
Daily water use per pupil	10	litres/pupil/day
After replacement of complete tap with a push tap		
Assume flowrate of	10	litres/min
Number of uses	8	per day per pupil
On average a screw head tap is left on for	6	seconds
Daily water use per pupil	8	litres/pupil/day
Proportion of total push taps retrofitted (x) =	number of push taps retrofitted/ total number of push taps in school	
Savings from push tap replacement	**2.0*x**	**litres/pupil/day**

Figure 33 - Assumptions for Estimating Water Savings in Schools from Complete Tap Replacement with a Push-Tap

Toilets - Dual-Flush Retrofit

No of toilet uses per day per pupil	2	
No of WC uses per pupil per day	1.33	
Assumed initial cistern volume	7.5	
Assumed average cistern volume after retrofit	5	
Average volume saved per toilet use	2.5	
Average water saving per pupil	3.3	litres per pupil per day
Proportion of total toilets retrofitted (y) =	number of WCs retrofitted/ total number of WCs in school	
Water savings from dual-flush retrofit =	**3.3*y**	**litres/pupil/day**

Figure 34 - Assumptions for Estimating Water Savings in Schools from Dual Flush Conversion

Toilets - Cistern Displacement Devices

No of toilet uses per day per pupil	2	
No of WC uses per pupil per day	1.33	
Assumed initial cistern volume	7.5	
Assumed average cistern volume after retrofit	6.5	
Average volume saved per toilet use	1	
Average water saving per pupil (x)	1.3	litres per pupil per day
Proportion of total toilets retrofitted (y) =	number of WCs retrofitted/ total number of WCs in school	
Water savings from cistern displacement devices =	**1.3*y**	**litres/pupil/day**

Figure 35 - Assumptions for Estimating Water Savings in Schools from Installation of CDDs

In-line flow regulators without push taps		
For twist taps assume flowrate of	10	litres/min
Number of uses	4	per day per pupil
On average a screw head tap is left on for	15	seconds
Daily water use per pupil	10	litres/pupil/day
After replacement of complete tap with a push tap		
Assume flowrate of	6	litres/min
Number of uses	4	per day per pupil
On average a screw head tap is left on for	15	seconds
Daily water use per pupil	6	litres/pupil/day
Proportion of total push taps retrofitted (z) =	number of regulators retrofitted/ total number of push taps in school	
Savings from flow regulator installation (no push tap)	**4.0*z**	**litres/pupil/day**

Figure 36 - Assumptions for Estimating Water Savings in Schools from In-line Flow Regulators without Push-Tap Retrofit

In-line flow regulators with push taps		
For twist taps assume flowrate of	10	litres/min
Number of uses	4	per day per pupil
On average a screw head tap is left on for	15	seconds
Daily water use per pupil	10	litres/pupil/day
After replacement of complete tap with a push tap		
Assume flowrate of	6	litres/min
Number of uses	8	per day per pupil
On average a screw head tap is left on for	6	seconds
Daily water use per pupil	4.8	litres/pupil/day
Proportion of total push taps retrofitted (z) =	number of regulators retrofitted/ total number of push taps in school	
Savings from flow regulator installation with push tap	**5.2*z**	**litres/pupil/day**

Figure 37 - Assumptions for Estimating Water Savings in Schools from In-line Flow Regulators with Push-Tap Retrofit

Installation of Urinal Control Device		
15 minute flush during occupancy	15	
School occupied 190 days out of 365 days	0.52	occupancy factor
9hrs/day, 6days/wk, 52wks/ann		
Available occupancy period	1624	hr/year
Annual flushes	6496	flushes
Consumption pre-service	58.47	m^3
Assume UCD serviced and switched to 20 minute flush frequency	30	
No of flushes per year	3248	
Consumption post-service	29.23	
Annual Water Savings	29.23	m^3/year
Daily Water Savings	0.08	m^3/day
Installation of UCD	**80**	**litres/day**

Figure 38 - Assumptions for Estimating Water Savings in Schools from Installation of Urinal Control Devices

Service of Urinal control devices		
15 minute flush during occupancy	15	
School occupied 190 days out of 365 days	0.52	occupancy factor
9hrs/day, 6days/wk, 52wks/ann		
Available occupancy period	1624	hr/year
Annual flushes	6496	flushes
Consumption pre-service	58.47	m^3
Assume UCD serviced and switched to 20 minute flush frequency	20	
No of flushes per year	4872	
Consumption post-service	43.85	
Annual Water Savings	14.62	m^3/year
Daily Water Savings	0.04	m^3/day
Service UCD	**40.0**	**litres/day**

Figure 39 - Assumptions for Estimating Water Savings in Schools from Servicing of Urinal Control Devices

4.3.3 Estimating Hot Water Savings

As there were few showers retrofitted as part of the work carried out in the 633 schools included in this report, showers are not included in the assessment of potential water savings in this report. As a result, the single most significant source of hot water savings in schools in this report comes from increasing the efficiency of hot taps.

A calculation was carried out to determine the proportion of the measured savings accounted for by hot water. This was necessary to understand the carbon emissions and energy savings which result from reduced hot water usage.

1. The first step is to understand the number of taps and toilets retrofitted and the number of taps and toilets in the school stock as a whole. This information was collected by Severn Trent Water and shared for the 43 logged schools.

2. Using the assumptions and equations developed in Figures 31 to 39, it is possible to estimate the savings for each of the devices installed as part of the schools projects. These individual savings are shown in the rows containing the savings for the different devices (EcoBeta savings, CDD savings, Push Taps - Retrofit savings, etc.) in Table 36.

3. These individual savings are summed to give the 'Total Theoretical Water Savings (litres/day)' row in Table 36. Dividing the values in this row by the site population of each school gives the 'Total Theoretical Water Savings (litres/pupil/day)' row in the table.

4. **The estimated water saved from tap retrofit and tap replacement is summed; this represents the hot water savings. The theoretical percentage of the total savings, including cold water and hot water savings, that this represents is assumed to be the actual percentage of hot**

water savings for each of the schools projects analysed as part of this report. This is shown in the bottom row of Table 36.

The hot water savings for each retrofitting project are calculated by multiplying the percentage of hot water savings calculated in step 4 by the measured water savings from each school. Where data is not available to enable the calculation to be carried out for a school, the mean hot water savings from the 43-school sample is applied (16%).

	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10	School 11	School 12	School 13	School 14	School 15
Ecobeta savings (litres/day)	0	9111	410	0	1974	10400	0	3301	316	2923	515	0	0	9401	0
CDD savings (litres/ day)	2123	359	323	57300	11664	4097	374	1300	187	16123	0	865	0	0	4861
Push Taps - Retrofit savings (litres/day)	0	4129	1476	0	0	1148	0	0	53	0	57	2832	5842	1847	12070
Push Taps - Complete tap savings (litres/day)	1172	0	0	8382	0	0	0	0	0	0	0	0	0	0	0
In-line flow regulators savings (litres/day)	37507	47566	0	10728	0	20657	0	2210	23950	0	6382	2212	19313	5319	24140
Urinal - Service UCD (litres/day)	40	40	80	120	0	0	0	40	40	40	0	120	0	80	0
Urinal - Installation of UCD (litres/day)	320	80	80	80	240	160	240	160	80	160	240	0	240	160	80
Total Theoretical Water Savings (litres/day)	41163	61285	2369	76610	13878	36461	615	7011	24626	19247	7194	6029	25395	16807	41152
Total Theoretical Water Savings (litres/pupil/day)	29	48	5	56	29	70	1	33	51	38	23	13	56	39	149
Hot water saved (litres/day)	586	2065	738	4191	0	574	0	0	27	0	28	1416	2921	923	6035
Theoretical percentage of hot water savings (%)	1	3	31	5	0	2	0	0	0	0	0	23	12	5	15

Table 36– Sample of spreadsheet used to calculate levels of hot water savings

The hot water savings provide the basis from which on-site hot water carbon emissions savings and energy savings can be calculated using Waterwise's Water Energy Calculator. However, the carbon emitted due to domestic water consumption can be divided into two components. One is related to the energy consumption and green house gas emissions **sourced from outside the school** for water and waste treatment and pumping. This type of emission would be categorised as **energy indirect** according to Defra's 'Guidance on how to measure and report your greenhouse gas emissions'[34]**.** The other component is **site hot water** carbon emissions and energy savings which are derived from reducing hot water consumption in the school itself. Both energy indirect and site hot water carbon emissions and energy savings are included in this report. How each of these types of energy and carbon emissions savings are relevant to water companies and to schools is explained below.

4.3.4 Cost Benefit Analysis: The Water Company Perspective

This report includes an estimate of the payback time from the water company perspective in section 4.5.1, and average incremental cost (AIC) and average incremental social cost (AISC) in section 4.7. This is important to water companies in determining the costs and benefits of undertaking a schools project.

34 Defra, 'Guidance on how to measure and report your greenhouse gas emissions', September 2009. Available at: http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-guidance.pdf

In terms of the water savings from retrofitting a school, the marginal cost of water is an estimate of the opex savings which accrue to the water company per unit of water saved. The marginal cost of water varies with time depending on, for example, the spare capacity in the network, the cost of capital, bulk transfer charges, abstraction charges and the cost of alternative supply options and is different for each water company.

The indirect energy savings are not directly included in the AIC and AISC calculations because these savings are implied in the opex savings which the water company realises from reduced water consumption in schools. The energy indirect carbon savings are not relevant to the water company payback calculation but are included in the calculation of AISC as shown in the Retrofit in Schools scenario in section 4.

4.3.5 Cost Benefit Analysis: The School Perspective

This report includes an estimate of the payback time from the school perspective in section 4.5.1.

Water savings from retrofitting accrue to the school at a value determined by the price of water the school pays to its water company. In this report, the price of water was taken as £2.25 per m^3 (the approximate average price of water valid across England and Wales and Scotland including supply and treatment). The electricity price used was 8.5 pence per kWh (varies greatly depending on tariffs but this is a typical price).

The site hot water energy savings are relevant to the school as these translate into monetary savings which the school would realise through reduced bills in the event that hot water is saved through retrofitting. These site hot water savings, along with the value of water saved, are included in the payback calculation.

4.3.6 The Weighted Central Value of Carbon Saved

The cost of carbon in this project was derived from the Department for Energy and Climate Change (DECC) document: 'A brief guide to the new carbon values and their use in economic appraisal'[35]. This document presents a table of carbon values and sensitivities for the period 2009 – 2050. For each year low, central and high carbon prices are presented for two different categories: traded and

[35] DECC, Carbon Appraisal in UK Policy Appraisal: A revised Approach A brief guide to the new carbon values and their use in economic appraisal, available at: http://www.renewableseast.org.uk/uploads/Carbon%20Appraisal%20in%20UK%20Policy%20appraisal%20revised%20approach.pdf

non-traded. Waterwise sought guidance from DECC as to how these prices should be applied to the two categories of carbon emission that stem from a reduction in water consumption: energy indirect and domestic hot water savings. The DECC guidance is as follows:

"Carbon emissions that are captured under the European Union Emissions Trading System (EU ETS) are known as 'traded' carbon emissions. This is understood to mean that: Carbon emissions produced by the use of electricity, such as for the operation of pumps and treatment of water on the distribution network, should be treated as traded carbon emissions. Carbon emissions produced by the use of gas, such as for the heating of hot water by a gas-fired boiler in the home, should be treated as non-traded carbon emissions."

The value of carbon which is applied to the AISC and AIC calculations in this report depends on the proportion of carbon emissions which fall into the energy indirect carbon savings (traded) and the domestic hot water carbon savings (non-traded), as these are valued differently. For 2010, traded carbon emissions are valued at £22 per tCO2e and non-traded carbon emissions are valued at £52 per tCO2e. This means that in the AIC and AISC calculations a value of £22 per tCO2e will be used because energy indirect carbon savings (traded carbon) are included in the calculation.

A full description of this water – energy model and its application to water savings was given in the first report of Phase II of the Evidence Base (pages 42 – 49), published in February 2010[36]. An electronic version is available on request.

36 The Evidence Base Phase II interim report, February 2010. Available at:

http://www.waterwise.org.uk/images/site/Policy/evidence_base/evidence%20base%20for%20large-scale%20water%20efficiency%20in%20homes%20-%20phase%20ii%20interim%20report.pdf

4.4 The Evidence

In this section the methodology described in section 4.3 is applied to the analysis of water company water efficiency retrofitting projects carried out in 633 schools in five English regions and Scotland. In addition to evidence provided by the Environment Agency, the water companies which have provided the evidence included in this report are:

- ⇒ Business Stream
- ⇒ Essex and Suffolk Water
- ⇒ Severn Trent Water
- ⇒ Southern Water
- ⇒ Thames Water (two projects)

This section will present the evidence from the seven water company-led school water efficiency programmes. In the case of the Severn Trent Water and Thames Water schools programmes, there were two sources of data: data loggers and meter readings. Data was provided by Essex and Suffolk Water in the form of meter readings.

Where logger data was collected it was possible to filter the data in order to include in the analysis only days when the children were in attendance at the school. The meter data quality was generally much coarser and did not allow the exclusion of days on which the school was closed to children. Furthermore, some of the schools have facilities which are used during periods when the school is closed, such as for sports or community events. Due to the difference in the level of uncertainty in the two data sources they are analysed separately and initially presented as such. However, the data was then combined where feasible to allow conclusions to be drawn from the larger dataset.

Southern Water's school trial and Business Stream's schools programme information are presented in the form of case studies.

In addition to the water companies listed above there are several companies who have carried out, are currently or will soon be carrying out water efficiency programmes in schools and whose work will be included in subsequent Evidence Base reports as the evidence becomes available. These include:

- ⇒ Essex and Suffolk Water
- ⇒ Severn Trent Water
- ⇒ South Staffordshire Water
- ⇒ Sutton and East Surrey Water
- ⇒ Thames Water
- ⇒ Welsh Water
- ⇒ Yorkshire Water

4.4.1 The Environment Agency's Schools Water Efficiency Grants Project

4.4.1.1 Summary

This Environment Agency Southern Region project took advantage of an opportunity to support the schools water efficiency initiatives being promoted by Southern Region Water Companies. The Environment Agency offered grants to schools in the region to help them improve their water efficiency. This project had three main objectives:

- ⇒ To encourage practical implementation of further water efficiency measures across the schools of Southern Region
- ⇒ To generate valuable information on water measures adopted through the scheme, as well as costs of measures applied and water savings achieved
- ⇒ To use opportunities to promote the importance of the water environment and encourage schools to use the water efficiency project to educate pupils and staff in the wise use of water and the relative scarcity of this natural resource.

The project was active from April 2002 to December 2004. During that period nearly 500 schools expressed an interest in the project proving that schools are interested in environmental issues and are open to schemes that help them deliver improvements.

65 schools received a grant and spent approximately £120,700 on their water efficiency projects across the region. Data was collected from four of the schools for further analysis and to investigate the benefits of installing water efficient fitting in schools.

The water efficiency devices installed were push taps, urinal flow control devices and replacement toilet cisterns.

4.4.1.2 Monitoring and Data Collection

Sub-metering was installed to monitor flows to taps and toilet facilities before and after the retro-fit. This allowed the effect of different fittings to be assessed. Where sub-metering could not be installed due to the layout of the internal plumbing, the main building meter flows were used to assess the effect of the overall retro-fit which might then include a number of different fittings i.e. push taps and new toilet fittings. Flow meters were installed for several weeks prior to the retrofit work, during normal term time, to gauge pre-installation consumption rates. Data loggers were installed to record the flow of water every 5 minutes for a period of three to four weeks and from this the operating characteristics of each device could be determined.

