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Evidence Base for Large-scale Water Efficiency in Homes

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Terms and abbreviations used

AIC	Average Incremental Cost
AISC	Average Incremental Social Cost
AMP	Asset Management Plan
Capex	Capital expenditure
CBA	Cost-benefit analysis
CP187	WRc (2005) “Increasing the value of domestic water use data for demand management”
DMA	District Metered Area
EBSD	Economics of balancing supply and demand; also refers to UKWIR (2002) “The economics of balancing supply and demand”
ESW	Essex and Suffolk Water
LRMC	Long Run Marginal Cost
MTP	Market Transformation Programme
NPV	Net Present Value
Opex	Operational expenditure
PR09	Price Review 2009
STW	Severn Trent Water
SWW	South West Water
UKWIR	UK Water Industry Research
UU	United Utilities
WEM	Water efficiency measure
WR25A	UKWIR (2006) “Sustainability of water efficiency measures”
WR25B	UKWIR (2007) “The cost effectiveness of demand management”
WRMP	Water Resource Management Plan
WRZ	Water Resources Zone
WSG	Water Saving Group

Foreword

As part of their work for the ministerial Water Saving Group, on which Waterwise sit alongside the water industry, its regulators, the Consumer Council for Water and government departments, Waterwise undertook a year-long examination of domestic water efficiency projects that had been or were being led by water companies. This report, which is the final outcome of the *Evidence Base for Large-scale Water Efficiency in Homes* project, includes analyses of several water company projects and also provides scenarios for possible cost-effective, large-scale water efficiency programmes.

Over last twenty or so years there has been a lot of water efficiency activity occurring within the UK water industry. Whilst there have been many projects, few of these have been sufficiently detailed to provide the evidence needed to undertake large-scale water efficiency programmes; however, since the establishment of the Water Saving Group, there has been a significant increase in the size and number of water efficiency trials and projects. Therefore, the water industry and its regulators agreed that an in-depth analysis of those projects with larger sample sizes was needed in order to establish an evidence base that could support the development of water demand management measures as resource options in their own right.

Building on the research of UKWIR, specifically on the WR25 series of reports that outlined best practice guidance for planning and implementing water efficiency programmes, this project has collated and analysed most existing water efficiency projects and has used the data to identify savings associated with a range of water efficiency measures. Findings were then used to develop best estimates of savings, costs, uptake rates and installation rates in order to create a series of scenarios of cost-effective, large-scale water efficiency programmes.

The results from the *Evidence Base for Large-scale Water Efficiency in Homes* are especially important for comparing water efficiency measures with new resource development options in the water resources planning process, for which this report was timed to provide best available evidence in the lead up to the Price Review 2009. The *Evidence Base* will also help water companies meet water efficiency targets that are currently being developed. It is worth noting, however, that in general water efficiency programmes can only be delivered effectively through water companies working in partnership with other organisations - joint action is crucial to success.

Though this project has identified many gaps that still need to be filled in the evidence base for demand management, the results presented herein do show that water efficiency is a viable option in water resources management.

Jean Spencer
Director of Regulation, Anglian Water
Chair, Waterwise *Evidence Base* Steering Group

1 Summary of findings and recommendations

Water resources in the United Kingdom are becoming increasingly strained due to climate changes, population growth and shifts toward more water intensive lifestyles. Demand management, therefore, is beginning to be taken as seriously as the development of new supplies, advancing a twin-track approach to water resources planning to balance supply and demand.

Water efficiency is one component of demand management, which also includes reductions in network leakage, the introduction of household metering and the use of variable water tariffs. The evidence base represents the best current available knowledge of water efficiency in the UK. This report has

- ⇒ extracted information of water savings from water efficiency trials and projects in the UK;
- ⇒ filtered projects in terms of accuracy and robustness;
- ⇒ developed a table of water efficiency measures (WEMs) and associated savings;
- ⇒ described the range of water efficiency measures available for projects; and
- ⇒ developed a set of scenarios for large-scale water efficiency programmes, with Average Incremental Cost (AIC), water savings and Net Present Value (NPV) presented.

Evidence was drawn from the water efficiency trails and projects that have been or are currently being undertaken by water companies in the UK. Many more projects and trials are still underway, and so results were not yet available for incorporation into this report.

Application of the methodology, which was largely based on the WR25 series of reports published by UK Water Industry Research (UKWIR), resulted in the extraction of water savings associated with individual water efficiency measures (WEMs). Results show the range of water savings that can be made through retrofit of homes.

A set of scenarios for large-scale water efficiency programmes were then developed, based on the costs, uptake rates and other information that was drawn from actual water company trials and projects. The scenarios show that large-scale water efficiency programmes can be cost-effective (table 1), particularly when carried out in partnership. However, they also show a very wide range in values between the best and worst case; this reflects the wide ranges in water savings for individual measures obtained from the water company projects. Increasing water savings and decreasing operational costs (most of which are associated with installation) have the greatest impact on decreasing AIC. Increasing the asset lives of WEMs and decreasing equipment cost also have a large impact. Increasing the uptake rate has negligible impact on AIC.

Table 1. Average Incremental Costs for the scenarios.

	AIC (p/m^3)		
	Best estimate	**Best case**	**Worst case**
Scenario 1 - In social housing	38.3	7.2	429.8
Scenario 2 - Within a Water Resource Zone	197.1	46.8	720.1
Scenario 3 - With an energy company	58.5	7.8	4,559.9
Scenario 4 - With an energy advice centre	134.7	4.9	11,486.2
Scenario 5 - Piggybacking on internal activities	35.9	1.0	94,067.8

1.1 How to use this report

This *Evidence Base* aims to provide consistent information in a standard format to enable water efficiency programmes to be designed in the most effective way. Organisations planning to undertake water efficiency programmes should use this report as a guide, in conjunction with the WR25 series of reports from UKWIR and Waterwise's *Water Efficiency Audit Programmes: A Best Practice Guide*, which will be updated based on the findings of this report.

Note that savings associated with WEMs do vary widely depending on a number of specific factors (section 6); therefore, summary table 6 should not be used as a lookup table, but in conjunction with background notes. Savings associated with WEMs are also dependent on the potential uptake of each of the measures. One cannot just single out a measure, multiply associated potential savings by the target population and arrive at projected savings for a water efficiency programme. Consideration must be given to the proportion of the population that is eligible for the measure, likely recruitment rates and the physical and financial constraints associated with rolling out a water efficiency programme.

1.2 Recommendations

There are several general recommendations that may be drawn from this report as well as from the process of gathering and analysing the evidence:

- ⇒ The process of collecting evidence and disaggregating savings of individual WEMs has highlighted the need for a common standard of reporting for water efficiency programmes; original trial and project reports were sometimes hard to follow, particularly when definitions were not uniform;
- ⇒ Waterwise's *Water Efficiency Audits: Best Practice Guide*, which was published in March 2008 and funded by Defra, should be updated based on the findings in this report;
- ⇒ A review of micro-component data and assumptions is needed since we found a wide range of different assumptions being used within the between reports;
- ⇒ Appropriate training for plumbers and fitters is required because many of the devices are fairly new and unfamiliar to plumbers, and both fitting rates and quality of installation have a major impact on costs and savings; and,
- ⇒ Partnerships are likely to be the most effective way to reduce costs per partner and to enhance installation rates.

For water companies

The *Evidence Base* should be used to inform water company investment and determinations in the forthcoming Periodic Review 2009. Table 6 can be used as a guide for estimating yields that can be realised from WEMs, while the scenarios present best available cost-benefit information for several options for delivering large-scale water efficiency programmes.

In order to increase the cost effectiveness of water efficiency programmes, several courses of action could be taken:

- ⇒ Approaches to decreasing costs associated with installation could be investigated, i.e. making the installation process more efficient per property. Reducing the cost of installation, however, needs to done without reducing the water saved per WEM. Therefore, relying on residents to fit devices might not be the best solution, unless water savings can be guaranteed;
- ⇒ Uptake rate does not have much impact on AIC but it has a direct impact on the total yield from a scheme, so there may be some approaches with a very attractive AIC but a low potential uptake that are not worth doing due to low yields;
- ⇒ Partnership working is the most effective way to deliver large-scale water efficiency programmes. By working in partnership with other stakeholders who also gain benefit from retrofitting, uptake rates may be increased as well as costs shared or even reduced (e.g. by relying on existing delivery mechanisms such as annual gas surveys). Three of the five scenarios presented in this report illustrate partnerships with an energy company, an energy advice centre and a housing association; however, other possibilities for partnership working should also be explored; in addition,
- ⇒ It would be useful in the future to produce guidelines on key analysis that should be carried out for water efficiency programmes. Guidance could also be given on key data that should be presented, along with suggested units.

For policymakers and regulators

Large-scale water efficiency programmes can make significant water savings that contribute to balancing supply/demand. This *Evidence Base* should be used to inform a strategy for addressing water consumption in existing homes, and for developing measures that would support the water companies in their work on water efficiency.

Water companies have already done a lot of work on water efficiency. In order to support the development of large-scale water efficiency programmes, policymakers and/or regulators should,

⇒ Note that delivering large-scale, cost-effective water efficiency programmes will require partnership working, which is difficult to establish. Therefore, government should try to facilitate partnerships, particularly in relation to housing, e.g. housing association refurbishment programmes could be used to refit homes with water (and energy) efficient devices;

⇒ Decreasing the unit costs and increasing the availability of WEMs will increase the cost-effectiveness of large-scale programmes, which will already benefit from economies of scale. In this respect, rebates and/or fiscal incentives such as VAT reductions on water efficient products should be examined, as well as government procurement policies and a possible label for water saving products;

⇒ Regulators should recognise that under the current regulatory regime water efficiency is a difficult area for water companies to deliver in:

- The capex/opex issue has been identified as a key barrier. Water companies are financially incentivised to deliver large-scale supply-side schemes since they generally increase regulatory asset value and may offer opportunities to over-perform on and make additional gains on capital expenditure. Water efficiency schemes require operational expenditure, which does not have the same potential benefits and also counts against companies' financial performance targets. Ofwat have stated the possibility of 'special' opex, which partially resolves this problem (discussed more in section 3.1);
- Due to the fact that water efficiency programmes are a relatively new area for water companies, the water efficiency trials and projects that have been carried out have a greater degree of uncertainly than supply-side measures. An allowance should be made for exploratory programmes, much like the demonstration activity allowed by Ofgem for the energy companies;
- Unlike supply-side measures, water efficiency programmes are best delivered through partnerships. Increased dialogue is needed between Ofwat and Ofgem on how joint working between water and energy companies would be treated, particularly in relation to the allocation of Carbon Emissions Reduction Target savings and to how joint programmes could potentially deliver water efficiency targets.

For manufacturers and delivery agents

The *Evidence Base* demonstrates that there is a large potential market for water efficiency measures that deliver savings at low cost. Suppliers of water efficiency measures are encouraged to increase the performance of their products in terms of water savings as well as asset life.

Since the both the installation rate and the speed of installation have a critical impact on the total yield of a scheme and its AIC, manufacturers should ensure that products are both acceptable to the customer (in terms of performance and, if appropriate, aesthetics) and simple and quick to install.

The projects used in this report have shown that there are wide variations in the quality of installation, installation rates, speed of installation and provision of information to customers. There is a need for an increase in the quality of installation consultants so that water companies can be offered a more standardised service; this would reduce the uncertainty associated with water efficiency programmes.

For energy companies and advice centres, housing associations and other potential partners

Increasing the efficiency of hot water use has the potential to prevent the release of significant amounts of carbon. Therefore, for energy companies and advice centres, working in partnership with water companies to deliver large-scale water efficiency programmes has great benefit since it will deliver savings in a much more cost-effective way.

Partnering with water companies will provide housing associations with low-cost retrofit or refurbishment of bathrooms and/or kitchens, and will result in reduced water and energy bills. Water efficiency can be piggybacked onto, for example, annual gas inspections.

1.3 Scaling-up and filling knowledge gaps

Much more work is needed to build the evidence base for water efficiency:

- ⇒ There remains a high degree of uncertainty around savings from individual water efficiency measures;
- ⇒ Little to no information of robust quality is available on the costs associated with implementing water efficiency programmes, particularly on costs associated with installations;
- ⇒ Apart from one five-year study conducted by Essex and Suffolk Water, there is no information on decay rates for water savings;
- ⇒ There is a significant lack of understanding of how behaviour is changed by the installation of devices, and also of behaviours before changes are made; and,
- ⇒ There is no information on whether consumers are willing to pay for retrofits.

It is unlikely that further information will be drawn from small-scale water efficiency trials and projects. What is now needed is a large-scale, multi-partner demonstration project covering tens of thousands of homes, with yields comparable to supply-side measures. At the same time we also need more single measure laboratory tests and field trials to determine micro-component savings; these must also involve testing of the impacts of installing devices with and without education and information.

2 Introduction

The Water Saving Group identified the lack of a robust evidence base for water efficiency as a barrier to large-scale water efficiency programmes. Therefore, the Group tasked Waterwise to undertake a review of the evidence with the aim of identifying gaps, analysing the data and establishing a common set of values for WEMs. This *Evidence Base* project was led by Waterwise with guidance from a Steering Group, Accounting Subgroup and Economics Subgroup whose members were drawn from the water industry, regulators and government.

An initial desk study assessing existing data showed that there were excellent examples of water efficiency projects that had been undertaken by UK water companies; however, these tended to be on a small-scale and so made it difficult to extrapolate results in order to inform large-scale water efficiency programmes.

The initial assessment also showed that previous studies had assimilated water efficiency information, making it difficult to attribute water savings to individual measures. Data was also often of little use due to insufficient detail and a lack of information on the context in which the project was undertaken. Anecdote-style studies were useful to provide a view of what was taking place, but did not guide on transferability or provide for the derivation of values for long run AICs or the permanence of measures.

Therefore, the project led by Waterwise had the clear objective of gathering robust, statistically significant data to populate an evidence base.

2.1 Objectives

The objectives for this project were to

- ⇒ extract information on costs and benefits from UK water efficiency trials and projects, including the UKWIR database;
- ⇒ filter projects in terms of local conditions, practicality of replication and transferability, and statistical robustness;
- ⇒ develop a table of water efficiency options and produce optimised possible cost-benefit figures for different classifications of water efficiency projects;
- ⇒ describe the range of water efficiency devices and approaches available;
- ⇒ develop a set of water efficiency scenarios with cost-benefit analyses;
- ⇒ translate cost-benefit figures into alternative accepted accounting figures, such as AIC and/or Long Run Marginal Cost (LRMC); and to,
- ⇒ map project outputs and timescales onto the PR09 timescales.

2.2 Report structure

The report begins with a discussion of the capex/opex issue and of the limitations of this work (section 3), particularly with regard to the above objectives. Section 4 then describes the methodology employed in this study, as well as the spreadsheet tool that was used to develop the scenarios. The evidence is described in detail in section 5 and results of the disaggregations are presented. Section 6 then summarises the disaggregations and briefly discuss WEMs and savings. Section 7 applies findings from this study to develop scenarios for large-scale water efficiency programmes, including AIC projections.

3 Issues and limitations

3.1 Issues

During the compilation of this report, an issue arose relating to the classification of water efficiency spend as capital expenditure (capex) or as operational expenditure (opex). Both the Steering Group and the Accounting Subgroup discussed this issue, and Ofwat confirmed that accounting rules meant that retrofit projects could only be classified as opex. There was some discussion of classifying retrofit projects as 'special' opex; however, in discussion it was noted that water companies sometimes have difficulty securing funding for opex and that opex classification would mean that retrofit projects were subject to efficiency and so would be progressively squeezed and would not contribute to regulatory asset value. Companies were seeking reassurance to avoid regulatory disincentives against retrofit projects. The Water Saving Group was also seeking explicit resolution of this issue.

Ofwat summarised their position as follows:

- ⇒ Water efficiency must be treated as opex not capex under UK Generally Accepted Accounting Practice. This is not an Ofwat rule. In the energy sector, giveaways such as free energy efficient light bulbs are treated as opex.
- ⇒ At price reviews Ofwat use the same opex figures for assessing relative efficiency and for establishing the starting point for future base service opex. If companies have carried out large one-off programmes of water efficiency work, which they do not want carried forward into future base service opex, then Ofwat will treat these costs as atypical and exclude them when they assess companies' relative efficiency. This would normally apply to work carried out over a short period within an Asset Management Plan (AMP) period. If the work takes an entire AMP period, it is more likely to be treated as 'normal' service to maintain supply/demand balance - and is unlikely to be treated as atypical.

3.2 Limitations

Costs

The costs of implementing a water efficiency programme vary greatly between and within water companies. One of the objectives of this study was to examine the costs and benefits of water efficiency trials and projects, including the cost effectiveness of individual measures. Since many trials and projects involve several water efficiency measures, it was expected that costs would have to be disaggregated in a similar manner to water savings in order to achieve a best estimate across the industry for individual WEMs.

Detailed information about the costs of the trials and projects was not usually available, with the exception of a handful of studies. Some fixed costs, such as the unit cost of water efficiency devices, were deemed in some instances as company confidential, while other overhead costs, such as project management, were completely variable and dependent on context.

Therefore, this *Evidence Base* does not include a detailed analysis of the costs associated with individual WEMs or with water efficiency trials and projects, as this was deemed to be beyond the current scope of the project.

Despite this lack of information about costs, five possible scenarios have been developed based on best available costs information, with expert input from practitioners in the field.

Social and environmental costs and benefits

Though the intention was to look at the environmental and social costs and benefits associated with large-scale water efficiency programmes, evidence of these impacts could not be derived directly from most of the water company project reports. Therefore, it was agreed that the quantification of these externalities was beyond the scope of this study. Only the AIC, rather than the AISC (Average Incremental Social Cost), has been calculated for each scenario. This area has been identified for future work.

An externality is a non-financial cost or benefit that may be environmental or social. The EBSD includes advice on quantifying environmental and social costs under Stage 5 and Appendix A of the Main Report. The Environment Agency's *Benefits Assessment Guidance* advises on the types of externalities to be considered, and defines externalities as follows:

> Because impacts on environmental resources remain outside the 'market place', they are commonly referred to as 'external' effects or 'externalities'. A full social CBA includes consideration of these 'external' effects in order to estimate the total social costs or benefits arising from a scheme. External costs and benefits include those corresponding to the range of environmental, human health and other non-market social impacts, and occur when the actions of one individual/firm cause a loss in wellbeing (or satisfaction) to another individual/firm, and no compensation has been paid for that loss taking place.

The limited list that follows is a starting point for agreeing what should be included in terms of environmental and social costs/benefits for water efficiency projects. The impacts can be expressed as monetary values or in some cases as an increase in greenhouse gas emissions that can then be converted into a value using the shadow price of carbon.

⇒ External costs
- Transportation: for installation and monitoring (pre and post) of projects; results in extra traffic, resulting in extra energy/fuel and $CO2$ emissions;
- Embedded emissions: in the materials involved (plastics, metals, paper etc.) through the raw materials, processing, transportation and delivery;
- Disruption to customers: caused by entry to property, installation of fittings, disruption to supply; and,
- Customer dissatisfaction: the experience of the water efficiency intervention may leave some customers dissatisfied.

⇒ External benefits
- Customer benefits: reduced water charges (if on a water meter); reduced energy charges (if water saving device reduces the use of heated or internally pumped water); reduced carbon emissions (reduced water use, saving on treatment and pumping, plus carbon use in the home if the water saving device reduces the use of heated or internally pumped water); positive customer liaison where the customer may be left with a more positive disposition to the water company;
- Reduced abstraction: less water may be abstracted from the environment, resulting in recreational, amenity and non-use (biodiversity) benefits;
- Greater flexibility within the supply-de,amd balance occurs when there are high levels of water efficiency promotion (for example that they can be scaled down or up as required, whereas a new reservoir built on the basis of forecasting will be in place even if the supply/demand context changes), and,
- We were unable to achieve a clear decision over whether the consumer receives an asset when a water efficient device is installed in their household and if the value of this device can be counted as an external benefit.

Clear guidance is needed on what to include and exclude in the social and environmental impact analysis for WEMs so that consistent rules are applied. Ofwat have recently completed a guidance document on the inclusion of externalities in the analysis of leakage targets. Some of the leakage activities will be common to water efficiency activities, so the leakage guidance might be a good starting point for guidance on how to include externalities in the water efficiency analysis. Using Ofwat's leakage guide as a starting point, a guide for the inclusion of social and environmental impacts into water efficiency measures should be produced.

Assumptions and available micro-component data

There are a large number of assumptions used in the project; these are based on existing reports or published data. The project has shown that there is a wide range in values used even for basic micro-components. Therefore, the project has highlights the need for a full review of values used for micro-components, and of the assumptions used to underpin them. Section 5 discusses these in more detail.

For example, we have used a 1:1 ratio for small to large flushes in dual-flush retrofits. We have some concerns over the validity of this assumption, but due to a lack of data in this area we have deemed it to be the best available, generally used by the Environment Agency and the Market Transformation Programme. More work is needed to build this assumption and all the assumptions made around toilet flushing.

Repeat programmes

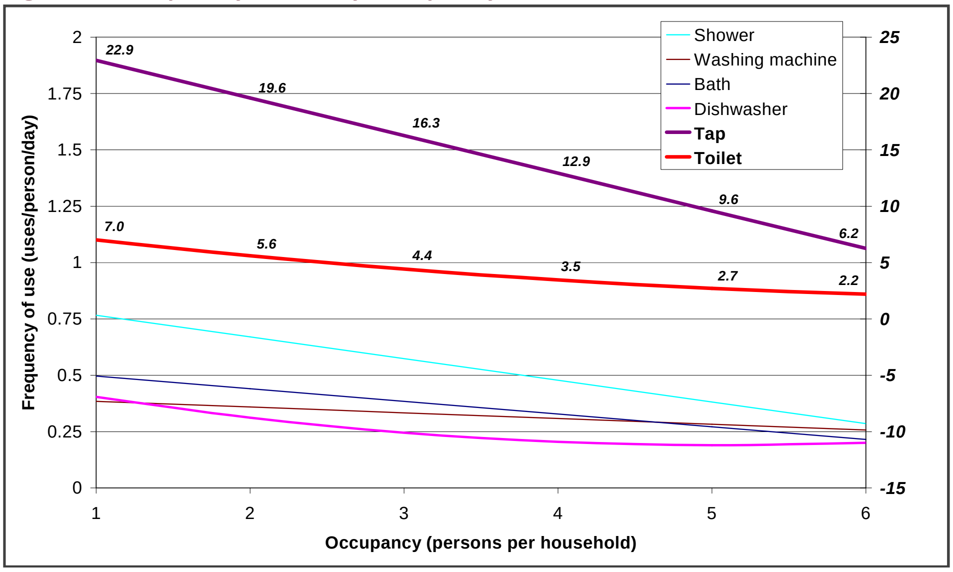
For the scenarios, we have also assumed that no replacement or repeat programmes would be carried out by water companies after the implementation of the original scheme. This is partly because Ofwat consider water efficiency as opex but will allow one-off water efficiency programmes to be considered as special opex. Repeat programmes are not allowed to be considered as special opex.

