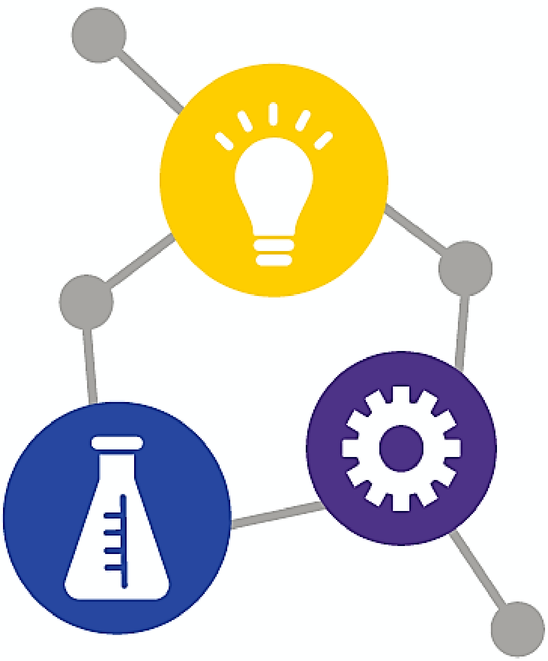
September 2019

Irish Water
CRU Water Services Innovation Fund

Promoting Sustainable Household Water Consumption



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Commission for Regulation of Utilities (CRU) Water Services Innovation Fund

Promoting Sustainable Household Water Consumption

Attached is (1) *An Assessment of the Efficiency of Water Saving Devices in Irish Households* produced for Irish Water by Trinity College Dublin and (2) *Attitudes to Water Conservation* produced for Irish Water and Behaviour & Attitudes Limited

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ACKNOWLEDGEMENTS

This report is published as part of the Commission for Regulation of Utilities (CRU) Water Services Innovation Fund.

In 2015, the CRU established the Water Services Innovation Fund. The Innovation Fund allows Irish Water to explore innovative technologies and approaches through projects that would not otherwise be funded as part of its normal operating costs or Investment Plans. By their nature, innovation projects may not succeed, however, for a project to be approved, Irish Water must demonstrate that it has a reasonable chance of delivering defined, tangible benefits for Irish Water's customers and that these benefits outweigh the cost of the project. Projects must be designed to deliver improvements in at least one of the following areas:

- Provision of safe, secure, and reliable water services;
- Increased understanding of customer behaviours and their drivers and effective customer engagement;
- Enhanced energy savings in the provision of water services;
- Achievement of relevant environmental standards and the objectives of the Water Framework Directive;
- Mitigation of negative climate change impacts;
- Provision of water services in an economic and efficient manner; *and*
- Improved conservation of water resources.

DISCLAIMER

An Assessment of the Efficiency of Water Saving Devices in Irish Households

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1. Introduction

In recent decades, considerable attention has been focused internationally on the sustainability of drinking water resources and its efficient use. To ensure that there is a sufficient supply of clean safe drinking water to meet the future demands of ever increasing populations in times of unpredictable climate change, effective planning, efficient usage and conservation will be imperative.

In Ireland, this has been highlighted by Joint Committee on the Future Funding of Domestic Water Services (Oireachtas, 2017) which has recommended that, '*conservation of water resources should be embedded as a principle of water policy in Ireland.'* In addition the committee recommended that a much more proactive approach is taken to promoting awareness of the importance of domestic water conservation in Ireland and that a cross departmental strategy needs to be developed to increase water conservation which should focus on education and awareness, retrofitting, stronger building standards and regulations for all new residential builds. Specific initiatives recommended include:

- *'proactive retrofitting programme to provide for the maximum level of water conservation, an ambitious amendment to existing building standards and regulations to ensure the maximum level of water conservation*
- *incentives in respect of the installation of practical/innovative systems that reduce water consumption, for example, rain water harvesting systems, grey water systems, water meters and other water saving technologies to provide for the maximum level of water conservation'*

These recommendations have been more recently embedded in the Water Services Policy Statement (WSPS) (Government of Ireland, 2018) which includes conservation as a theme. This highlights the benefits of utilising meter read data to identify the most significant leaks as well as incentivising savings in water use and discouraging wastage by encouraging changes in behaviour.

In Ireland, the nationwide installation of water meters and the establishment of an excess use charge for domestic customers, which is due to come into effect during 2019, will place more emphasis on household water usage and have the potential scope for improvements in efficiency. While improving household water usage efficiency on a national scale can be multifaceted, a number of easily installable water saving devices are currently available on the market which offer considerable savings to customers.

Although water saving devices are known to improve specific water usage appliance efficiency, little research has been done on their success at the household scale in an Irish context. Through a combination of household water usage audits, water diaries, improved metering data resolution and the installation of various readily available water saving devices, this research aims to assess the effectiveness of various water saving devices in improving household water efficiency.

2. Literature review

2.1 The need for conservation

An adequate supply of clean and safe drinking water is a fundamental human necessity. While water may appear to be an abundant resource, approximately 97.5% of the world's water is saline, with just 2.5% considered freshwater. Much of this freshwater is, however, not readily available to humans, with approximately 75% frozen as ice caps and glaciers. Of the remaining freshwater, 24% exists as groundwater, while less than 1% is found in rivers, lakes and soil (Gray, 2010). Hence, while water may seem abundant, very little is actually available for human use.

Water is central to life, but with ever increasing populations and rapid global development, water resources are being placed under increasing strain. Global freshwater withdrawals from surface water and groundwater sources have increased by roughly 1% per year since the 1980s (WWAP, 2016). As the global population is estimated to exceed more than 9 billion people by 2050 (FAO, 2016), this upward trend of water consumption is set to continue.

In parallel with this growing demand, the ever-increasing threats associated with climate change and extreme weather events have brought about growing uncertainty surrounding the distribution, quantity and quality of future water resources. It is expected that climate change will alter the intensity, frequency, seasonality and amount of rainfall, all of which impact surface water and groundwater (International Energy Agency, 2016). UN Water (2012) state that it is expected that by 2025, 1.8 billion people will live in countries or regions with absolute water scarcity and two-thirds of the world population could be affected by water stressed conditions. In fact, UN Water (2012) suggest that no water users, anywhere in the world, can be guaranteed they will have uninterrupted access to the water supplies they need or want or to the water-derived benefits from key developmental sectors such as agriculture, energy and health.

While water scarcity may not always be at the forefront of the minds of people who live in countries, such as Ireland, where water sources appear plentiful (although the recent drought in the summer of 2018 did clearly shake such public complacency), effective management and conservation is still critical. To ensure water resources are protected and that future requirements can be met, effective management, planning and conservation is of critical importance (OECD, 2013; UN Water, 2016).

The need for water conservation is also highlighted by the close relationship between water and energy. The term "water-energy nexus" refers to how water and energy are intrinsically linked. Meeting modern energy demands requires vast quantities of water (e.g. mineral/fossil fuel extraction and transport, hydropower, power plant cooling etc.), while meeting modern water demands requires energy (e.g. pumping, treatment and distribution of drinking water and the treatment of wastewater etc.) (IEA, 2016; Copeland and Carter, 2017). Although challenging to accurately determine, IEA (2016) estimate that approximately 120 million tonnes of oil equivalent (Mtoe) of energy was used worldwide in the water sector in 2014, almost equivalent to the entire energy demand of Australia. Roughly 60% of that energy is consumed in the form of electricity, corresponding to a global demand of around 820 terawatt-hours (TWh) (or 4% of total global electricity consumption) (see Figure 2.1).

With respect to wastewater treatment in Ireland, Fitzsimons *et al.* (2016) outlines how treatment is a resource-intensive process that requires several inputs, including energy, chemicals and water, to produce an effluent that meets designated environmental standards. In a study of ten Irish wastewater treatment plants, the average amount of energy required for the treatment of 1 m^3 of wastewater ranged from 0.21 – 0.92 kWh/m^3 (Fitzsimons *et al.* 2016).