Schools were retrofitted during the school holiday periods where possible and following retrofit the flow meters were monitored again for a period of three to four weeks.

4.4.1.3 Analysis of Results

Table 37 presents a summary of the logger data collected during the Environment Agency Schools Water Efficiency Grants Project. This shows that an average 18.92% reduction in water consumption or 3.60 m^3/day was observed from the 43 schools at a cost of £0.48 per litre per day. Of the four schools which were included in the project, all reduced their water consumption from before to after the retrofit was carried out.

No of Schools	**4**
Mean Pre-intervention consumption (m3/pupil/year)	**8.49**
Mean Post-intervention consumption (m3/pupil/year)	**6.89**
Mean water savings (m3/pupil/year)	**1.61**
Mean water savings (m3/day)	**3.60**
Percentage change of water savings	**18.92**
Mean cost of retrofit (£)	**1730**
Cost per litre per day (£)	**0.48**
Probability of saving water	**100%**

Table 37- Summary of results from the Environment Agency's Schools Water Efficiency Grants Project

The bar chart in Figure 40 shows the distribution of water savings for each of the four schools. All the schools demonstrated a reduction in consumption in the monitoring periods before and after the intervention.

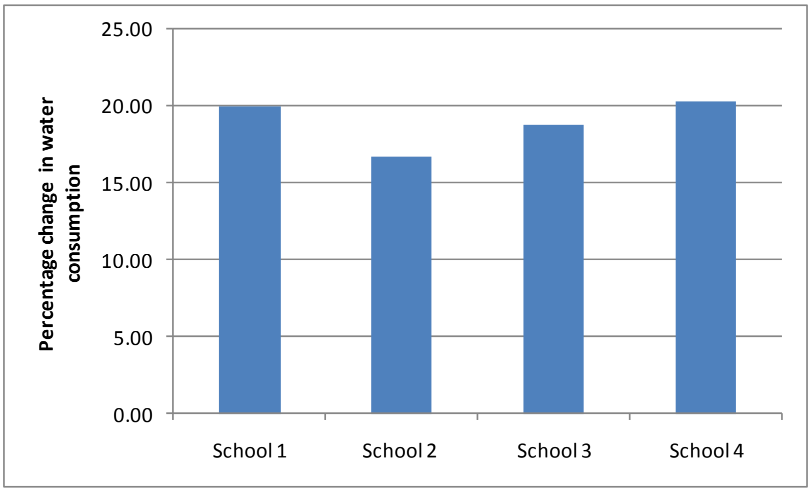

Figure 40 - Distribution of savings from logger data from the Environment Agency's Schools Water Efficiency Grants Project

Table 38 gives the confidence intervals for the water savings from four schools from which the logger data is currently available from the Environment Agency's Schools Water Efficiency Grants Project.

	Max	Min
90% Confidence interval (% water saved)	21.7	16.2
90% Confidence interval (m3/pupil/year)	3.7	-0.4

Table 38 - Water savings confidence intervals for meter data from the Environment Agency's Schools Water Efficiency Grants Project

4.4.1.4 Carbon Emission and Energy Savings

Table 39 presents the carbon emissions and energy savings which derive from hot water savings from the schools. The methodology for calculating these savings is described in Chapter 4. The savings were derived from the measured water savings from which hot water savings were then calculated. Energy indirect carbon emissions savings of 78 kgCO_2e/annum were achieved, alongside estimated domestic hot water carbon emissions of 839 kgCO_2/annum. Mean energy savings of approximately 4075 kWh/annum per school are estimated to have resulted from retrofitting in these four schools.[37]

Mean energy indirect carbon emissions saved (kgCO2e/annum)	78
Mean site hot water carbon emissions saved (kgCO2/annum)	839
Mean energy saved (kWh/annum)	4075

Table 39- Summary of carbon emissions and energy savings derived from logger data the Environment Agency's Schools Water Efficiency Grants Project

[37] The energy indirect carbon emissions savings are relevant to the water company as a benefit in AIC and AISC calculations whereas the site hot water energy savings are a benefit which accrues to the school and are relevant to the school's payback calculation. The site hot water carbon emissions savings are relevant to the school but are not applied here in either the calculation of AIC/AISC or in the payback calculation.

4.4.2 Essex & Suffolk Water – Schools Water Efficiency Programme

4.4.2.1 Summary

As part of Essex & Suffolk Water's Schools Water Efficiency Programme carried out during 2010, 39 schools were retrofitted, in order to help them to reduce their water consumption and lower their water bills.

55 schools within a town were identified and written to by Essex & Suffolk Water. This was followed up with a phone call to the Finance Officer/Bursar to provide further explanation and encourage them to sign up. Once a school agreed to take part in the project a pre-audit survey was scheduled to ascertain the condition of the water-using devices on the school's premises. It was at the pre audit survey that the first meter reading was taken or a data logger was installed to enable daily meter reading to be collected. A minimum of two further meter readings were scheduled if no data logger was installed.

A recommendation report was written following the completion of the pre-audit survey which was then sent to the school and Essex & Suffolk Water. The school was then contacted and given the option to either opt out or schedule a date for the installation of the water efficient measures based on the recommendations. On the day of the audit, a meter reading or logger data download was planned to finalise the pre-installation monitoring period. A date to collect the final meter reading or logger data was planned and scheduled. The range of devices recommended/fitted was as follows:-

Toilets	Dual flush valve conversion
	EcoBETA dual flush siphon
	Cistern Dams
	Cistern Displacement Devices
Taps	Push Taps - Retrofit
	Push Taps - Complete tap
	In-line flow regulators
	Outlet aerators regulator
	Re-time existing tap
Urinals	Service UCD
	Hydromate - Mains 240v
	Hydrocell - Battery 6v
	Hydrocell Ultra - Battery 6v
	Isolation valve
Showers	AV Wall mounted shower
	Wall mounted shower
	Hand held showers
	TD Valve - New
	TD Valve - Replace

Figure 41 - Full list of products available for installation in the schools.

4.4.2.2 Monitoring and Data Collection

39 schools, which received installations during Phase 2 of this project, had meter readings collected from them. In order to determine pre and post-intervention consumption a minimum of three meter readings were collected, with the first meter reading being taken at the time of the pre audit survey and a minimum of two further meter readings scheduled.

4.4.2.3 Analysis of Results

Meter readings were collected from 39 schools as part of Phase 2 of Essex and Suffolk Water's Schools Programme allowing calculation of pre and post-intervention water consumption in the schools. Table 40 summarises some of the key results from these 39 schools. Mean water savings of 0.78 m^3 per day were achieved, which equates to a reduction of 11.69% in water consumption across the schools. Cost data and details of the school population were not available at the time of writing so it was not possible to determine the cost per litre of water saved or the per pupil consumption change in this instance.

No of Schools	**39**
Mean Pre-intervention consumption (m3/pupil/year)	**-**
Mean Post-intervention consumption (m3/pupil/year)	**-**
Mean water savings (m3/pupil/year)	**-**
Mean water savings (m3/day)	**0.78**
Percentage change of water savings	**11.69**
Mean cost of retrofit (£)	**-**
Cost per litre per day (£)	**-**
Probability of saving water	**72%**

Table 40- Summary of results derived from meter reading data from Phase 2 of Essex and Suffolk Water's Schools Programme

The bar chart in Figure 43 shows the distribution of water savings for each of the 39 schools. It is clear from the chart that the majority of schools saw a reduction in consumption between the pre and post-intervention periods although increases in consumption were observed in a few schools. 72% of the schools (28 out of 39) demonstrated a reduction in consumption in the monitoring periods after the intervention.

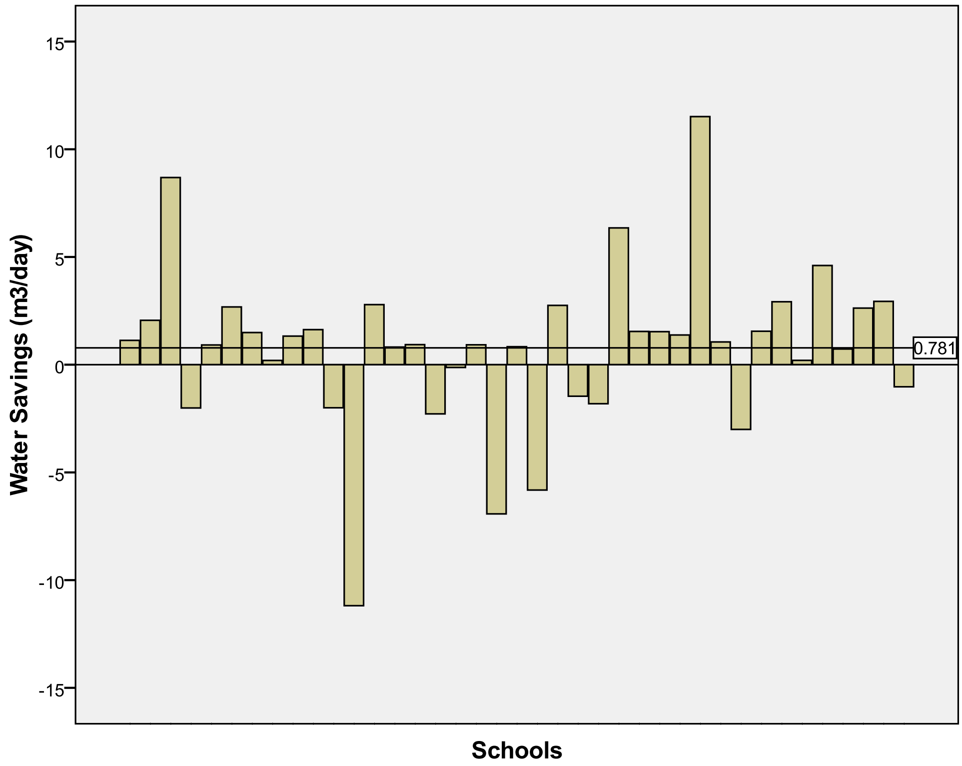

Figure 42- Distribution of savings from school meter read data from Phase 2 of Essex and Suffolk Water's Schools Programme

Table 41 gives the 90% confidence intervals for the sample of schools in terms of percentage reduction in consumption (Data was not available to include the m^3 per pupil per year figures)

	Max	Min
90% Confidence interval (% reduction in consumption)	107.1	-96.7
90% Confidence interval (m3/pupil/year)	-	-

Table 41 - Water savings confidence intervals for meter data from Phase 2 of Essex and Suffolk Water's Schools Programme

4.4.2.4 Carbon Emissions and Energy Savings

The data was not available to calculate the carbon emissions and energy savings for the Essex and Suffolk Water Schools Programme. However, this section will be updated once the data is made available.

4.4.3 Severn Trent Water – Schools Water Efficiency Programme

4.4.3.1 Summary

As part of Severn Trent Water's Schools Water Efficiency Programme run in 2008/2009, 600 schools were retrofitted, in partnership with local councils. Approximately 482 schools had consumption data collected from them before and after the retrofit was undertaken.

The starting point for the process was contacting the council and outlining the benefits of working with schools on water efficiency retrofitting to reduce the school's water consumption and therefore reduce its water bills. Local authorities are important in this process because they can help facilitate communication with schools, through their existing relationships. Schools within the council's area were identified jointly by Severn Trent Water and the council and then contacted by the council. Once a school agreed to take part in the project an audit was scheduled to ascertain the condition of the water-using devices on the school's premises. At the audit, the first meter reading was taken or a data logger installed to enable daily meter reading to be collected. A minimum of two further meter readings were scheduled if no data logger was installed.

A recommendation report was written following the completion of the audit, to inform a decision on whether to go ahead with the work, firstly by Severn Trent and subsequently by the council and the school. Once the audit recommendations were accepted, a date for the installation of the water efficiency measures was scheduled. On the day of installation, a meter reading or logger data download was planned to finalise the pre-installation monitoring period. A date to collect the final meter reading or logger data was planned and scheduled.

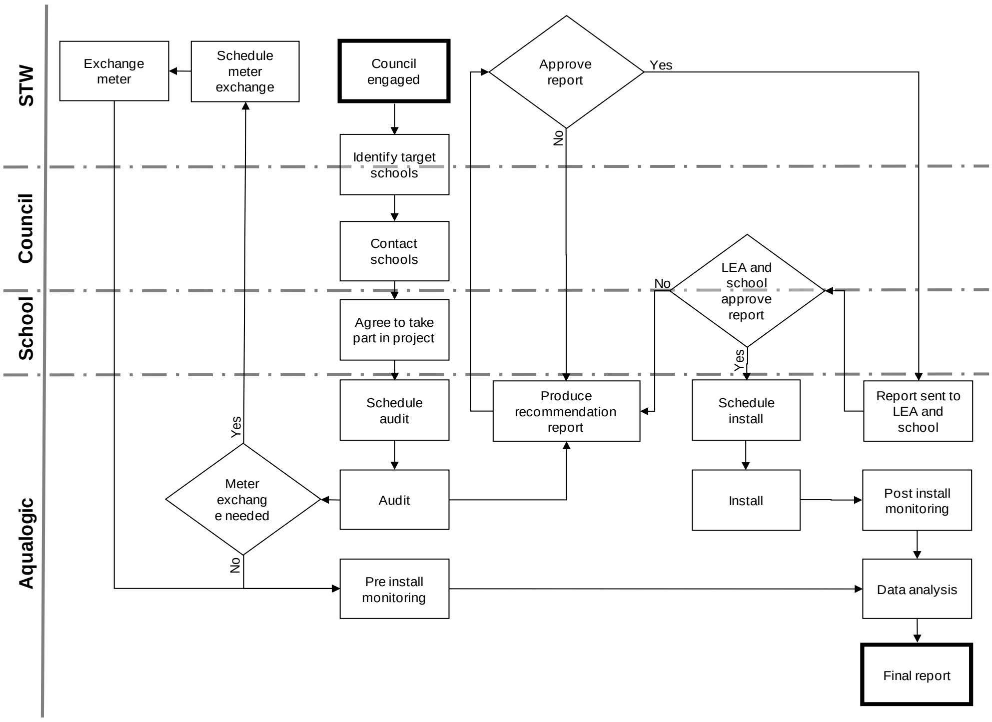

Figure 43 - Process map describing the approach used by Severn Trent Water to carry out water efficiency retrofitting projects in schools in partnership with the local councils

Toilets	Dual-flush valve conversion
	EcoBETA dual flush siphon
	Cistern Dams
	Cistern Displacement Devices
Taps	Push Taps - Retrofit
	Push Taps - Complete tap
	In-line flow regulators
	Outlet aerators regulator
	Re-time existing tap
Urinals	Service UCD
	Hydromate - Mains 240v
	Hydrocell - Battery 6v
	Hydrocell Ultra - Battery 6v
	Isolation valve
Showers	AV Wall mounted shower
	Wall mounted shower
	Hand held showers
	TD Valve - New
	TD Valve - Replace

Figure 44 - Full list of products available for installation in the schools.

4.4.3.2 Monitoring and Data Collection

There are two sources of data from this trial. Flow readings were collected every 15 minutes by Severn Trent Water from 43 schools which were then aggregated to provide daily consumption data. Over the same period meter readings were collected from approximately 560 more schools which had received installations.