Occupancy

There is a general assumption throughout of an occupancy rate of 2.4 persons per property, and all the data in the report is presented as litres per property per day. In some cases specific occupancy data was used in the assumptions for some of the projects; where this was the case, savings were then translated into litres per property per day.

The impact of various WEMs will be affected by household occupancy. We know from previous micro-component studies that frequency per use, for example, is related to occupancy (figure 1).

Figure 1. Frequency of use by occupancy **(presented at the WRc CP187 Identiflow final project seminar, 2002).**



Water savings were not reported by occupancy in this report because

- ⇒ Occupancy data was often not available for the trials and projects included in this study, and so to enable comparisons across all projects the data had to be presented on a per property basis;
- ⇒ Where occupancy data was presented, there was no clear way of gauging the impact of occupancy on multiple WEMs;
- ⇒ If the sample of properties were broken down into occupancy groups, the sample size may become too small for analyses.

Occupancy is clearly an important factor, for example, for WC and tap use. Future projects should explore whether occupancy data can be used in the disaggregation of multiple WEM projects and trials; or, where single WEM trials are undertaken, whether occupancy relationships can be derived and then applied more widely to other studies.

Behavioural interactions

One underlying issue that has not been addressed in this meta-analysis or in many of the water company trial and project reports is the split between water savings from device installation and those from behavioural changes. There have been very few projects that have tested the impact of education alone, and existing studies have not been able to identify a change in water use behaviours.[1]

Several of the large-scale projects detailed in this report have included an education/awareness component; in general, no data are available for the impact of these WEMs, and they have not been included in the disaggregations apart from some of the customer audit data from the Essex and Suffolk Water projects.

The observed discrepancies between the estimated versus measured savings for both the Sutton and East Surrey project and United Utilities' projects could be attributed to behavioural changes and the impact of education and awareness-raising activities. For example, the Sutton and East Surrey project hired an outreach officer who was responsible specifically for education.

There is a need for a lot more work to assess consumer attitudes to water saving, which will help inform uptake rates, use of products, behaviour change and potential rate of removal of devices (which affects the product half-life). Such research will require long-term monitoring and assessment.

International evidence

Many gaps could be filled with reference to international examples. The inclusion of international experiences was part of the original remit of this report, but until a standard framework has been established for inclusion of this information, it was difficult to draw out relevant information from international trials. There is an issue over transferability, both technically and socially/culturally.

Metering

There is a need for a separate study on the role of metering alongside retrofitting of devices and education, as part of an integrated demand management approach.

Non-household water efficiency trials and projects

This report focuses on water savings in households, which is the remit of the Water Saving Group. There have been a number of projects that have looked at non-household savings from schools, hospitals and businesses; these have delivered good water savings and should be analysed for a future publication.

[1] Environment Agency (2003)

4 Methodology

The methodology used in this project was drawn primarily from 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, from which the confidence grading system used for the water efficiency projects has been based on; 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 AIC is consistent with the WR25B approach, the EBSD and the Water Resource Planning Guidelines. The steering group agreed that a discount rate of 4.5 percent was appropriate for the project as this was consistent with the value used for the company Water Resource Plans, and that a 25-year planning horizon should be used as this is common practice for water companies (practically this means assigning a zero value to all figures after 25 years up to 60 years when calculating the AIC values).

The methodology was applied in six steps:

1. Collect, verify and assess the quality of the evidence;
2. Extract data on water savings from WEMs, via disaggregation if necessary;
3. Allocate confidence grades to individual WEMS, in line with WR25A;
4. Use data from the evidence to construct scenarios of large-scale water efficiency programme in order to demonstrate the application of the data contained in this report;
5. Analyse the costs and benefits, in terms of water savings, for these scenarios using the spreadsheet tool developed under the WR25B project; and,
6. Produce a set of outputs that could be used in the EBSD process.

The results of the application of this methodology have yielded useable evidence, 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 CBA.

4.1 Data collection

Information was gathered from UK water companies through written data requests, desk study, pro formas and personal communications. These efforts were followed up by visits to the water companies.

Information was collated into four lists:

⇒ current water efficiency projects;

⇒ proposed water efficiency projects;

⇒ wish list of water efficiency projects if funding was available; and,

⇒ day-to-day water efficiency activities.

The information was then collated and analysed. Specific project reports and raw data were obtained from the companies. As the project progressed a number of water companies undertook additional pilot programmes; Waterwise staff inputted into the design of a number of these pilots, drawing on their knowledge of the existing data and the gaps. As these pilot projects were completed the data was collected and fed into the evidence base project.

When reviewing the range of water efficiency trial and project reports, a great deal of time was spent trying to find data of water savings (measured and estimated) and trying to find out what some of the data actually related to and how robust it was. This was largely due to the range of different analysis methods used and the way in which the data was presented.

A number of the projects have small sample sizes for certain WEMs. In general, small sample sizes are taken into account in the disaggregation since it includes installation rate information. We have excluded samples where there are less than 10 participants with no control.

4.2 The evidence

Evidence of water savings presented in this report (section 4) has been drawn from several trials and projects that have been undertaken by water companies in the UK (table 2), either within recent years or currently underway. We would like to thank the water companies for their support of this research.

Many of the projects analysed in this report were carried out by Essex and Suffolk Water, which have been leaders in the design, development and implementation of water efficiency projects for a number of years. Because some of Essex and Suffolk's projects relied in part on assumptions rather than measured savings, the projects have been awarded, according to the *Evidence Base* methodology, a lower confidence grade. Despite the lower confidence grades, Waterwise would like to underline the importance of these projects not only in their own right, but also for the important role they have played across the industry as examples of effectively designed water efficiency schemes.

Table 2. Evidence used in the *Evidence Base*.

Water company trial / project	Reference	Section	Method for quantifying savings
Essex and Suffolk Water (1998) "Household water audits in Moulsham" **Essex and Suffolk Water (2002) "Water audit follow up in Moulsham"**	Watersmart (1998) "Household audits in Moulsham, 1997/8" Utilities Project Management (2002) "Moulsham and Silver End follow up audit"	**5.1**	Estimated and not directly measured. Measurements were taken from district flow meters; however, the recorded drop in consumption post-audit is thought to be an underestimation because longer term savings (such as those arising from changing to showering, garden watering, pipe lagging and advice) may not have been realised at the time of the analysis.
Essex and Suffolk (2006) "Sustainable water audits research in Chelmsford"	Ewan Group plc (2006) "NW345: Sustainable water audits research" Essex and Suffolk Water (2006) "Sustainable audits: progress in 2006/7", WE/0006/06	**5.2**	Loggers were fitted to a sample of the properties.
Essex and Suffolk (2004) "Home surveys in Brentwood and Romford"	H2O Water Services Ltd (2004) "Home Surveys in Brentwood"	**5.3**	Estimated.
Essex and Suffolk (2007) "Toolkit: 1000 homes visit and fix"	Mouchel Parkman (2007) "Water Saving Toolkit"	**5.4**	Meter data were collected from properties that had an externally accessible water meter, and 187 flow loggers were installed to collect detailed water use information.
South West Water (2007) "Water efficiency trial"	Jacobs (2007) "South West Water water efficiency trial, 2006/7"	**5.5**	Metered properties used as sample to estimate overall savings; control group set up to check if any change in consumption unrelated to trial.

Water company trial / project	Reference	Section	Method for quantifying savings
Thames Water (2008) "Liquid Assets, Phase 1"	Mouchel Parkman (2007) "Domestic water audit and retrofit study report", final draft	**5.6**	Before and after meter readings (five) on a trial of only metered properties.
Environment Agency (2004) "Retrofitting of variable flush devices"	Environment Agency (2005) "Retrofitting variable flush mechanisms to existing toilets", ea/br/e/std/vr1	**5.7**	Water savings were measured using meter reads from 15-minute logger data.
Essex and Suffolk (2002) "Home surveys in Witham"	H2O Water Services Ltd (2002) "Home Surveys in Witham"	**5.8**	Estimated savings from audits (e.g. shower flow rates were measured by customers).
Essex and Suffolk (2006) "Thurrock home surveys"	Essex and Suffolk Water (2006) "NW330: Thurrock home surveys", WE/0025/07	**5.9**	Estimated savings from audits (e.g. shower flow rates were measured by customers)
Essex and Suffolk (2008) "H2eco water audits"	Mouchel Parkman (2008) "H2eco"	**5.10**	Estimates, meter readings and logger data.
Essex and Suffolk (2007) "ecoBETA study in Chelmsford"	Mouchel Parkman (2007) "Chelmsford ecoBETA"	**5.11**	Estimates, meter readings and logger data.
Sutton and East Surrey (2007) "Preston water efficiency initiative"	Waterwise (2008) "Preston water efficiency initiative", interim report	**5.12**	District Meter Area readings for before consumption; meters fitted to measure after consumption.
United Utilities (2008) "Water efficient showerhead offer"	United Utilities (2008) "Water efficient showerhead offer"	**5.13**	Customers measured shower flow rates before and after.
United Utilities (2008) "Home audits"	WRc (2008) "United Utilities home audit project", UC7803.03	**5.14**	Metered properties used to estimate overall savings; control group set up to check if any change in consumption unrelated to trial.
Yorkshire Water (2008) "Water saving trial"	Yorkshire Water (2008) "Periodic Review 2009 water saving trial"	**5.15**	Metered properties used to estimate overall savings; control group of 50 metered properties.
Severn Trent Water (2008) "Domestic water efficiency trial"	Artesia Consulting (2008) "Additional analysis of the STW domestic water efficiency trial", AR 1011	**5.16**	All properties in trial metered; data cleansed to give reduced sample of 805 properties from which average water savings estimated.
Anglian Water (2008) "Ipswich water efficiency audit trial"	Anglian Water (2008) "Memo 2: Ipswich water efficiency audit trial"	**5.17**	Before and after meter readings from 56 properties.

Waterwise collected and assessed the data to determine suitability for inclusion in the *Evidence Base*. Our assessment was based on the availability of a project report (some company pilots had not yet reported at time of publication), the scale of the pilot, the scope of the pilot, the certainty of the data (i.e. what level of monitoring was carried out) and the age of the study.

Many of the projects included in this study had two phases, involved follow-up audits or could be analysed for a single WEM. As a result, more sets of disaggregations are presented in this report than company projects included. Results obtained from disaggregation have been used to inform the development of the five large-scale water efficiency programme scenarios (section 7), utilising the AIC tool developed as part of the WR25B project.

4.3 Water efficiency measures and sub-measures

There are dozens of fixtures, fittings and interventions that can be classified as WEMs, which may be used alone or in combinations to deliver water savings through large-scale water efficiency programmes:

- ⇒ WEMs for toilets
  - o Cistern displacement devices, such as a Hippo or Save-a-Flush
  - o Retrofit dual-flush devices, such as the ecoBETA
  - o Retrofit interruptible flush devices, such as the Interflush
  - o Replacement dual-flush toilets
  - o Replacement low-flush toilets
- ⇒ WEMs for taps
  - o Tap inserts, such as aerators
  - o Low flow restrictors
  - o Push taps
  - o Infrared taps
- ⇒ WEMs for showers
  - o Low-flow showerheads
  - o Aerated showerheads
  - o Low flow restrictors
  - o Shower timers
  - o Bath measures
- ⇒ Reuse
  - o Large-scale rainwater harvesting
  - o Small-scale rainwater harvesting with water butt
  - o Greywater recycling
- ⇒ WEMs addressing outdoor use
  - o Hosepipe flow restrictors
  - o Hosepipe siphons
  - o Hose guns
  - o Drip irrigation systems
  - o Water audits, including do-it-yourself or with assistance of a plumber or other professional
- ⇒ Seek-and-fix of internal leaks and/or dripping taps
- ⇒ Metering with/without sophisticated tariffs
- ⇒ Water efficient white goods, including washing machines and dishwashers
- ⇒ Education, publicity, promotions and behaviour change campaigns

Several manufacturers are continuously working to improve the performance, desirability and price of efficient water using products. Similarly, retailers are also taking steps to ensure they stock efficiency products.

Most water efficiency projects to date have used combinations of water efficiency measures rather than single devices. For example, water audits have often been combined with retrofit installation of a dual-flush conversion device and an aerated showerhead. Such ‘baskets’ of measures are likely to have a total impact that is not equal to the sum of the individual measures, thus requiring a methodology for disaggregation in order to assess components individually.

4.4 Disaggregating the evidence

To quantify water savings associated with individual measures, data about the WEMs and information about the context of the trial/project and its implementation and scale were extracted into summary tables (table 3).

Table 3. Information on costs (where available) and water savings extracted from evidence.

A: Measures	Most likely	Worst case	Best case
Costs • Capex • Opex • Externals			
Yield			
Half life			

B: Scenarios	Most likely	Worst case	Best case
Costs • Capex • Opex • Externals			
Target population			
Uptake rates			

Where,

⇒ *Yield* was in litres per day per household for a specific target population;

⇒ *Half life* was the time in years from the peak water saving to a time when half the peak saving was delivered;

⇒ *Costs* were the unit costs per household in GB£ over twenty-five years, at the start year prices (not discounted); and,

⇒ *Installation rates* were the percentage of households in the target population where water efficiency measure were fitted or undertaken.

Where possible, data were extracted directly from the evidence reported and supplied to Waterwise. If a trial or project involved only one WEM, then data were extracted directly into tables A and B (table 3); however, since many projects included multiple WEMs, a methodology was developed to disaggregate the measures:

1. Average frequency, duration and volume of use for all WEMs was specified based in the CP187 dataset and WRc micro-component data;
2. Theoretical savings were calculated for each device for the average property;
3. Each devices' contribution to the total water savings recorded in the trial/project report was calculated;
4. The percentage contribution was then applied to the total water savings to give the disaggregated results; finally,
5. Confidence grades were assigned to indicate the robustness of assumptions used for each device and the robustness of data used in the project.

Individual WEMs in each project were given a confidence grade of high, medium or low to indicate uncertainty associated with the above process of estimating micro-component data:

High	Medium	Low
Toilet WEMs (e.g. ecoBETA)	Tap WEMs (e.g. aerators)	External WEMs (e.g. hose guns)
Cistern displacement devices	Showerheads (e.g. low flow)	Behaviour related WEMs (e.g. shower timers)

These confidence grades were based on the influence of behaviour on the water use of an individual micro-component (the lower behavioural influence, the higher the confidence grade).

A whole project confidence grade (presented as reliability followed by accuracy) was then given based on the principles set out in the WR25 reports for assessing confidence in data collected during small-scale water efficiency projects.

Water savings for unmeasured properties are more uncertain than for measured properties because savings are based on estimates and assumptions rather than actual measurements from meter readings. Therefore, unmeasured studies are of lower confidence than measured studies. The reliability bands are based on whether household water savings were based on any measured consumption data:

⇒ **Band A** for measured micro-component data that requires no disaggregation;
⇒ **Band B** for measured consumption data based on before and after comparison at DMA or household meter readings. This category includes partial measurement of savings where consumption per device (e.g. shower flow rates) is measured for each household and savings are built up using assumptions on frequency and duration of use. Measurements may involve only a sample of the properties; or,
⇒ **Band X** for savings base on judgement only, with no measured consumption data.

The accuracy bands are based on 95 percent or 90 percent confidence intervals around the water savings for each project:

⇒ **Band 1** for projects that give confidence limits (upper and lower) and in which all limits are less than or equal to 25 percent of the water savings;
⇒ **Band 2** for projects that give confidence limits (upper and lower) and at least one limit (upper or lower) exceeds 25 percent of the water savings; or,
⇒ **Band X** for projects that give no confidence limits or only one-sided limits (either upper or lower).

Outcomes from the disaggregation were used to populate another summary table (table 4).

For example, a basket of WEMs was installed into measured properties (table 4). The example project scores an ‘A’ (high) for reliability because meter readings were used to measure the savings and a ‘1’ (high) for accuracy since small confidence limits were reported.

Table 4. Example of the outcomes of disaggregation and the application of accuracy and reliability bands.

Measured	**Basket of measures**	
	Yield	**Confidence grade**
WCs	00 litres per property per day	High
Taps	00	Medium
Showerhead	00	Medium
Advice	00	Low
	Project Confidence Grade	**A1**

The yield from the WEMs involved in this example project where not individually measured and so some estimation and disaggregation were required to separate the individual information from the sum of total water savings. Devices associated with WCs, such as cistern displacement devices, are considered to be reliable in delivering consistent water savings per use; therefore, WCs were assigned a high confidence. While there is still some uncertainty associated with the frequency of use of toilets, research done through the Market Transformation Programme and by others has helped build some reasonable assumptions.

In contrast, water savings from taps and showers are more uncertain because they vary more on volume, duration and frequency of use than WCs. Water savings could be quantified theoretically, but since assumptions are less robust for these WEMs than for WCs, both taps and showers score a medium for confidence.

Advice and similar WEMs score a low confidence grade of 'X' since savings from these measures are uncertain, relying heavily on user behaviour.

Appendix 1 provides an example of a disaggregation.

Once the disaggregation process was complete, data on water savings for individual WEMs was used to construct scenarios for large-scale water efficiency programmes. These scenarios are underpinned by a number of assumptions. In general the maximum and minimum water savings are taken from the water company project data presented in table 6; the best estimate is based on the data and practical experience outlined in the company reports. The maximum, minimum and best estimates of the costs are derived from figures given in the company reports and from discussions with the Steering Group and water company professionals. It is clear that all of these figures are approximate and will vary depending on company area and method of implementation; however, we have attempted to include a wide range of possibilities in the scenarios and this is reflected in the very large variation in AIC values (see appendix 2 for AIC calculation).

4.5 The spreadsheet tool

Screenshots of the tool are provided in appendix 3.

For each step in the spreadsheet tool where data is entered, uncertainty is accounted for with a range of values: a best estimate (i.e. most likely), best case (i.e. an optimistic result) and a worst case (i.e. a less likely result). For example, for costs the best case would be the lowest cost and the worst case would be the highest cost. The best estimate would be the most likely cost.

The tool is used in six stages:

Step 1: Target households

Projected household numbers (i.e. target households) are input for up to four subgroups of households in each zone. These subgroups can vary from each other either in the water savings made or costs incurred. For example, the target population may be split between metered and unmetered households or between urban and rural households. Each subgroup can be treated individually with regard to scheme uptake, costs and water savings; however, each household subgroup must be mutually exclusive in order for the total households' yields and AICs calculated to be meaningful.

Step 2: Uptake rates and uncertainties

The uptake rate is the percentage of the target population that participates in a scheme. In most cases the uptake rate is crucial to determine the water savings that may be made. Given the unpredictability of behaviour, uncertainties around uptake rate are in many cases the most significant.

In developing scenarios, assumptions need to be clearly stated. For example, "measured households are usually assumed to achieve a higher uptake rate for water efficiency schemes than unmeasured due to the financial incentive to save water" or "uptake rate is assumed to be closely related to what the scheme offers in terms of subsidies for water-saving devices and their installation, and the extent to which the scheme is promoted".

When rolling out water efficiency programmes, there are several populations that need to be considered:

- ⇒ The total number of households in the programme area;
- ⇒ the households that are invited to participate;
- ⇒ the households that agree to participate (i.e. the uptake rate);
- ⇒ the households where access is achieved; and,

⇒ the households where installation takes place (i.e. the installation rate).

The installation rate has a big influence on the success of a programme, as it influences the overall yield of the programme.

A scheme can be assessed as a ‘one-off’ or as a ‘periodic implementation’. A one-off implementation assumes that the scheme is implemented in Year 1 and takes X years to complete, with no re-implementation. Periodic implementation allows the planner to implement the scheme as many times as is required throughout the twenty-five year planning period, in order to maintain savings. Periodic implementation can also be used to allow uptake to be delayed until scheme set up is completed, if scheme set up is deemed to take more than two years. All the projects and examples in this report are one-off implementations and assume that there is no replacement or repeat programme led by a water company after the initial installation of devices.

The tool also allows for a change in water savings over time to be included, if supported by evidence; however, for most of the projects there will be limited time series data, typically only one or two years. Therefore, the spreadsheet tool uses a method of projecting water savings forward in time that allows for decay in savings that may be due to behaviour, customer intervention (e.g. removal or replacement of the device) and/or device underperformance.

WEMs are installed in multiple households and result in a volume of water saved. It is assumed that the volume saved in Year 1 is known and so the savings are calculated as the sum of households multiplied by water savings per year per household. After this time we do not know what the water savings may be: they may continue at the same level or they may decrease. The reason for the decrease may be that a proportion of households each year remove a WEM or that a proportion of the WEM deteriorate such that water saving is reduced. The reduction in water saving may start immediately; therefore, the volume should take into account any fall off in water savings during the first year.