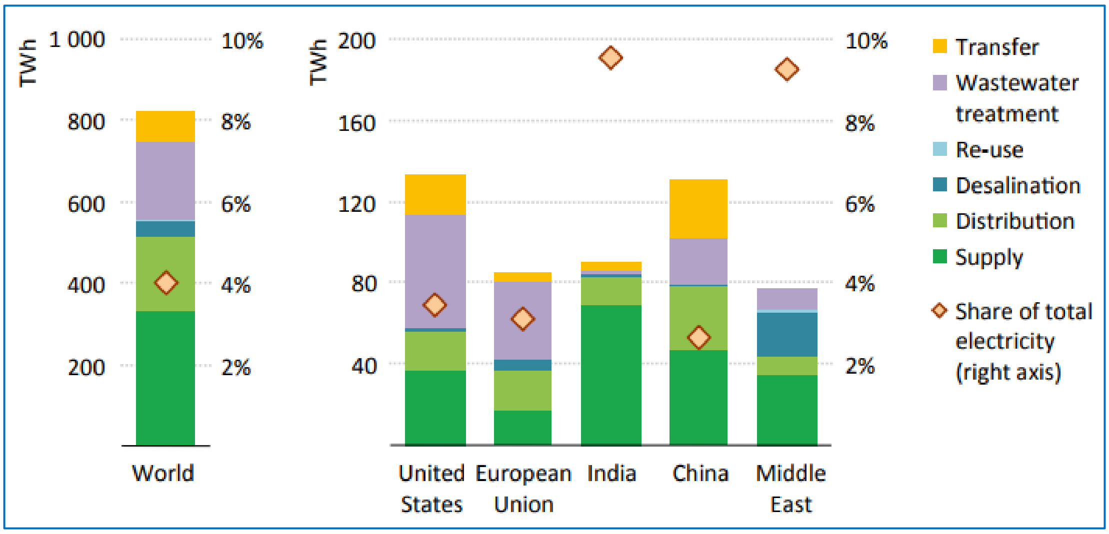

Figure 2.1 Global electricity consumption by the water sector (IEA, 2016).

This interdependency of the water-energy nexus relationship comes with considerable risk (IEA, 2016). The availability of water affects the viability of energy supplies, while the dependence of water services on the availability of energy may impact the ability to provide clean drinking water and sanitation services. Increased energy demand in the water sector (as a result of increased consumption) can increase the water needs for energy production. Similarly, an increase in water required for the energy sector could tighten overall water supply to the point of requiring increased levels of treatment depending on how water used in primary energy is managed (IEA, 2016). While beyond the scope of this current review, these complexities highlight the need for careful consideration, particularly given the fact that global energy use in the water sector is projected to more than double by 2040 (IEA, 2016).

In view of the increasing demand, the uncertainty surrounding climate change, water quantity and quality, and the complexities of the water-energy nexus it is imperative that deliberate actions are taken to improve the efficiency of the water industry. Copeland and Carter (2017) identify water conservation as one key area that could reduce the energy demands associated with water services.

Household water conservation and an overall reduction in usage can offer considerable benefits from both environmental and monetary standpoints. International research has examined water usage in the home and the potential mechanisms and approaches for reducing household water usage. However, comparatively less research has been performed in Ireland. The following research assesses the efficiency and potential savings attainable through the installation of common water saving devices in Irish households.

2.2 Water usage in Ireland

Prior to the installation of domestic water meters in Ireland, various estimates existed for both per capita and household water usage in Ireland. Often, however, these estimates were based on small scale studies and although useful, their applicability to Ireland as a whole was uncertain. The installation of domestic water meters has brought about substantial improvements in our understanding of household water usage throughout Ireland, as well as other benefits from the perspective of network management such as determining areas of high / low usage and enabling leaks to be identified, high / low usage, in addition to helping consumers to understand their own water consumption.

Household consumption

Most recently, the Commission for Regulation of Utilities (CRU), the economic regulator of Irish Water, has reviewed water consumption data for households in Ireland based on Irish Water meter data from 2016 (CRU, 2017). The CRU focused its analysis on 475,000 meters out of the approximately 884,000 domestic meters installed by Irish Water by the end of 2016. The CRU only used customers that had a meter reading at the start and at the end of the year in its analysis (i.e. data was not included from any meters that were installed during 2016). The average dwelling demand per day in 2016 was 342.5 L/d, compared 356.2 L/d in 2015. However, when the effect of leaks was disregarded the average dwelling demand per day in 2016 (and 2015) drops to 268.5 L/d. In the 2016 dataset 8.3% of dwellings contained leaks at either the start or end of the year.

Per capita consumption

While metering data, summarised in CRU (2017), provides an insight into household water consumption, per capita consumption can be more variable and difficult to assess accurately. Irish Water has no way of knowing how many people live in individual households at any given time so per capita consumption is somewhat of an estimate (Irish Water, 2017).

To calculate estimated individual consumption, Irish Water has previously used household occupancy figures that were based on original household registration data (which is regarded as incomplete as it was reliant on self-declaration from householders and is increasingly out of date) and a sample survey Irish Water took of metered households in 2014 (Morgenroth, 2014 – see below) which provided a snapshot in time. Irish Water will recommence regular reporting to the Commission for Regulation of Utilities (CRU) regarding estimated domestic water consumption once excessive use charging commences in 2019.

The source data to be used for this report is likely to change from the original household registration data collected in 2014, and the structure of the report will depend on the design of the excess use charge policy. The purpose of the domestic consumption reports will be to monitor trends in domestic consumption having particular regard to excess usage. Per capita consumption estimates for the seven quarterly reports currently available from Q1 2015 to Q3 2016 are presented in Figure 2.2.

The range of consumption in these reports relate to the Regulated Per Capita Consumption (PCC) which omits high users, distinguishing it from actual per capita consumption (PCC) i.e. actual PCC includes outliers or high usage, making it higher. Outliers have been defined as dwellings with exceptionally high usage as follows. Outliers were those metered dwellings where demand was over 800 litres of water per day for occupancies up to five persons and over 1,000 litres per day where occupancy was six or more. Per capita consumption estimates range from 110 to 119 Lcd.

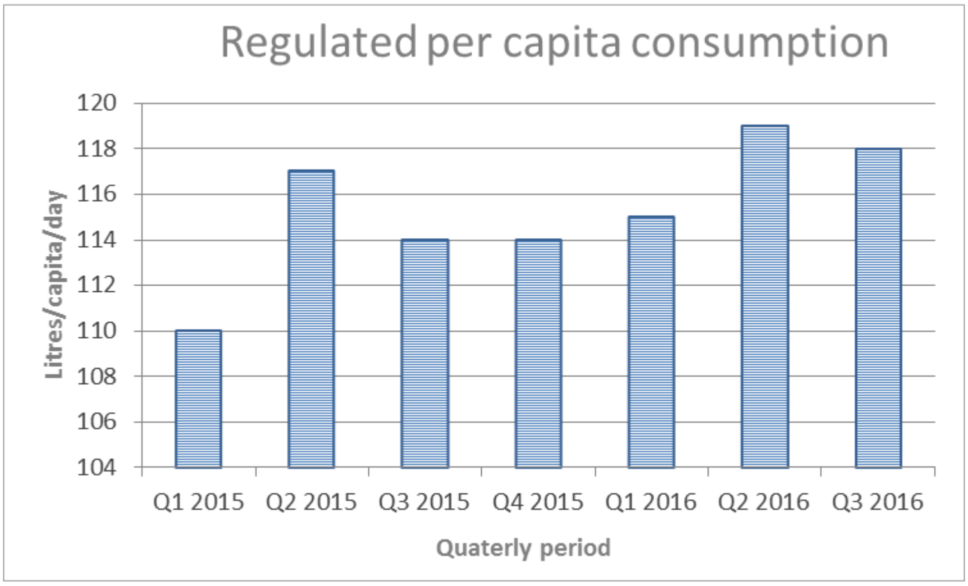

Figure 2.2 Regulated per capita consumption estimates (Irish Water, 2016).

The study by Morgenroth (2014) conducted on data obtained during the early stages of water meter installation provided early insights into household and per capita consumption. Water usage data was collected from 1650 Irish households over a three-month period along with details pertaining to property type, the number of persons in the household and the number of bedrooms.