For schools which were monitored with data loggers, the installation of water-efficiency measures was carried out within the period that daily measurement of consumption was taking place, and there was typically at least 3-4 weeks' worth of data available to help understand the pre-retrofit water consumption. Data was therefore available to allow water savings from the intervention to be assessed. The logger data was filtered in order to include only days when the children were in attendance.

For the metered schools, pre and post-intervention consumption were calculated from the minimum of three meter readings that were collected. The consumption figures were modified to take into account that the schools are closed on weekends and during school holidays. For schools monitored using manual meter readings, the first meter reading was taken at the time of the audit and a minimum of two further meter readings scheduled.

4.4.3.3 Analysis of Results – Logger Data STW Schools Programme

Table 42 presents a summary of the logger data collected during the Severn Trent Water schools programme. This shows that an average 14.52% reduction in water consumption or 1.18 m^3/day was observed from the 43 schools at a cost of £0.72 per litre per day. Of the 43 logged schools which were included in the programme, 35 reduced their water consumption and an increase in consumption was observed in 8 schools. Further analysis is carried out in Chapter 8 to consider whether the Department for Education and Schools (DfES) benchmarking framework can provide further insight to help effectively target future school retrofitting activities.

No of Schools	43
Mean Pre-intervention consumption (m3/pupil/year)	5.93
Mean Post-intervention consumption (m3/pupil/year)	4.66
Mean water savings (m3/pupil/year)	0.9963
Mean water savings (m3/day)	1.18
Percentage change of water savings	14.52
Mean cost of retrofit (£)	850.56
Cost per litre per day (£)	0.72
Probability of saving water	81%

Table 42- Summary of logger data from Severn Trent Water's Schools Water Efficiency Programme

The bar chart in Figure 45 shows the distribution of water savings for each of the 43 schools. 81% of the schools (35 out of 43) demonstrated a reduction in consumption in the monitoring periods before and after the intervention.

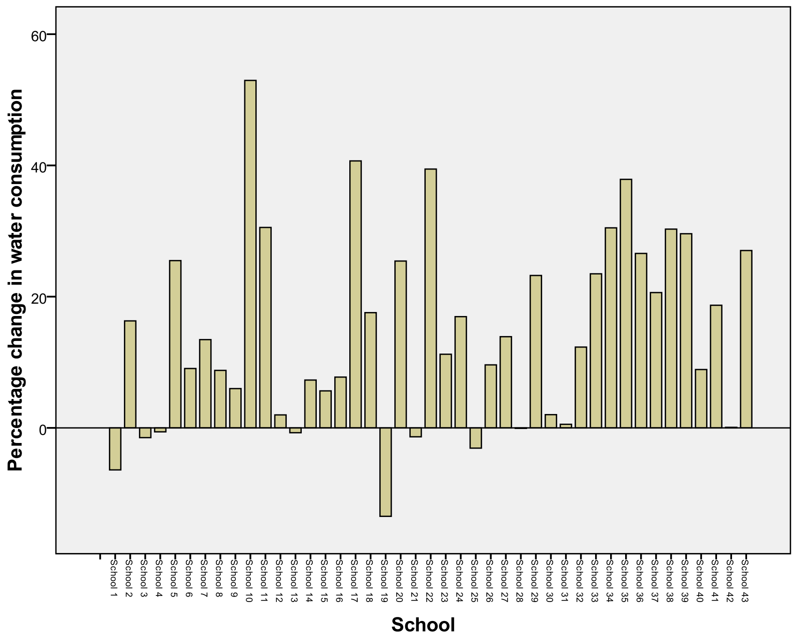

Figure 45 - Distribution of savings from logger data from Severn Trent Water’s Schools Water Efficiency Programme

Table 43 gives the confidence intervals for the water savings from 43 schools from which the logger data is currently available from Severn Trent Water's Schools Water Efficiency Programme. In addition, Table 44 gives the average monitoring period both before (37 days) and after (64 days) installation of products in the schools.

	Max	Min
90% Confidence interval (%water saved)	38.5	-9.4
90% Confidence interval (m3/pupil/year)	5.8	-3.4

Table 43 - Water savings confidence intervals for meter data from Severn Trent Water's Schools Water Efficiency Programme

Mean no of days pre-retrofit monitoring	37
Mean no of days post-retrofit monitoring	64

Table 44- Mean monitoring periods before and after retrofitting for logged data collected from Severn Trent Water's Schools Water Efficiency Programme

4.4.3.4 Carbon Emission and Energy Savings

Table 45 presents the carbon emissions and energy savings which derive from hot water savings from the schools. The methodology for calculating these savings is described in Chapter 4. The savings were derived from the measured water savings from which hot water savings were then calculated. Energy indirect carbon emissions savings of 272 $kgCO_2e$/annum were achieved, alongside estimated domestic hot water carbon emissions of 294 $kgCO_2$/annum. Mean energy savings of approximately 1429 kWh/annum per school are estimated to have resulted from retrofitting in these 43 schools.[38]

Mean energy indirect carbon emissions saved (kgCO2e/annum)	272
Mean site hot water carbon emissions saved (kgCO2/annum)	294
Mean energy saved (kWh/annum)	1429

Table 45- Summary of carbon emissions and energy savings derived from logger data from Severn Trent Water's Schools Water Efficiency Programme

[38] The energy indirect carbon emissions savings are relevant to the water company as a benefit in AIC and AISC calculations whereas the site hot water energy savings are a benefit which accrues to the school and are relevant to the school's payback calculation. The site hot water carbon emissions savings are relevant to the school but are not applied here in either the calculation of AIC/AISC or in the payback calculation.

4.4.3.5 Analysis of Results – Meter Data STW Schools Programme

In addition to the logger data from 43 schools, meter readings were collected from 439 schools as part of Severn Trent Water's Schools programme, allowing calculation of pre and post-intervention water consumption in the schools. Table 46 summarises some of the key results from these 439 schools. Mean water savings of 1.76 m^3 per pupil per year were achieved, which equates to a 23% reduction in water consumptions across the 439 schools. The water savings were achieved at a cost of £0.42 per litre per day with an average cost of approximately £740 per school.

No of Schools	**439**
Mean Pre-intervention consumption (m3/pupil/year)	**6.57**
Mean Post-intervention consumption (m3/pupil/year)	**4.81**
Mean water savings (m3/pupil/year)	**1.7615**
Mean water savings (m3/day)	**1.78**
Percentage change of water savings	**23.07**
Mean cost of retrofit (£)	**739.39**
Cost per litre per day (£)	**0.42**
Probability of saving water	**90%**

Table 46- Summary of meter reading data from Severn Trent Water's Schools Water Efficiency Programme

The bar chart in Figure 46 shows the distribution of water savings for each of the 439 schools. 90% of the schools (397 out of 439) demonstrated a reduction in consumption in the monitoring periods after the intervention.

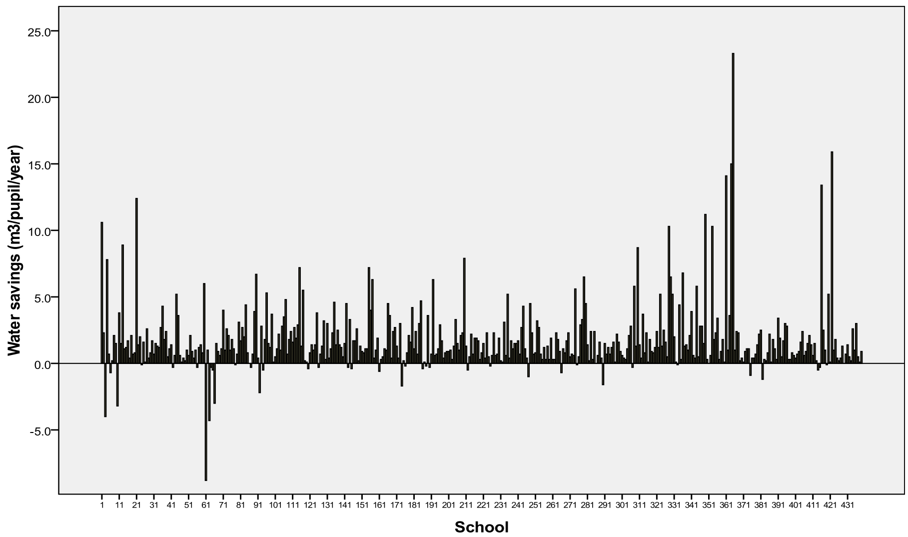

Figure 46 - Distribution of savings from meter reading data from Severn Trent Water's Schools Water Efficiency Programme

Table 47 gives the 90% confidence intervals for the sample of schools in terms of both percentage reduction in consumption and m^3 per pupil per year. There are wide confidence bands due to the huge variability in the results from the 439 schools. The confidence intervals are much wider than those seen for the 43 schools which yielded the logger data. This may be due to the larger size of the sample of schools in this case, but it may also be due to the greater uncertainty in the data itself. The savings were calculated from three meter readings and although the data was modified to take account of the fact that the children are not present in the schools on weekends and school holidays, it is difficult to predict the level of consumption in a school at the weekend. Schools may be used for their sports facilities or for community events and very often have significant consumption when not officially open.

	Max	Min
90% Confidence interval (%water saved)	62.5	-16.4
90% Confidence interval (m3/pupil/year)	6.0	-2.5

Table 47 - Water savings confidence intervals for meter data from Severn Trent Water's Schools Water Efficiency Programme

4.4.3.6 Carbon Emission and Energy Savings

Table 48 presents the carbon emissions and energy savings which derive from hot water savings from the schools. The methodology for calculating these savings is described in Chapter 4. The savings were derived from the measured water savings from which hot water savings were then calculated. Energy indirect carbon emissions savings of 485 $kgCO_2e$/annum were achieved, alongside estimated domestic hot water carbon emissions of 836 $kgCO_2$/annum. Mean energy savings of approximately 4058 kWh/annum per school are estimated to have resulted from retrofitting in these 43 schools.[39]

Mean energy indirect carbon emissions saved (kgCO2e/annum)	485
Mean site hot water carbon emissions saved (kgCO2/annum)	836
Mean energy saved (kWh/annum)	4058

Table 48 - Summary of carbon emissions and energy savings derived from meter read data from Severn Trent Water's Schools Water Efficiency Programme

[39] The energy indirect carbon emissions savings are relevant to the water company as a benefit in AIC and AISC calculations whereas the site hot water energy savings are a benefit which accrues to the school and are relevant to the school's payback calculation. The site hot water carbon emissions savings are relevant to the school but are not applied here in either the calculation of AIC/AISC or in the payback calculation.

4.4.4 Thames Water - Water Makeover Project

In 2009 Thames Water partnered with Aqualogic and ech2o as part of Thames Water's Schools Water Makeover which consisted of an audit, retrofit and education programme for 22 primary and 10 secondary schools in the Thames Water area. The project aimed to produce a measurable reduction in water consumption whilst engaging and educating the school's pupils about the need for water conservation, and to generate case studies to encourage other schools to use water wisely. The project's findings have helped Thames Water to better understand water use, and potential water savings, in schools.

14 of the schools were logged to measure current water use and this, combined with historical bills data, was used to rate each school against DFES benchmark tables. In the other 18 schools, meter reading data was collected to allow assessment of the change in consumption. After an assembly about the project by ech2o, and an audit of the school by a group of pupils, Aqualogic technicians visited the school to undertake a professional audit and to fit various water-saving technologies including urinal controls, dual-flush mechanisms and push taps. Logging the schools throughout the process enabled the effect of both behavioural changes and different technical solutions to be identified and quantified.

Various water awareness workshops were run and 33 "Be Water Aware" assemblies, covering 7,446 pupils and 264 teachers, explaining why it is important to save water and the link between water and CO2 emissions. Pupils were urged to be more water-aware and were challenged to save at least 10 litres of water a day. The project worked with 557 pupils in 21 of the schools to carry out a water audit and to identify low-cost and zero-cost water efficiency measures which could be implemented to reduce their water consumption, as well as encouraging pupils to contribute other ideas toward reducing their school's water footprint. In addition two short films were produced to demonstrate how to fit a save-a-flush bag, and shown to 2539 pupils in 31 schools.

4.4.4.1 Monitoring and Data Collection

Of the 32 schools that were monitored using data loggers, 14 schools yielded flow readings every 15 minutes, which were collected by Thames Water and aggregated to provide daily consumption data. One school, which reduced its consumption by an amount greater than the other 13 schools combined, was treated as an outlier and was removed from the analysis. This left a sample of 13 schools yielding logger data for analysis. 18 more schools, which received installations, had meter readings collected to allow the change in consumption from before to after the intervention to be assessed.

4.4.4.2 Analysis of Results

Logger data from 13 schools included in Thames Water's Water Makeover Project is analysed here. Table 49 summarises some of the key results from these 13 schools. Mean water savings of 1.78 m^3 per pupil per year were achieved, which equates to a 23% reduction in water consumption across the 13 schools. The water savings were achieved at a cost of £0.41 per litre per day with an average cost of approximately £1277 per school.

No of Schools	13
Mean Pre-intervention consumption (m3/pupil/year)	8.22
Mean Post-intervention consumption (m3/pupil/year)	6.44
Mean water savings (m3/pupil/year)	1.78
Mean water savings (m3/day)	3.13
Percentage change of water savings	23.41
Mean cost of retrofit (£)	1276.74
Cost per litre per day (£)	0.41
Probability of saving water	93%

Table 49- Summary of results derived from meter reading data from Thames Water's Water Makeover Project

The bar chart in Figure 47 shows the distribution of water savings for each of the 13 schools. 93% of the schools (12 out of 13) demonstrated a reduction in consumption in the monitoring periods before and after the intervention.

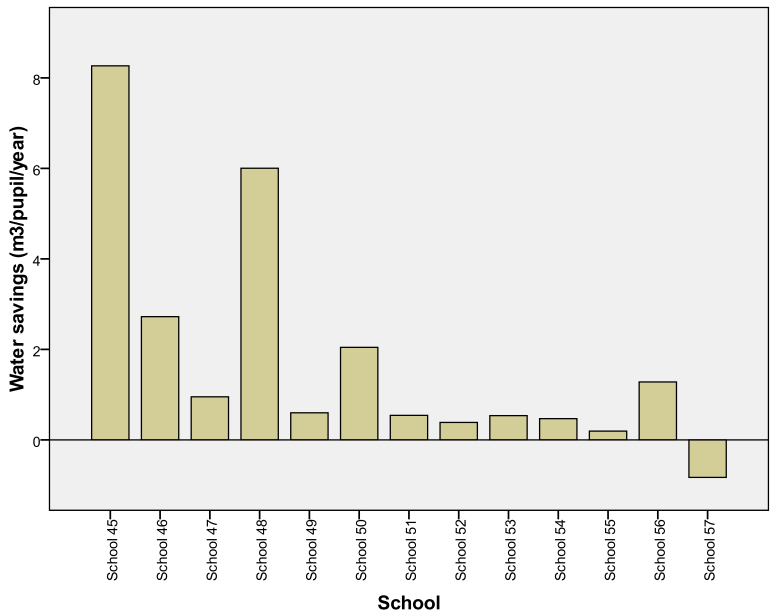

Figure 47 - Distribution of savings from logger data from Thames Water's Water Makeover Project

Table 50 gives the 90% confidence intervals for the sample of schools in terms of both percentage reduction in consumption and m^3 per pupil per year. As with previous results, there are wide confidence bands due to the huge variability in the results from the 13 schools.