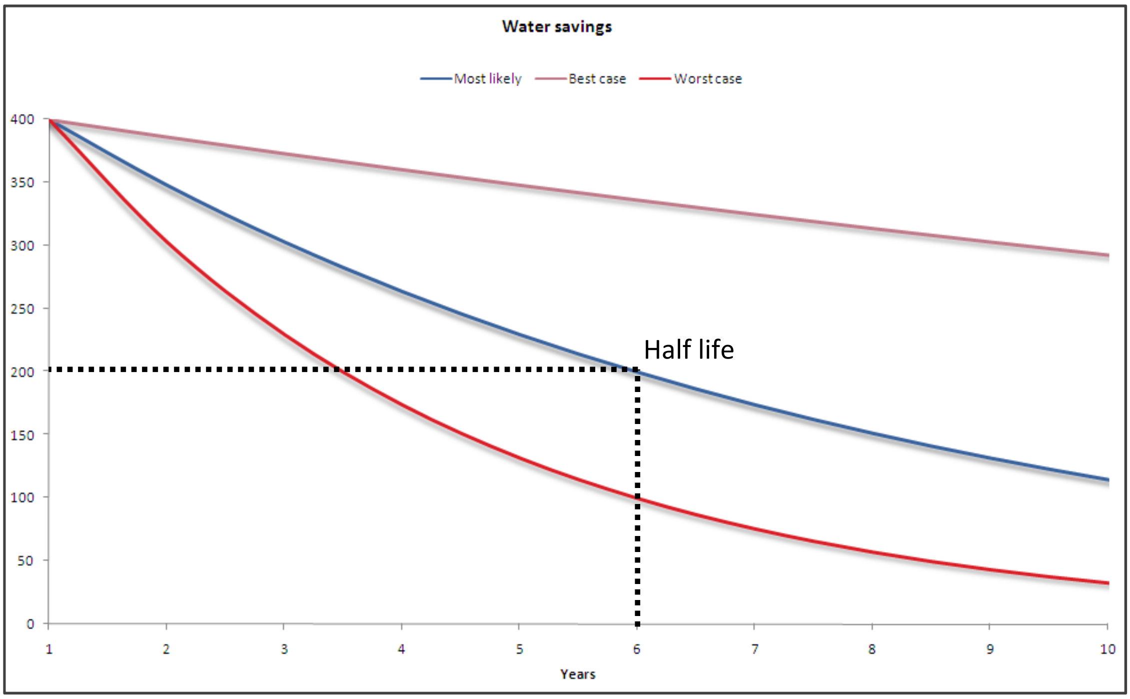
The WEM is assigned a 'half-life' distribution: the years from time of peak savings until only half peak savings are delivered. The half-life represents the length of time in which half of the measures will be replaced or abandoned. It also represents the time taken for deterioration of devices to yield half the peak savings. It is assumed that when the measure is replaced, abandoned or deteriorates, no future water savings are made.

Using this approach, a range of projected water savings is made as best estimate, best case and worst case. The half-life needs to be estimated for each of these cases. Time series evidence can be used, if available, to estimate the half-life; however, in most cases this information will not exist. Therefore, guidance has been developed and applied to ensure consistency:

⇒ The best estimate (i.e. most likely) value is given by a half-life equal to half the asset life;
⇒ The best case is given by a half-life equal to two times the asset life; and,
⇒ The worst case is given by a half-life equal to one quarter of the asset life.

For example, a water saving measure may have an asset life of ten years (where asset life is a distribution with a mean of ten) after which time it is expected that the water savings from this particular WEM will become zero. The initial water savings is 400 units. Using the process set out above, the result is a half-life for most likely as five years, so the savings are halved to 200 units at the end of Year 5 (figure 2).

Figure 2. Water savings and half-life of a water saving device.



Half-life feeds into the uptake rate calculations and determines how quickly the households that take up the scheme are returned to the 'not taken up' population.

This method allowed for guaranteed maintenance by the water company in the first year, which is common practice.

Step 3: Costs

The *Evidence Base* was used to estimate the range of costs for each of the scenarios. The cost of fitting will depend on whether the scheme includes free professional installation, subsidised professional installation or if the customer is expected to fit the device themselves. If the company employs a plumber to install the device(s) then the cost of installation will then be based on the average hourly rates and the average time it takes to fit the device.

Customer recruitment costs apply to the entire target population, regardless of whether they participated in the scheme or not. There are also administrative and data handling costs.

All costs of all devices, visits and installations mentioned in this report were met by the water company or other authorities and none by the customer.

Step 4: Water Savings

Savings (yield) in litres per household per day for the worst case, best estimate (i.e. most likely) and best case for each target population are input into the tool.

Step 5: Social and environmental costs and benefits

If data is available, social and environmental costs and benefits should be considered in order to include externalities such as the cost/benefit of the water remaining in the environment and/or the impact of the scheme on householders. The environmental and social costs/benefits may be entered as the best case, best estimate and worst case savings in megalitres and/or per installation. The net costs/benefits are entered with savings applied as a negative value.

Step 6: Results

After all the data have been input, a worksheet of the tool displays the AICs and yield/cost profiles over the twenty-five year assessment period for each of the target household groups, as well as for all households. The spreadsheet tool allows planners to see instantly how cost-effective spending is in different areas by looking at the change in the AIC.

4.6 Evidence for sustained water savings and half-life

There is very little evidence relating to the sustainability of water savings. Some analysis of time series data on water savings, which was provided by Essex and Suffolk Water (ESW), was done as part of this project.

ESW have continued to analyse thirty properties that were included in the original variable flush WC retrofit project that was carried out by a consortium of water companies and the Environment Agency in 2004/5. Time series data for the years 2005, 2006, 2007 and 2008 were analysed and reported by ESW in May 2008.[2]

Savings per property per day where the devices remained in the property were calculated, as well as the number of properties in which the devices had been removed for one reason or another. Table 5 shows the number of properties analysed each year (some are excluded due to logging failures, occupancy changes or device removal), the average savings in properties where devices remained installed (can be less due to reductions in performance or changes in characteristics of sample properties each year), the number of properties where devices remained installed, and the average saving per property averaged across the original sample of thirty properties (i.e. this figure takes into account reductions in water savings due to removal of devices as well as reduction in performance).

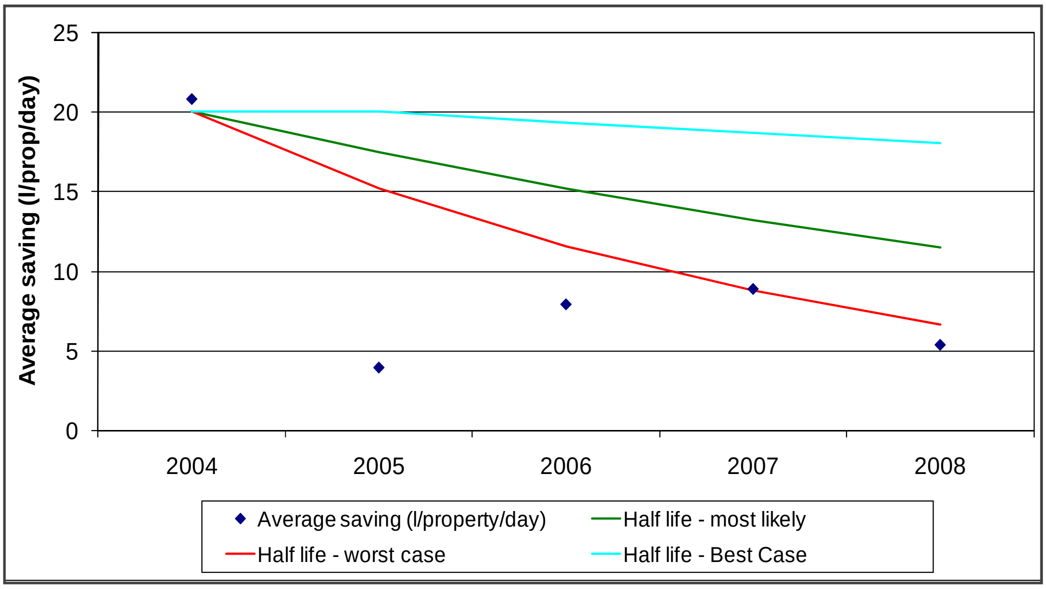
Table 5. Water savings.

Year	Sample size	Average savings (l/prop/day) where devices installed	No of properties with devices	Average savings (l/prop/day) averaged across original number of properties
2004	136	20.8	30	20.8
2005	12	4.4	27	4.0
2006	5	9.9	24	7.9
2007	11	12.7	21	8.9
2008	8	8.5	19	5.4

Compared to the original report, the table shows an initial decrease in savings that is unexplained but may be due to the characteristics of the properties in the sample. The average savings per property averaged across the original sample of thirty properties can be compared to the half-life prediction that is currently used in this *Evidence Base*. Figure 3 shows the half-life lines based on an asset life of ten years plotted alongside the long-term data from the ESW report. The graph indicates that the data from the trial, with the exception of the 2005 data, lies in a trend approximately along the worst case half-life line.

[2] Essex and Suffolk Water (2008)

Figure 3. Water savings and half-life lines.



Note: Average saving is average across the original sample of 30 properties, so includes reductions in water savings due to removal of devices.

Whilst the sample size is small and the sample properties may be different each year, this is the only long-term data currently available to quantify the sustainability of water efficiency savings in the UK. On the basis of this analysis, the half-life estimation does not look unduly pessimistic, however more data, with larger sample sizes, across a wider number of devices is still required to improve the estimation process.

5 The evidence disaggregated

The methodology was applied to a number of company trials and projects, which are detailed in this section. Results from the disaggregations, which attribute water savings to individual WEMs, are reported for each of the projects below and are also summarised in section 6.

5.1 Essex and Suffolk Water: household water audits in Moulsham

Between May and October 1997, Essex and Suffolk Water (ESW) developed an initiative that was piloted in the district metered area (DMA) of Moulsham in Chelmsford. In total, 1,419 audits were carried out of which 1,375 audits were within the pilot DMA. The response rate for the pilot was 76 percent of all domestic properties. A control zone in a similar neighbouring DMA was established for comparative evaluation purposes.

The pilot delivered 5,449 individual measures, including cistern displacements devices, showerheads, water butts, and water efficiency packs with advice. Over two hundred plumbing losses were repaired, as well as several external leaks. Loft pipe and tank surveys were also carried out.

The water savings achieved from this trial were estimated and not directly measured. Measurements were taken from district flow meters, but were masked by leaks and other variations in demand. Estimated savings were based upon customer audit responses and may be conservative due to longer term savings, such as switches from baths to showers, having not been realised at the time of the analysis.

In assessing water savings, three methods were considered: a direct estimate on the basis of measures installed, the comparative changes of water input into the pilot and control zones, and individual case studies carried out by ESW. The best estimate of the savings recorded is 55,000 litres per day, representing ten percent (with a seven to eleven percent range) of estimated average daily water delivered for properties within the pilot zone.

Results of the disaggregation follow:

Essex and Suffolk Household Water Audits in Moulsham 1997-98 **Phase 1**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Cistern displacement devices	25.00	Not applicable		Not applicable	High
2	Showerheads	8.00				Medium
3	Tap washers	5.25				Medium
4	Fixed external leaks	12.00				Low
5	Water butts	2.47				Low
					Project confidence grade	**X2**

Total estimated water savings (l/prop/day)	**42.00**
Total measured water savings (l/prop/day)	**n/a**

Assumptions used to derive estimated savings:	
1	Based on assumptions used by ESW for this study. Note that the assumption for showerheads includes both flow reduction and a switch from bathing to showering. Refer to report for full details.
2	
3	
4	
5	

The results from this project are given a low confidence grade as there were no direct measurements of savings and the savings were derived from audit responses.

5.2 Essex and Suffolk Water: sustainable water audits in Chelmsford

In 2005, ESW carried out a research project that examined the impacts of various audits on changing customers' water-using behaviours. The research compared the effectiveness of six audits, and twenty customers participated in each audit. Disaggregation was done on both the retrofit audit and the full audit as these had actual devices fitted. The other audits were questionnaire-based and associated with changing behaviours.

Loggers were fitted to a sample of the properties and measured savings obtained from the retrofit audit and the full audit. The results of the disaggregation follow:

Essex and Suffolk Sustainable Water Audits in Chelmsford **Retrofit Audit**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Ecoflush	23.04	10.53%	2.43	22.14	High
2	Variflush	23.04	26.32%	6.06	22.14	High
3	Dudley Turbo 88	23.04	52.63%	12.13	22.14	High
4	Save-a-Flush	11.52	5.26%	0.61	11.07	High
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**21.23**
Total measured water savings (l/prop/day)	**20.40**

Assumptions used to derive estimated savings:	
1	Assumes 11.52 flushes per property per day; 2 litres saved per flush
2	Assumes 11.52 flushes per property per day; 2 litres saved per flush
3	Assumes 11.52 flushes per property per day; 2 litres saved per flush
4	Assumes 11.52 flushes per property per day; 1 litre saved per flush

Essex and Suffolk Sustainable Water Audits in Chelmsford **Full Audit**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Save-a-Flush	11.52	100.00%	11.52	6.66	High
2	Water butts	2.74	36.84%	1.01	1.58	Low
3	Hose gun	2.08	63.16%	1.31	1.20	Low
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**13.84**
Total measured water savings (l/prop/day)	**8.00**

Assumptions used to derive estimated savings:	
1	11.52 flushes per property per day; 1 litre saved per flush
2	250 litre water butt fills four times per year
3	Saves 5% of outdoor tap use

Both of these projects have a reasonable match between the estimated and measured water savings. The assumptions for toilet flush devices use higher values than in some of the other projects, but this is because there was a high degree of customer education and interaction that may have increased the likelihood of proper use, e.g. no double flushing.

5.3 Essex and Suffolk Water: Home Surveys in Brentwood and Romford

Between January and September 2004, 83,573 domestic customers in the Brentwood and Romford areas of Essex and Suffolk were invited to take part in the Water21 Home Water Conservation Scheme via a direct mail marketing campaign designed to improve customer and public relations. The main aim of the scheme was to encourage water efficiency through educating domestic customers in techniques for using water wisely and to raise awareness of the limited water resources situation in the ESW area. A combination of direct mail and personal home visits were used to promote practical household solutions that could reduce consumption. Phase 1 was conducted in Brentwood and Phase 2 in Romford.

Of the 84,973 invited to participate in the scheme, 33,381 Water Conservation Packs were delivered to customers. Subsequently, 21,271 Audit Forms were completed and returned between January and September 2004. As a direct result of these surveys, 86,497 measures or components were installed or used at customers' properties that amounted to water savings of 240,190 litres per day, for total saving of eleven litres per audited property per day.

These water savings are estimated and not measured. Results of the disaggregation follow, based on the assumptions used by ESW:

Essex and Suffolk Home Surveys in Brentwood **Phase 1**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Save-a-Flush	9.44	74.03%	6.99	Not applicable	High
2	Tap washers	9.90	0.40%	0.04		Medium
3	Turning tap off when brushing teeth	26.73	5.00%	1.34		Low
4	Hose gun	1.58	79.73%	1.26		Low
5	Showerheads	19.11	5.00%	0.96		Medium
					Project confidence grade	**XX**

Total estimated water savings (l/prop/day)	**10.58**
Total measured water savings (l/prop/day)	**n/a**

Assumptions used to derive estimated savings:	
1	Based on assumptions used by ESW for this study. Refer to report for full details.
2	
3	
4	
5	

Essex and Suffolk Home Surveys in Romford **Phase 2**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Save-a-Flush	10.80	76.71%	8.28	Not applicable	High
2	Tap washers	13.08	0.26%	0.03		Medium
3	Turning tap off when brushing teeth	29.75	5.00%	1.49		Low
4	Hose gun	1.58	75.92%	1.20		Low
5	Showerheads	22.36	5.00%	1.12		Medium
					Project confidence grade	**XX**

Total estimated water savings (l/prop/day)	**12.12**
Total measured water savings (l/prop/day)	**n/a**

Assumptions used to derive estimated savings:	
1	Based on assumptions used by ESW for this study. Refer to report for full details.
2	
3	
4	
5	

These projects have a fairly low overall confidence grade as the estimated savings are assumptions with no direct measurements; however, the audit responses provided the company with behavioural data that could be used to underpin the estimates. These and the ESW Thurrock homes survey are the only projects where data was gathered on behavioural measures, and whilst the confidence is low the data is valuable. It would be useful if all future water company projects gathered data on behaviour and attitudes alongside direct measurements of savings, as in many projects the discrepancy between estimated and measured results (in either direction) could be due to behaviour.

5.4 Essex and Suffolk Water: water saving toolkit

As part of ESW's long-term water efficiency programme, the Water Saving Toolkit project was commissioned to take place in Chelmsford, Essex. An application pack was mailed to over 5,000 domestic customers that presented details of eighteen water saving products and services that customers could choose from in exchange for details about their home and water use characteristics.

A database was constructed to store the large volumes of data generated by the project. Extracts of the customer database, customer contact details and customer survey forms were all stored in the project database. Additionally, the database was used for scheduling of appointments to deliver and fit the selected products and services, recording which items they received, collating meter read data and producing daily work schedules for the site technicians visiting the customers' homes. Of 5,378 customers contacted, 1,073 households completed the audit and were fitted with water saving products and services between November 2006 and March 2007.

Meter-reading data were collected from those properties that had an externally accessible water meter, and 187 flow loggers were installed to collect detailed water use information. Calculations were also undertaken to estimate the theoretical water savings achieved as a result of installing the products during the Water Saving Toolkit project.

The project resulted in each participating property saving on average 13.85 litres per day, or about 0.015 megalitres per day in total for the project study area. The disaggregation of this project was split into plumbed savings that required plumber assistance and non-plumbed savings that included audits, advice and devices to encourage behavioural change.

The results from the disaggregation follow:

Essex and Suffolk Toolkit **Plumbed fittings**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Aerated showerheads	6.25	24.32%	1.52	6.51	Medium
2	Variflush	23.04	19.82%	4.57	23.98	High
3	Dudley Turbo 88	23.04	23.42%	5.40	23.98	High
4	Tap inserts	11.37	32.43%	3.69	11.83	Medium
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**15.17**
Total measured water savings (l/prop/day)	**15.79**

Assumptions used to derive estimated savings:	
1	Reduction of 1/6 of original flow
2	Assumes 11.52 flushes per property per day; 2 litres saved per flush
3	Assumes 11.52 flushes per property per day; 2 litres saved per flush
4	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)

Essex and Suffolk Toolkit **Not plumbed**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Digital shower timer	1.29	37.70%	0.49	1.95	Low
2	Sand shower timer	1.29	9.84%	0.13	1.95	Low
3	Save-a-Flush	11.52	34.43%	3.97	17.46	High
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**4.59**
Total measured water savings (l/prop/day)	**6.95**

Assumptions used to derive estimated savings:	
1 2	Reduce shower duration to 95% of normal
3	Assumes 11.52 flushes per property per day; 1 litre saved per flush

This project has a high confidence grade and shows a good match between estimated and measured savings.

5.5 South West Water: water efficiency trial

South West Water (SWW) conducted a water efficiency trial that involved measuring the effectiveness and costs of fitting a range of self-selected WEMs to measured customers' houses. The devices were chosen from a selection that was made available to the customer by the company.

The trial was designed to measure the effect of a group of customer-selected WEMs rather than to measure the effectiveness of any individual device. There were some customers who selected just one device from the basket of measures, but the number was too small to enable the drawing of statistically valid conclusions. These results are nevertheless presented below for those devices where sample size was greater than ten:

South West Water Efficiency Trial - single measure, where sample greater than 10 properties

A	B	F		
	WEM	**Measured savings (l/prop/day)**	**Properties in sample**	**Confidence**
1	Dudley Turbo 88	24.39	22	High
2	Cistern displacement devices	0.01	29	High
3	Dudley Turbo 88 and cistern displacement device	11.70	56	High
4	Tap inserts	24.89	25	Medium
			Project confidence grade	**BX**

Note that the combination of the Dudley Turbo 88 and the cistern displacement device is not in the summary table; it was not possible to disaggregate the individual water savings.

The project aimed to recruit 500 customers to have devices fitted, with a further 100 customers to act as a control group. A total of 2,056 WEMs were installed into 349 metered homes. Most customers opted for a multi-measure retrofit and few customers chose an individual device.

Metered properties were used as a sample to measure the overall savings from the metered and unmetered properties included in the trial. In addition, a separate metered control group was set up (with appropriate consideration of the proportion that were optant or non-optant and located in Barnstaple or Newton Abbot) to check if there were any background changes in consumption during the trial.

It was reported that there was an initial water reduction across the whole sample of approximately five percent after the devices were fitted, which reduced to four percent between six and seven months after the trial.

The water savings for the 293 properties with more than one device fitted were disaggregated; results follow:

South West Water Efficiency Trial - multi measure

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Dudley Turbo 88	23.04	58.17%	13.40	4.19	High
2	Hippo	11.52	26.36%	3.04	2.10	High
3	Save-a-Flush	11.52	61.32%	7.06	2.10	High
4	Aerated showerhead	6.25	39.26%	2.45	1.14	Medium
5	Low flow showerhead	6.25	28.37%	1.77	1.14	Medium
6	Sand shower timer A	1.29	11.17%	0.14	0.23	Low
7	Sand shower timer B	1.29	13.18%	0.17	0.23	Low
8	Digital shower timer	1.29	9.17%	0.12	0.23	Low
9	Miracle tap sprayer (kitchen mixer)	11.37	56.73%	6.45	2.07	Medium
10	Tap aerator	11.37	29.23%	3.32	2.07	Medium
11	Tap Magic spray insert 1	11.37	65.33%	7.43	2.07	Medium
12	Tap Magic spray insert 2 dual flow	11.37	9.17%	1.04	2.07	Medium
13	Tap restricter valve	11.37	1.72%	0.20	2.07	Medium
14	Hose gun	1.52	93.12%	1.42	0.28	Low
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**48.02**
Total measured water savings (l/prop/day)	**8.74**

Assumptions to derive estimated volume saved:	
1	Assumes 11.52 flushes per property per day; 2 litres saved per flush
2	Assumes 11.52 flushes per property per day; 1 litre saved per flush
3	Assumes 11.52 flushes per property per day; 1 litre saved per flush
4	Reduction of 1/6 of original flow
5	Reduction of 1/6 of original flow
6	
7	Reduce shower duration to 95% of normal
8	
9	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
10	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
11	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
12	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
13	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
14	Saves 5% of outdoor tap use

The SWW trial has a high confidence grade because it was a detailed study; however, there is a large discrepancy between the estimated and measured savings. This may in part be due to the wide range of products offered to the participants and the high degree of behavioural influence over products such as tap inserts and shower timers. This project also included a number of larger properties that may have had more than one toilet or shower, which could lead to devices being fitted in bathrooms that were less frequently used. So, whilst the individual event would have a reduced flow, the impact on household water use would be limited.