The average water consumption based on the raw meter data from the 1650 households was just under 120 litres per person. However, just over 71% of the observations have a water consumption below the average and the median (corresponding to the level of water consumption which splits the sample into two halves) which is just under 99 litres per person. Once outliers were removed consumption reduced to 109 litres per person. Both values are nonetheless in line with estimates from the quarterly reports published by Irish Water – see Figure 2.2. In this study Morgenroth employed a statistical approach to identify outliers based upon the DFFITS (difference in fits) method proposed by Welsh and Kuh (1977) that assesses the influence of individual observations on the overall estimated method.

Morgenroth (2014) also illustrated that single households have the highest per capita consumption, and that per capita consumption decreases as the household size increases. As shown in Table 2.1, single household occupants have a mean per capita water consumption of 173.6 Lcd. While houses with two occupants will naturally use a larger total volume of water (adding a second occupant increases consumption by approximately 101.8 L per day – see Table 2.2), per capita consumption reduces. This trend was also observed by Irish Water (2016) and preceding quarterly reports.

Table 2.1 Household water consumption per person by size of household: comparison of Morgenroth (2014) vs CRU (2017).

Occupancy	Mean per capita water consumption (L/d)		
	Morgenroth (2014) – outliers removed	Morgenroth (2014) – all data	CRU (2017) – all data
1	173.6	203.2	208.2
2	137.7	155.6	152.1
3	110.1	118.1	122.4
4	97.7	103.7	103.4
5	86.4	87.1	95.9
6 or more	87.7	89.1	-

Table 2.2 Additional consumption per additional household member: Morgenroth (2014) vs CRU (2017).

	Mean additional water consumption per capita (L/d)		
Occupancy	Morgenroth (2014) – outliers removed	Morgenroth (2014) – all data	CRU (2017) – all data
1	173.6	203.2	208.2
2	101.8	108.0	95.9
3	54.9	43.1	63.0
4	60.5	60.5	46.6
5	41.2	20.7	65.8
≥6	94.2	99.1	-

For another set of 1206 observations, where data were available on household composition (i.e. number of adults and children), Morgenroth (2014) was able to investigate the influence of household composition on water usage. The data showed that the per capita water consumption declines with increasing number of adults or increasing number of children. Regression analysis estimated water consumption per additional child of 53.2 litres and additional adult of 76.1 litres. The estimated standard errors for these values imply a range between 54 and 98 litres (±29%) for the consumption of an additional adult and between 44 and 63 litres (±18%) for the consumption of an additional child. Morgenroth (2014) notes that the findings must carry a caveat that they are based on relatively small sample sizes. Note, the two aspects of the study by Morgenroth (2014) had 1650 and 1206 observations respectively. This current research has significantly fewer observations, highlighting the need for careful interpretation.

The CRU (2017) estimated the annual rate of demand by an occupant in 2016 was 47,000 litres (128.8 L/d): when the effects of leaks are disregarded this returns an annual rate of demand in 2016 of 38,000 litres (104.1 L/d). Their analysis also shows that per capita consumption decreases as the household size increases, as shown on Table 2.2.

When analysing water meter data care must be taken to assess data quality and the possible presence of extreme events. The presence of extreme events, or “outliers”, apart from being due to high consumption, can also be due to household leaks which can give rise to abnormally large meter readings. The inclusion of such readings in analyses can give rise to unrepresentative results and erroneous conclusions. The quarterly reports produced by Irish Water (see Irish Water, 2016) exclude such outliers to ensure accuracy. Specifically, households using more than 800 litres per day were treated as outliers and removed from the dataset. The resulting average usage metric is then referred to as the ‘Regulated Per Capita Consumption’ to distinguish it from actual per capita consumption which includes outliers.

2.3 Household water “end-uses”

While domestic metering has provided insightful data regarding overall household water usage, considerably less is known about household water end-uses. “End-uses” refer to the specific points within a household where water is used (e.g. toilet, showers, baths, taps, dishwashers, washing machines etc.). Reliable information on household water end-uses is imperative in understanding consumer behaviour and hence where savings can be made (Beal and Stewart, 2011). While notable research has been conducted into the volume of water used by end-uses internationally, relatively little research has been conducted into the breakdown of household end-uses in Ireland.

Due to the absence of detailed water usage patterns, previous research into potential savings attainable through the installation of water saving devices by Dubber and Gill (2013) used data from studies conducted in the UK (Liu *et al*., 2010). The data (see Figure 2.3) was deemed likely to reflect water usage patterns in Ireland due to the country’s proximity, similar socio-economic conditions, climate, culture etc. The following subsections provide a brief overview of the water usage characteristics of each of the common household end-uses and how their efficiency has changed over time. Note, a more detailed description of the specific water saving devices installed as part of this current research is presented in Section 3.2.

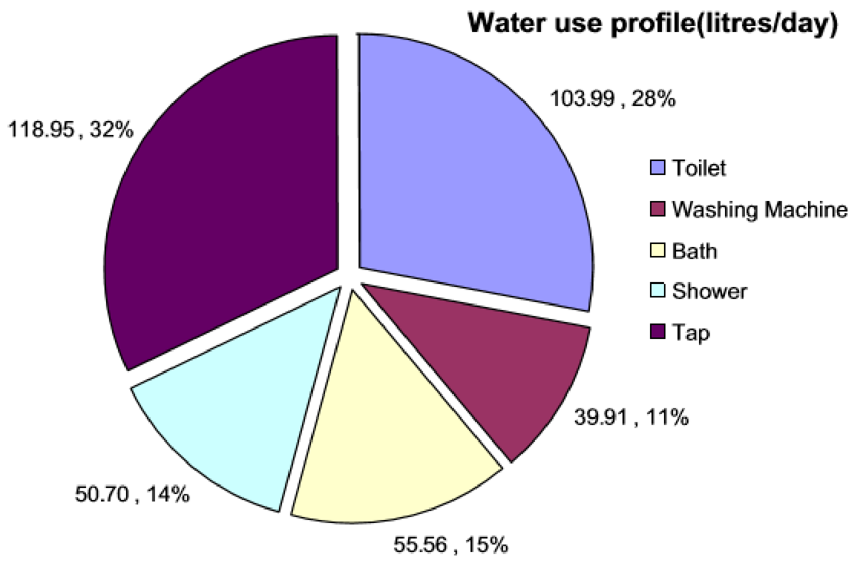

Figure 2.3 Water use patterns for three-person households in the UK (from Liu *et al.,* 2010).

Washing machine

The review by Dubber and Gill (2013) states that older washing machines (pre-1980) used up to 150 litres per cycle but that over the past decades average water usage has been reduced to approximately 50 litres per cycle. Waterwise (2017) do however state that significant variation can exist between washing machines. When adjusted for capacity, some use as much as 20 litres per kilogram while others as little as 6 litres per kilogram (Waterwise, 2017).

A 2007 study which compared 51 high efficiency models against 232 lower efficiency models found that the former are approximately 24% more efficient (Dubber and Gill, 2013). In view of the fact that Liu *et al.* (2010) found that washing machines accounted for 11% (16.5 Lcd), Dubber and Gill (2013) suggest that there is potential to save just 4 Lcd by using more efficient washing machines. Hence, replacement would not be recommended unless a new machine is required. Waterwise (2017) do however suggest several practices that should be employed to ensure the most efficient usage, including the use of full load.

Dishwasher

Waterwise (2017) state that unfortunately many manufacturers, suppliers and retailers do not provide information about the water efficiency of their models. However, Dubber and Gill (2013) suggest that there is a common misconception that a dishwasher uses more water than washing up by hand. While in the 1970s a dishwasher used >50 L per cycle, many modern machines can use as little as 10 L. Using a modern efficient dishwasher wisely (i.e. by only using it for full loads, by using eco or economy settings and by avoiding pre-rinsing) can use less water than washing up by hand (Waterwise, 2017).