	Max	Min
90% Confidence interval (% water saved)	65.0	-18.2
90% Confidence interval (m3/pupil/year)	6.0	-2.4

Table 50 - Water savings confidence intervals for meter data from Thames Water's Water Makeover Project

4.4.4.3 Carbon Emission and Energy Savings

Table 51 presents the carbon emissions and energy savings which derive from hot water savings from the schools. The methodology for calculating these savings is described in Chapter 4. The savings are drawn from the measured water savings from which hot water savings are then calculated. Energy indirect carbon emissions savings of 853 $kgCO_2e$/annum were achieved, alongside estimated domestic hot water carbon emissions of 1470 $kgCO_2$/annum. Mean energy savings of approximately 7137 kWh/annum per school are estimated to have resulted from retrofitting in these 13 schools.[40]

Mean energy indirect carbon emissions saved (kgCO2e/annum)	853
Mean site hot water carbon emissions saved (kgCO2/annum)	1470
Mean energy saved (kWh/annum)	7137

Table 51- Summary of carbon emissions and energy savings derived from logger data from Thames Water's Water Makeover Project

[40] The energy indirect carbon emissions savings are relevant to the water company as a benefit in AIC and AISC calculations whereas the site hot water energy savings are a benefit which accrues to the school and are relevant to the school's payback calculation. The site hot water carbon emissions savings are relevant to the school but are not applied here in either the calculation of AIC/AISC or in the payback calculation.

4.4.5 Case Study: Business Stream

In 2007, a local council in Scotland approached Business Stream, setting out as their major priority the reduction of their water consumption levels and identification of where the largest savings could be made. The local council was aware that water consumption levels varied widely across many of their schools. Leaks, poorly-adjusted valves and inefficiencies were responsible, but without being able to monitor fluctuation levels the council was unable to address these problems. With the help of Business Stream the local council was able to significantly reduce its water consumption levels, resulting in year-on-year savings of over £56,000.

Business Stream's water experts suggested the local council benchmark its consumption levels against recognised national standards. Benchmarking enabled the highlighting of those schools with the greatest potential for savings. Taking into account the number of pupils and the areas of each school, five schools were identified as having excessive water consumption.

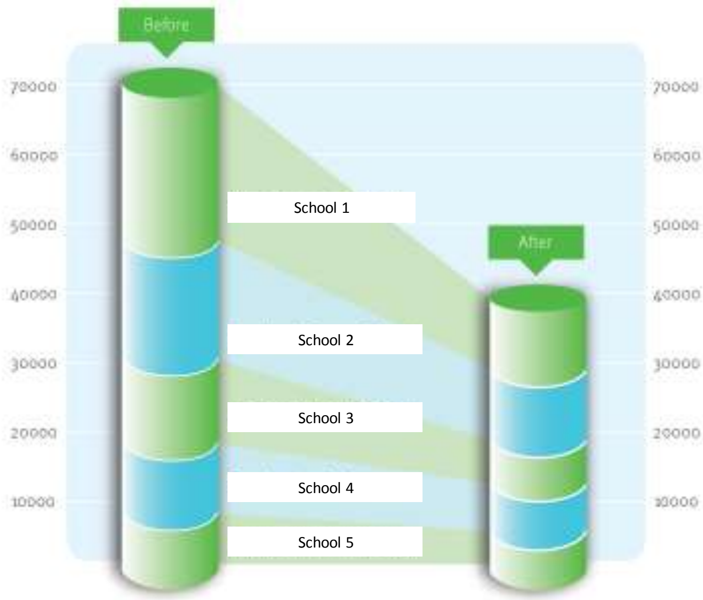

Figure 48 – The schools' water consumption in cubic meters before and after leakage repairs carried out by Business Stream

Business Stream installed smart meters in each of these five schools to provide more in-depth meter reads. Smart meters provide a number of benefits, including the ability to control and monitor water usage in real-time. They are able to gather and record water readings every 15 minutes, allowing monitoring of consumption patterns as well as identification of leaks and wastage.

The combined use of benchmarking and the installation of smart meter technology enabled the gathering of detailed data which was used to identify a number of leaks across the five schools. When the work was fully completed Business Stream provided the local council with a series of water management recommendations to enhance their water efficiency.

The project delivered a number of business benefits to the council. Firstly the annual water consumption in these five schools fell by 31,000 m^3, which represented a significant 44% of the previous year's total, greatly improving water efficiency. Improved water efficiency also resulted in major financial savings for the local council: these five sites alone are now saving the council over £56,000 a year in water and sewerage charges.

4.4.6 Thames Water Liquid Assets Project

This project, carried out in 2006, aimed to establish the level of water saving that could be achieved through improved water efficiency in the public sector, and to build an understanding of the key areas in which, and how, this reduction could be achieved.

In order to increase understanding of where water savings could be made, it was important to understand water use across a range of sites. Working with over two hundred public sector sites, Thames Water identified key water-using areas, and produced guidance on how best to manage both domestic and process use of water effectively in each of these areas, with reference to actual savings made throughout the project.

The 247 sites involved included 154 schools with high water consumption within their respective geographical areas, identified in partnership with fourteen local authorities. The project also covered council-owned municipal and service sites (40 in total), the largest London hospitals (7) and prisons (8) in the Thames Water region.

The schools were provided with a water audit, helping them to understand their current consumption, identify any potential leaks and make recommendations on how to reduce consumption on site. In order to assist the sites in implementing change Thames Water provided a budget for each school, to fund the installation of some or in many cases, all the technology recommended. Seed funding was also provided to many of the councils involved to help implement change. The schools were then provided with a report detailing water use on site, the measures funded and installed by Thames Water and the associated savings expected, as well as any recommendations still requiring action.

In addition to the audits, an educational programme was run within the secondary schools. 441 pupils across 23 secondary schools were involved in the workshops, which brought together the technical and behavioural aspects of water efficiency, with activities to raise the awareness of the water industry, everyday water use and the reasons why it is becoming increasingly important to use water wisely. Water efficiency auditors attended the school on the same day so that when the pupils carried out their own audit, they could discuss the potential solutions with the auditors and take part in the technological change.

In total, 247 audits were undertaken and 4336 measures funded and installed by Thames Water, including new urinal controls, service of existing urinal controls, push taps and cistern devices. A number of the schools have acted on the additional recommendations made and installed further measures and changed processes.

4.4.6.1 Monitoring and Data Collection

95 schools which received installations had meter readings collected from them. For the metered schools, pre and post-intervention consumption were calculated from the minimum of three meter readings which were collected, with the first meter reading being taken at the time of the audit and a minimum of two further meter readings scheduled. The consumption figures were modified to take into account that schools are closed on weekends and during school holidays.

4.4.6.2 Analysis of Results

Meter readings were collected from 95 schools as part of Thames Water's Liquid Assets Project allowing calculation of pre and post-intervention water consumption in the schools. Table 52 summarises some of the key results from these 95 schools. Mean water savings of 0.58 m^3 per pupil per year were achieved, which equates to a 1.85 % reduction in water consumption across the schools. There was no cost data available for this project so it was not possible to determine the cost per litre of water saved in this instance.

No of Schools	95
Mean Pre-intervention consumption (m3/pupil/year)	6.37
Mean Post-intervention consumption (m3/pupil/year)	5.80
Mean water savings (m3/pupil/year)	0.5780
Mean water savings (m3/day)	0.52
Percentage change of water savings	1.85
Probability of saving water	65%

Table 52- Summary of results derived from meter reading data from Thames Water's Liquid Assets Project

The bar chart in Figure 49 shows the distribution of water savings for each of the 95 schools. It is clear from the chart that a number of schools saw significant increases in consumption between the pre and post-intervention periods. 65% of the schools (62 out of 95) demonstrated a reduction in consumption in the monitoring periods before and after the intervention, which is a lower proportion than seen in the other projects. However, 33 schools showed an increase in consumption and about 24 of these increased consumption by 1 m^3 per pupil per year or more.

The reason for this is unclear, but it may be because the audits identified necessary works under the Water Regulations which required certain flow which had been shut off to be restored. It could also be that there were leakage issues during the post-intervention monitoring period.

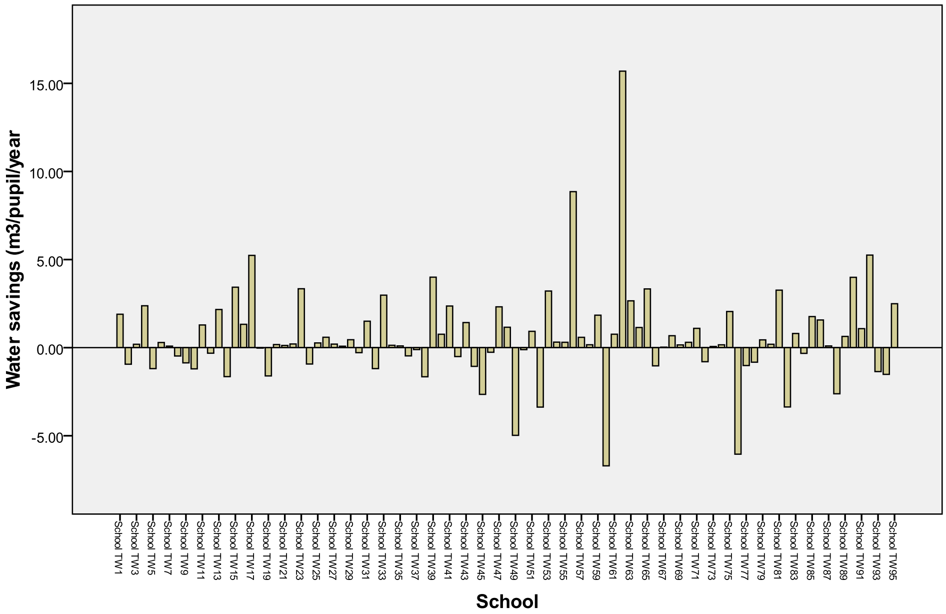

Figure 49- Distribution of savings from school meter read data from Thames Water's Liquid Assets Project

Table 53 gives the 90% confidence intervals for the sample of schools in terms of both percentage reduction in consumption and m^3 per pupil per year.

	Max	Min
90% Confidence interval (%water saved)	67.0	-63.3
90% Confidence interval (m3/pupil/year)	5.0	-3.8

Table 53- Water savings confidence intervals for meter data from Thames Water's Liquid Assets Project

4.4.6.3 Carbon Emissions and Energy Savings

Table 54 presents the carbon emissions and energy savings which derive from hot water savings from the schools. The methodology for calculating these savings is described in Chapter 4. The savings are drawn from the measured water savings, from which hot water savings are then calculated. Energy indirect carbon emissions savings of 142 $kgCO_2e$/annum were achieved, alongside estimated domestic hot water carbon emissions of 246 $kgCO_2$/annum. Mean energy savings of approximately 1193 kWh/annum per school are estimated to have resulted from retrofitting in these 95 schools.[41]

[41] The energy indirect carbon emissions savings are relevant to the water company as a benefit in AIC and AISC calculations whereas the site hot water energy savings are a benefit which accrues to the school and are relevant to the school's payback calculation. The site hot water carbon emissions savings are relevant to the school but are not applied here in either the calculation of AIC/AISC or in the payback calculation.

Mean energy indirect carbon emissions saved (kgCO2e/annum)	142
Mean site hot water carbon emissions saved (kgCO2/annum)	246
Mean energy saved (kWh/annum)	1193

Table 54- Summary of carbon emissions and energy savings derived from logger data from Thames Water's Liquid Assests Project

4.4.7 Case Study: Southern Water

This project, carried out in 2000, was a joint initiative between Southern Water, the Environment Agency and West Sussex County Council. The purpose was to demonstrate the water and cost savings achievable in a practical school environment and to provide information and know-how which could be applied more widely.

Southern Water's 'Water Efficient Schools' programme had previously identified that substantial water savings can be achieved in schools through the installation of water-efficient equipment. This project aimed to establish which particular fittings were likely to provide the largest water savings and the resulting financial paybacks. The results were used to produce a case study with low-budget but effective water efficiency advice for other schools in the region.

The project was conducted in Chesswood Middle School, Worthing. To keep costs down, all monitoring was undertaken by logging the main meter on the incoming supply. The equipment installed included passive urinal controls, push taps, in-line flow restrictors, save-a-flush cistern displacement devices and water butts for rainwater collection.

The project demonstrated that the largest savings are likely to be gained from the installation of urinal controls, with the installation costs fully recouped in less than a year and around 68% reduction in water consumption. Significant savings also arose from the installation of self-closing taps, although the payback period was much longer. The savings attributable to other measures were less clear, although reasons other than simple reduction in consumption may prompt schools to consider them in their water efficiency strategy. For example, in-line flow restrictors could be installed as an alternative to water-efficient taps and they could also be installed as part of routine maintenance.

		School Days			Weekends/Holidays	
Phase	Equipment/period	Number of days	Average consumption (litres/day)	Per capits consumption (litres/head/day)	Number of days	Average consumption (litres)
1	Summer Term	9	10614	*	2	4850
2	Summer Vacation	0	*	*	45	3585
3	Pre-trial	17	7966	17.4	6	4948
4	Save-a-flush installed	17	9525	21.3	9	6571
5	Urinal controls installed	14	4006	8.70	13	2143
6	Push-taps installed	24	3498	7.57	26	298
7	Flow restrictors installed	19	3567	7.60	8	194
8	Save-a-flush removed	16	3654	7.65	14	494
9	Save-a-flush re-installed	17	3420	7.28	6	280
Total days		133			129	

Table 55: Average daily consumption during each phase of the project

The project resulted in overall savings in water of about 73% of the initial consumption, with the school using less water during a school day now than it did previously during a holiday period.[42]

4.5 Analysis

In this section the data presented in the last section is analysed in order to understand how the evidence can guide future water company activities. The analysis is presented under the following three headings:

⇒ Payback Period
⇒ Targeting Water Efficiency Retrofitting Programmes in Schools
⇒ Comparison of the theoretical and actual savings

4.5.1 Payback Period

The calculation of the payback period was carried out, based on 43 schools (from the Severn Trent Water Schools Programme) for which sufficient data has been collected to determine electricity and carbon savings, using the water industry's standard approach based on assessment of discounted cash flows. The calculation of payback requires different cashflows to be considered from the perspective of:

⇒ A water company
⇒ A school

The perspectives for each are explained below.

4.5.1.1 The Water Company Perspective

The payback period from the water company perspective refers to the time taken for the installation cost of a device paid for by the water company to pay itself back at the quoted marginal cost. The marginal cost of water is an estimate of the opex savings the water companies benefit from where consumption is reduced in schools. The marginal cost of water varies with time depending on, for example, spare capacity in the network, the cost of capital, bulk transfer charges, abstraction charges and the cost of alternative supply options. It is different for each water company. The energy indirect carbon savings are not relevant to the water company payback calculation but are included in the calculation of average incremental social cost (AISC) as shown in the Retrofit in

[42] This case study demonstrates that the largest savings are likely to be gained from the installation of urinal controls, however the installation of a flushing device in urinals is required under the Water Supply (Water Fittings) Regulations 1999, available at: http://www.legislation.gov.uk/uksi/1999/1148/schedule/2/crossheading/wcs-flushing-devices-and-urinals/made

Schools scenario in Chapter 6. The AISC of a project is calculated by dividing the net present value of project costs by its discounted contribution to balancing supply and demand.

The discount rate was taken to be 4.5%. The marginal cost of water varies widely depending on the water resources scenario in each company area and so in order to take into account the variability, three different values were used in the analysis: £0.10 per m^3, £0.40 per m^3 and £0.70 per m^3. Ofwat used a value of £0.40 per m^3 in their assessment of the case for smart metering and so this was taken as the central marginal cost of water but a sensitivity analysis was used to assess the impact on payback time of using lower and higher marginal costs in the calculation.