It should also be noted that the low savings for aerated showerheads have a dramatic impact on the AIC for the scenarios that involve showerhead replacement; this is a real impact and care should be taken to ensure that replacement showerheads will actually be used. This implies that more work is needed on identifying optimal properties for retrofit.

5.6 Thames Water: Liquid Assets (draft findings)

In November 2006, Thames Water (TW) appointed Mouchel Parkman to carry out a Water Efficiency Audit Project on domestic properties in Bromley and Swindon. The objectives of the project were to:

- ⇒ gain a better understanding of household water use and quantify a reduction in consumption in audited households;
- ⇒ carry out 1,000 water efficiency audits (500 in Bromley and 500 in Swindon);
- ⇒ quantitatively assess different water efficiency technologies;
- ⇒ assess the costs and benefits of water efficiency to inform the Water Resources Management Plan; and, to
- ⇒ compare theoretical water savings from water efficient technologies against actual measured savings.

A total of 10,454 metered domestic customers within Bromley and Swindon were sent an invitation letter inviting them to take part in the project, in which a TW-approved plumber would install free WEMs, including dual-flush retrofit device, Save-a-Flushes, tap aerators, reduced flow showerheads and shower timers.

Of the 10,454 households invited to participate, a total of 1,307 households responded positively, making the initial uptake rate 12.5 percent. At the completion of the project, a total of 962 audits were achieved (420 from Bromley and 542 from Swindon).

Using household data, product data and assumptions, theoretical savings were calculated for each device and for each household. Actual savings were based on meter reads. A total of five meter reads were taken throughout the project, one in the month prior to the audit, one during the audit and three post-audit. Together with the measurements taken during the audit, these meter readings were used to analyse what savings the households made as a result of having WEMs installed.

At time of writing, TW was finalising their project report and so individual measured water savings were not verified. The report used theoretical savings, but these should be verified in the future against measured savings. The overall water savings in the two areas were measured at a DMA level and so the disaggregation carried out has been tested against this measured saving. Results follow:

Thames Water Liquid Assets (draft report)

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Aerated showerhead	6.25	34.74%	2.17	5.95	Medium
2	Tap aerator	11.37	38.96%	4.43	10.82	Medium
3	Sand shower timer	1.29	74.50%	0.96	1.23	Low
4	Save-a-Flush	11.52	44.58%	5.14	10.97	High
5	ecoBETA	11.52	41.57%	4.79	10.97	High
6	Miracle tap aerator	11.37	30.72%	3.49	10.82	Medium
					Project confidence grade	**B1**

Total estimated water savings (l/prop/day)	**21.42**
Total measured water savings (l/prop/day)	**20.39**

	Assumptions to derive estimated volume saved:
1	Reduction of 1/6 of original flow
2	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
3	Reduce shower volume to 95% of normal
4	Assumes 11.52 flushes per property per day; 1 litre saved per flush
5	Saves 2 litres for a small flush at 1:1 ratio small:large flush
6	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)

This project has a high confidence and shows a good match between estimated and measured savings. The estimates for toilet flushing are lower than those for the ESW projects as less information was available on consumer behaviour.

5.7 Environment Agency and water companies collaborative research: Retrofitting Variable Flush Devices

In 2003 and 2004, a collaborative water efficient toilet retrofit trial was undertaken by nine water companies to build on previous research and to explore further whether retrofit devices were suitable for demand management programmes. The Environment Agency then independently analysed the results and published the final report.

Devices were installed into 136 measured properties across the different water company areas. In the weeks after installation, water demand fell by an average of 8.5 percent per property. Results follow:

Environment Agency variable flush project

A	B	F	
	WEM	**Measured savings (l/prop/day)**	**Confidence**
1	Variflush	24.00	High
2	Ecoflush	16.90	High
3	Both	9.80	High
		Project confidence grade	**B1**

Note that the combination of the Variflush and the Ecoflush is not in summary table X; individual water savings were not able to be disaggregated.

This project has a very high confidence as it assessed single devices with direct measurement across a number of different water company customers. Similar collaborative projects should be undertaken with individual testing of devices.

The reduced savings observed when both devices were fitted could possibly be the result of misuse since the devices operate in slightly different ways, or the presence of two or more toilets in the home that would result in similar savings per flush but lower savings per property.

5.8 Essex and Suffolk: home surveys in Witham

In 2002, 11,881 domestic properties in the Witham and Maldon areas of Essex were invited to partake in the Water21 Home Water Conservation Scheme via a direct mail marketing campaign designed to improve customer and public relations. The approach for this scheme was focused on the company H2O Home Services completing home water conservation audits on behalf of customers. Of the 11,881 properties invited to participate in the scheme, 4,207 Home Water Conservation Audits were completed at customers' homes between August and December 2002.

In addition to water audits, 55,136 measures or components were installed or used at customers' properties, which amounted to water savings of 57,557 litres per day. This is a total saving of 13.6 litres per property per day. The disaggregation used a series of assumptions to calculate the water savings for this trial. Results follow:

Essex and Suffolk Home Surveys in Witham

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Save-a-Flush	8.00	100.00%	8.00	3.77	High
2	Tap washers	8.00	5.20%	0.42	3.77	Medium
3	Sand shower timer	1.12	70.30%	0.78	0.53	Low
4	Turning tap off when brushing teeth	41.22	43.50%	17.93	19.41	Low
5	Hose gun	1.58	69.70%	1.10	0.74	Low
6	Float valve repair	72.00	0.90%	0.65	33.91	Low
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**28.88**
Total measured water savings (l/prop/day)	**13.60**

Assumptions to derive estimated volume saved:	
1	Based on assumptions used by ESW for this study. Refer to report for full details.
2	
3	
4	
5	
6	

Measured savings in this project were calculated from customer responses to audits rather than being directly measured; these were then compared against the estimated values based on the percentage uptake of each device and its theoretical saving.

5.9 Essex and Suffolk: Thurrock homes survey

The Thurrock Home Survey Project follows on from similar previous projects. Customers were invited to take part between July 2006 and March 2007. The target was to complete 9000 audit forms. In order to achieve this outcome, it was anticipated that 30,000 customers had to be targeted. In order to achieve this response rate, incentives were offered to encourage customers to accept a survey pack and return the audit form. The incentives offered were a free tea towel (for those customers who returned their survey forms), a monthly prize draw for 200 water butts, a one-off draw for £100 and for five £20 Tesco vouchers.

In total 31,571 customers were invited to take part, of which 11,578 requested a water efficiency pack and 8,705 completed the survey and returned their form. Approximately 75 percent of customers fitted the Save-a-Flush provided in the audit pack, and over 50 percent of the participating customers requested extra information.

The project resulted in water savings of 133.19 m^3 per day or 15.3 litres per participating property per day. The disaggregation results follow:

Essex and Suffolk Home Surveys in Thurrock

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Save-a-Flush	12.89	Refer to ESW full report		Not applicable	High
2	Tap wahers	0.47				Medium
3	Shower timer	26.05				Low
4	Replacing bathing with showering	37.31				Low
5	Turning tap off when brushing teeth	10.31				Low
6	Hose gun	1.51				Low
					Project Confidence Grade	**BX**

Total estimated water savings (l/prop/day)	**15.30**
Total measured water savings (l/prop/day)	**n/a**

Assumptions to derive estimated volume saved	
1	Based on assumptions used by ESW for this study. Refer to report for full details.
2	
3	
4	

ESW used the results of the customer audits to calculate estimated savings for each device. This included some information on the impacts of customer behaviour as well as devices. A number of behavioural interventions appear to have high associated savings but the confidence in each measure is low; this is a difficult area for water companies as they cannot influence behaviour alone and this is an area where more partnership working is required.

5.10 Essex and Suffolk Water: H2eco water audits

Mouchel were commissioned to undertake the H2eco project within Chelmsford, Essex. This project was based on the concept of customers working through the self-audit process by completing a workbook, which asked a series of questions about property, appliances, and how they currently use water, and it also explained how they could use less in the future with the help of advice and a range of eleven WEMs. An application pack was mailed to over 7,500 domestic customers.

The Water Saving Toolkits Project in 2006-2007 was the first project by ESW to offer complete choice of products to the participating customers, but with some restrictions on quantities of particular products. H2eco progressed further by offering unrestricted quantities on most products, but refining the selection of products available to those that were judged to offer the greatest return in terms of water savings and cost-benefit.

Of the 7,524 customers contacted, 1,495 households completed the audit and were fitted with WEMs between December 2007 and March 2008. Of these completed audits, 62 percent were metered (930 households) and 38 percent were unmeasured (565 households). Meter data was collected from those properties that had an externally accessible water meter, and additionally 193 flow loggers were installed to collect more detailed water use information.

The disaggregation for the purposes of the *Evidence Base* uses the measured data (meter reads and loggers). Results for the plumbed and not plumbed devices follow:

Essex and Suffolk H2eco **Plumbed fittings**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation**	**Adjusted for measured savings (l/prop/day)**	**Confidence grade**
1	Aerated showerhead	6.25	20%	1.26	5.69	Medium
2	Water butts	1.97	66%	1.30	1.79	Low
3	ecoBETA	11.52	60%	6.96	10.48	High
4	Tap inserts	11.37	81%	9.19	10.35	Medium
5	Tap washers	9.90	11%	1.05	9.01	Medium
					Project confidence grade	**B2**

Total estimated water savings (l/prop/day)	**19.76**
Total measured water savings (l/prop/day)	**17.98**

Assumptions to derive estimated volume saved:	
1	Reduction of 1/6 of original flow
2	250 litre water butt fills four times per year
3	Saves 2 litres for a small flush at 1:1 ratio small:large flush
4	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
5	Based on assumptions used by ESW for this study. Refer to report for full details.

Essex and Suffolk H2eco **Not plumbed**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation**	**Adjusted for measured savings (l/prop/day)**	**Confidence grade**
1	Soil crystals	0.02	84.48%	0.02	0.02	Low
2	Bath measure	4.94	35.79%	1.77	4.44	Low
3	Hose gun	1.51	68.63%	1.03	1.35	Low
4	Save-a-Flush	11.52	35.05%	4.04	10.35	High
					Project confidence grade	**B2**

Total estimated water savings (l/prop/day)	**6.86**
Total measured water savings (l/prop/day)	**6.16**

Assumptions used to derive estimated savings:	
1	
2	Based on assumptions used by ESW for this study. Refer to report for full details.
3	
4	Assumes 11.52 flushes per property per day; 1 litre saved per flush

This was a comprehensive trial that looked at a wide range of devices. Note that there were a number of specific assumptions associated with this project (see project report for details).

5.11 Essex and Suffolk: ecoBETA study in Chelmsford

A toilet dual-flush retrofit device, the ecoBETA, was offered to customers who also received a home water audit pack to help review their water use and encourage them to adopt water saving practices. The mail shot to customers was delivered in two batches between 26-30 March and 29 May to 1 June 2007.

Of the 4,866 customers who were mailed, 910 customers applied to take part (18.7 percent). The installation of 1,012 ecoBETA devices in 555 properties was carried out between 17 April and the 7 July

2007 by ecoBETA trained plumbers. Home water audit forms were completed and returned by 187 customers.

Meter reading data was collected from those properties that had an externally accessible water meter, and 56 flow loggers were installed to collect detailed water use information. Of the participating homes, 33 percent were metered and 67 percent were unmeasured. Three different methods were used to calculate water savings:

⇒ A direct calculation of savings based on the change in cistern flush volume, performed on a per property basis;
⇒ A direct calculation taken from reading water meters to give actual water consumption before and after the installation; and,
⇒ A direct interpretation of data collected by flow loggers.

The project resulted in savings of on average 31.38 litres per property per day, equating to a total savings of 0.017 megalitres per year for the study area. Results from measured savings for the ecoBETA follow:

Essex & Suffolk ecoBETA reftrofit - Chelmsford

A	B	F	
	WEM	**Measured saving per day**	**Confidence**
1	ecoBETA	31.38	High
Project confidence grade B2			

This trial has a high confidence level. The work focussed on a single measure with detailed readings from both meters and data loggers. It is also worth noting that the installers were given specific training in how to fit the device, which meant that the recall and failure level was much lower than in other projects and so savings may be higher than if the product was fitted by plumbers without specific training or as part of a multi-measure retrofit.

5.12 Sutton and East Surrey Water: Preston water efficiency initiative

The Preston Water Efficiency Initiative (PWEI) aimed to reduce water demand in the Preston Estate, an area of social housing in North East Surrey owned and run by Raven Housing Trust. The project also aimed to reduce water demand in the secondary and primary school in this area; however, non-domestic water efficiency schemes are beyond the scope of this *Evidence Base* and so these savings have not been considered here.

At the time of the project's inception, Raven owned and managed in excess of 500 tenanted houses and flats on the estate, as well as a number of leasehold units. Works through the PWEI to individual properties were restricted to tenanted units. The project was divided into the following areas:

⇒ Bathroom refurbishment programme to include new shower installation;
⇒ Demand management retrofit programme; and,
⇒ Rainwater harvesting trial.

The results of the rainwater trial were not available at the time of this report, but will be included in Sutton and East Surrey Water's final report.

As part of their obligation to meet Decent Homes standards by 2010, Raven Housing Trust is undertaking an ongoing bathroom refurbishment programme, which includes the replacement of all water fittings. Under this refurbishment plan, 162 houses and flats had bathroom refurbishments between July 2007 and March 2008. The standard programme comprised of the fitting of a standard toilet, washbasin and bath. As part of the new project, it was decided to introduce two new water efficient products: the Twyfords Galerie Flushwise 4/2.6-litre dual-flush toilet and a first time shower fitted over the bath. The majority of houses had cold water feeds from a roof tank and a Mira Sport 9.0 kW shower was installed. Where a combi-boiler was available in the house or flat, a Mira Element thermostatic mixer shower was used instead.

The retrofit programme was targeted at the 354 remaining Raven-tenanted properties on the Preston Estate following the refurbishment of the bathrooms. These properties were offered a package of water conservation devices. Devices were installed in 205 properties (uptake of 57.9 percent) between April 2007 and July 2008. Where households were invited to participate but did not, this was mainly due to a lack of response rather than a refusal.

Under the retrofit programme, households were offered ecoBETAs, leakage alarms and water butts. A small number of homes (about 10) had a second downstairs high-level toilet replaced with a new dual-flush model. All other houses had a single toilet in the bathroom and this was fitted with an ecoBETA.

None of the properties that participated in this scheme were metered prior to the scheme. In order to measure the water savings achieved by the scheme, a selection of meters were installed. Monitoring was conducted at three levels: individual property/block of flats, small meters areas and DMA. Each of these monitoring methods produced an estimated saving for both the bathroom refurbishments and retrofit programme. This saving was estimated by subtracting the water consumption post installation of devices from an estimate of water use in the Preston Estate prior to the scheme (400 l/prop/d). Results of the disaggregation follow:

Sutton and East Surrey Preston project **Retrofit**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	ecoBETA	25.87	92.2%	23.85	53.49	High
2	Water butts	2.30	9.3%	0.21	4.76	Low
3	Digital shower timer	1.29	100.0%	1.29	2.67	Low
4	Efficient washing machine	12.96	2.9%	0.38	26.79	High
5	Dual-flush toilet	70.27	5.4%	3.77	145.29	High
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**29.50**
Total measured water savings (l/prop/day)	**61.00**

Assumptions to derive estimated volume saved	
1	Saves 4.5 litres for small flush at 1:1 ratio small:large flush
2	Capacity of 210 fills four times per year
3	Reduces shower volume to 95% of normal.
4	Uses 45 litres for 7 kg load compared with 61 litres for a standard machine
5	Saves 6.1 litres per flush on average

Sutton and East Surrey Preston project **Refurbishment**

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	New dual-flush toilet	70.27	100%	70.27	61.32	High
2	Replacing bathing with showering	45.22	99%	44.66	39.46	Medium
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**114.93**
Total measured water savings (l/prop/day)	**100.30**

Assumptions to derive estimated volume saved:	
1	Saves 6.1 litres per flush on average
2	Average savings of 47.6 litres per use to switch bath to shower; frequency kept constant at 0.95 events per day

This was a detailed project with high confidence in the data. The refurbishment data shows a good match between estimated and measured values, which reflects a large water savings from first-time shower installation and toilet replacement. The retrofit data, however, shows that measured savings are much greater than the estimated savings based on the performance of the individual devices. Reasons for this are not clear.

5.13 United Utilities: water efficient showerhead offer

The aim of the United Utilities Water Efficient Showerhead Offer was to understand the likely take-up rate of a free water efficient showerhead, and to see how customers found the experience of using an aerated showerhead. In total, 2,000 domestic metered customers were contacted about the offer. Of these customers, 850 had opted to have a water meter and the remaining 1,150 were customers who live in new homes that include water meters.

In total, 155 showerheads were sent to customers with fitting instructions and a shower flow measuring bag. Customers were instructed to use the bag to measure the flow of their shower before and after fitting the showerhead. Since there was no supervision of flow measurement and customers could misinterpret directions, all flow measurements should be treated with caution.

The average water savings for all customers was 4.12 litres per minute, which equates to a daily saving of 39.5 litres per property (assuming that there were 2.4 people per household, each showering 0.7 times per day with shower duration of five minutes). The reduction in flow was slightly lower for optant customers (3.91 litres per minute) than the overall reduction and slightly higher for new customers (4.37 litres per minutes). Results from the measured savings follow:

United Utilities showerhead offer

A	B	F	
	WEM	**Measured savings (l/prop/day)**	**Confidence**
1	Aerated showerhead	39.5	Medium
		Project confidence grade	**BX**

This single measure project relied upon customer measurements of shower flow and self fitting, which reduces the confidence in the results. This was a relatively low-cost project with a low installation rate.

5.14 United Utilities: home audit project

A total of 4,642 customers in two DMAs in the Great Sankey area of Warrington were invited to participate in the United Utilities Home Audit Trial. Of the 509 households that originally volunteered to take part in the project, 393 audits were successfully completed.

The objectives of the project were to determine the practicality of fitting and promoting a selection of WEMs, to gain a better understanding of the likely costs of fitting these devices and to determine associated savings of these devices through property and DMA metering.

Of the 393 customers who underwent an audit, 313 were metered and 70 were unmetered. Ten were removed from the analysis. For the metered properties, the difference between the pre-audit and post-audit average daily water consumption was used to estimate water savings.

Daily water consumption in a control group of properties in the study area was lower during the post-audit period than the pre-audit period, indicating that a proportion of the measured water savings from the audit were in fact background savings due to factors external to the project. These background changes in water consumption (12 litres per property) were subtracted from the total water savings prior to the disaggregation exercise.

The project report used a regression analysis to determine the savings from each device, this method contained an assumption relating to behavioural change resulting from involvement in the project, associated with the process of visiting customers' homes, providing literature on efficient water use and a shower timer and undertaking a water audit. This approach highlights the need to gain a better understanding of the contribution of behavioural influences. However, as there is currently no robust evidence relating to the quantifiable savings from behaviour change and as this saving was not observable in other projects (apart from possibly in the Preston housing project where there was a specific education officer for the project) we applied the standard disaggregation method we have used for the other projects.

Disaggregation results follow:

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	ecoBETA	11.52	49%	5.64	34.60	High
2	Save-a-Flush	11.52	98%	11.29	34.60	High
3	Showerhead	6.25	54%	3.38	18.77	Medium
					Project confidence grade	**B2**

Total estimated water savings (l/prop/day)	**20.31**
Total measured water savings (l/prop/day)	**61**

Assumptions to derive estimated volume saved:	
1	Saves 2 litres for a small flush at 1:1 ratio small:large flush
2	Assumes 11.52 flushes per property per day; 1 litre saved per flush
3	Reduction of 1/6 of original flow

5.15 Yorkshire Water: Water Saving Trial

A letter was sent to 5,000 properties across two areas to recruit households to take part in the Water Saving Trial. All of the properties were metered. Across the two areas, 968 properties agreed to take part and 500 were selected from this group to have audits carried out. Ultimately, 444 properties were visited.

Customer visits were carried out by Eaga and East Coast Gas Services with surveyors visiting up to six properties in each day. The installations were completed between October 2007 and April 2008; the number of products installed varied from none to seventeen.

Overall estimated water savings were 31.68 litres per property day; however, once this value had been adjusted to account for changes in consumption seen in the control group, savings reduced to 14.62 litres per property per day. Although 444 properties were visited during the trial, meter readings from only 290 of these had been used to calculate the average saving per household per day.

The report notes that the overall estimate of the water savings due to the installation of water efficiency devices ranged from 19.20 to 31.68 litres per property per day, depending upon the definition of exclusions (i.e. both extreme values and outliers or just extreme values). Alternatively, an estimate of the water savings was either seven percent or ten percent from a sample of 278 or 290 properties, respectively. Results of the disaggregation follow:

Yorkshire Water Water Saving Trial

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Dudley Turbo 88	23.04	0.90%	0.21	11.46	High
2	ecoBETA	11.52	104.95%	12.09	5.73	High
3	Save-a-Flush	11.52	38.06%	4.38	5.73	High
4	Showerhead A	6.25	22.97%	1.44	3.11	Medium
5	Showerhead B	6.25	15.77%	0.99	3.11	Medium
6	Digital shower timer	1.29	6.53%	0.08	0.64	Low
7	Shower timer A	1.29	7.21%	0.09	0.64	Low
8	Shower timer B	1.29	14.64%	0.19	0.64	Low
9	Miracle tap sprayer	11.37	35.14%	3.99	5.66	Medium
10	Tap aerator	11.37	12.16%	1.38	5.66	Medium
11	Tap Magic	11.37	38.06%	4.33	5.66	Medium
12	Hose gun	1.52	14.19%	0.22	0.76	Low
					Project confidence grade	**B2**

Total estimated water savings (l/prop/day)	**29.39**
Total measured water savings (l/prop/day)	**14.62**

Assumptions to derive estimated volume saved	
1	Assumes 11.52 flushes per property per day; 2 litres saved per flush
2	Saves 2 litres for a small flush at 1:1 ratio small:large flush
3	Assumes 11.52 flushes per property per day; 1 litre saved per flush
4	Reduction of 1/6 of original flow
5	
6	
7	Reduce shower volume to 95% of normal
8	
9	
10	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
11	
12	Assume 5% saving

This project has a high confidence and was very detailed. Like the South West Water trial, however, there is a discrepancy between the estimated and observed savings. This may in part be due to the wide range of products offered to the participants and to the high degree of behavioural influence with products like tap inserts and shower timers.