Toilet

Toilets account for about 28% of the total water used in a household (Liu *et al.,* 2010). Cistern capacities and hence water consumption can, however, vary considerably between houses. Flush toilets installed during the mid-20th century typically had cistern volumes of approximately 20 L, while more modern toilets can use as little as 6 L or less per flush. A comprehensive review of toilet water usage and potential saving through the installation of various water saving devices is provided by Dubber and Gill (2013). In the UK, Waterwise (2017) states that of 45 million toilets used in households, approximately 26% still use 13 L of water per flush, while just 11% are dual flush models capable of using either 6 L or 4 L for a full of half flush, respectively.

Shower and bath

Based on end-use research by Liu *et al.* (2010) in the UK, showers account for approximately 14% of household water use. As with many water usage devices, shower water consumption varies depending on user behaviour and the specific shower type. Irish Water (2013) state that the average 7-minute shower uses approximately 49 L of water (7 L/min). However, over the same period, power showers can use as much as 175 L (25 L/min). Although power showers use considerably larger volumes of water, Irish Water (2013) state that 65% of people surveyed have a power shower at home. Consequently, individuals could be using approximately 63,800 litres of water annually on showering alone. Reducing your shower time by just one minute could save up to 9,000 litres of water per year.

The average bath uses 80 L of water per use. Hence, significant savings are attainable through switching to even an average 7-minute shower (49L). Savings will however depend on the shower type and behaviour.

Taps

Liu *et al.* (2010) state that approximately 32% of household water consumption can be attributed to tap usage. Flow rates from kitchen taps has been shown to vary considerably, with values ranging from 2-25 L/min depending on tap specific settings and user behaviour (Waterwise, 2017). Similar issues are noted with respect to bathroom faucets. Irish Water (2013) state that brushing your teeth with the tap running can use up to 6 L/min, while brushing your teeth with the tap off will use a just 1 litre.

2.4 Water saving devices

There are two key approaches often taken to reduce water consumption: targeting behavioural change and promoting the use of water efficient/saving technology (Beal and Stewart, 2011). The success of each method is as variable as the previously discussed water consumption patterns, with behaviour, climate, socio-demographics, house size, family composition, water appliances, cultural and personal practices all likely to be influential.

As discussed in Section 2.3, technological advancements have improved the efficiency of most household appliances. Currently, a range of water saving devices are available on the market that are capable of further improving water usage efficiency in the home. Available devices include various tap aerators/regulators, high efficiency shower heads, dual flush toilets and toilet cistern displacement products.

Numerous studies have shown that the installation of these water saving devices can significantly reduce household water usage. In the USA, Mayer *et al.* (2004) observed that retrofitting houses with water saving devices (i.e. high efficiency toilets, washing machines, showerheads, and taps) can reduce per capita water usage by up to 49.7%. Similarly, Inman and Jeffrey (2006) observed savings of between 35 - 50% post the installation of water saving devices (toilets, washing machines, dishwashers, kitchen and bathroom taps and shower heads).

While these products are known to improve the efficiency of many devices, evidence has indicated that this extent of improvement can be lessened through offset behaviour in the user. Early work by Peltzman (1975), regarding automobile safety regulations, brought about suggestions that offsetting behaviour can decrease the effectiveness of policies which can in fact lead to perverse outcomes such as people consuming more of a product than they normally would. Inman and Jeffrey (2006) state that there is evidence of such behaviour in response to water conservation policies, whereby people engage in offsetting behaviour when they know water saving devices are installed.

This compensatory behaviour was noticed in research by Geller *et al.* (1983) in a study of the efficacy of educational, behavioural and engineering strategies for water conservation. While water savings were observed following the installation of water saving devices, the amount of water saved with these devices was much less than expected based on manufacturer estimates. It was hypothesised that this was result of offsetting behaviour with householders tending to use appliances fitted with water saving devices more often (e.g. toilet flushes) or for longer (e.g. shower usage). Notably, Geller *et al.* (1983) also report evidence that in situations where people don't know that the water saving devices have been installed, such devices do succeed in conserving significant amounts of water, which is further consistent with offsetting behaviour.

Further evidence was apparent in a large-scale study by Campbell *et al.* (2004) which examined more than 200,000 monthly observations of more than 19,000 household accounts in Arizona over six years. Through the assessment of water consumption before and after the installation of water saving devices it was illustrated that offsetting behaviour can be so strong that it can actually increase water consumption. Campbell *et al.* (2004) recommend that other policies be used in concurrently with water saving devices to alleviate the impact of offsetting behaviour, such as through communication. Regardless, the study concluded that at least for water conservation, simply giving households engineered water saving devices is not as effective as offsetting behaviour is so strong that effectiveness is swamped.

3. Methodology

3.1 Research structure

This section outlines the field and desk based procedures applied throughout this research. An overview of tasks and the order of their completion are illustrated in Figure 3.1.

Figure 3.1 Order of research methodology.

Two study sites (Athlone, County Galway and Douglas, County Cork) were selected for inclusion in the research. Within each area, households were recruited via local media, with notices placed in the respective local newspapers outlining the research. Households that expressed interest in participating and met the criteria were placed on a shortlist for inclusion. While large sample sizes are ideally needed to facilitate statistical tests and the elucidation of meaningful trends, it was deemed that this study could facilitate 200 households within resource constraints of the project.

Upon shortlisting, an independent market research company (B & A) was contracted to complete questionnaires with the participants. B&A contacted a number of households into the two areas (Athenry and Douglas), ensuring that they contacted a mix of house types, and invited them to participate in a water conservation study being undertaken by Trinity College Dublin. Variables assessed by the survey include house type (e.g.

detached vs semi-detached), number of occupants, their attitude to water consumption (e.g. perceived level of consumption, perception of various water saving devices, perceived need for consumption) and other social variables (e.g. life stage, social class, employment status). Note, the results of this survey have been reported previously and hence they are not comprehensively assessed in this report. However, in general they undertook quantitative research in September and October 2016 to identify the key drivers of attitudes to water usage and interest in conservation, including the level of effort consumers are prepared to undertake to conserve water. Please find attached a copy of the full report and the executive summary. In addition, the historical water usage for each house was evaluated from meter records taken from the preceding year (January – December 2016) – see Section 4.2.

Once surveyed, a water diary was distributed to participating households for completion during the week (SW1) from 05/03/17 to 12/03/17. Each water diary consisted of a series of appliance usage record sheets (see Appendix 1). The householder was advised to place one sheet beside each water usage appliance and to tick the diary every time the device was used. Concurrently, for the duration of this week, household water meters were programmed to collect improved resolution (hourly) water usage data. All meters were reprogrammed to the original settings after the trial week.

Upon completion of the first water diary, all houses were visited by a water conservation specialist. Each water usage device in the house was audited to measure the flow rate and, hence, the water usage properties. Where suitable, water saving devices were installed. Post installation, the appliances were again audited to assess the reduction in flow rates brought about by the retrofitting. The water diary procedure was then repeated for the week (SW2) (03/09/17 – 10/09/17), with meters again programmed to collect the hourly usage data.

3.2 Water saving device installation

All water saving devices were supplied and installed by an independent contractor. Note, the following review includes the proposed savings (i.e. flow reductions) according to the manufacturer's claims. This shows clearly that if these devices are used appropriately they can assist in water conservation measures. The actual reductions observed during the water audit are discussed later in Section 4.5.

3.2.1 Kitchen sink

Kitchen tap swivel aerator

Tap aerators introduce air into the water stream to produce a large, soft non-splashing stream while reducing flow rates (Dubber and Gill, 2013). Several different models are available; however, the most suitable one should be chosen to match the pressure and flow requirements of the house.

The swivel aerator is simply installed by screwing it onto an existing kitchen tap. By aerating the water, the device can reduce flow rates to 8 L/min. This reduced flow rate can yield savings through lower water usage and reduced water heating bills (i.e. a reduction in the use of hot water). The manufacturer states a return on investment is achievable within 2 months. The device is WRAS approved (Renergise, 2017).

Kitchen tap aerator

Another aerator, this device is easily screwed onto the existing kitchen tap and is capable of reducing flow rates to approximately 8 L/min. The manufacturer claims savings of up to 75% compared to a standard tap. It is both WRAS (Water Regulations Advisory Scheme) approved and WaterSense certified (Renergise, 2017).