Figures 50, 51 and 52 show the distribution of payback times for a sample of 43 schools from the Severn Trent Water's School Retrofitting Programme.

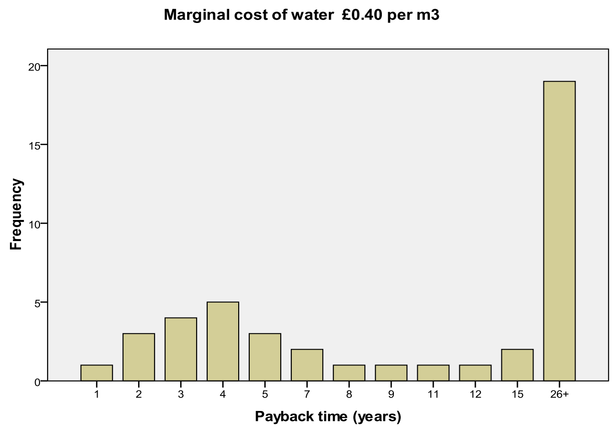

Figure 50 - Distribution of payback times for 43 schools from Severn Trent Water's Schools retrofitting programme valuing water saved at a marginal cost of £0.40 per m3

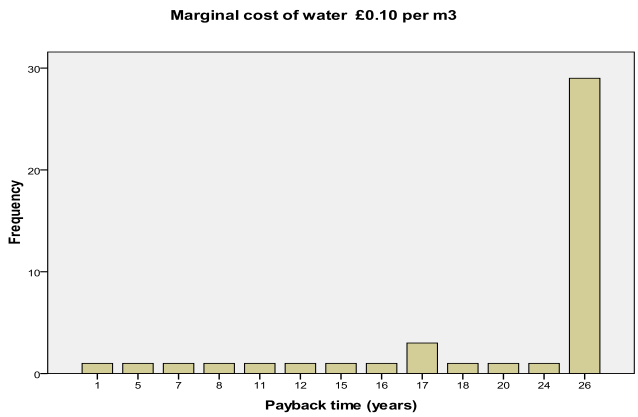

Figure 51- Distribution of payback times for 43 schools from Severn Trent Water's Schools retrofitting programme valuing water saved at a marginal cost of £0.10 per m3

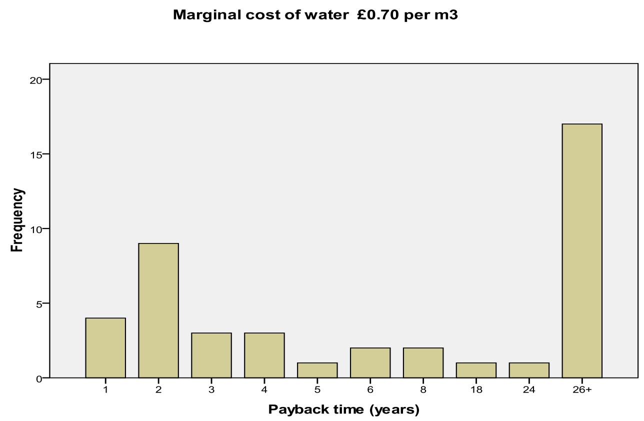

Figure 52- Distribution of payback times for 43 schools from Severn Trent Water's Schools retrofitting programme valuing water saved at a marginal cost of £0.10 per m3

In addition to the Figures 50, 51 and 52, Table 56 provides a means of comparing, from a water company perspective, the effect on the payback time for schools of varying the marginal cost of water. At a marginal cost of water of £0.10 per m^3, 5% of schools pay back by Year 5 but as the marginal cost is increased, as would be expected, the percentage of schools that pay back by Year 5 also increases: 37% where a value of £0.40 per m^3 is applied and 47% where £0.70 per m^3 is used. It is also remarkable that a substantial number of schools, between 40% and 67%, fail to payback within the 25-year period of assessment. Reasons for this are that:

⇒ there was an increase in water consumption observed in a few schools
⇒ low water savings were achieved but a comparatively large amount was spent on retrofitting activities.

	Marginal Cost of Water (£/m3)					
	0.4		0.1		0.7	
	Number	%	Number	%	Number	%
Schools with Payback by Year 5	16	37	2	5	20	47
Schools with Payback by Year 10	20	47	4	9	24	56
Schools with Payback later than Year 25	19	44	29	67	17	40

Table 56- Comparison of payback times for schools from a water company perspective using a range of marginal cost of water values.

4.5.1.2 The School Perspective

A school that reduces its consumption through retrofit would realise a different set of benefits to the water company which supplies it. The payback period from the school perspective refers to the time taken for the installation cost devices paid for by the school to pay itself back at the quoted price of water and energy used to heat water in the school. In addition to the savings which schools can secure through reducing their water bills, site hot water energy savings are relevant to the school as these translate into monetary savings which the school would realise through reduced energy bills in the event that hot water is saved through retrofitting. Therefore, site hot water savings, along with the value of water saved (valued at the price of water the customer pays) are included in the payback calculation.

In calculating the payback, the discount rate is taken to be 4.5%. The price of water is taken as £2.25 per m^3 (the approximate average price of water valid across England and Wales and Scotland), and for electricity the price used was 8.5 pence per kWh (varies greatly depending on tariffs but this is a typical price).

Figure 53 shows the distribution of payback times for the 43 schools and Table 57 provides a summary of some key results. Of the 43 schools, 27 (63%) pay back within 5 years, 31 (72%) pay back with in 10 years and 11 schools do not pay back within the 25 year assessment period.

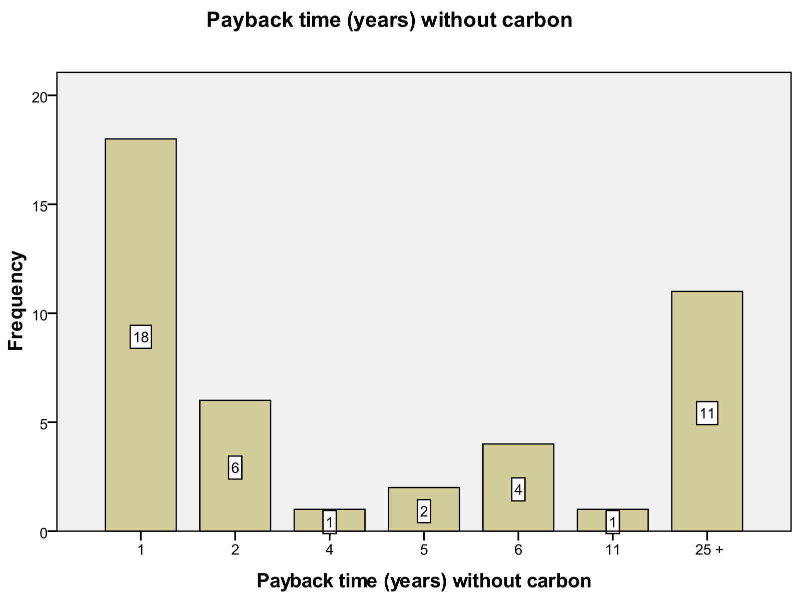

Figure 53- Payback period not including the value of carbon saved in the assessment

	Schools	
	Number	%
Schools with Payback by Year 5	27	63
Schools with Payback by Year 10	31	72
Schools with Payback later than Year 25	11	26

Table 57 - Comparison of payback times for schools from a school perspective.

4.5.1.3 Payback - Summary

⇒ The benefits of retrofitting in schools accrue at a faster rate for schools than they do for water companies. This is shown by the proportion of schools which pay back within 5 years from the water company's and the school's different perspectives. 63% of schools pay back by Year 5 from the school's point of view and for a water company, even using the highest marginal cost value of £0.70 per m3, 47% of schools payback by Year 5. Reasons for the quicker accrual of benefits to the school are:

→ schools see the benefit of water savings at the price of water (e.g. £2.25 per m^3) as opposed to water companies who realise only the marginal cost of water (e.g. £0.40 per m^3), which is about 5 to 6 times lower and includes the benefit of energy indirect energy savings

→ schools benefit financially from site energy savings where hot water consumption is reduced whereas this benefit does not accrue to the water company

⇒ The fact that the benefits of retrofitting accrue significantly faster to the school than they are likely to do to the water company is an argument in favour of using spend-to-save schemes as a means to finance water efficiency in schools. The use of spend-to-save schemes to finance water efficiency retrofitting in schools is discussed further in section 4.6.

⇒ There is significant scope for improving the proportion of schools which pay back within five years. This could be achieved if activities are targeted better, such as by using benchmarking. This will be discussed further in section 4.5.2.

4.5.2 Targeting Water Efficiency Retrofitting Programmes in Schools

In this section, further analysis is carried out to ascertain how the evidence provided by the water company activities presented earlier in this section of the report might help to guide future water efficiency retrofitting activities planned as part of future price reviews and water resource management plans. The following three approaches are employed:

⇒ Linear regression

⇒ Comparison of savings from primary and secondary schools

⇒ The Department for Education and Schools (DfES) water consumption benchmarking tool

These approaches are considered in turn below.

4.5.2.1 Linear Regression

As in the February 2010 interim Evidence Base Phase II report, linear regression is used in this report to model the relationship between the pre and post-intervention water consumption. The model depends linearly on the unknown parameters to be estimated from the data[43]. For each property, the post-intervention consumption (y-axis) is plotted against the pre-intervention consumption, so that each school represents one point plotted on the chart. A straight line is then drawn through the points on the chart, which is calculated to be a line of best fit. The method of least squares assumes that the line of best-fit of a given type is the line that has the minimal sum of the offsets squared (least square error) from a given set of data[44]. This method of finding a line of best-fit is the most commonly used.

In order to understand how good the fit of the line is, a quantity referred to as R^2 can be used. This represents the percentage of the variation in the outcome that can be explained by the model. This provides a good way of assessing whether there is a substantive relationship between the pre and post-trial consumption. This means that if R^2 is found to be 0.6, then the line of best fit describes 60% of the relationship between the two variables.

The statistical modelling required to accomplish this was carried out using statistical analysis software (SPSS), but could be carried out using Microsoft Excel. Using this technique enables the forecasting of water savings achievable in future schools projects.

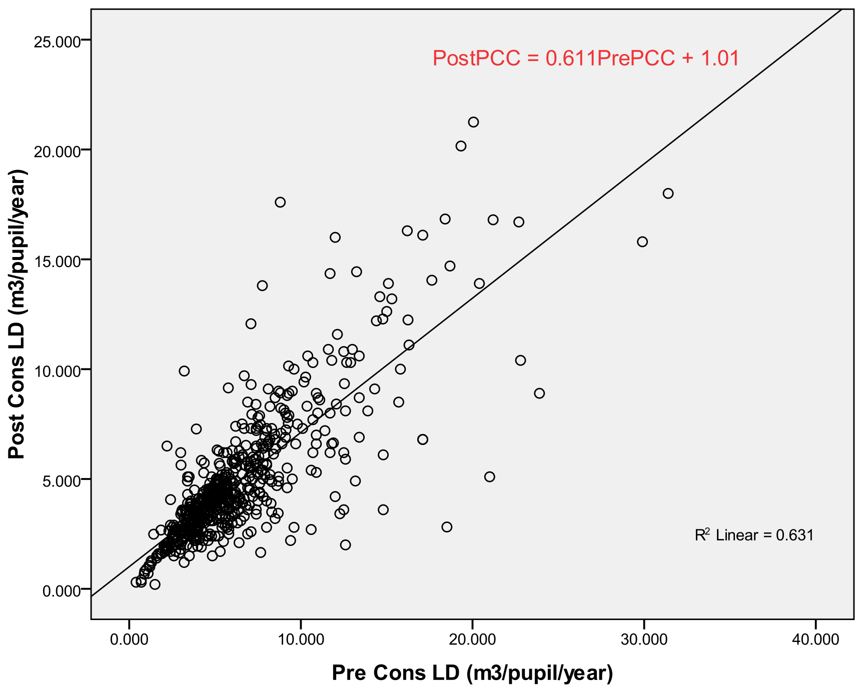

Figure 54 – Scatter plot showing use of linear regression to derive a relationship between the post-intervention and the pre-intervention consumption in 589 schools

Figure 54 gives the scatter plot from which the relationship can be derived between the before and after consumption for schools in which water efficiency measures are carried out. The R^2 value is

[43] Field, A., 2009, 'Discovering Statistics Using SPSS'. Third Edition Sage Publications Ltd.

[44] http://www.efunda.com/math/leastsquares/leastsquares.cfm

found to be 0.631 in this case. The line of best fit through the points, each of which are defined by one school is:

$$\text{Post PCC} = 0.611*\text{Pre PCC} + 1.008$$

where Post PCC is the post-intervention consumption in m^3 per pupil per year and Pre PCC is the pre-intervention consumption in m^3 per pupil per year.

Table 58 shows for a given school consumption (School Pre PCC) its predicted consumption after receiving a retrofit using the approach of auditing and recommending devices which has been used by both Severn Trent Water and Thames Water (and implemented in both cases by Aqualogic)

School Pre PCC (m3/pupil/year)	School Post PCC (m3/pupil/year)	Percentage reduction in consumption
1.00	1.62	-61.90
2.00	2.23	-11.50
3.00	2.84	5.30
4.00	3.45	13.70
5.00	4.06	18.74
6.00	4.67	22.10
7.00	5.29	24.50
8.00	5.90	26.30
9.00	6.51	27.70
10.00	7.12	28.82
11.00	7.73	29.74
12.00	8.34	30.50
13.00	8.95	31.15
14.00	9.56	31.70
15.00	10.17	32.18

Table 58 - Use of linear regression derived relationship to determine post-intervention consumption for an input pre-intervention consumption in m3/pupil per year

In addition to the savings calculated above, two important conclusions can be drawn from this analysis:

⇒ According to this simple model there is a minimum consumption of 2.55 m^3 per pupil per year, below which it would not be cost-effective to carry out retrofit because there would be no savings achieved

⇒ The results from this linear regression modelling demonstrate that there is value in benchmarking of schools to help prioritise water company activities.

This being the case, it is worthwhile exploring how the Department for Education and Schools benchmarking tool introduced in section 4.3.1 might be used to guide water company activities.

4.5.2.2 Comparison of Savings from Primary and Secondary Schools

Some analysis has been carried out to understand whether there is any difference in the results achieved from primary and secondary schools, and a dataset was produced by combining all the schools from the programmes included in this report for which the type of school (whether primary or secondary) is known. This results in a dataset of 593 schools of which 476 schools are primary and 117 schools are secondary. The water savings from the different types of schools are presented in Figures 55 (m^3 per pupil per year) and Figure 56 (m^3 per day).