5.16 Severn Trent Water: domestic water efficiency trial

The Severn Trent Water (STW) Domestic Water Efficiency Trial Project was undertaken by RPS Water and Hetek Solutions between summer 2007 and April 2008. 11,946 households in Nottingham and Worcester were invited to participate. Of these, 932 metered households took part in the trial, for an uptake rate of 7.8 percent. Participants were offered a wide selection of WEMs.

The aim of the trial was to evaluate the effectiveness of retrofit WEMs in residences in these two areas within the STW delivery area. The WEMs were installed by trained technicians.

Water savings were estimated by comparing pre-trial and post-trial meter readings at an individual property level. The analysis of the meter data showed that the overall water saving after installation of the devices was 25.5 litres per property per day (10.2 percent of pre-installation water use), based on a sample of 805 properties. Meter readings were taken for all 932 participating households, but this study sample was screened to exclude unreliable data (due either to errors in the meter reading process, transcribing the data into spreadsheet form or where new meters where installed). Results follow:

Severn Trent Water Water Efficiency Trial

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	Save-a-Flush	11.52	44%	5.1	11.22	High
2	Dudley Turbo 88	11.52	10%	1.2	11.22	High
3	ecoBETA	11.52	92%	10.57	11.22	High
4	Showerhead A	6.39	1%	0.08	6.23	Medium
5	Showerhead B	6.39	100%	6.39	6.23	Medium
6	Tap aerators	11.37	25%	2.83	11.07	Medium
					Project confidence grade	**BX**

Total estimated water savings (l/prop/day)	**26.18**
Total measured water savings (l/prop/day)	**25.50**

Assumptions to derive estimtated volume saved	
1	Assumes 11.52 flushes per property per day; 1 litre saved per flush
2	Assumes 11.52 flushes per property per day; 2 litres saved per flush
3	Saves 2 litres for a small flush at 1:1 ratio small:large flush
4	Reduction of 1/6 of original flow
5	Reduction of 1/6 of original flow
6	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)

This was a detailed study with savings taken from direct meter readings; therefore, there is high confidence in the data. There is a good match between the estimated and observed data.

5.17 Anglian Water: Ipswich water efficiency audit trial

The Ipswich Water Efficiency Audit Trial is an ongoing project that has been running since December 2007. Households are offered free installation of a range of retrofit flow reduction devices by a qualified plumber. Trial participants are recruited via publicity at a number of events and locations, such as the Suffolk Show or through articles in the local newspaper. Anglian Water also publicise the project when writing to customers by telling them how much they would pay if they switched to a meter.

At the time of reporting, water savings had been calculated based on meter readings from 56 properties where devices have been installed under the trial. The average consumption before and after the audits/installation of devices was 310 and 270 litres per property per day, respectively, indicating a water savings of 40 litres per property per day (approximately 12.9 percent of pre-audit/installation demand). Results follow:

Anglian Water Ipswich Water Efficiency Audit

A	B	C	D	E	F	
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**	**Confidence**
1	ecoBETA	11.52	173.2%	19.95	11.38	High
3	Shower timer	1.29	148.2%	1.91	1.27	Low
5	Save-a-Flush	11.52	44.6%	5.14	11.38	High
7	Tap Magic	11.37	100.0%	11.37	11.23	Medium
8	Shower flow restrictor	6.25	33.9%	2.12	6.18	Medium
					Project confidence grade	**B1**

Total estimated water savings (l/prop/day)	**40.50**
Total measured water savings (l/prop/day)	**40.00**

Assumptions to derive estimated volume saved	
1	Saves 2 litres for a small flush at 1:1 ratio small:large flush
3	Reduce shower volume to 95% of normal
5	Assumes 11.52 flushes per property per day; 1 litre saved per flush
7	1.7/2.3 of initial flow for 50% of tap uses; other 50% are volume related (e.g. filling a sink)
8	Reduction of 1/6 of original flow

The report notes that a paired sample t-test indicates that the differences in consumption before and after the audit/installation of devices are statistically significant, at a 95 percent confidence interval. These correlations suggest that the installation of shower flow controllers and dual-flush devices in high occupancy households is likely to have a positive impact on rates of water use; however, the correlations are weak and so other factors may be more significant. These could include seasonal, long-term and positive bias effects (i.e. the Hawthorne effect which refers to the possibility that people may improve their behaviour simply in response to the attention they receive from being a participant in a survey).

6 Water savings from WEMS

Table 6 summarises the findings from section 5; more discussion of the WEMs follows.

Table 6. Disaggregated water savings from WEMs, litres per property per day.

							Toilets						Shower and bath					Taps			Outdoor				Plumbing	
Company	Project	Section	Measured or estimated	Single or multi measure	Project confidence grade	Year	Cistern displacement devices	Dual-flush toilet	Dudley Turbo 88	ecoBETA	Ecoflush	Variflush	Shower timer	Shower flow restrictor	Showerheads	Bath measure	Replacing bathing with showering	Tap inserts and restrictors	Tap washers	Turning the tap off when brushing teeth	Water butts	Hose gun	Soil crystals	Efficient washing machine	Fixed external leaks	Float valve repair
ESW	Moulsham	4.1	e	m	X2	1997	25.00								8.00				5.25		2.47				12.00	
ESW	Chelmsford - retrofit	4.2	m	m	BX	2005	11.07		22.14		22.14	22.14														
ESW	Chelmsford - full	4.2	m	m	BX	2005	6.66														1.58	1.20				
ESW	Brentford	4.3	e	m	XX	2004	9.44								19.11				9.90	26.73		1.58				
ESW	Romford	4.3	e	m	XX	2004	10.80								22.36				13.08	29.75		1.58				
ESW	Toolkit	4.4	m	m	BX	2006/07	17.46		23.98			23.98	1.95		6.51			11.83								
SWW	Multi measure	4.5	m	m	BX	2005/06	2.10		4.19				0.23		1.14			2.07				0.28				
SWW	Single measures	4.5	m	s	BX	2005/06	0.01		24.39									24.89								
TW	Liquid Assets	4.6	m	m	B1	2006	10.97			10.97			1.23		5.95			10.82								
EA	Variable flush	4.7	m	s	B1	2003/04					16.90	24.00														
ESW	Witham	4.8	e	m	BX	2002	3.77						0.53					3.77		19.41		0.74				33.91
ESW	Thurrock	4.9	e	m	BX	2006/07	12.89						26.05				37.31		0.47	10.31		1.51				
ESW	H2eco	4.10	m	m	B2	2007/08	10.35			10.48					5.69	4.44		10.35	9.01		1.79	1.35	0.02			
ESW	ecoBETA	4.11	m	s	B2	2007				31.38																
SES	Preston - retrofit	4.12	m	m	BX	2007/08		145.29		53.49			2.67								4.76			26.79		
SES	Preston - refurb	4.12	m	m	BX	2007/08		61.32									39.46									
UU	Showerhead offer	4.13	m	s	BX	2007									39.50											
UU	Home audits	4.14	m	m	B2	2006/07	34.60			34.60					18.77											
YOR	Water Saving Trial	4.15	m	m	B2	2007/08	5.73		11.46	5.73			0.64		3.11			5.66				0.76				
STW	Water Efficiency Trial	4.16	m	m	BX	2007/08	11.22		11.22	11.22					6.23			11.07								
ANG	Water Efficiency Audit	4.17	m	m	B1	2007-	11.38			11.38			1.27	6.18				11.23								
Number of projects that include WEM							16	2	6	8	2	3	8	1	11	1	2	9	5	4	4	8	1	1	1	1
Savings range for WEM (l/prop/day)							0.01-34.60	61.32-145.29	4.19-24.39	5.73-53.49	16.90-22.14	22.14-24.00	0.23-26.05	6.18	1.14-39.50	4.44	37.31-39.46	2.07-24.89	0.47-13.08	10.31-29.75	1.58-4.76	0.28-1.58	0.02	26.79	12.00	33.91

ANG = Anglian Water; SES = Sutton & East Surrey Water; TW = Thames Water; ESW = Essex & Suffolk Water; STW = Severn Trent Water; UU = United Utilities; EA = Environment Agency; SWW = South West Water; YOR = Yorkshire Water

6.1 General issues

The data table presents the best available evidence for water savings from a wide range of measures covering toilets, showers, baths, taps, plumbing, wet white goods and outdoor water use. The aim of the table is to present the best available data in a single sheet. We do not intend for it to be used as a lookup table; therefore, we have not included averaged values for each data set but rather a range.

The range reflects the uncertainty associated with the projects, the influence of behaviour, the fitting and installation of devices, and possible inaccuracies in the disaggregation methodology, particularly in the assumptions. The methodology was agreed by the Steering Group as a pragmatic approach to tackling multi-measure projects, but it is heavily reliant on a priori assumptions about water savings for individual devices; many of commonly held assumptions are questionable.

There are real reasons for the wide range in values. For instance, plumbers used in the ESW ecoBETA trial were highly trained whereas plumbers used in the UU Home Audit project were focussed more on maximising the number of ecoBETA installations. UU therefore had a higher product recall rate, implying that installation quality was lower.

Similarly the SES Preston project installed first-time showers that resulted in large savings; whereas in the SWW project, showerheads were offered as part of a package of measures that were targeted at larger properties that may have had more than one shower, and so the impact of a showerhead on savings would be much lower.

The wide range of values has a detrimental affect on the scenarios, resulting in large ranges in AIC. Despite this range, the values do enable water companies to make best estimates for savings by comparing their projects with projects undertaken by other companies, allowing for the assumption of similar savings for similar approaches.

6.2 Internal and external leaks

There are few studies of the savings associated with internal and external leaks. The Moulsham project looked at fixing external leaks and estimated a twelve litre saving per fixed leak; the Witham project included float valve repairs and resulted in a high saving per household.

Savings in both cases are high but uptake rates are low as this is an opportunistic saving made during a visit to install other devices; therefore, it would be difficult for a company to devise a water efficiency programme around fixing leaks, but leak fixing can add value as one component in a larger company water efficiency programme.

6.3 Outdoor water use

There are a number of projects that looked at savings from outdoor devices. Values are fairly consistent but savings reply heavily on customer behaviours and weather conditions.

6.4 Showers and baths

Most projects involved shower and bath devices. The impact of aerated and low-flow showerheads is partly dependent on behaviour and plumbing systems. The shower duration and flow rate determine volume.

It is worth noting that there may be an increase in length of time spent in the shower as volume of water is reduced; this is less likely with sophisticated aerated or low-flow showers as they ensure that spray patterns are optimised to improve the showering experience. With flow restrictors, however, households may compensate reduced flow with increased shower time.

The impact of shower timers is difficult to measure since savings relate to behavioural changes; savings in company reports are underpinned by a number of general assumptions and/or consumer feedback.

Values for replacing bathing with showering are reasonably robust and include a measured value where first-time showers were installed and an audit measure where customers changed behaviour to shower instead of bathe.

6.5 Taps

A large number of projects installed tap inserts or restrictors. Values are reasonably consistent but are, again, underpinned by a number of assumptions on frequency of use. Inserts and restrictors are clearly an effective measure, but there does need to be more work done on impact of behaviour and the interaction between tap use and dishwasher use in the kitchen.

Turning the tap off while brushing teeth was looked at in a handful of projects. Confidence in these results is fairly low since the data was drawn from customer audit responses. This area does offer large potential savings; however, it is difficult for water companies alone to influence this type of behaviour and so requires combined messaging from a range of stakeholders.

Tap re-washering was also considered in a handful of projects. Savings per property showed wide variation, which may be expected due to the difference in tap type, the variability in leaks and the amount of time associated with each re-washering. Re-washering is an opportunistic measure that could be added into a device retrofit visit rather than being carried out as a specific measure.

6.6 Toilets

Toilet flushing is the largest single water use in the home; therefore, all but one of the projects installed water saving toilet devices in customers' homes. But there is a need for more projects that compare different flushing devices and gather information on user behaviour.

It is concerning that such a basic measure as cistern displacement devices resulted with a wide range of savings. This is likely due to the range of toilet sizes, the varying number of toilets in households and our lack of understanding of how much water displacement devices actually displace. The range of values (0.01 to 34.6 litres per household per day) means that there is a very large range of AIC values in the scenarios.

With regard to retrofit flushing devices, there is a need for better training on plumbing and to revisit the Environment Agency's work on retrofit devices to carry out more trials of dual- and interruptible-flush devices. Such work would enable guidance to be drawn up on savings, fitting times, reliability, consumer interaction and suitability of different devices.

Some projects also looked at replacement of old toilets or cisterns with dual-flush or low-flush models. These appear to give high, reliable savings but clearly the costs and fitting times are much higher than for retrofits.

There are no projects in this report that have included interruptible flushing devices (e.g. the Interflush). These should be included in future trials in which behaviour is also recorded.

6.7 Wet white goods

This is an area where more work is required. Only one project looked at the impact of water efficient washing machines and there were no projects looking at dishwashers. These devices have the potential to deliver large savings but are clearly high-cost and so unlikely to have a high uptake rate. Water companies should look at using the Preston project model of offering discount vouchers for efficient models in conjunction with a manufacturer; however, this is complex to undertake and difficult to target so further trials should be undertaken.

7 Scenarios

The Water Saving Group identified problems of transferability as a key barrier to large-scale water efficiency. Therefore, a set of scenarios have been developed that use the range of savings values identified from the evidence and apply them to a set of possible water efficiency programmes. The scenarios demonstrate a range of applications, from maximising uptake in a single Water Resource Zone to achieving the best AIC by working with social housing providers.

The scenarios show extremely wide ranges for AIC values. This is because we have taken the maximum and minimum water savings associated with each of the water saving measures from the water company projects, and these water savings show a very large range (table 6). In most cases the worst and best cases are exaggerated as in reality the lowest costs are associated with the lowest savings and the highest costs are associated with the highest savings for each individual measure, i.e. more money spent on plumber training and more time per installation will increase costs but will also ensure higher savings. Therefore, it is unlikely that high costs and low savings will be co-incident in the same project.

Furthermore, a lot of this variation could be constrained by adapting implementation and by using company specific variables, since some of the scenarios are more applicable to some companies than others due to geography and structure.

The scenarios show that partnership is probably the best way to deliver large-scale water efficiency. Although water companies work in partnership with a range of organisations, it is not common for them to work with other organisations to deliver water savings, which means that it will be difficult to put partnerships into place for PR09.

There are risks associated with partnership working, for example if a partner pulls out of a project or if energy savings associated with showerhead retrofit are not allowed under the Carbon Emissions Reduction Target. There are also risks associated with the division of costs and access between partners.

To illustrate how the evidence in this report can be used for water resources planning, a range of five example scenarios have been developed:

- ⇒ Scenario 1: Toilet flush retrofit devices into homes managed by a housing association;
- ⇒ Scenario 2: Retrofit of a basket of water efficiency measures within a single Water Resource Zone;
- ⇒ Scenario 3: Showerhead retrofit in partnership with an energy supply company;
- ⇒ Scenario 4: Showerhead retrofit in partnership with a local energy advice centre; and,
- ⇒ Scenario 5: Retrofit of a cistern displacement device while undertaking other water company activities (e.g. water quality sampling, debt recovery, metering, etc.).

Each scenario is described in detail, with the input data used in the AIC spreadsheet tool provided. Results from the analyses are displayed for the best estimate, best case and worst case variations of each scenario (table 7).

Table 7. AIC values for scenarios 1 to 5.

	AIC (p/m^3)		
	Best Estimate	**Best case**	**Worst Case**
Scenario 1 - social housing	38.3	7.2	429.8
Scenario 2 - water resource zone	197.1	46.8	720.1
Scenario 3 - energy company	58.5	7.8	4,559.9
Scenario 4 - energy advice centre	134.7	4.9	11,486.2
Scenario 5 - Internal piggybacking	35.9	1.0	94,067.8

Data for water savings have been derived from the disaggregation analyses carried out for this project, while costs have been derived from best estimates and/or from company experience. The estimated costs associated with the scenarios relate to water company costs, not total project costs since many of the projects rely on partnerships in which product costs, installation costs and management costs will be shared.

The scenarios are illustrative but could be easily adapted by companies within their Water Resource Plans or PR09 submissions. Waterwise are keen to work with companies to help develop these types of programmes.

7.1 Scenario 1: toilet flush retrofit devices into homes managed by a housing association

Aim: to maximise installation rates of toilet retrofit devices with minimal administration costs

Scenario 1 describes a water company partnering with a relatively small housing association to convert eligible toilets into dual-flush using retrofit devices. The fitting would take place when a plumber visits a home to undertake an annual gas survey, which is required for all homes managed by a housing association.

The partnership reduces the costs of installation since the surveyor is already entering the home, and also reduces costs associated with recruitment. High uptake rates are expected since the housing association can encourage retrofit into their properties.

Table 8. Data used for input into the AIC spreadsheet tool for scenario 1.

Scenario 1 - Toilet flush retrofit device into homes managed by a housing association		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	10,000	Based on the number of homes typically 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 scheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Installation rates		
Best estimate	80%	Captive market; best case based on Sutton and East Surrey Preston estate project
Best case	90%	
Worst case	70%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£10.00	Waterwise estimate; one toilet per home; water company pays full cost
Best case	£8.00	
Worst case	£10.00	
Installation costs (per property)		
Best estimate	£10.00	Contribution to housing association for additional time taken by gas surveyor; personal communication with Severn Trent, based on case of
Best case	£8.00	

Worst case	£12.00	Birmingham housing department
Administration costs (per property)		
Best estimate	£0.10	For procurement of retrofit toilet flush device
Best case	£0.00	
Worst case	£0.50	
Recruitment costs and project management (per property)		
Best estimate	£0.50	Letter to participants, which may be done by the housing association, and project management, which may be handled 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	No procurement is necessary
Best case	£0.00	
Worst case	£0.00	
Recruitment costs and project management (per property)		
Best estimate	£0.50	Cost of initial letter to participants and project set-up
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	25.00	Median for Dudley Turbo 88 and Variflush across the companies
Best case	53.49	Sutton and East Surrey retrofit ecoBETA
Worst case	4.19	South West Water multi measure Dudley Turbo 88

The AIC and NPV are given in the table below, followed by the graph of total yield over time and a graph comparing the AIC and the yield over the range of uncertainties.

Table 9. AIC and NPV results for scenario 1.

	Best Estimate	Best case	Worst Case
AIC (p/m^3)	38.3	7.2	429.8
NPV values			
WAFU* (Ml)	433.04	3,997.84	31.18
Capex (£M)	0.00	0.00	0.00
Opex (£M)	0.166	0.288	0.134

* Water Available For Use

Figure 4. Scheme annual yield for scenario 1.

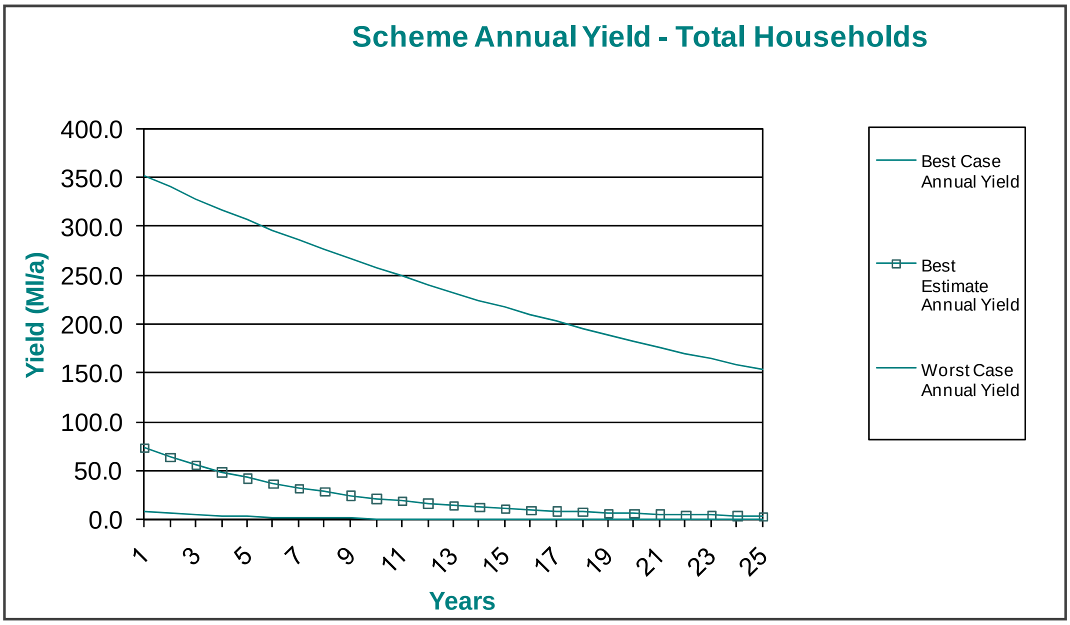
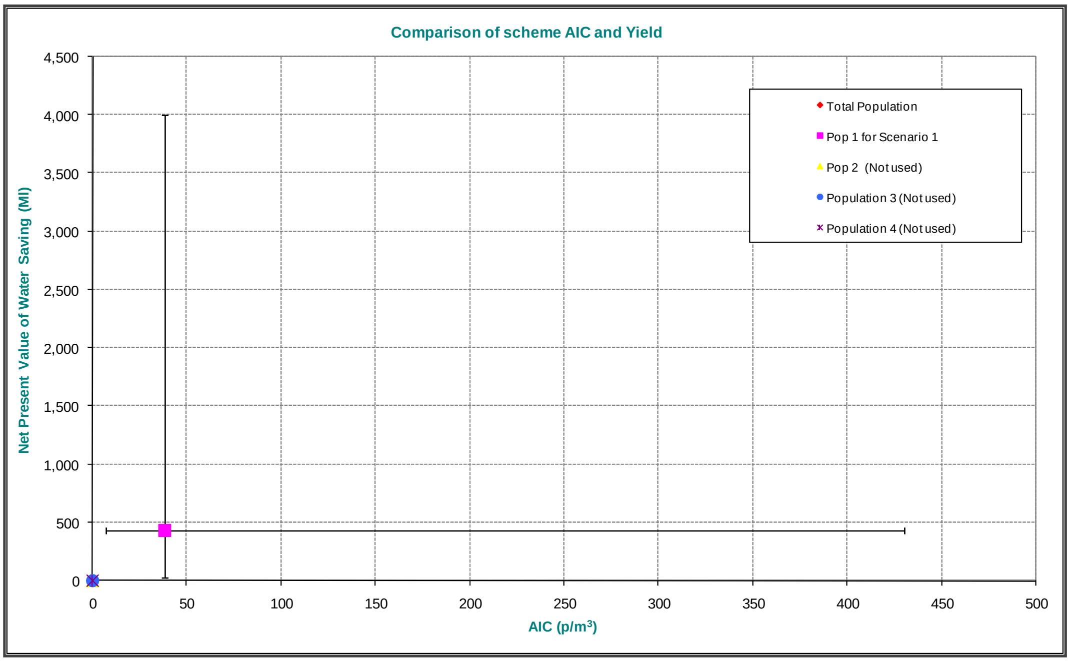


Figure 5. Comparison of scheme AIC and yield for scenario 1.