3.2.2 Shower

Amphiro A1 Shower Energy Monitor

The Amphiro A1 Shower Energy Monitor provides the shower user with information on water consumption, water temperature, energy usage and shower efficiency during and after showering. The device is designed to fit standard domestic showers by attaching between the shower hose and shower head. As water passes through the device it drives a small turbine which measures the flow rate while simultaneously supplying the device with enough power to run the visual display, negating the need for an external power supply. By providing water and energy usage data it aims to improve user awareness and encourage a reduction in consumption (Amphiro, 2017).

In a randomised controlled study of 697 Swiss households by Tiefenbeck *et al.* (2014), Amphiro A1 Shower Energy Monitors were used to assess the impact of the real-time feedback display against baseline use and a control group. Approximately 47,000 showers were recorded over a 2-month period. The study found that participants who received real-time feedback on their consumption in the shower reduced both their energy and their water consumption by 23% compared to the control group. Extrapolated to a period of one year, the results suggest that for an average household (one shower per person per day and the Swiss average household size of 2.2 persons), yearly energy savings would be 443 kWh of energy and 8,500 litres of drinking water, making the device cost-effective within 6-9 months.

Individuals with high baseline consumption exhibited a stronger response to the intervention. However, for participants with stronger pro-environmental attitudes, a reduction in consumption was found to be more challenging due to the fact that those individuals tended to start out from a lower baseline, making it harder for them to further reduce their consumption. Notably, the baseline data indicated that the amount of energy and water used per shower is negatively correlated with age, with 20-29 year-olds using 72% more energy and water per shower than participants over 65. However, given their higher baseline consumption, young people show a stronger response to the real-time feedback.

A more recent study by Staake *et al.* (2016) assessed the performance of Amphiro Shower Energy Monitors in 637 Dutch houses. Data from 74,000 showers were recorded in a three-month monitoring period. During a baseline assessment (i.e. prior to the provision of real-time data to the householder) the average consumption was 3.2 kWh and 54 litres per shower. Once real-time data was provided, participants saved, on average, between 19% and 21% of their energy consumption in the shower. Savings per shower amounted to 0.6 kWh. Extrapolated over a one-year period, a three-person household in the Netherlands (with 0.85 showers per person and day) would on average save 561 kWh of heat energy and 8.7 m^3 litres of water. This equates to monetary savings of approximately €86 per year.

Shower flow regulator

The shower flow regulator requires no plumbing and simply screws in between the shower head and the shower hose. The device regulates the flow rate to 7.6 L/min, and hence offers savings in terms of energy and water. The manufacturer states a return on investment is achievable within 2 months. The device also claims to keep the flow rate constant and independent of the line pressure. The device is WaterSense certified.

Air-Jet water saving shower head

This device is designed to pressurise and strengthen the delivery of water during showering while reducing the overall flow volume. The design and performance are based upon a vacuum valve which is located within the shower head. The valve draws air into the shower head due to atmospheric pressure differences and creates compressed air bubbles which expand at the top of the shower head causing increased pressure. The system can be used to deliver a high-pressured shower in houses with low pressure water systems. The manufactures states that it can reduce flows to 5, 7 or

9 L/min depending on the model that is fitted. The device is available in either fixed or hose head configurations. The device is WaterSense certified.

Water-Jet shower head for low pressure systems

The Water-Jet shower head reduces normal shower water usage by approximately 20%. They are particularly suited to where there is low water pressure, poor flow rate and poor spray patterns. The Water-Jet Shower provides good shower spray coverage even in low pressure systems.

Shower timer

The shower timer is a simple sand timer designed to reduce shower duration. The timer counts down over four minutes, encouraging the user to complete the shower within this period. The device is relatively inexpensive and is simply held onto the shower wall using a suction cup. The UK manufacturer states that cutting one minute off shower times could save up to £30 per person per year, based on lower energy and water bills (Save Water Save Money, 2017).

3.2.3 Toilet

Toilet tank bank

The toilet tank bank is easily installed by filling it with water and clipping it within the toilet cistern. The device displaces water from the cistern and hence reduces the volume used during each flush. The manufacturers states that it can save between 2-3 litres per flush depending on whether one or two are installed.

Flush Wiser WC Variable Flush Device

The Flush Wiser device is designed to attach to the siphon in your toilet cistern and works by allowing your toilet to fill with air instead of water. The Flush Wiser has five settings and thus is adjustable to suit the efficiency of each individual toilet cistern. The manufacturer claims that up to 3 litres of water can be saved per flush. Note, the Flush Wiser device is designed to work effectively in all toilet cisterns installed pre-2001. It is not suitable for use on dual flush toilets. The device is WRAS approved.

3.2.4 Bathroom basin

Bathroom tap flow aerator

Similar to the kitchen tap flow aerator, this device is easily screwed onto the existing bathroom faucet and is capable of reducing flow rates to 3.5 L/min. The manufacturer claims that this device can save you up to 75 percent water compared to a standard aerator. It is both WRAS approved and WaterSense certified (Renergise, 2017).

Thread-less tap flow regulator

Thread-less tap flow regulators are useful where taps are not suited to the standard threaded tap aerator (see above). These devices are estimated to offer water savings of between 40 to 50% by the manufacturers: however, this can vary between houses.

Toothy timer

The toothy timer is a simple sand timer device that encourages children to brush their teeth for the recommended 2 minutes while also encouraging them to the turn off the tap during brushing. The manufacturer states that the device can save up to 12 L of water every time a child brushes by encouraging them to turn off the tap in between rinses (Save Water Save Money, 2017). The device is relatively inexpensive and is easily installed.

4. Results

4.1 Sample size and household participation

In total, 144 households (63 and 81 in Athenry and Douglas, respectively) responded to the study's call for participants and were deemed suitable and were included in the research. Upon shortlisting, an external independent market research company completed questionnaires with all 144 households. As discussed above, the results of this survey have been presented previously, and are only included in this report where relevant.

All households were then sent water diary packs for completion. The percentage of households that returned the diary is presented in Table 4.1. The return rates were notably similar between the two different study areas. While this relatively large non-response rate may be due in part to natural reasons (i.e. illnesses or holidays during the diary week), it may also be indicative of householder sentiment towards water usage research. This response rate should be used as an indication of likely responses for any future research.

Table 4.1 Survey return rate for the first survey week.

	Total sent	Total returned	% return rate
Douglas	81	53	65%
Athenry	63	42	67%
Total	144	95	66%

All households were subsequently visited by an independent contractor after the first diary week in order to carry out a water audit and to fit water saving devices. Several houses, however, refused to facilitate a water audit and/or did not permit the installation of water saving devices (see Table 4.2). Just 48 households in Douglas and 38 households in Athenry returned the water diary <u>and</u> agreed to water audit/installation of devices.

Table 4.2 Percentage of households that declined a water audit and water saving devices.

	Visited by contractor	Declined further involvement	% refusal rate
Douglas	81	17	21%
Athenry	63	15	24%
Total	144	32	22%

A second water diary was then distributed for completion. Note, the second water diary was not sent to households that did not return the first water diary and/or did not agree to a water audit. Just 32 households returned the second water diary (10 in Athenry and 22 in Douglas). This represents a 22% return rate (based on the original 144 participants). Although such a response rate would not be considered particularly low for a once-off survey, this is a low rate of return given that the 144 householders had already signed up and engaged in some parts of the study. Although, there were no common specific reasons given for dropping out of the study, it is thought that some of the attrition may have been due to the timing of this study which was just after a highly contentious and political period in Ireland regarding water charging in the country which had received a lot of publicity.

In summary, houses were requested to complete two water diaries and participate in a water audit/installation of water saving devices in order to satisfy the requirements of the research. Just 32 households of the initial 144 households met these requirements and also had historical water usage records (see Section 4.2). This substantial reduction in public participation greatly limits this research and the execution of the analysis. Nevertheless, the data that does exist contains interesting information (for example, different appliance usage statistics), which has been analysed in the following sections. Due to the reduction in sample sizes at each stage of the research, the following sections and analyses are based on different sample sizes (i.e. the maximum number at each stage of the research) – see discussion on this later in Section 5.2.