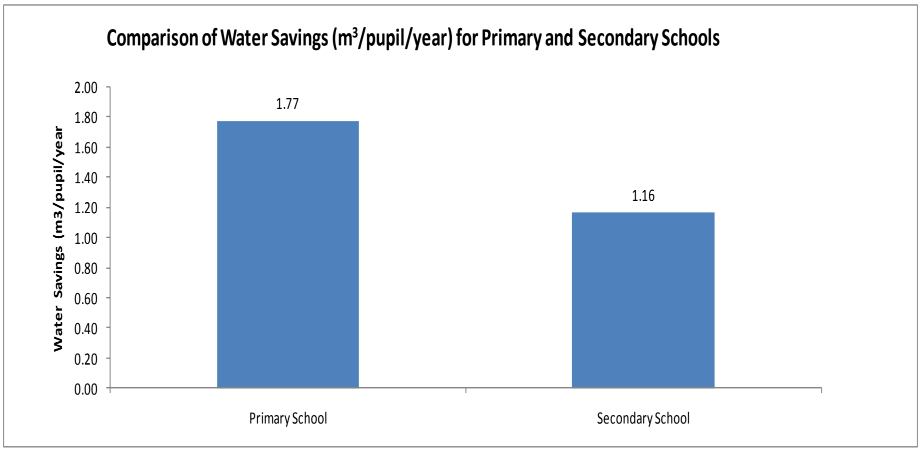

Figure 55- Comparison of water savings in m3/pupil/year for Primary and Secondary Schools

Figure 55 shows that higher water savings per pupil were achieved in primary school than in secondary schools.

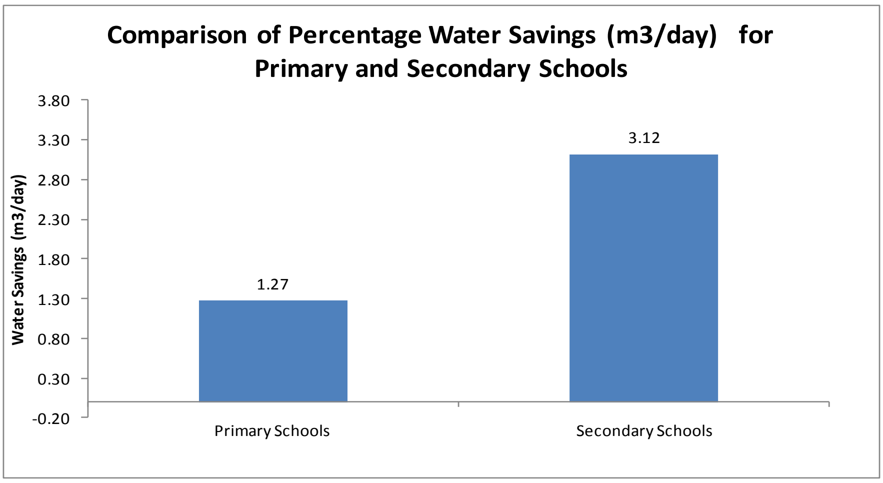

Figure 56 - Comparison of water savings in m3/day for Primary and Secondary Schools

However, Figure 56 shows that on average double the water savings are available from secondary schools than are available from primary schools, due to the larger scale of secondary schools. The mean site population of a secondary school in this dataset is 977, compared to 300 for a primary school. When the cost per litre per day is compared for the different types of school, the result is as shown in Figure 57.

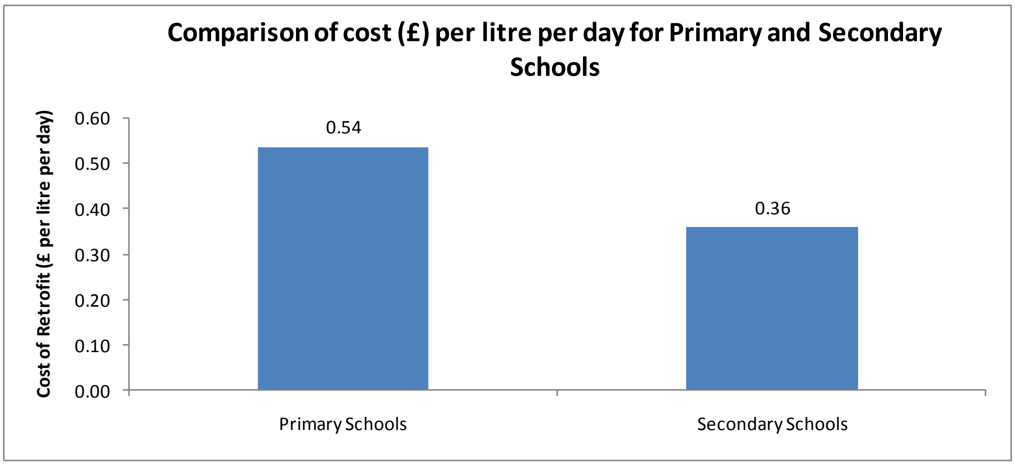

Figure 57 - Comparison of cost per litre per day of water savings for Primary and Secondary Schools

The water savings in the secondary school are obtained at a cost of £0.36 per litre per day, which is about 33% cheaper than that achieved for primary schools even considering that on average more was spent retrofitting secondary schools (£1118 was spent on each secondary school compared to £683 per school for primary schools). This indicates strongly that economies of scale are achievable from targeting secondary schools compared to primary schools.

4.5.2.3 Use of Consumption Benchmarking to Target School Water Efficiency Retrofitting Programmes

This section presents analysis of the results from the 590 schools for which data is currently available with the aim of determining whether the DfES water benchmarking tool may be of use to help water companies to target their activities in a way which may help make water efficiency retrofitting in schools more effective. Section 4.3.1 introduced the DfES benchmarking tool, in which schools are benchmarked according to water use per area and water use per pupil. In the analysis in this report the focus is placed on water use per pupil, because there was no data available to allow the size of each school to be determined. Table 59 gives the distribution of schools included as part of this analysis across the quartile performance categories. Primary and secondary schools are assessed against the appropriate quartile performance levels and then all the results are grouped together.

There are 590 schools in the sample analysed here and cost data is available for 489 schools. The distribution of schools across the four quartiles in Table 59 shows that the distribution of schools is skewed – 27% of schools are first and second quartile performers and 73% of schools are third and fourth quartiles. The DfES benchmarking data indicates that the distribution of schools is in general skewed with more schools performing poorly (third or fourth quartile). This is indicated by the fact that the median is significantly less than the mean in each of the categories (primary and secondary schools).

Quartile	Number of schools	Percentage of Schools
1	56	9
2	108	18
3	170	29
4	256	43
Overall	**590**	**100**

Table 59- Summary of the DfES water benchmark performance for 590 schools

Figure 58 shows analysis which starts with all the 590 schools in the sample and step by step removes, firstly, top quartile performing schools, then second and then third ending with a sample of schools which are only bottom quartile performers. Figure 58 shows that by targeting school retrofitting activities at the poorest performing schools, identified by their benchmarked water consumption per pupil per school per annum through the DfES water consumption benchmarking tool, more water is likely to be saved than if a random approach is taken.

Water savings of 1.654 m^3 per pupil per annum are achieved across the entire sample of schools but if top quartile schools are removed the water savings increase by 0.153 m^3 per pupil per annum. When second quartile performing schools are removed water savings increase by a further 0.372 m^3 per pupil per annum. Finally, removing third quartile schools leads to a large increase of 0.768 m^3 per pupil per annum, which leaves only bottom quartile performing schools which save on average 2.94 m^3 per pupil per annum, compared to 1.654 m^3 per pupil per annum where all schools are included (78% improvement).

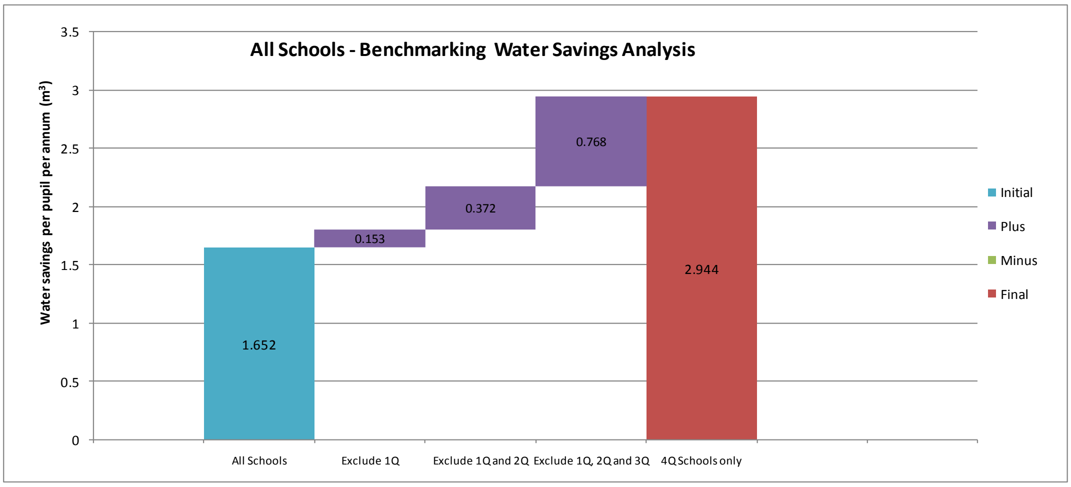

Figure 58- Analysis of Water Savings using the DfES Benchmarking tool

Figure 59 carries out the same process and shows that targeting activities helps to improve cost-effectiveness of school retrofitting. The cost per litre per day reduces significantly, by £0.266 per litre per day, upon filtering out top quartile schools. There is a very slight increase in cost (£0.025 per litre per day) when second quartile performers are removed and this may be because there were a few examples of high-cost retrofitting projects amongst the second quartile schools. However, filtering out the third quartile schools again increases the cost-effectiveness of water savings. By including just bottom quartile schools the cost per litre per day of water saved becomes £0.273 compared to a starting cost of £0.716. This amounts to a 62% improvement in cost-effectiveness of water savings.

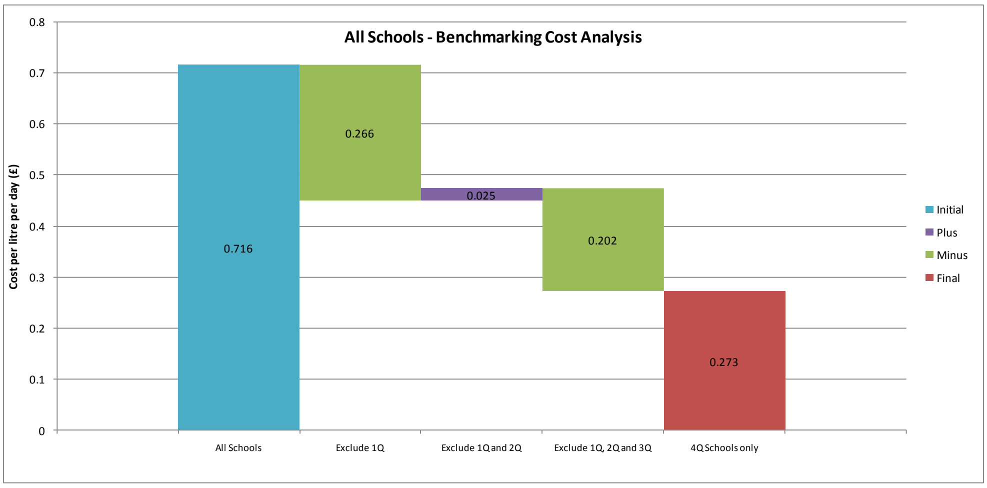

Figure 59- Analysis of Cost Effectiveness using the DfES Benchmarking tool

The analysis carried out here shows the value of targeting schools based on their per pupil annual water consumption. Following the approach of targeting poorest performers first will significantly boost (by approximately 62%) the cost-effectiveness of water savings achieved.

There is a need to target schools in a smarter way, using benchmarking tools to maximise the savings. The linear regression in section 4.5.2 indicates a strong relationship between the water savings achieved and the initial per pupil school water consumption. Furthermore, Business Stream's case study in section 4.4.5 shows that benchmarking tools are already being used to select schools for water efficiency programmes in schools.

4.5.3 Theoretical Versus Actual Savings

4.5.3.1 The Basis of the Theoretical Water Savings

In this section analysis is carried out to assess the appropriateness of the assumptions set out in section 4.3 surrounding water savings from retrofitting devices in schools. The assumptions presented below, in Figure 61 and Table 60, are applied to the data collected from the 43 schools which were logged as part of the Severn Trent School Water Efficiency Programme. Audits were carried out at each of the 43 schools prior to installation visits, to establish the needs of the individual schools.

$$x = Proportion\ of\ total\ push\ taps\ retrofitted = \frac{Number\ of\ push\ taps\ retrofitted}{Total\ number\ of\ taps\ in\ the\ school}$$

$$y = Proportion\ of\ total\ WCs\ retrofitted = \frac{Number\ of\ WCs\ retrofitted}{Total\ number\ of\ WCs\ in\ the\ school}$$

$$z = Proportion\ of\ total\ push\ taps\ retrofitted = \frac{Number\ of\ in-line\ regulators\ installed}{Total\ number\ of\ taps\ in\ the\ school}$$

Figure 60 - Equations defining the factors x, y and z

During Severn Trent Water's school audits, data was also collected on the numbers of hot and cold taps and toilet cisterns in each of the schools. This allows x, y and z, as shown in Figure 60, to be calculated. Assumed water savings are then calculated for each of the devices (or interventions) listed in Table 60.

Category	Device	Assumed Water Savings	Units for savings
Toilets	Dual-flush valve conversion	-	
	EcoBETA dual flush siphon	3.3*y	litres/pupil/day
	Cistern Dams	-	
	Cistern Displacement Devices	1.3*y	litres/pupil/day
Taps	Push Taps - Retrofit	2.0*x	litres/pupil/day
	Push Taps - Complete tap	2.0*x	litres/pupil/day
	In-line flow regulators	4.0*z	litres/pupil/day
	Outlet aerators regulator	-	
	Re-time existing tap	-	
Urinals	Service UCD	40	litres/day
	Hydromate - Mains 240v	80	litres/day
	Hydrocell - Battery 6v	80	litres/day
	Hydrocell Ultra - Battery 6v	80	litres/day
	Isolation valve	-	

Table 60 – Summary of the water savings assumptions initially applied to estimate the savings from a school retrofitting programme.

4.5.3.2 Comparison of Theoretical and Actual Water Savings

In order to test the robustness of the assumptions given in Table 60, the difference in the actual water savings achieved in each school and the theoretical water savings calculated using the equations in the two figures is plotted. This plot is presented in Figure 61. The result shows a very poor fit between the actual and theoretical savings, with the mean difference being an overestimate of actual savings of 18.0 m^3 per day. This discrepancy may be due to the fact that the initial assumptions derived frequency of use and flow volumes for taps and toilets which apply to water use in the home rather than to water use in schools.

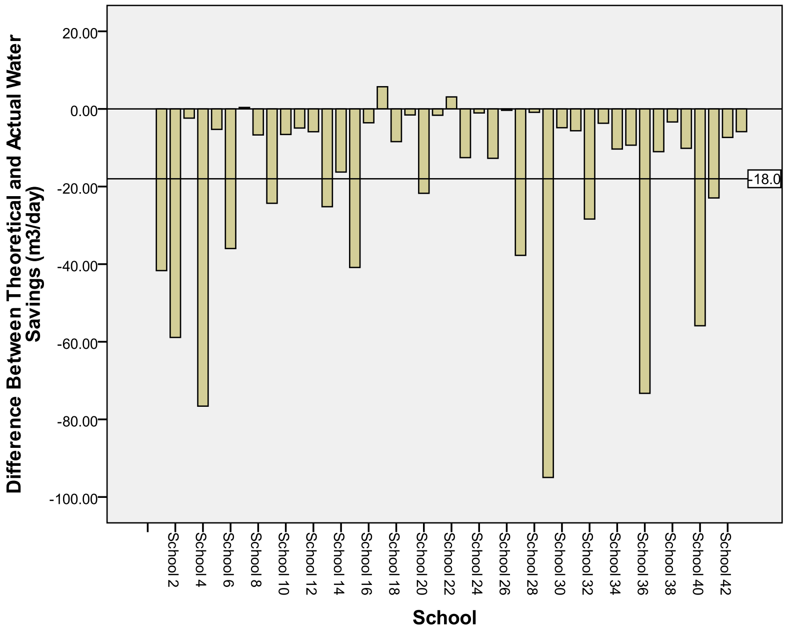

Figure 61 - The difference between actual and theoretical water savings (m3/day) for 43 schools which were part of the Severn Trent School Water Efficiency Programme.