7.2 Scenario 2: retrofit of a basket of water efficiency measures within a single Water Resource Zone

Aim: to maximise water saving within a specific resource zone with a total yield that is sufficient to have an impact on the supply/demand balance

This scheme involves retrofitting a basket of water efficiency measures within a water stressed water resource zone (WRZ). This would be a large-scale scheme that would include a widespread media and communications campaign and mail shot to all households within the defined area. The implementation of the scheme will be planned on a street by street basis if possible, which would maximise the efficiency of installing the devices and reduce costs. The water savings would be measured at DMA level.

Table 10. Data used for input into the AIC spreadsheet tool for scenario 2.

Scenario 2 - Retrofit of a basket of water efficiency measures within a single Water Resource Zone		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	50,000	Based on retrofit of a small proportion of the households in a typical Water Resource Zone
Max expected	60,000	
Min expected	40,000	
Implemented as a one-off?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of scheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Installation rates		
Best estimate	25%	Essex and Suffolk home surveys in Brentwood and Romford
Best case	35%	Essex and Suffolk home surveys in Witham
Worst case	13%	Thames Liquid Assets
Implementation (years)	1	
Capital expenditure	£0.00	As per WR25b guidance
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£45.00	Water butt £10; tap aerator x2 @ £3 each; shower timer £2; aerated showerhead £17; dual flush £10; best/worst +/- 20 percent
Best case	£36.00	
Worst case	£54.00	
Installation costs (per property)		
Best estimate	£50.00	United Utilities, six visits at plumber rate of £300 per day
Best case	£37.50	Best practice in Australia, eight visits per day at UK plumber rate of £300 per day
Worst case	£100.00	Three visits per day at plumber rate of £300 per day
Administration costs (per property)		
Best estimate	£3.00	Waterwise estimate; typical across company projects; includes procurement
Best case	£2.00	
Worst case	£4.00	
Recruitment costs and project management (per property)		
Best estimate	£17.00	Letters, press, etc. and project management
Best case	£10.00	
Worst case	£20.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	No procurement or appointments necessary
Best case	£0.00	
Worst case	£0.00	
Recruitment costs and project management (per property)		
Best estimate	£1.50	Letters, press, etc.
Best case	£1.00	
Worst case	£2.00	
Water savings (litres per property per day)		
Best estimate	28.00	Average of Essex and Suffolk and Severn Trent
Best case	45.00	Sutton and East Surrey Preston project
Worst case	20.00	South West Water

The AIC and NPV values are given in the table below, followed by the graph of total yield over time and a graph comparing the AIC and the yield over the range of uncertainties.

Table 11. AIC and NPV results for scenario 2.

	Best Estimate	Best case	Worst Case
AIC (p/m^3)	197.1	46.8	720.1
NPV values:			
WAFU (Ml)	757.82	3923.85	138.20
Capex (£M)	0.00	0.00	0.00
Opex (£M)	1.494	1.835	0.995

Figure 6. Scheme annual yield for scenario 2.

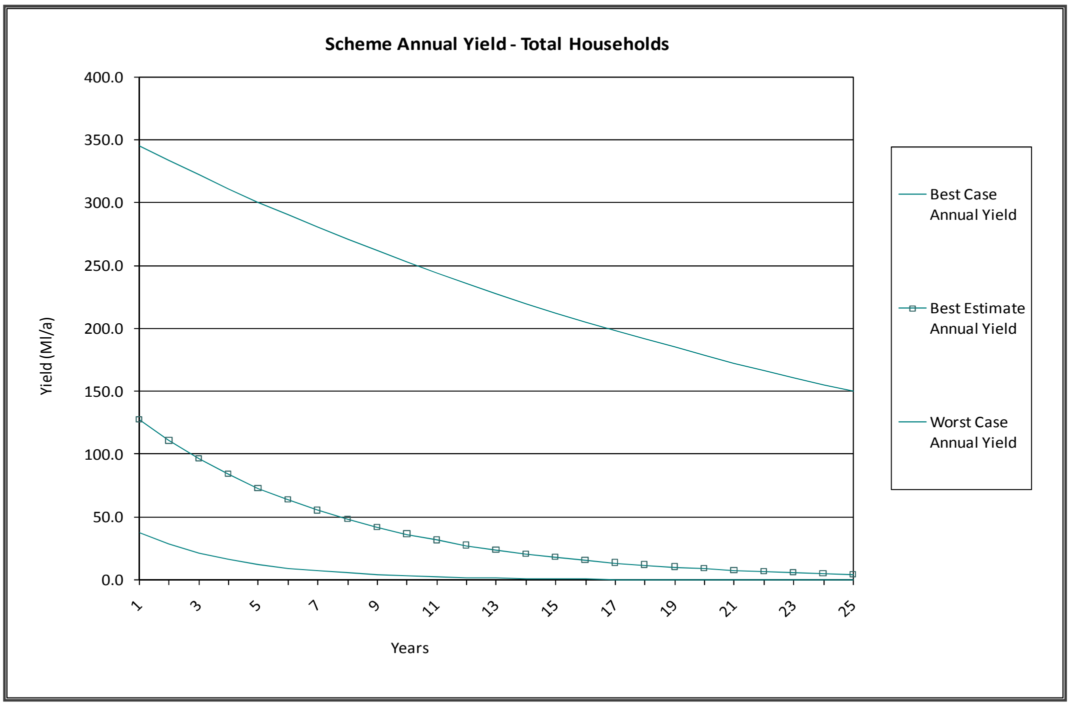
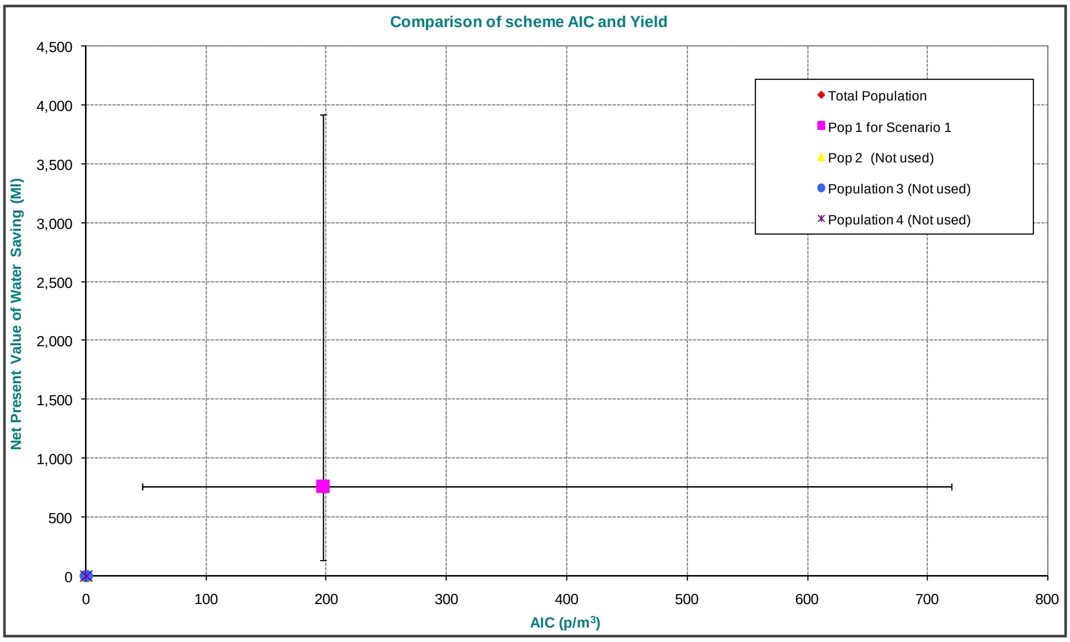


Figure 7. Comparison of scheme AIC and yield for scenario 2.



7.3 Scenario 3: showerhead retrofit in partnership with an energy supply company

Aim: to achieve large-scale showerhead retrofit in the highest number of homes per annum at the lowest cost

This scheme involves partnering with an energy supply company to retrofit water efficient showerheads into a large number of homes. This would result in lower costs since installation would be in the worst case split 50/50.

Table 12. Data used for input into the AIC spreadsheet tool for scenario 3.

Scenario 3 - Showerhead retrofit in partnership with an energy supply company		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	100,000	Energy companies undertake large campaigns, via post and media
Max expected	110,000	
Min expected	90,000	
Implemented as a one-off?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of scheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Installation rates		
Best estimate	25%	Essex and Suffolk home surveys in Brentwood and Romford
Best case	35%	Essex and Suffolk home surveys in Witham
Worst case	13%	Thames Liquid Assets
Implementation (years)	1	
Capital expenditure	£0.00	As per WR25b guidance
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£17.00	Waterwise estimate; water company pays full cost
Best case	£8.00	
Worst case	£17.00	
Installation costs (per property)		
Best estimate	£10.00	Energy company pays bulk
Best case	£0.00	
Worst case	£25.00	
Administration costs (per property)		
Best estimate	£3.00	Waterwise estimate; typical across projects; expect no decrease through partnership
Best case	£2.00	
Worst case	£4.00	
Recruitment costs and project management (per property)		
Best estimate	£2.00	Economies of scale; assumes most project management by energy company
Best case	£1.00	
Worst case	£3.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	No appointments, no procurement
Best case	£0.00	
Worst case	£0.00	

Recruitment costs and project management (per property)		
Best estimate	£2.00	Economies of scale; assumes most project management by energy company
Best case	£1.00	
Worst case	£3.00	
Water savings (litres per property per day)		
Best estimate	30.00	Waterwise estimate
Best case	39.50	United Utilities
Worst case	1.14	South West Water

The AIC and NPV values are given in the table below, followed by the graph of total yield over time and the graph comparing the AIC and the yield over the range of uncertainties.

Table 13. AIC and NPV results for scenario 3.

	Best Estimate	**Best case**	**Worst Case**
AIC (p/m³)	58.5	7.8	4,559.9
NPV values:			
WAFU (Ml)	1,623.90	6,314.49	17.72
Capex (£M)	0.00	0.00	0.00
Opex (£M)	0.950	0.495	0.808

Figure 8. Scheme annual yield for scenario 3.

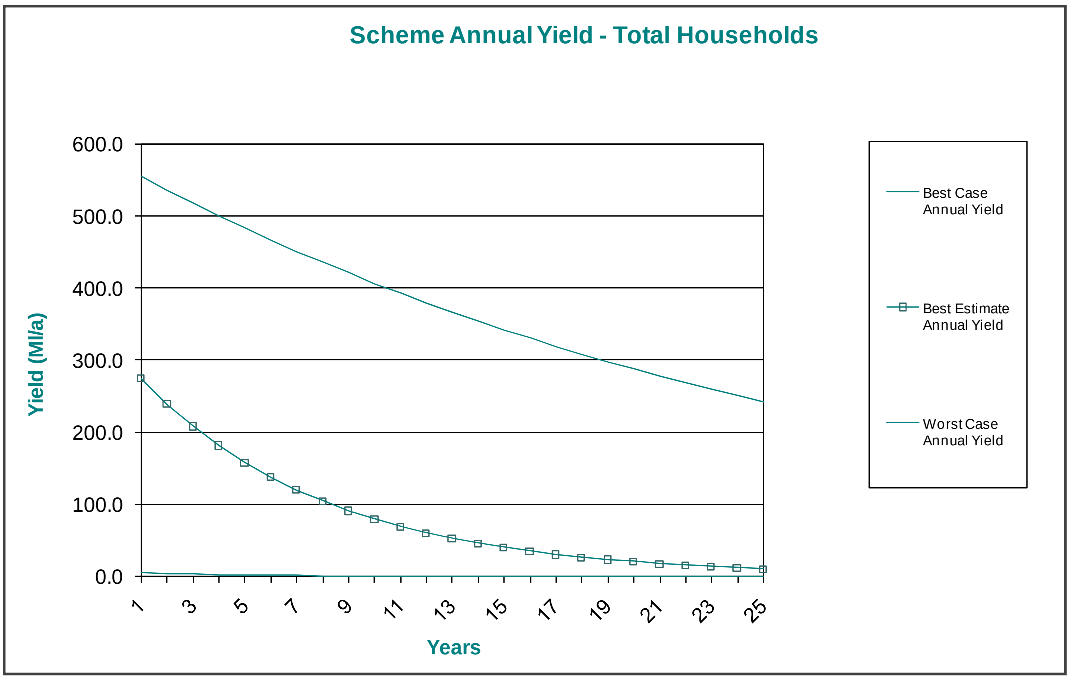
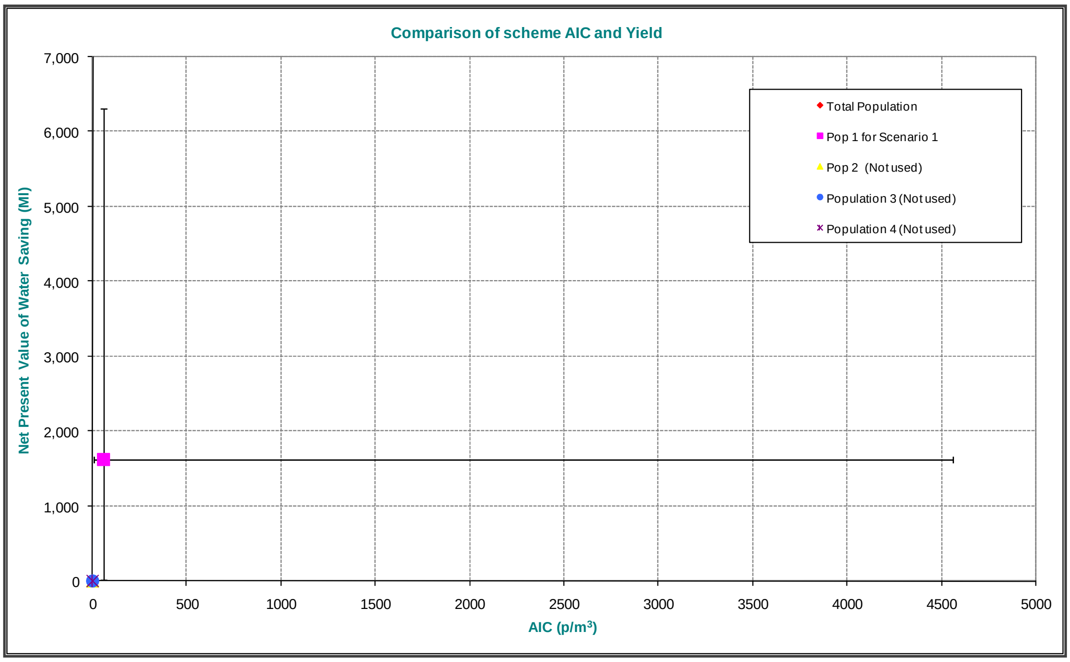


Figure 9. Comparison of scheme AIC and yield for scenario 3.



7.4 Scenario 4: showerheads retrofit in partnership with a local energy advice centre

Aim: to develop a long-term programme for shower retrofit at the lowest cost

This approach is similar to scenario 3, but costs are higher because it is assumed that energy advice centres are less well resourced than energy companies and that they have a smaller outreach capacity.

Table 14. Data used for input into the AIC spreadsheet tool for scenario 4.

Scenario 4 - Showerhead retrofit in partnership with a local energy advice centre		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	50,000	Based on customers coming into the centre, mail out and media campaign
Max expected	60,000	
Min expected	40,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of scheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Installation rates		
Best estimate	10%	Generally less well resources than an energy or water company
Best case	20%	
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	£17.00	Waterwise estimate; water company pays full cost

Best case	£8.00	
Worst case	£17.00	
Installation costs (per property)		
Best estimate	£25.00	Costs split 50/50 with advice centre
Best case	£0.00	
Worst case	£50.00	
Administration costs (per property)		
Best estimate	£1.50	Expect 50 percent decrease through partnership
Best case	£0.00	
Worst case	£2.00	
Recruitment costs and project management (per property)		
Best estimate	£8.00	Shared 50/50 with advice centre
Best case	£0.00	
Worst case	£10.00	
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 and project management (per property)		
Best estimate	£4.00	Based on half the costs of that for take up
Best case	£2.50	
Worst case	£5.00	
Water savings (litres per property per day)		
Best estimate	30.00	Waterwise estimate
Best case	39.50	United Utilities
Worst case	1.14	South West Water

The AIC and NPV values are given in the table below, followed by the graph of total yield over time and the graph comparing the AIC and the yield over the range of uncertainties.

Table 15. AIC and NPV results for scenario 4.

	Best Estimate	Best case	Worst Case
AIC (p/m^3)	134.7	4.9	11,486.2
NPV values			
WAFU (Ml)	324.78	1,968.15	3.03
Capex (£M)	0.00	0.00	0.00
Opex (£M)	0.438	0.096	0.348

Figure 10. Scheme annual yield for scenario 4.

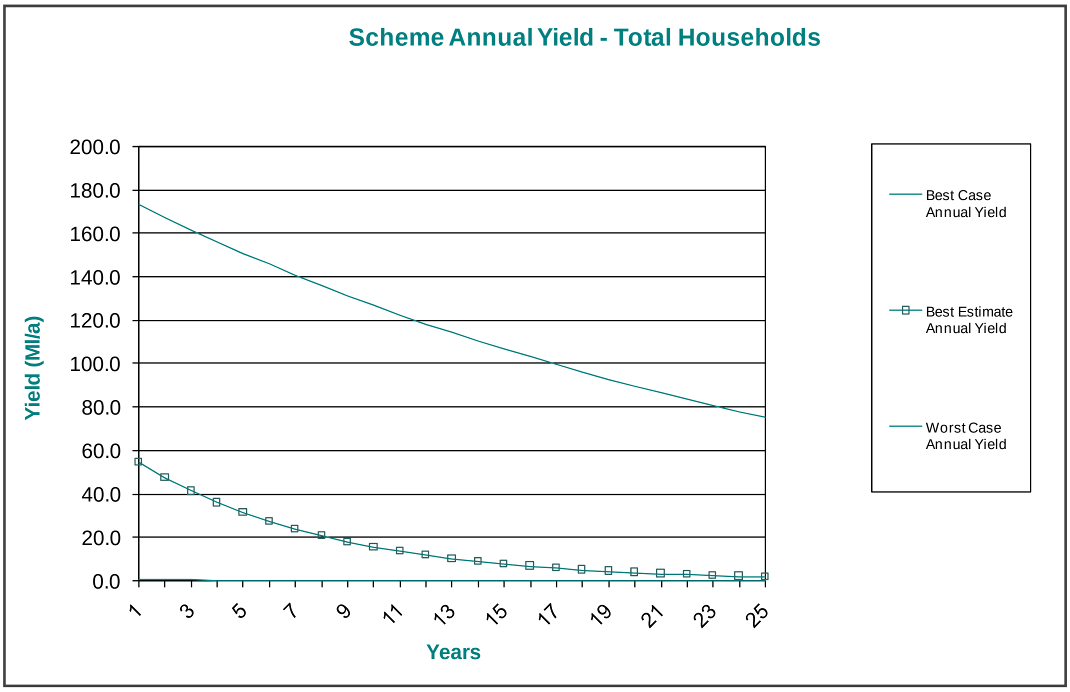
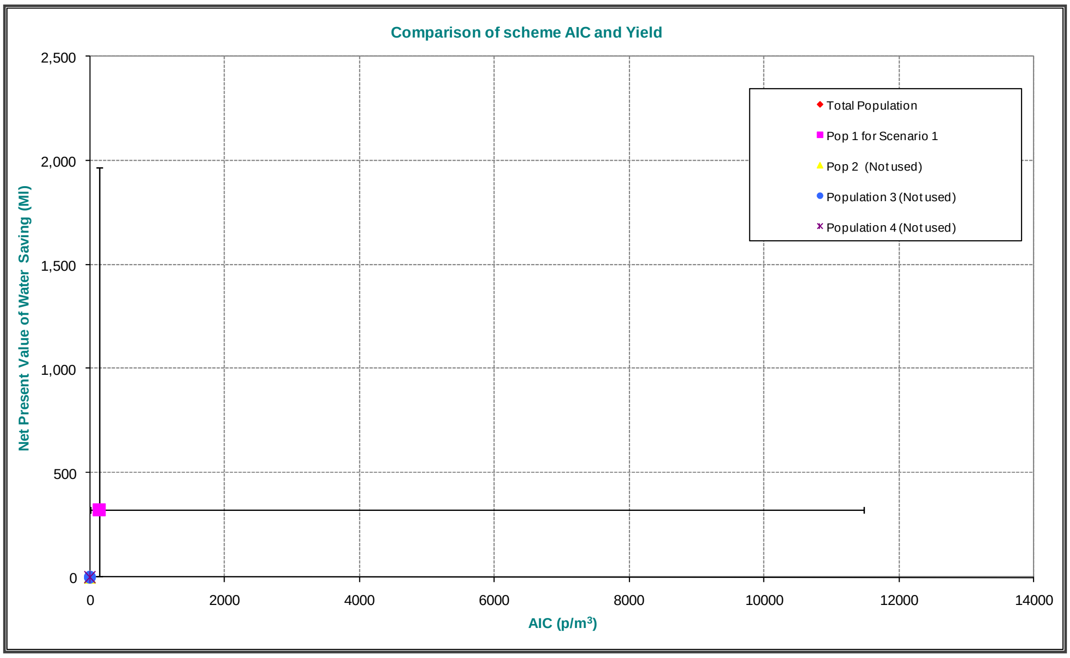


Figure 11. Comparison of scheme AIC and yield for scenario 4.