4.2 Historical water usage

This section outlines the historical water usage of the households that agreed to participate in this research. In addition to providing useful insights into household and per capita usage, this historical data also provides a useful baseline against which numerous comparisons can be made. Firstly, this historical record can be used to assess whether the households participating in this research are representative of national household water usage. Secondly, it can be used to provide a comparison of overall long-term (relatively) water usage before and after the installation of water saving devices.

For the majority of subject houses, the period of historical water usage was taken as the preceding year (January – December 2016). By encompassing an entire calendar year, potential temporal trends in water usage can be examined. Note, for a small number of houses an unbroken 12-month record was not available due to metering errors. For the houses where there were missing monthly consumption values the averages were calculated from the remaining months. Three houses had no historical water usage record. The total number of houses discussed below is therefore 141 (n=62 in Athenry and n=79 in Douglas).

Athenry

Water usage varied considerably between the households included in the study (see Figures 4.1 – 4.3). Overall historical mean daily household water usage was 273 L/d (n = 62). However, for individual households, their averages ranged from 78 – 935 L/d across all the households (i.e. including outliers), linked to the range of occupancies from 1 to 6. This overall average is consistent with average dwelling demand per day in 2016 (and 2015) of 268.5 L/d (when the effect of leaks was disregarded) quoted by CSO (2017) (see Section 2.2).

With respect to per capita consumption, the overall average for all households (i.e. including outliers) was 101 Lcd, with values ranging between house from 33 – 285 Lcd. While this per capita average is slightly lower than the values illustrated in Figure 2.2, the difference is slight. The disparity is likely due to the limited sample size in this current research. As illustrated in Figure 4.3, per capita water consumption decreases as household occupancy increases. This is consistent with the findings of Morgenroth (2014), where single occupancy households were found to have the highest per capita water usage (see Table 2.1).

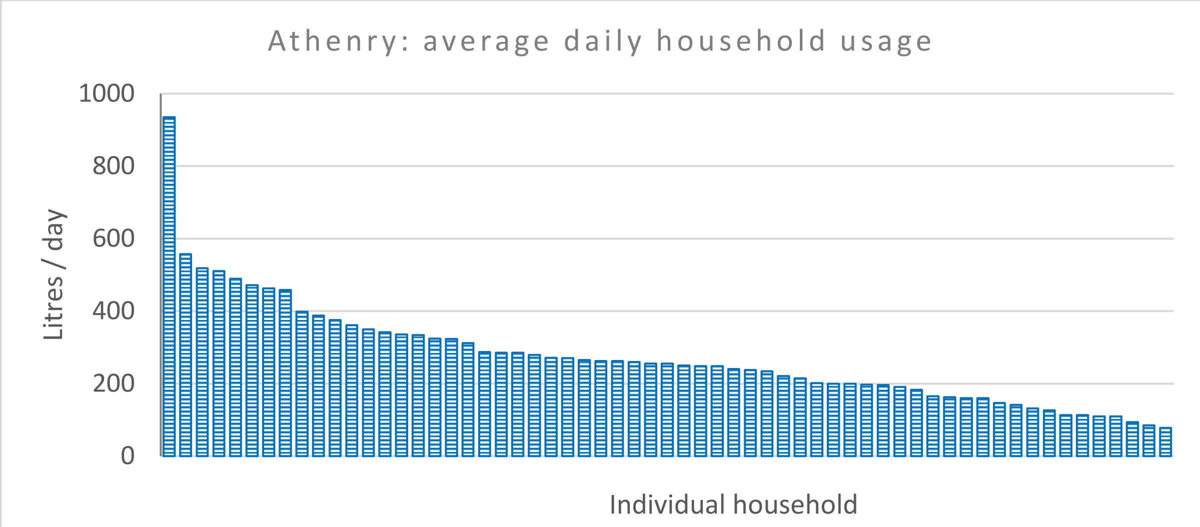

Figure 4.1 Average daily historical household water usage (n = 62, mean = 272.9 ± 143.3L/d).

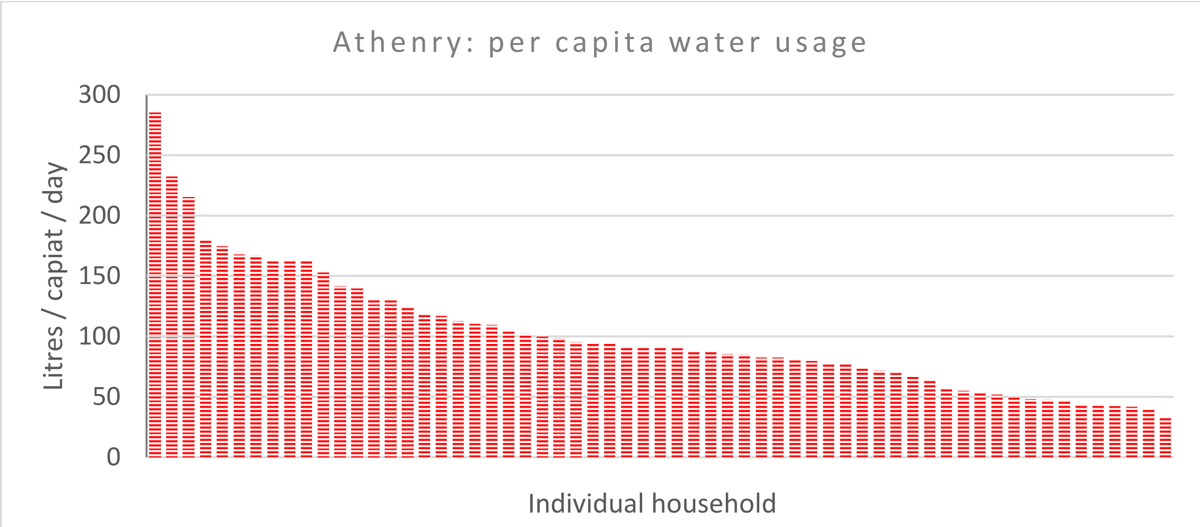

Figure 4.2 Per capita historical water usage for each household (n= 62, mean = 101.3 ±50.7 L/d).

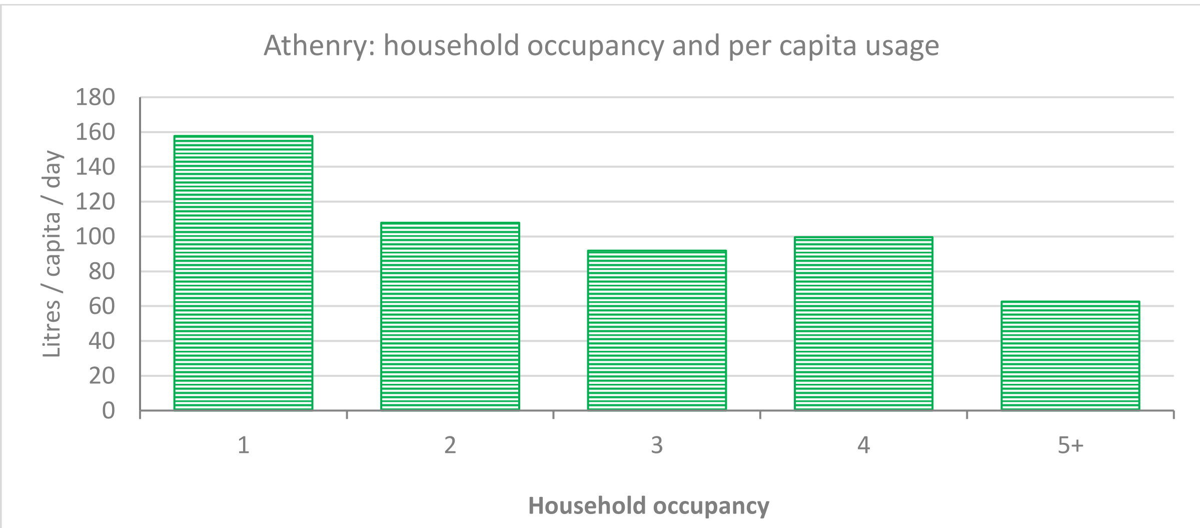

Figure 4.3 Household occupancy and per capita water usage.