In order to improve the fit of the theoretical water savings to the actual values, a simple iterative process is undertaken. A factor is applied to the theoretical savings with the aim of bringing the mean difference across all the schools to its minimum value. Essentially the process used is:

1. Calculate the theoretical savings using the assumptions in Figure 60 and Table 60
2. Calculate the mean difference between actual and theoretical savings for the sample of schools
3. If the mean difference is greater than 0.1 m^3 per day, multiply the theoretical savings by a factor and return to step 2.
4. Conclude when a mean difference between actual and theoretical water savings of less than 0.1 m^3 per day is achieved

The result of this process is shown in Table 61. The mean difference between actual and theoretical savings is initially -18.0 m^3/day (actual savings are significantly overestimated by the theoretical savings assumptions given in Table 60). By applying the factor in the left hand column of Table 61, starting with 0.5 (½) and then progressively reducing this value to see if it reduces the difference between actual and theoretical savings, the difference reaches its minimum at a value of 0.053 or 1/19.

Factor applied to theoretical savings	Mean difference between actual and theoretical water savings (m3/day)
Original assumptions	-18.4043
0.500	-8.7040
0.250	-3.8539
0.125	-1.4288
0.100	-.9438
0.063	-.2163
0.056	-.0815
0.053	-.0248
0.050	.0262
0.045	.1144

Table 61 – Calibration process for theoretical saving model – Adjustment theoretical savings to fit actual savings more closely

Figure 62 shows the result of the calibration process and the mean difference between the actual and theoretical savings for the 43 schools has been reduced to -0.0248 m^3/day.

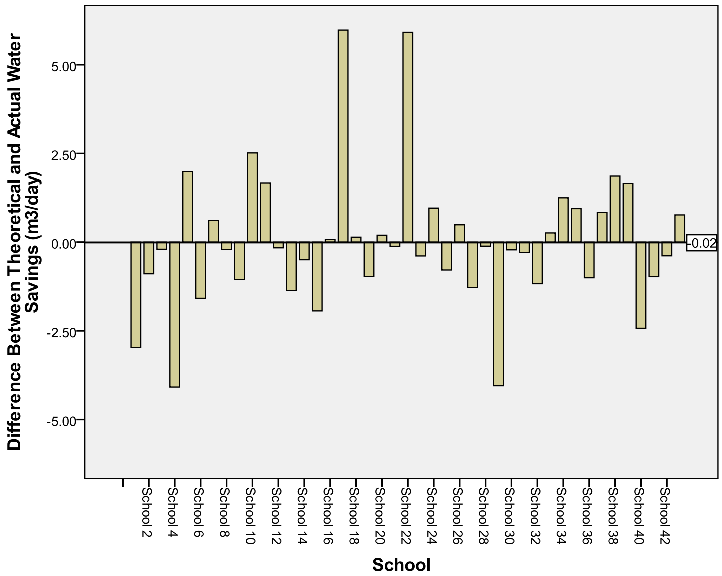

Figure 62 – Result of calibration process - the difference between actual and theoretical water savings (m3/day) for 43 schools which were part of the Severn Trent School Water Efficiency Programme.

The calibration process allows an improved set of water savings assumptions for the measures used in the 43 schools included in this study. The revised set of assumptions is given in Table 62.

Category	Device	Assumed Water Savings	Units for savings
Toilets	Dual-flush valve conversion	-	-
	EcoBETA dual flush siphon	0.174*y	litres/pupil/day
	Cistern Dams	-	-
	Cistern Displacement Devices	0.068*y	litres/pupil/day
Taps	Push Taps - Retrofit	0.105*x	litres/pupil/day
	Push Taps - Complete tap	0.105*x	litres/pupil/day
	In-line flow regulators	0.211*z	litres/pupil/day
	Outlet aerators regulator	-	-
	Re-time existing tap	-	-
Urinals	Service UCD	40	litres/day
	Hydromate - Mains 240v	80	litres/day
	Hydrocell - Battery 6v	80	litres/day
	Hydrocell Ultra - Battery 6v	80	litres/day
	Isolation valve	-	-

Table 62 – Result of calibration process – Revised water savings assumptions for 43 schools which were part of the Severn Trent School Water Efficiency Programme.

The derived assumptions in Table 62 provide significantly more accurate estimates of the savings from a school retrofit programme than the initial assumptions described in Table 60.

4.5.3.3 Assessing Whether the Results are Statistically Significant

The sample size is 43 schools. In order to assess whether this is an appropriate number of schools from which to generalise these assumptions, a power calculation is used and the following pieces of information are needed:

- ⇒ Standard deviation of the population
- ⇒ Maximum acceptable difference
- ⇒ Desired confidence level (%)

The mean pre-installation consumption of the 15 schools is 5.70 m^3/day and the standard deviation is 3.69. The maximum acceptable difference is the maximum difference by which the sample mean can deviate from the true population mean before the difference can be classified as significant. It is also assumed that the maximum acceptable difference is 1 m^3/day. The desired confidence level is taken to be 90%. Using this information and applying it to the power calculation, the required sample size is 36: large enough to use as a basis for assumptions such as the ones given in Table 62. However, there are two important limitations:

⇒ This analysis is derived from a sample of 43 schools and is to be applied to planning a school retrofitting programme (involving several schools), rather than applying it to individual schools

⇒ The maximum acceptable difference is taken as 1 m3/day and this is the maximum amount of error considered acceptable. The fact that the assumptions are coarse should be borne in mind when applying them in water resource planning.

However, despite these limitations the assumptions given in Table 62 provide an improved source of assumptions for planning retrofitting programmes in schools.

4.6 Conclusions

This report draws on evidence from 633 schools from four water companies and five water company school retrofitting programmes in order to show what water savings are achievable from schools, what the savings cost to deliver and what carbon emissions and energy savings can be obtained by reducing hot water consumption. Table 63 provides the summary of the key outcomes from the school programmes and case studies included in this report.

	Severn Trent Water Schools Programme - Logged Schools	Severn Trent Water Schools Programme - Metered Schools	Thames Water Liquid Assets - Metered Schools	Thames Water Water Makeover Project - Logged Schools	EA School Water Efficiency Grants Project	Essex & Suffolk Water Schools Programme - Phase 2	Overall
No of schools monitored	43	439	95	13	4	39	633
Mean number of pupils per school	433	368	330	640	818	-	497
Mean water savings (m3/pupil/year)	1.00	1.76	0.58	1.78	1.61	-	1.34
Mean water savings (m3/day)	1.18	1.78	0.52	3.13	3.60	0.78	1.83
Percentage change of water savings	14.52	23.07	1.85	23.41	18.92	11.69	19.67
Probability of water savings	81%	90%	65%	93%	100%	72%	84%
Cost per litre per day (£)	0.72	0.42	-	0.41	0.48	-	0.51
Mean energy indirect carbon emissions saved (kgCO2e/annum)	272	485	142	853	78	-	420
Mean site hot water carbon emissions saved (kgCO2/annum)	294	836	246	1470	839	-	716
Mean energy saved (kWh/annum)	1429	4058	1193	7137	4075	-	3477

Table 63 - Summary Table from some of the school retrofitting projects which are included in this report

Water Savings

Analysis of the data shows that mean water savings of between 0.58 and 1.78 m^3 per pupil per year are achievable through retrofitting in schools. This is equivalent to between 0.52 and 3.13 m^3 per day. Linear regression is used as a tool to enable the results from the 633 schools to be grouped together and then guide future school activities but it also shows that the more a school uses per pupil the more it is should be able to save through water efficiency retrofitting.

Table 64 provides a look-up table which can be used by water companies when planning water efficiency retrofitting programmes in schools. The table is derived from the equation below which is produced using linear regression.

$$\text{Post PCC} = 0.611 * \text{Pre PCC} + 1.008$$

(where Post PCC is the post-intervention consumption in m^3 per pupil per year and Pre PCC is the pre-intervention consumption in m^3 per pupil per year).

A percentage reduction in water consumption of about 23% was achieved in two separate school programmes and in both instances this coincided with a high proportion of schools saving water: 90% and 93% of schools in each programme reduced their consumption. One programme achieved a reduction of 1.85% and across the 95 schools to which this applied there was only a 65% probability of saving water. A number of the schools saw significant increases in consumption which is unusual. The reason for this is unclear, but it may be because the audits identified works necessary under the Water Regulations which required certain flow which had been shut off to be restored. It could also be that there were leakage issues during the post-intervention monitoring period.

School Pre PCC (m3/pupil/year)	School Post PCC (m3/pupil/year)	Percentage reduction in consumption
1.00	1.62	-61.90
2.00	2.23	-11.50
3.00	2.84	5.30
4.00	3.45	13.70
5.00	4.06	18.74
6.00	4.67	22.10
7.00	5.29	24.50
8.00	5.90	26.30
9.00	6.51	27.70
10.00	7.12	28.82
11.00	7.73	29.74
12.00	8.34	30.50
13.00	8.95	31.15
14.00	9.56	31.70
15.00	10.17	32.18

Table 64 - Use of linear regression derived relationship to determine post-intervention consumption for an input pre-intervention consumption in m3/pupil per year

Cost-Effectiveness of Retrofitting

The cost of the water savings from the schools programmes included in this report are given in Table 63. **The cost ranges from £0.41 to £0.72 per litre per day based on cost data from about 500 schools. This compares very favourably to the cost of water savings achievable through domestic**

retrofit. The February 2010 Evidence Base Phase II report[45] showed that the most cost-effective saving achieved through domestic retrofit to date was £1 per litre per day and could be as high as £21 per litre per day.

Hot Water, Carbon Emissions and Energy Savings

As far as the 633 schools analysed in this report are concerned, there were few showers fitted so the main means of targeting hot water was through hot taps: tap retrofit or replacement or using in-line flow regulators. **The single most significant source of hot water savings in schools comes from increasing the efficiency of use of hot taps**

Table 63 gives the mean energy indirect carbon emissions saved (kgCO2e/annum), the mean domestic hot water carbon emissions saved (kgCO2/annum) and the mean energy saved (kWh/annum) which were calculated using the above assumptions on hot water savings and then applying Waterwise's Water-Energy Calculator (for further explanation see the Evidence Base Phase II interim report – February 2010)[13]. Significant carbon emissions and energy savings are achievable from retrofitting schools, evidenced from the programmes included in this report:

⇒ **Mean energy indirect carbon emission savings (from supply and treatment) ranging from 142 to 853 kgCO_2e per annum**

⇒ **Mean site hot water carbon emission savings of between 246 and 1470 kgCO_2 per annum**

⇒ **Mean energy savings of between 1193 and 7137 kWh per annum.**

The energy indirect carbon emissions savings result from less cold water needing to be treated and pumped through water company networks. The level of site hot water carbon emissions savings from these schools projects depends on the extent to which hot water is targeted.

Where data is not available to allow the calculation of hot water savings to be carried out for a school, the mean hot water savings from the 43-school sample from Severn Trent Water's school water efficiency retrofitting programme is applied (16%).

Payback

The benefits of retrofitting in schools accrue at a faster rate for schools than they do for water companies. This is shown by the proportion of schools that payback within 5 years from the water company's and the school's different perspectives. Reasons for the quicker accrual of benefits to the company are:

45 The Evidence Base Phase II interim report, February 2010. Available at: http://www.waterwise.org.uk/images/site/Policy/evidence_base/evidence%20base%20for%20large-scale%20water%20efficiency%20in%20homes%20-%20phase%20ii%20interim%20report.pdf

⇒ Schools see the benefit of water savings at the price of water (e.g. £2.25 per m3) compared to water companies who realise only the marginal cost of water (e.g. £0.40 per m3), which is about two orders of magnitude lower and includes the benefit of energy indirect energy savings

⇒ Schools benefit from site energy savings where hot water consumption is reduced whereas this benefit does not accrue to the water company

⇒ The fact that the benefits of retrofitting accrue significantly faster to the school than they are likely to do to the water company is an argument in favour of using spend-to-save schemes as a means to finance water efficiency in schools.

There is also significant scope for improving the proportion of schools which pay back within five years. This could be achieved if activities are targeted better, such as by using benchmarking. This is discussed further in section 4.5.2.

Spend-to-save schemes in schools

In general, retrofitting water saving devices in schools is very cost-effective and offers a relatively quick payback. However, there are a number of barriers that discourage schools from undertaking these works independently. There is uncertainty over the level of savings for any specific school, there is a difficulty in securing capital funding for operational savings even if the payback is of the order of two years, and there is a lack of awareness and ownership of the issue.

The combination of these potential benefits and barriers means that there is an opportunity to devise a targeted spend-to-save scheme for schools. Such an approach would involve an assessment of a group of schools within a specific locality: the data would then be analysed to provide a ranking to prioritise retrofits and retrofit work undertaken for specific schools under a payback agreement which fixed the current level of bills until the cost of retrofit and finance had been recovered. Schools would be taken out of the water company’s tariff basket and a bilateral agreement would need to be negotiated. Additional measures would need to be put in place to cover lower than expected savings, changes to the fabric of the school or make-up of the student body during the agreement, and issues such as leakage.

Waterwise and some water companies are currently developing spend-to-save trials.

Targeting Water Efficiency Retrofitting Programmes in Schools

Three different methods have been used in this report to analyse the evidence from the 600 schools to determine what insight might be gained about how to target school water efficiency retrofitting programmes to make them more cost-effective.

⇒ The results from this linear regression modelling demonstrate that **there is value in benchmarking of schools to help prioritise water company activities.**

⇒ Section 4.5.2 shows that using the DfES water consumption benchmarking tool and focusing on bottom quartile schools in place of randomly choosing schools can significantly improve water savings. A **78% improvement in water savings was achieved: 1.65 m^3 per pupil per year for all schools becomes 2.94 m^3 per pupil per year when activities are focused on schools which use the most water per pupil (bottom quartile).** Targeting activities at bottom quartile schools also results in the cost of water savings reducing from £0.716 per litre per day (including all schools) to £0.273 per litre per day(targeting bottom quartile schools). **This is equivalent to a 62% reduction in the cost of water savings through a targeted approach using the DfES water consumption benchmarking tool. These are encouraging results and would seem to justify the use of benchmarking in targeting future activities.**

⇒ Comparison of the water savings achieved in primary schools versus secondary schools show that the savings in secondary schools are obtained at a cost of £0.36 per litre per day, which is about 23% cheaper than was achieved for primary schools. Secondary schools yield more cost-effective savings even considering that on average more was spent retrofitting secondary schools (£1092 was spent on each secondary school compared to £680 per school for primary schools). **This indicates strongly that economies of scale are achievable from targeting secondary schools compared to primary schools.**

Estimates of water savings from devices in schools

The derived estimates in Table 65 have been developed through comparison of the assumptions initially derived in section 4.5.3 with the measured savings from 43 schools logged as part of Seven Trent's Schools Water Efficiency Programme. **These derived estimates of water savings could be used by water companies to plan for future school retrofitting projects such as in future price reviews or the Water Resource Management Plan process.**

In order to ensure that these assumptions are updated with the results of future trials, **details of the stock of water-using devices such as showers, taps, toilet cisterns and urinals need to be collected as part of future school retrofitting projects.** This could be undertaken as part of an initial audit carried out by water companies, prior to installation of measures, to assess what measures are needed in school.