7.5 Scenario 5: retrofit of cistern displacement device while undertaking other water company activities (e.g. water quality sampling, metering, etc.)

Aim: to utilise existing water company activities to enhance baseline cistern displacements device (CDD) uptake and installation rates at the lowest cost

This approach enhances baseline CDD activities. Active promotion during a scheduled water company visit is likely to result in a higher uptake. CDDs have been chosen as it is unlikely that staff undertaking other activities would be qualified or equipped to install or promote more complex devices. The high range of AICs in this scenario is due to the large range in reported CDD savings from the evidence.

Table 16. Data used for input into the AIC spreadsheet tool for scenario 5.

Scenario 5 - Retrofit of cistern displacement device while undertaking other water company activities (e.g. water quality sampling, debt recovery, metering, etc.)		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	20,000	Based on the number of company water quality sampling visits undertaken annually
Max expected	30,000	
Min expected	10,000	
Implemented as a one-off?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of scheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Installation rates		
Best estimate	50%	Entering home already; about half will be eligible; captive market
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	£0.50	Save-a-Flush
Best case	£0.50	
Worst case	£0.50	
Installation costs (per property)		
Best estimate	£5.00	Contribution to other department
Best case	£0.00	
Worst case	£10.00	
Administration costs (per property)		
Best estimate	£1.50	Procurement of cistern displacement device
Best case	£1.00	
Worst case	£2.00	
Recruitment costs (per property)		
Best estimate	£0.00	None necessary
Best case	£0.00	
Worst case	£0.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	Admin for positive responses that are then not needed in the project
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.00	Based on half the admin of that for take up
Best case	£0.00	
Worst case	£0.00	
Water savings (litres per property per day)		
Best estimate	9.00	Best case from United Utilities Home Audits; best estimate from Waterwise based on 2.3 persons, 4 short flushes, 1 l saved per flush = 9; worst case from South West Water single measure study
Best case	34.60	
Worst case	0.01	

The AIC and NPV values are given in the table below, followed by the graph of total yield over time and the graph comparing the AIC and the yield over the range of uncertainties.

Table 17. AIC and NPV results for scenario 5.

	Best Estimate	Best case	Worst Case
AIC (p/m^3)	35.9	1.0	94,067.8
NPV values:			
WAFU (Ml)	194.87	2,586.00	0.05
Capex (£M)	0.00	0.00	0.00
Opex (£M)	0.07	0.027	0.05

Figure 12. Scheme annual yield for scenario 5.

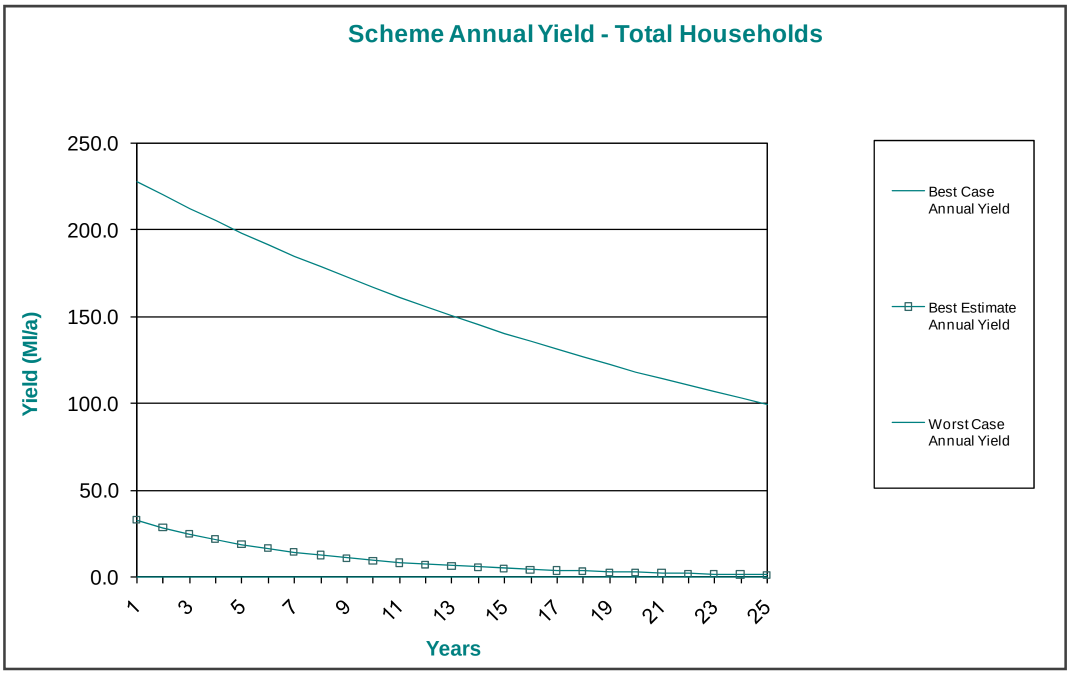
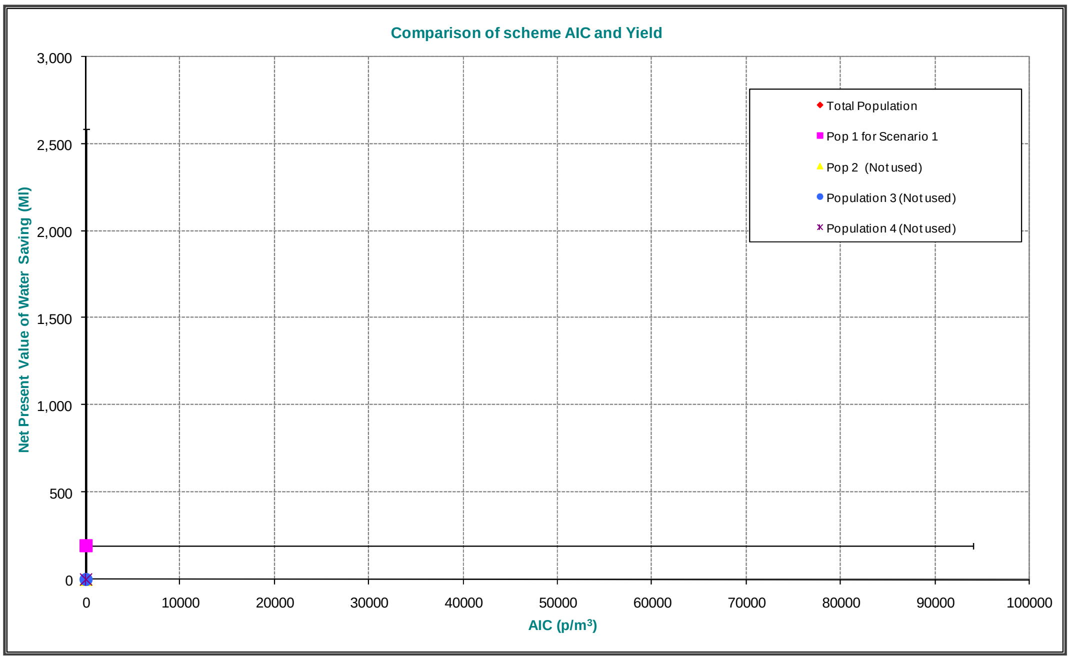


Figure 13. Comparison of scheme AIC and yield for scenario 5.



7.6 Sensitivity testing of scenario inputs

Scenario 2, retrofit of a basket of water efficiency measures within a single Water Resource Zone, was used to test the sensitivity of changing the input values for the cost-benefit analysis spreadsheet tool. The following variables were changed from the default value in turn (i.e. each change was tested independently):

- ⇒ Asset life, which affects the half-life of water savings;
- ⇒ Up-take rates;
- ⇒ Operational costs, which include equipment, installation, administration and recruitment costs; and,
- ⇒ Water savings.

Each input variable was changed by a percentage value, as shown in table 20 for changes that had a positive impact on the AIC and table 21 for changes that had a negative impact on AIC.

Table 18. Sensitivity testing with positive impact on AIC (i.e. a decrease in AIC).

Sensitivity Testing using Scenario 2 - Retrofit of a basket of water efficiency measures within a single Water Resource Zone											
POSITIVE impact on (i.e. decreases) AIC											
Parameter	Original value	New value	% Change	New value	% Change	New value	% Change	New value	% Change	New value	% Change
Asset life and half life of scheme savings											
Asset life	10	15	50%								
Half life - best estimate	5	7.5	50%								
Half life - best case	20	30	50%								
Half life - worst case	2.5	3.75	50%								
Uptake rates											
Best estimate	25%			28%	10%	38%	50%				
Best case	35%			39%	10%	53%	50%				
Worst case	13%			14%	10%	20%	50%				
Operational expenditure (total for scheme, including administration, recruitment, installation and equipment costs)											
Best estimate	£1,493,750							£1,181,000	-21%		
Best case	£1,834,500							£1,441,000	-21%		
Worst case	£995,200							£787,000	-21%		
Water savings (l/prop/day)											
Best estimate	28.00									35	25%
Best case	45.00									56.25	25%
Worst case	20.00									25	25%
AIC (p/m^3)	Original	New AIC	% Change	New AIC	% Change	New AIC	% Change	New AIC	% Change	New AIC	% Change
Best estimate	197.1	154.1	-21.8%	196.1	-0.5%	193.7	-1.7%	155.9	-20.9%	157.7	-20.0%
Best case	46.8	42.4	-9.4%	46.6	-0.4%	46.2	-1.3%	36.7	-21.6%	37.4	-20.1%
Worst case	720.1	537.7	-25.3%	716.0	-0.6%	699.9	-2.8%	569.6	-20.9%	576.1	-20.0%

Table 19. Sensitivity testing with negative impact on AIC (i.e. an increase in AIC).

Sensitivity Testing using Scenario 2 - Retrofit of a basket of water efficiency measures within a single Water Resource Zone											
NEGATIVE impact on (i.e. increases) AIC											
Parameter	Original value	New value	% Change	New value	% Change	New value	% Change	New value	% Change	New value	% Change
Asset life and half life of scheme savings											
Asset life	10	5	-50%								

Best estimate	5	2.5	-50%								
Best case	20	10	-50%								
Worst case	2.5	1.25	-50%								
Uptake rates											
Best estimate	25%			22.50%	-10%	13%	-50%				
Best case	35%			31.50%	-10%	18%	-50%				
Worst case	13%			11.70%	-10%	7%	-50%				
Opex costs (total for scheme)											
Best estimate	£1,493,750							£1,806,000	21%		
Best case	£1,834,500							£2,228,000	21%		
Worst case	£995,200							£1,203,000	21%		
Water savings (l/prop/day)											
Best estimate	28.00									21.00	-25
Best case	45.00									33.75	-25
Worst case	20.00									15.00	-25
AIC (p/m3)	**Original**	**New AIC**	**% Change**	**New AIC**	**% Change**	**New AIC**	**% Change**	**New AIC**	**% Change**	**New AIC**	**% Change**
Best estimate	197.1	321.2	63.0%	198.2	0.6%	206.2	4.6%	238.3	20.9%	262.8	33.3%
Best case	46.8	60.5	29.3%	46.9	0.2%	48.2	3.0%	56.8	21.4%	62.3	33.1%
Worst case	720.1	1180.0	63.9%	726.6	0.9%	769.7	6.9%	870.6	20.9%	960.2	33.3%

The impacts of the changes are shown at the bottom of tables 20 and 21. Main findings follow:

- ⇒ A 50 percent increase in asset life reduces the AIC by approximately 20 percent. This effectively increases the half life of the water savings, i.e. they deliver more for longer.
- ⇒ A 10 percent increase in uptake rate has a negligible impact on the AIC. A 50 percent increase in uptake rate decrease the AIC by only about 1.7 percent.
- ⇒ A decrease of about 20 percent in operational expenditure, which includes installation, equipment, administration and recruitment, reduces the AIC by about 20 percent.
- ⇒ A 25 percent increase in water savings reduces the AIC by approximately 20 percent.

An increased asset life, greater water savings made, and a reduction in operational expenditure have the biggest impact on the overall AIC. The impact of increasing the uptake rate is negligible. Even when guaranteed a 100 percent uptake rate, the AIC decreases only by about four percent.

Changes in operational expenditure resulted in symmetric effects on AIC; that is, a 21 percent decrease in opex lead to a 21 percent decrease in the AIC while a 21 percent increase in opex led to a 21 percent increase in AIC. Such symmetry was not seen with the other variables:

- ⇒ The AIC was very sensitive to asset life changes. A 50 percent increase in asset life resulted in a 22 percent decrease in the AIC for the best estimate, but a 50 percent decrease in asset life led to a 63 percent increase in AIC for the best estimate.
- ⇒ The AIC was more sensitive to decreases in water savings than to increases. A 25 percent reduction in savings resulted in a 33 percent increase of AIC for the best estimate, while a 25 percent increase in savings led to a reduction in AIC of 20 percent.
- ⇒ The AIC was not as sensitive to changes in uptake rates. A 10 percent increase/decrease in the uptake rate resulted in a decrease/increase in AIC of lass than one percent. A 50 percent change the in uptake rate had a more significant affect on the AIC. An increase of 50 percent led to an AIC decrease of 1.7 percent for the best estimate, while a 50 percent decrease resulted in a 4.6 percent increase in the AIC.

8 References

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Appendix 1: example of disaggregation

This example, which is based on phase one of Thames Water's Liquid Assets project, illustrates one potential method for disaggregating individual WEM savings from a project that has implemented a basket of measures. Note that the results from the Thames project are only initial findings, and so may change after project completion.

Thames Water undertook a water efficiency trial in Swindon and Bromley that included water audits and the installation of water efficiency devices. Householders were offered a range of WEMs, and water savings were recorded for the entire basket (not individually). Water savings attributable to each WEM therefore had to be disaggregated using the *Evidence Base* methodology (section 2.3). Uptake rates for each WEM were available.

The following information was extracted from Thames Water's report and used for disaggregation:

Number of properties	498
Total litres saved per day	10,154
Volume saved (l/prop/day)	**20.39**

Using the following assumptions, estimates of water savings for each WEM (table 19) were disaggregated from the trial:

1. If an aerated showerhead is fitted, this will result in the delivery of 10/12 of the initial flow rate, i.e. a reduction of 2/12 of the original flow.
2. If tap inserts are fitted, the flow delivered will be 1.7/2.3 of the initial flow rate for 50 percent of tap uses. The remaining 50 percent are volume-related, e.g. filling up a sink, and so would not result in a water efficiency savings as the usage is not dependent on flow rate.
3. Using a shower timer equates to a shower duration of approximately 0.95 of the normal.
4. Post-installation a Save-a-Flush will save one litre for every flush regardless of the cistern size.
5. A properly installed ecoBETA will save two litres for a small flush at 1:1 ratio small:large flush.
6. As for normal tap aerator (i.e. as per assumption 2).

Thames Water Liquid Assets (draft report)

A	B	C	D	E	F
	WEM	**Estimated savings (l/prop/day)**	**Installation rate**	**Estimated savings adjusted for installation (l/prop/day)**	**Adjusted for measured savings (l/prop/day)**
1	Aerated showerhead	6.25	34.74%	2.17	5.95
2	Tap aerator	11.37	38.96%	4.43	10.82
3	Sand shower timer	1.29	74.50%	0.96	1.23
4	Save-a-Flush	11.52	44.58%	5.14	10.97
5	ecoBETA	11.52	41.57%	4.79	10.97
6	Miracle tap aerator	11.37	30.72%	3.49	10.82
					Project confidence grade

Total estimated water savings (l/prop/day)	**21.42**
Total measured water savings (l/prop/day)	**20.39**

Estimates of water use per household (column C, highlighted in blue) were built-up using a set of assumptions and best available evidence of ownership, frequency and duration of use from CP187 (WRc's micro-component data set). This data, combined with assumptions, allowed for the volume of water saved for each WEM to be estimated. The estimates for each WEM added to a total WEM basket savings of 21.42 litres per property per day. The actual measured water savings per property from the Thames trial were 20.39 litres per property per day. The estimated savings were therefore adjusted to fit the actual savings (column F, highlighted pink), using ratios of water saved per device. This adjustment then produced a profile of water savings per WEM that correlated with the actual savings recorded from the trial.

After arriving at an adjusted yield for each WEM, confidence grades were assigned for the disaggregated water savings, according to the *Evidence Base* methodology. The trial as a whole scored a 'B' for reliability because the water savings were based on meter readings, and a '1' for accuracy because the confidence limits given in the Thames Water report were less than or equal to 25 percent of the water savings for the upper and lower confidence limits.

Appendix 2: AIC calculation

The AIC calculation method is similar to that presented in WR25B, but the NPV is calculated over twenty-five rather than sixty years, which matches the calculations in the WR25B spreadsheet:

$$AISC = \frac{C + O + E - OS}{W}$$

Where,

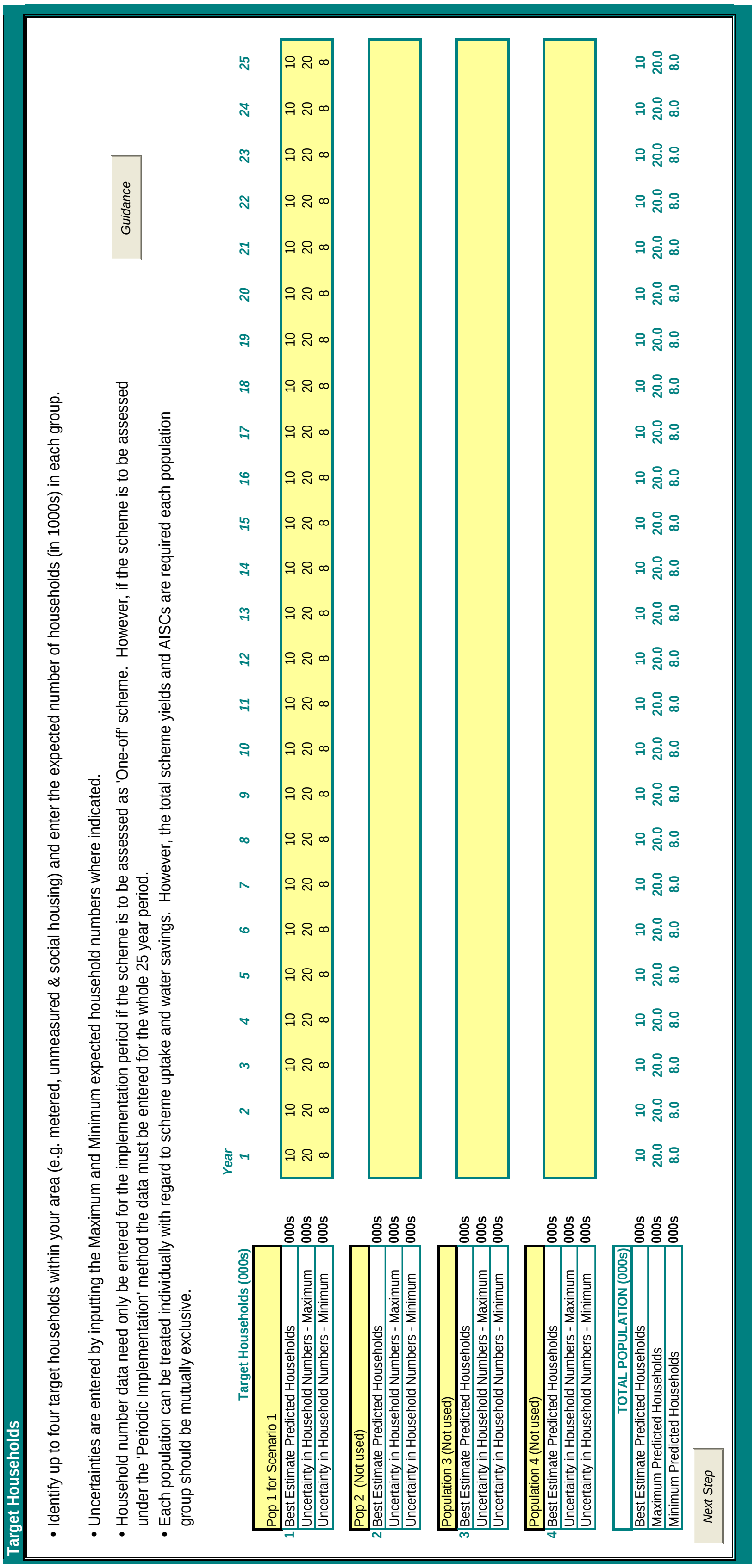
- *C* is the NPV of the capex in GB£;
- *O* is the NPV of the opex;
- *E* is the NPV of the social and environmental costs and benefits of the scheme;
- *OS* is the NPV of the opex saving, i.e. the money saved by not producing the water saved by the scheme (including OS reflects the advice given in the EA's Water Resource Planning Guidelines); and,
- *W* is the NPV of the total water saved in megalitres.

The NPV of each element is defined as the sum of the annual costs/savings over twenty-five years (regardless of scheme life), with future costs/savings discounted at a rate input by the user.

Appendix 3: WR25B spreadsheet tool for AIC

Step 1: Target households

Populate the spreadsheet with data in order to achieve the desired customer participation.