Douglas

Household and per capita water consumption trends for Douglas are presented in Figures 4.4 – 4.6. The mean household water usage was 299 L/d (n = 79), with individual household averages ranging from 42 – 604 L/d across all the households (i.e. including outliers), lined to the range of occupancies from 1 to 6. With respect to per capita consumption, the overall average was 102 Lcd, with values ranging between house from 34 – 302 Lcd. As discussed with respect to Athenry, these household and per capita averages are largely consistent with the findings of Morgenroth (2014), Irish Water (2016) and CRU (2017). Again, as anticipated, per capita consumption decreases with increasing occupancy.

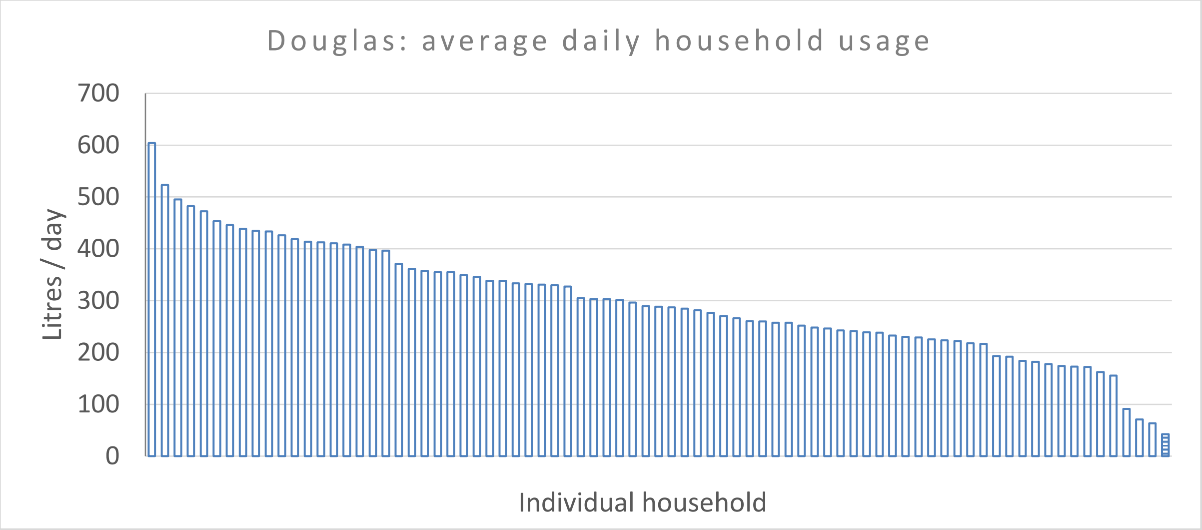

Figure 4.4 Average daily historical household water usage (n = 79, mean = 299.0 ± 108.7L/d).

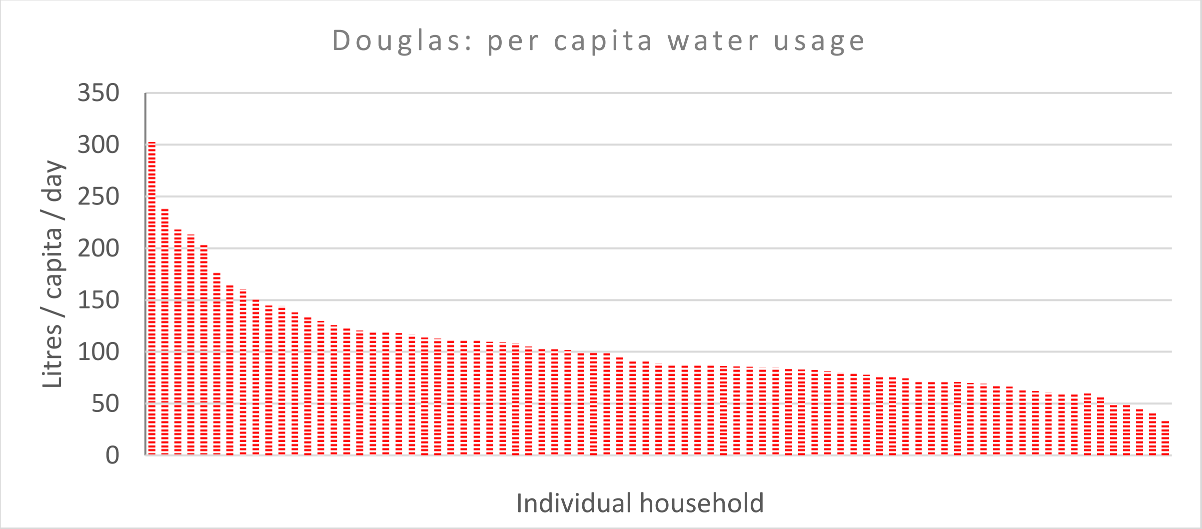

Figure 4.5 Per capita historical water usage for each household (n = 79, mean = 102.5 ± 45.8L/d).

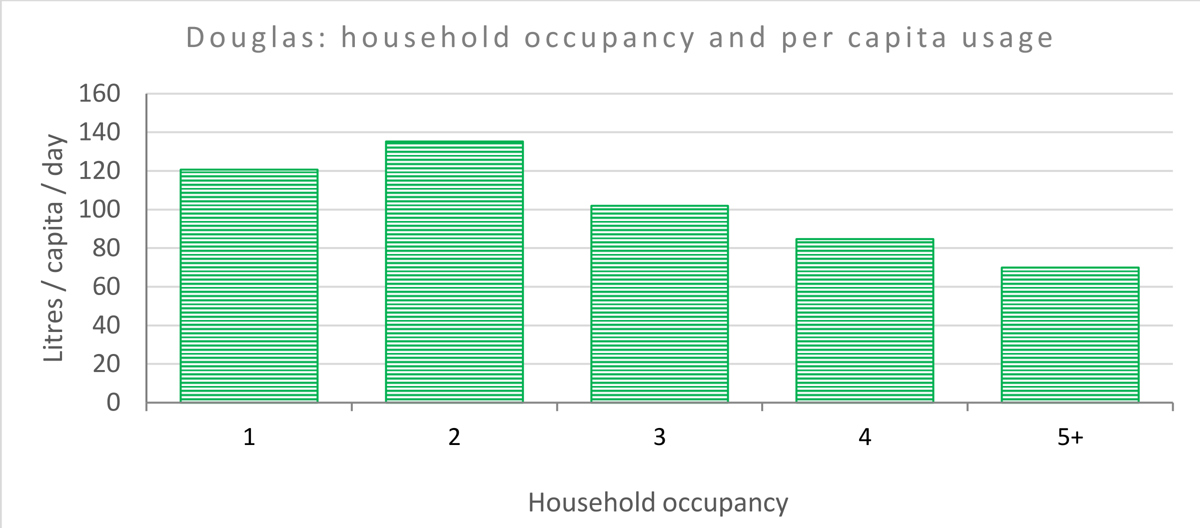

Figure 4.6 Household occupancy and per capita water usage.

4.3 SW1 Water Usage

All water meters were reprogrammed to provide hourly resolution usage data for the study houses during SW1 and SW2. This provides an overall weekly usage and hourly usage data for the period over which the household completed the water diary. While the initial sample size was 144, the following data is based on 60 and 80 houses in Athenry and Douglas, respectively. Four houses were omitted due to erroneous meter data.

Athenry

Water usage varied considerably between households during SW1 (see Figures 4.7 and 4.8). In Athenry, overall average daily household water usage was 292 L/d. With respect to the per capita consumption, the average was 108 Lcd, which is notably similar to the historical data (Section 4.2).