Category	Device	Derived Water Savings	Units for savings
Toilets	Dual-flush valve conversion	-	-
	EcoBETA dual flush siphon	0.174*y	litres/pupil/day
	Cistern Dams	-	-
	Cistern Displacement Devices	0.068*y	litres/pupil/day
Taps	Push Taps - Retrofit	0.105*x	litres/pupil/day
	Push Taps - Complete tap	0.105*x	litres/pupil/day
	In-line flow regulators	0.211*z	litres/pupil/day
	Outlet aerators regulator	-	-
	Re-time existing tap	-	-
Urinals	Service UCD	40	litres/day
	Hydromate - Mains 240v	80	litres/day
	Hydrocell - Battery 6v	80	litres/day
	Hydrocell Ultra - Battery 6v	80	litres/day
	Isolation valve	-	-

Table 65 – Revised water savings assumptions for 43 schools which were part of the Severn Trent School Water Efficiency Programme.

Data collection

The following observations can be made on the data collected for monitoring the school retrofitting projects

- ⇒ Datasets are generally of short duration (for example 1 to 6 months) and monitored periods inevitably cover half terms, Christmas, Easter or summer holidays
- ⇒ Most schools consume significantly less water on weekends and during holidays but some may consume more depending on whether the school is used as a sports facility or for community events
- ⇒ The before and after retrofit monitoring periods invariably include vastly different proportions of time when the school is open and closed.

There is a need for a consistent approach to collecting data to assess the savings from school retrofitting programmes. If meter readings are used to measure the school's consumption, monitoring should ideally take place for an entire year before and after the intervention in order to understand the effect on the school's water bills. This would also ensure an equal proportion of days when the school is open and closed in the pre and post-intervention monitoring periods. Continued monitoring of the school's consumption in subsequent years is also extremely useful in order to understand how savings are maintained. However, account must also be taken of whether or not the amount of water used when the school is closed is highly variable.

The use of logger data enables a more accurate determination of the consumption when the school is open and enables the short-term effect on consumption of the water efficiency retrofitting programme to be determined. **To understand how savings are sustained over time it would be useful to monitor school consumption using data loggers for a school-term period per year over the course of three or more years after the intervention.**

4.7 Retrofit in Schools Scenario: Calculation of AIC and AISC

The October 2008 and February 2010 Evidence Base reports both identified problems with the transferability of large-scale water efficiency from smaller-scale projects as a key barrier to progress. In order to assist water companies with this issue, Evidence Base reports have presented scenarios which were extremely well-received by the water companies and other stakeholders planning water efficiency projects and trials. In order to continue to assist water companies with the planning of school retrofitting projects, including in the context of their regulatory commitments, a new scenario has been developed using the range of savings values identified from the evidence in this report.

Scenario 1 - Retrofit in Schools		
Parameter	**Value**	**Comments / build-up**
Target schools		
Best estimate	350	
Max expected	600	
Min expected	35	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of scheme savings (years)		
Best estimate	8.4	Waterwise estimate
Best case	25	
Worst case	2.5	
Uptake rates		
Best estimate	90%	Varying degrees of local council involvement in recruitment of schools. 100% uptake assumed where schools are approached by the council
Best case	100%	
Worst case	70%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Audit costs (per school)		
Best estimate	£0.00	Included in overall cost
Best case	£0.00	
Worst case	£0.00	
Overall costs (per school)		
Best estimate	£940.00	Recruitment, audit, product and installation costs combined
Best case	£600.00	
Worst case	£1,500.00	
Administration costs (per school)		
Best estimate	£0.00	Included in overall cost
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per propoerty)		
Best estimate	£0.00	Included in overall cost
Best case	£0.00	
Worst case	£0.00	
Operational costs where scheme NOT taken up		
Administration costs (per school)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per school)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Water savings (cubic meter per school per day)		
Best estimate	1.78	Severn Trent Water School Programme
Best case	3.13	Thames Water Water Makeover Project
Worst case	0.52	Thames Water Liquid Assets Project

Table 66 - Data input into the AISC spreadsheet tool for the Retrofit in Schools scenario

4.7.1 The Retrofit in Schools Scenario

A local council and a water company form a partnership brokered in order to carry out retrofitting of urinals, toilets, showers and taps in schools. Schools are recruited by letter through the council and subsequently audits are scheduled and carried out in the recruited schools in order to benchmark their consumption per pupil and identify their stock of water-using devices which could be retrofitted. Once the audits are carried out the retrofits are prioritised based upon their benchmarked consumption to maximise savings.

Table 67 below summarises the average incremental cost (AIC), average incremental social cost (AISC) and NPV (net present value) results from the Retrofit in Schools scenario presented in this chapter. A full description of the spreadsheet tool which is used to calculate AIC and AISC in this scenario is given in Appendix 3 of the October 2008 report.[46] Hence this will not be covered here.

Opex Cost of Water 40.00 p/m3

		Best Estimate	Best Case	Worst Case
	AIC (p/m3)	13.94	0.36	213.08
	AISC (p/m3)	12.30	-1.28	211.44
NPV values				
	WAFU*(Ml)	1466.84	7433.81	16.93
	Capex (£M)	0	0	0
	Opex (£M)	0.2632	0.324	0.03675
	Opex Saving (£M)	-0.059	-0.297	-0.001
	Social & Env Costs (£M)	-0.024	-0.122	0.000

Opex Cost of Water 10.00 p/m3

		Best Estimate	Best Case	Worst Case
	AIC (p/m3)	16.94	3.36	216.08
	AISC (p/m3)	15.30	1.72	214.44
NPV values				
	WAFU*(Ml)	1466.84	7433.81	16.93
	Capex (£M)	0	0	0
	Opex (£M)	0.2632	0.324	0.03675
	Opex Saving (£M)	-0.015	-0.074	0.000
	Social & Env Costs (£M)	-0.024	-0.122	0.000

Opex Cost of Water 70.00 p/m3

		Best Estimate	Best Case	Worst Case
	AIC (p/m3)	10.94	-2.64	210.08
	AISC (p/m3)	9.30	-4.28	208.44
NPV values				
	WAFU*(Ml)	1466.84	7433.81	16.93
	Capex (£M)	0	0	0
	Opex (£M)	0.2632	0.324	0.03675
	Opex Saving (£M)	-0.103	-0.520	-0.001
	Social & Env Costs (£M)	-0.024	-0.122	0.000

Table 67 – Summary of AIC and AISC results for each of the Retrofit in Schools scenario for a range of opex cost of water values

Figure 63 gives a graphical representation of the yield over time and the yield over the range of uncertainties.

[46] http://www.waterwise.org.uk/images/site/Policy/evidence_base/evidence%20base%20for%20large-scale%20water%20efficiency%20in%20homes,%20waterwise,%20october%202008.pdf

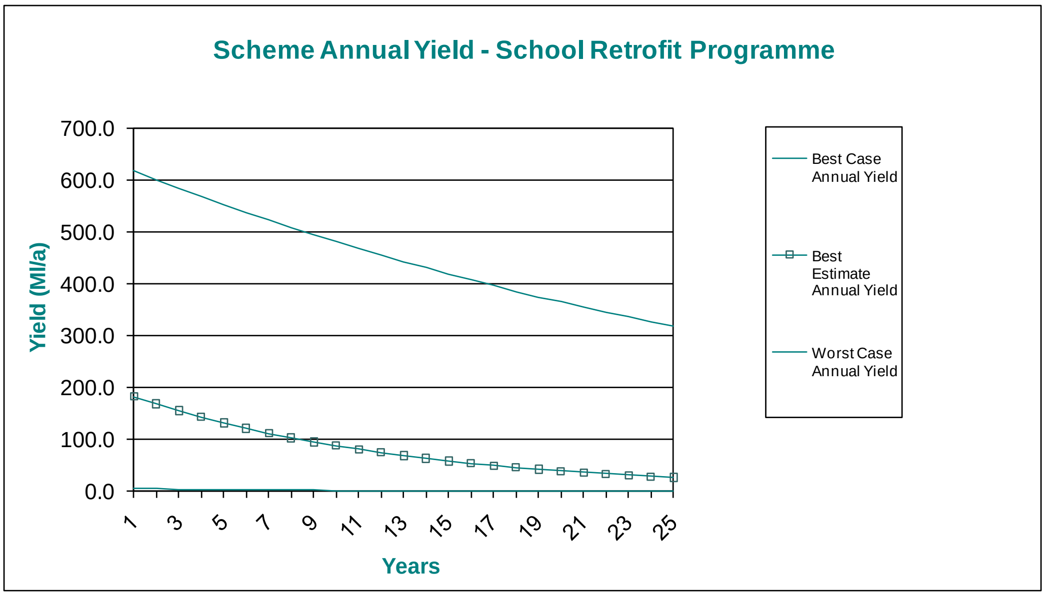

Figure 63 - Annual yield for the Retrofit in Schools scenario

4.7.2 Sensitivity of Scenarios to Changes in Discount Rate

The summary of results in Table 67 above includes sensitivity to water savings, uptake rates, and costs of auditing, recruitment, equipment, installation and the opex cost of water. However, it does not include analysis of sensitivity of results to the discount rate used in the calculation of AIC and AISC. Understanding how changes in discount rate affect the cost-benefit analysis for water efficiency is extremely important for water company investment plans. In order to understand the sensitivity of the AIC and AISC values calculated in the scenarios to discount rate, some analysis was carried out as shown in Table 68. The discount rate was varied from its original 4.5% to high and low levels of 6% and 3% respectively. The opex cost of water is held constant at 40 p/m^3.

Discount rate 3.00 %

		Best Estimate	Best Case	Worst Case
	AIC (p/m3)	12.32	-0.16	204.77
	AISC (p/m3)	10.68	-1.80	203.12
NPV values				
	WAFU*(Ml)	1612.77	8440.47	17.60
	Capex (£M)	0	0	0
	Opex (£M)	0.2632	0.324	0.03675
	Opex Saving (£M)	-0.065	-0.338	-0.001
	Social & Env Costs (£M)	-0.027	-0.139	0.000

Discount rate 4.50 %

		Best Estimate	Best Case	Worst Case
	AIC (p/m3)	13.94	0.36	213.08
	AISC (p/m3)	12.30	-1.28	211.44
NPV values				
	WAFU*(Ml)	1466.84	7433.81	16.93
	Capex (£M)	0	0	0
	Opex (£M)	0.2632	0.324	0.03675
	Opex Saving (£M)	-0.059	-0.297	-0.001
	Social & Env Costs (£M)	-0.024	-0.122	0.000

Discount rate 6.00 %

		Best Estimate	Best Case	Worst Case
	AIC (p/m3)	15.57	0.89	221.17
	AISC (p/m3)	13.92	-0.75	219.52
NPV values				
	WAFU*(Ml)	1345.14	6619.16	16.32
	Capex (£M)	0	0	0
	Opex (£M)	0.2632	0.324	0.03675
	Opex Saving (£M)	-0.053805513	-0.264766332	-0.000652854
	Social & Env Costs (£M)	-0.022	-0.109	0.000

Table 68 – Summary of AIC and AISC results for each of the Retrofit in Schools scenario for a range of discount rate values

Glossary

BERR – The Government Department for Business, Enterprise and Regulatory Reform

CLG - Communities and Local Government, which sets policy on local government, housing, urban regeneration, planning and fire and rescue

Confidence Interval - Confidence intervals are used to indicate the reliability of an estimate; instead of estimating the parameter by a single value, an interval likely to include the parameter is given

DECC - The Department of Energy and Climate Change (DECC) was created in October 2008, to bring together energy policy (previously with BERR, which is now BIS - the Department for Business, Innovation and Skills[external Link]), and Climate change mitigation policy (previously with Defra - the Department for Environment, Food and Rural Affairs).

DEFRA – the Government Department for Environment, Food and Rural Affairs

District Metered Area - An area within the water supply network that is permanently defined by closed valves or other physical constraints in which distribution losses are measured and managed.

Dual-Flush –This term refers to toilets that provide a choice of two flushing mechanisms; one which makes a full flush available and the other which uses a reduced amount of water.

Logger - An electronic device that records water use data over time either with a built in instrument or sensor or via external instruments and sensors. Loggers are useful because they can help provide a better resolution measurement of water consumption than is possible with a water meter alone.

Microcomponent – Overall domestic water use in the home can be broken down into components which represent water used by individual appliances and equipment in the home such as showers, toilets, washing machines, dishwashers, kitchen and bathroom taps as well as an outside supply. These components that make up water use in the home are known as micro-components.

Net Present Value – NPV is the present value of an investment's future net cash flows minus the initial investment. If positive, the investment should be made (unless a better investment exists), otherwise it should not.

Ofwat - The Water Services Regulation Authority which is the economic regulator of the water and sewerage companies in England and Wales.

Period X – Consumption monitoring period starting immediately after the installation of devices in a retrofitting trial

Period Y – Consumption monitoring period starting at the point that Period X ends

Pre-Period – Consumption monitoring period which takes places prior to the installation of devices in a retrofitting trial

PR09 - Periodic Review 2009; the Ofwat periodic review of price limits to be completed in 2009 to set prices for 2010-2015.

Retrofitting - This term describes the measures taken to allow new or updated parts, for example cistern displacement devices, low-flow showerheads or tap fittings that reduce tap flow rates, to be fitted to old or outdated equipment through which we use water in the home.

The Environment Agency – The EA are an Executive Non-departmental Public Body responsible to the Secretary of State for Environment, Food and Rural Affairs and an Assembly Sponsored Public Body responsible to the National Assembly for Wales. Its principal aims are to protect and improve the environment, and to promote sustainable development. They play a central role in delivering the environmental priorities of central government and the Welsh Assembly Government through their functions and roles

UKWIR – UK Water Industry Research was set up by the UK water industry in 1993 to provide a framework for the procurement of a common research programme for UK water operators on 'one voice' issues. UKWIR's members comprise 24 water and sewerage undertakers in England and Wales, Scotland and Northern Ireland

Water Efficiency Project – A project, which has as its main purpose to reduce water consumption as a means of water demand management. This involves the implementation in homes of one or more water efficiency measures such as dual flush devices in toilets, aerated showerheads, tap fittings, shower timers, self-audit questionnaires, plumber audits, or customer engagement through education in the need for water efficiency.

Water Efficiency Trial – A study carried out to ascertain the willingness of those approached to participate and improve their water efficiency, the reduction in water consumption achievable through application of the water efficiency measures and any change in behaviour on the customers' part due to engagement during the study. This involves the offer to customers of one or more water efficiency measures such as dual flush devices in toilets, aerated showerheads, tap fittings, shower timers, self-audit questionnaires, plumber audits, or customer engagement through education in the need for water efficiency and the subsequent assessment of the efficacy of the measures.

Water Industry Commission for Scotland - WICS is a non-departmental public body with statutory responsibilities. Established in 2005, WICS took over responsibility for regulation of water and sewerage services from the former Water Industry Commissioner for Scotland.

Water UK - represents all UK water and wastewater service suppliers at national and European level. It provides a positive framework for the water industry to engage with government, regulators, stakeholder organisations and the public.