Target Households

- Identify up to four target households within your area (e.g. metered, unmeasured & social housing) and enter the expected number of households (in 1000s) in each group.
- Uncertainties are entered by inputting the Maximum and Minimum expected household numbers where indicated.
- Household number data need only be entered for the implementation period if the scheme is to be assessed as 'One-off' scheme. However, if the scheme is to be assessed under the 'Periodic Implementation' method the data must be entered for the whole 25 year period.
- Each population can be treated individually with regard to scheme uptake and water savings. However, the total scheme yields and AISCs are required each population group should be mutually exclusive.

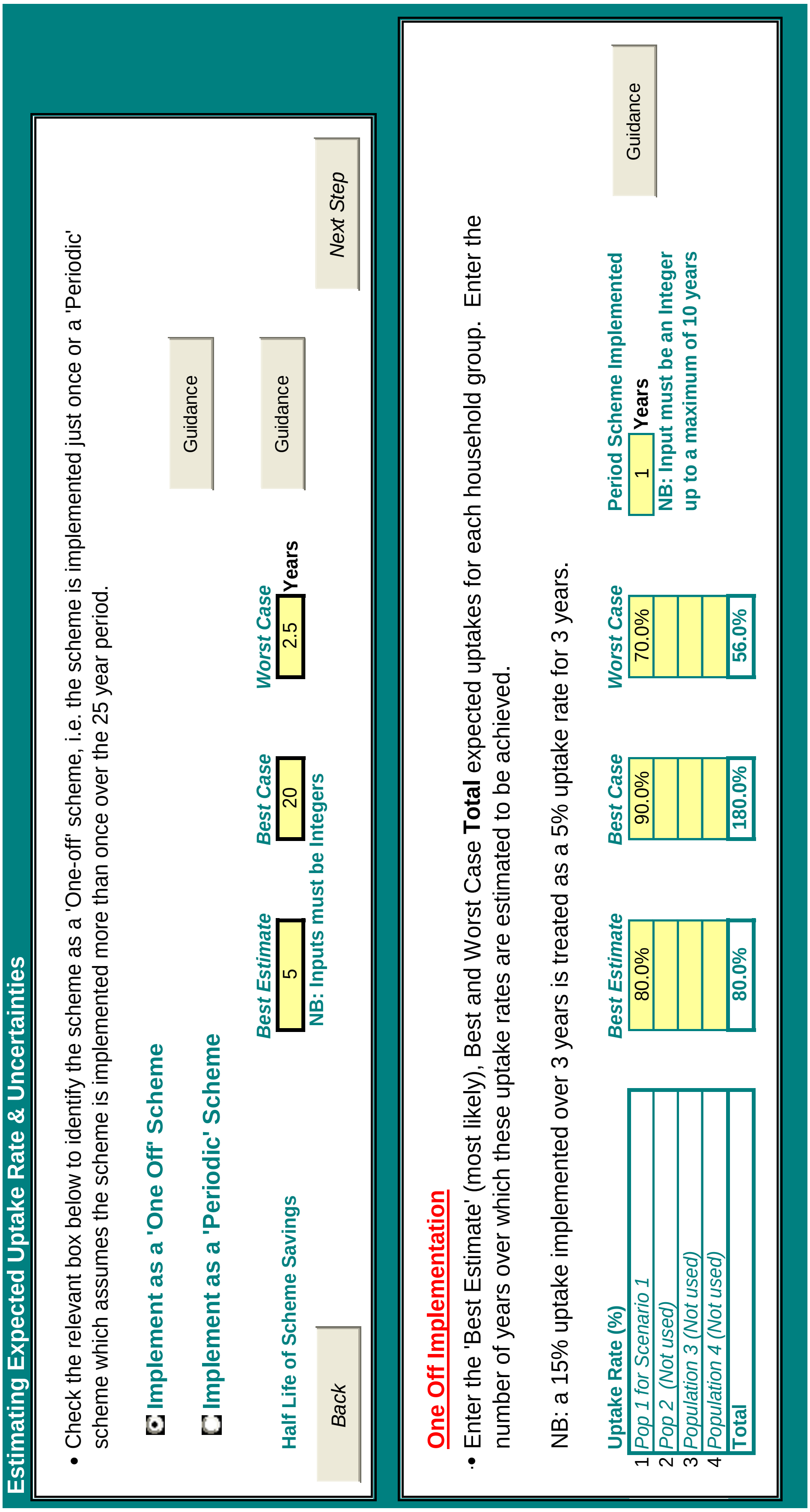
Guidance

Target Households (000s)		Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Pop 1 for Scenario 1																										
1 Best Estimate Predicted Households	000s	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Uncertainty in Household Numbers - Maximum	000s	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Uncertainty in Household Numbers - Minimum	000s	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Pop 2 (Not used)																										
2 Best Estimate Predicted Households	000s																									
Uncertainty in Household Numbers - Maximum	000s																									
Uncertainty in Household Numbers - Minimum	000s																									
Population 3 (Not used)																										
3 Best Estimate Predicted Households	000s																									
Uncertainty in Household Numbers - Maximum	000s																									
Uncertainty in Household Numbers - Minimum	000s																									
Population 4 (Not used)																										
4 Best Estimate Predicted Households	000s																									
Uncertainty in Household Numbers - Maximum	000s																									
Uncertainty in Household Numbers - Minimum	000s																									
TOTAL POPULATION (000s)																										
Best Estimate Predicted Households	000s	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Maximum Predicted Households	000s	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Minimum Predicted Households	000s	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0

Next Step

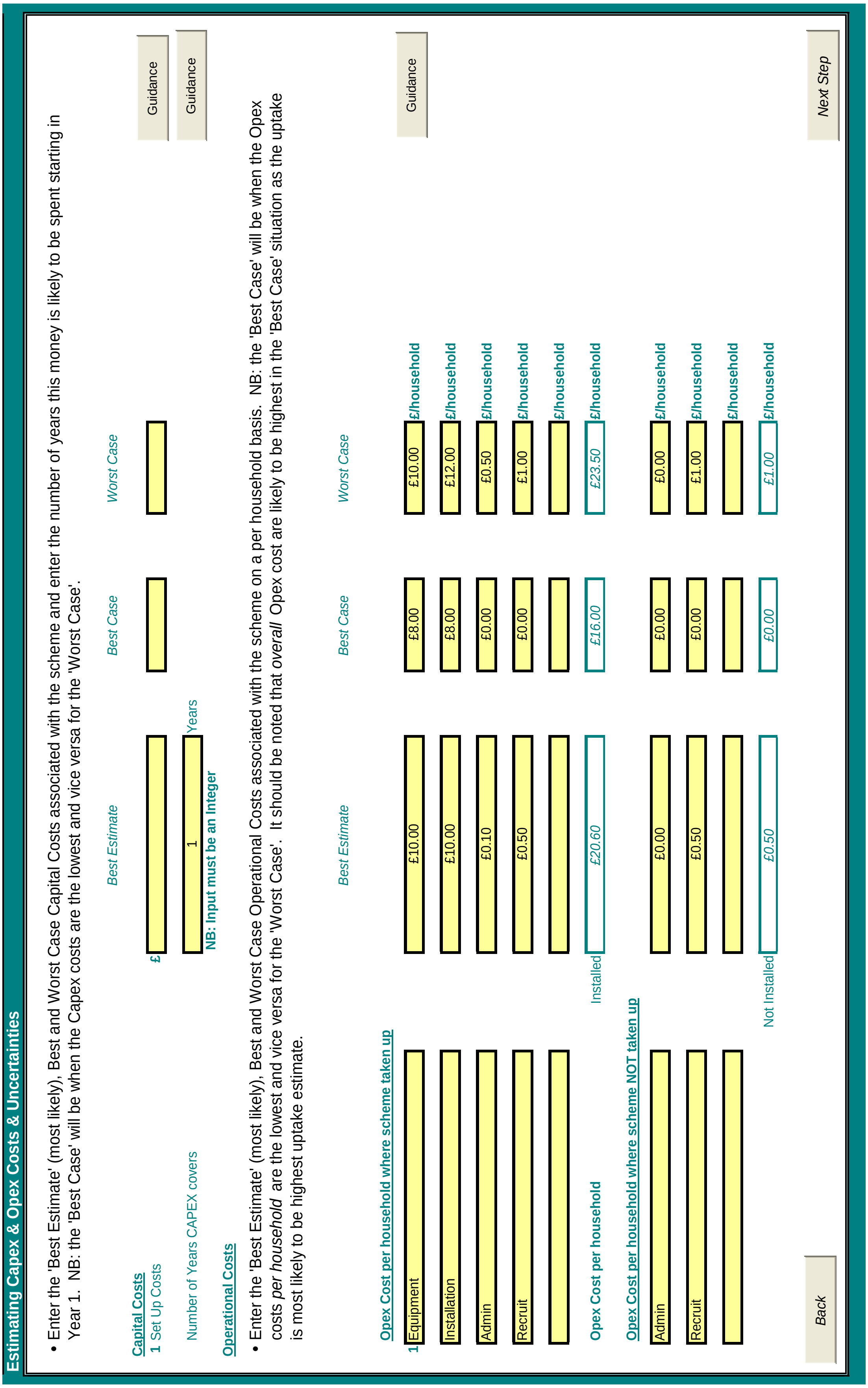
Step 2: Uptake rates and uncertainties

This includes an estimation of what type of scheme it will be: a one-off or a periodic over a set amount of years. Input assumption of half-life and the best, most likely and worst case assumptions.



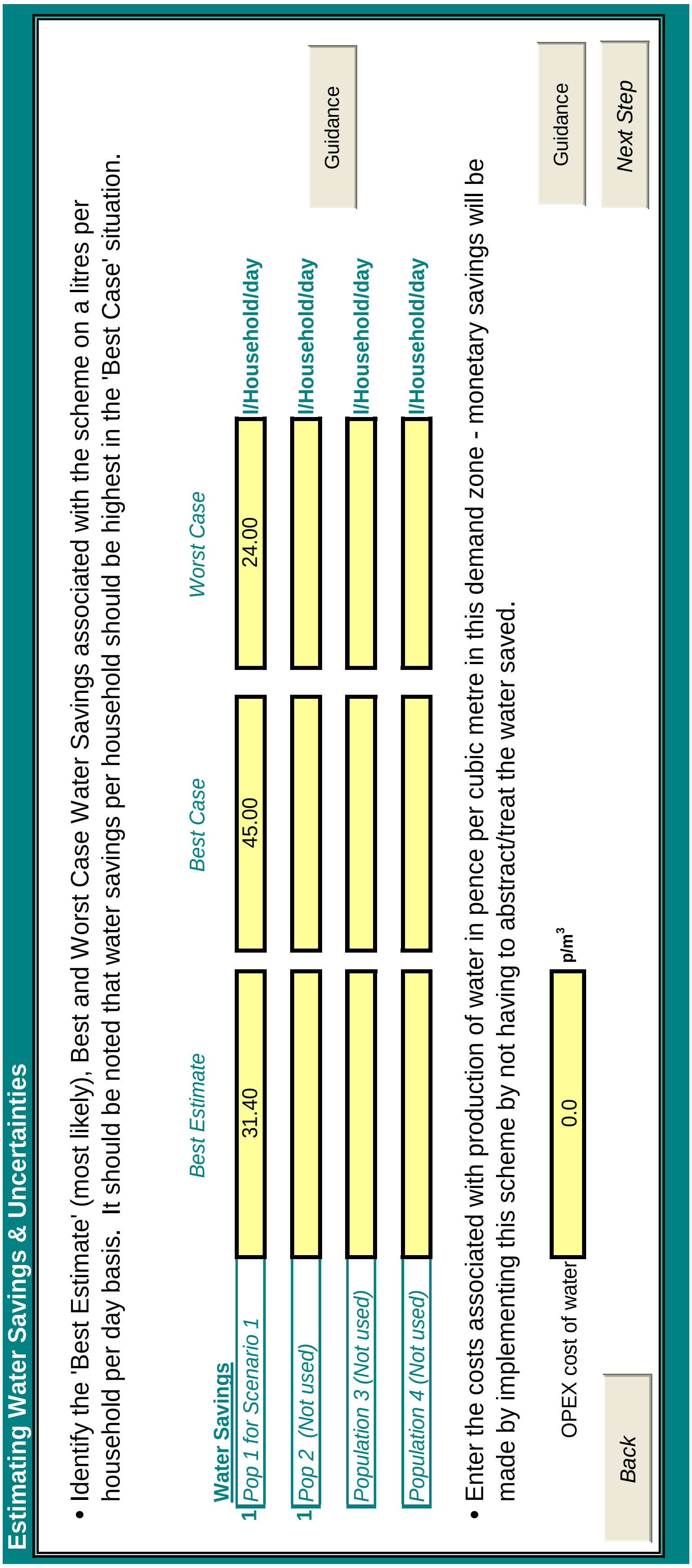
Step 3: Costs

Input costs derived from best available information from previous studies. Assumptions regarding efficiencies of scale, scaling-up costs from small trials to large schemes, and project management costs must all be referenced.



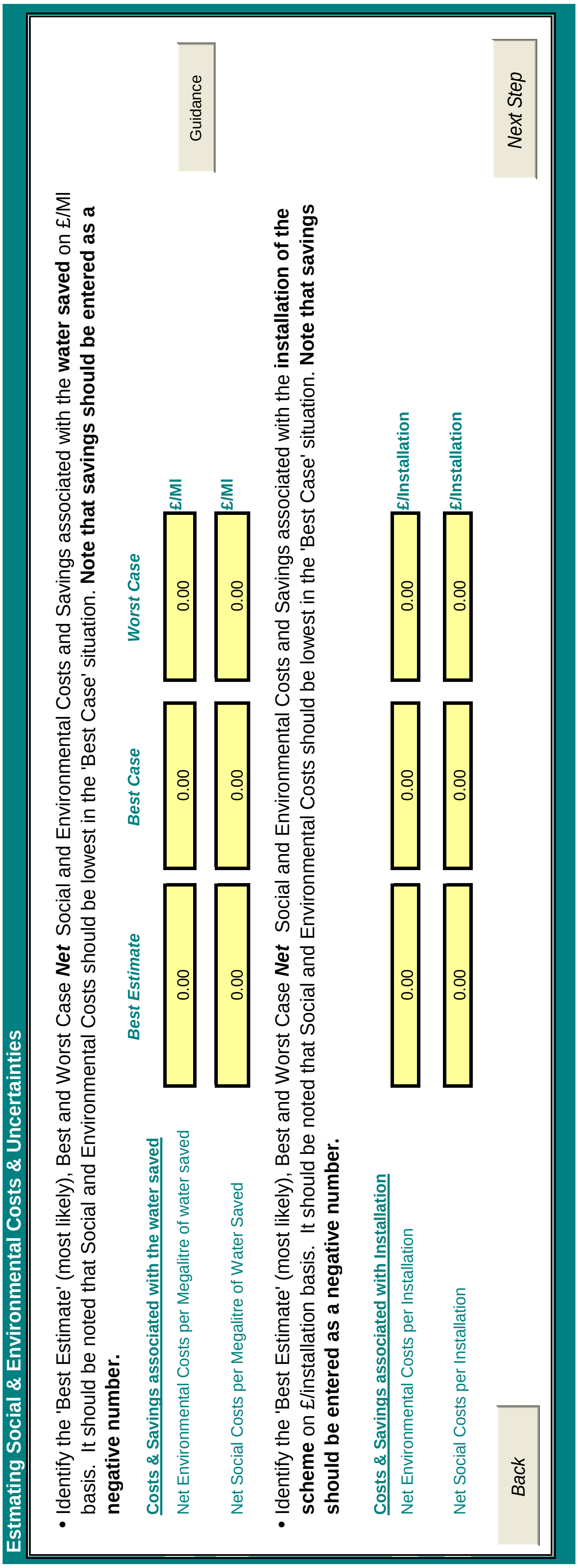
Step 4: Water savings

Data inputted derived from the disaggregation process. All assumptions should be referenced and documented. The water saving will have best case, best estimate and worst case limits. Opex cost can be accounted for during this stage of the AIC calculation.



Step 5: Social and environmental costs

An AIC calculation must evaluate costs and benefits of environmental and social impacts. This has not been possible at this stage of the project due to a lack of data.



Results: AI(S)C results

AIC results in p/m^3 for best case, best estimate and worst case limits for the scenario.

Scheme Reults Summary - 'One Off' Implementation Method

- Enter the discount Rate at which costs and savings are to be discounted into the future

Guidance

Annual Discount Rate: 4.5 %

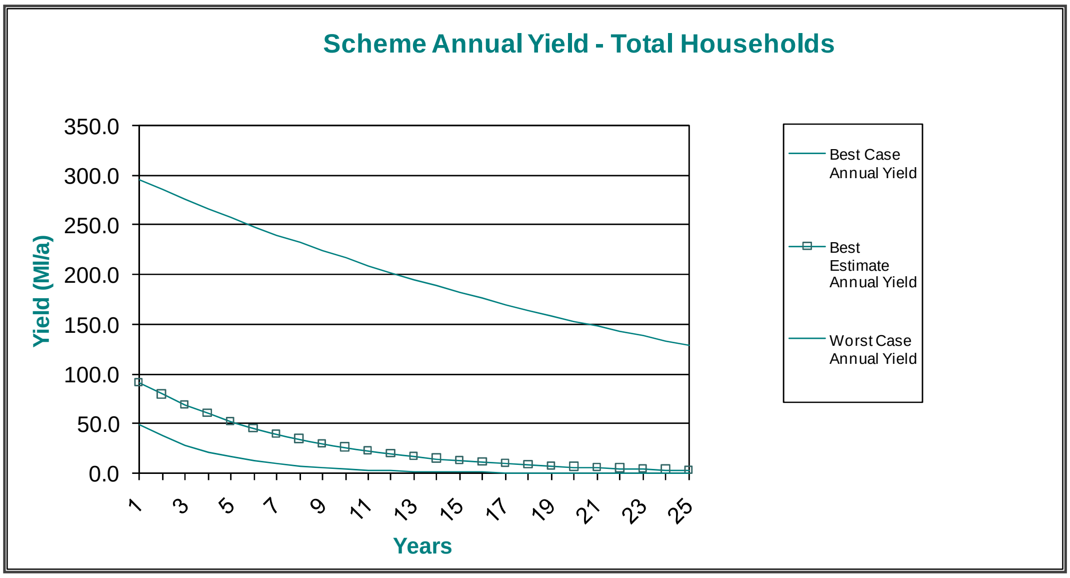
Average Incremental Social Cost (p/m^3)

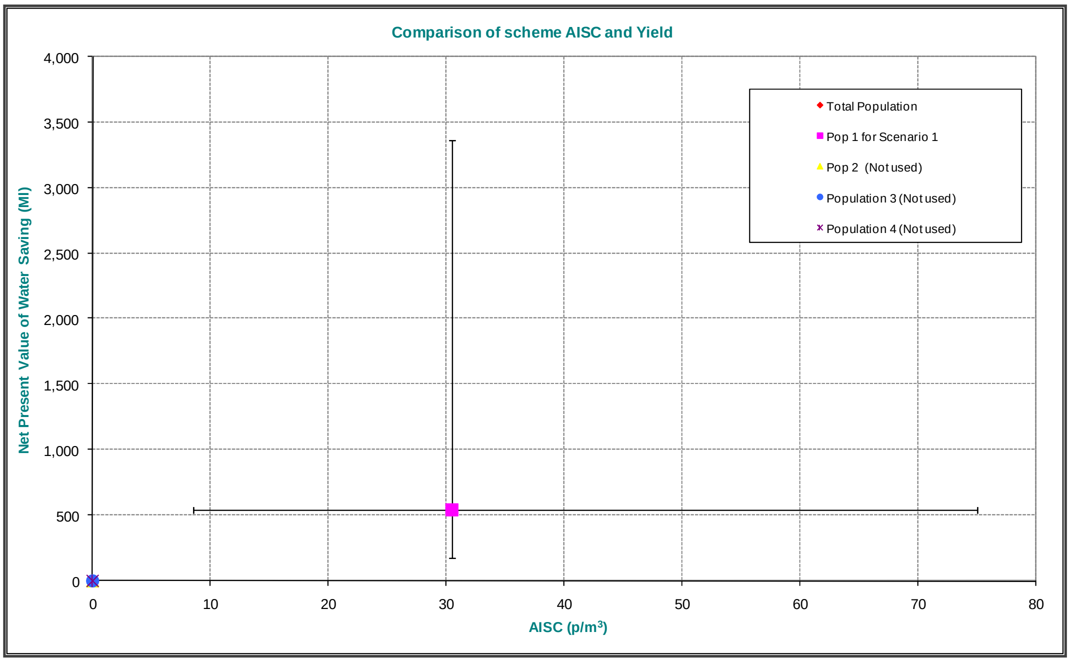
	Best Estimate AISCs		Best Case AISCs		Worst Case AISCs	
Pop 1 for Scenario 1	30.5	p/m^3	8.6	p/m^3	75.0	p/m^3
Pop 2 (Not used)		p/m^3		p/m^3		p/m^3
Population 3 (Not used)		p/m^3		p/m^3		p/m^3
Population 4 (Not used)		p/m^3		p/m^3		p/m^3
Total Population	30.48	p/m^3	8.56	p/m^3	75.03	p/m^3

Net Present Values (Assessed over a 25 year period)

	Best Estimate		Best Case		Worst Case	
WAFU NPV	543.90	Ml	3363.30	Ml	178.59	Ml
CAPEX NPV	0.000	£M	0.000	£M	0.000	£M
OPEX NPV	0.166	£M	0.288	£M	0.134	£M
Opex Savings NPV	0.0000	£M	0.0000	£M	0.0000	£M
Social & Env Costs NPV	0.000	£M	0.000	£M	0.000	£M

Back


Scheme Annual Yield - Total Households
Yield (Ml/a)
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1
3
5
7
9
11
13
15
17
19
21
23
25
Years
Best Case Annual Yield
Best Estimate Annual Yield
Worst Case Annual Yield


Comparison of scheme AISC and Yield
Net Present Value of Water Saving (Ml)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
10
20
30
40
50
60
70
80
AISC (p/m³)
Total Population
Pop 1 for Scenario 1
Pop 2 (Not used)
Population 3 (Not used)
Population 4 (Not used)

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