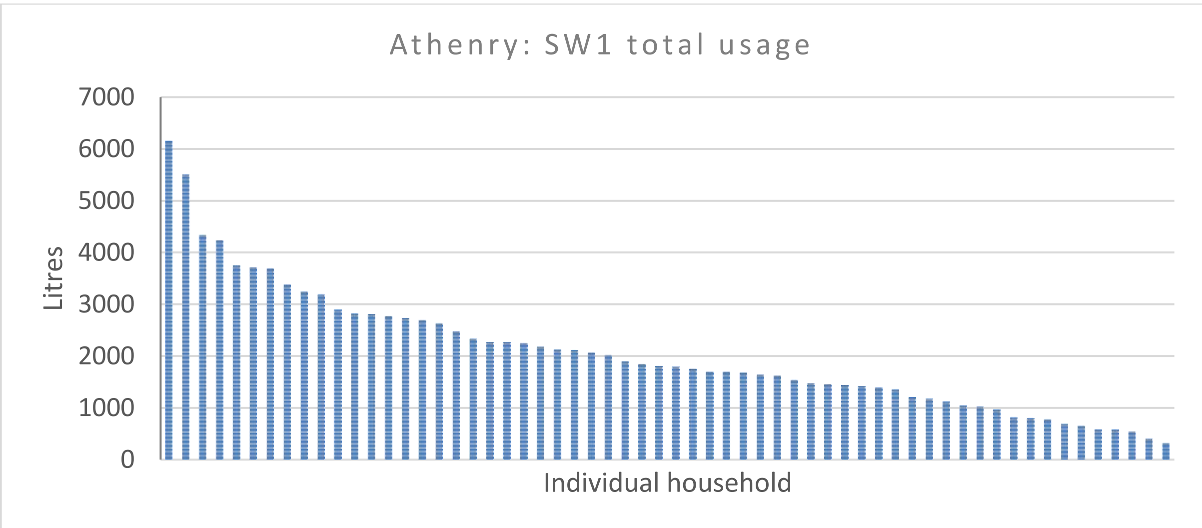

Figure 4.7 Average daily household water usage during SW1.

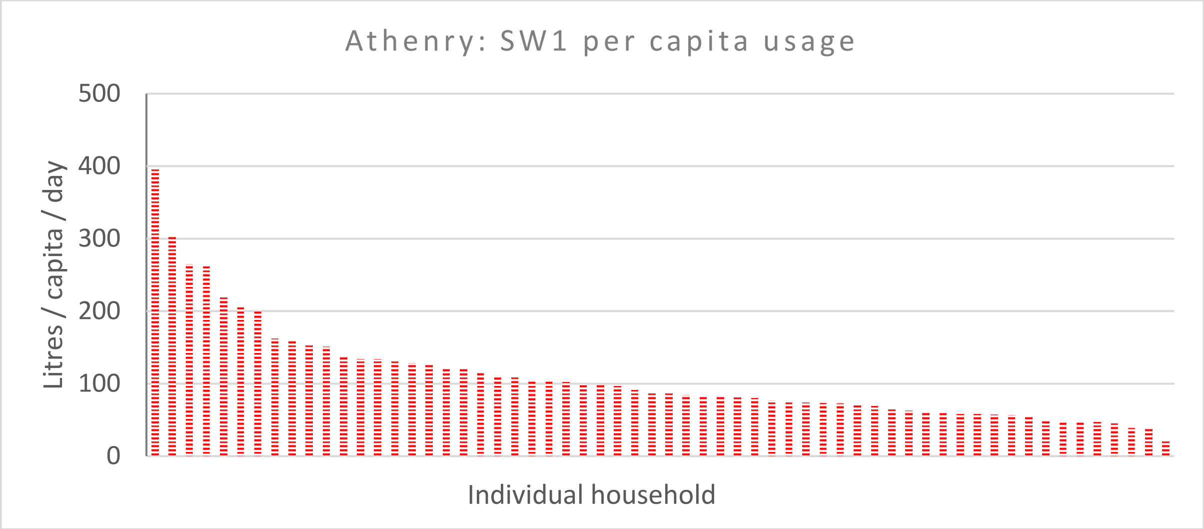

Figure 4.8 Per capita water usage for each household.

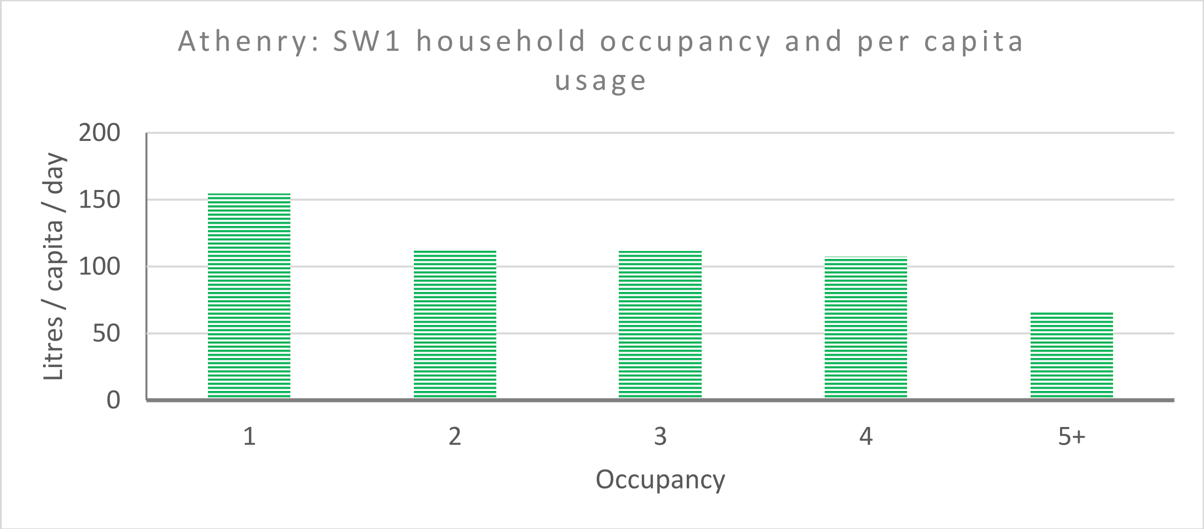

Figure 4.9 Household occupancy and per capita water usage.

Douglas

With respect to water usage in Douglas (Figures 4.10 – 4.12), overall average daily household water usage was 317 L/d. With respect to per capita consumption, the overall average was 106 Lcd, with values ranging between house from 36 – 358 Lcd.

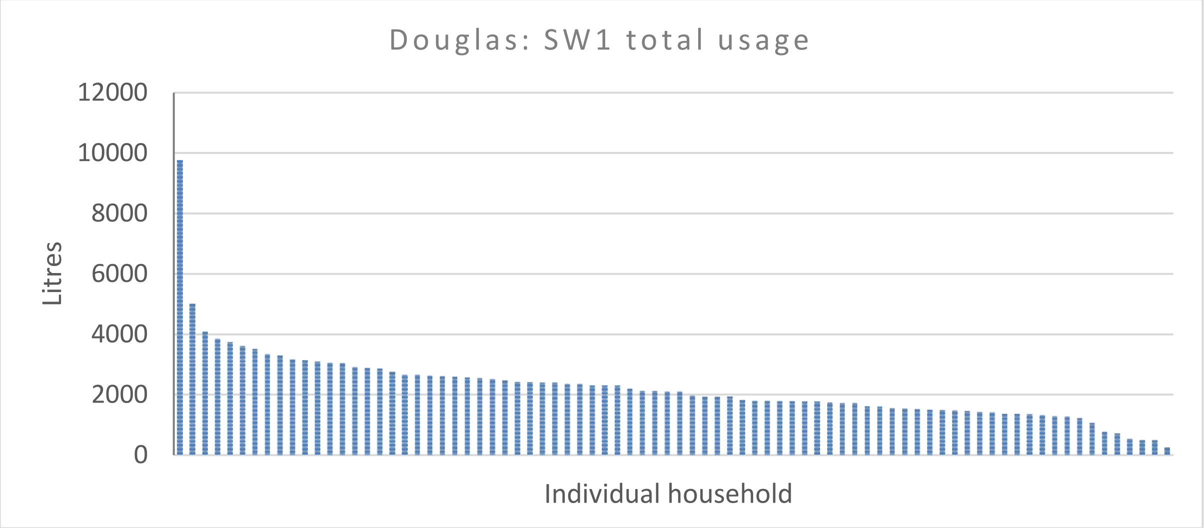

Figure 4.10 Average daily household water usage during SW1.

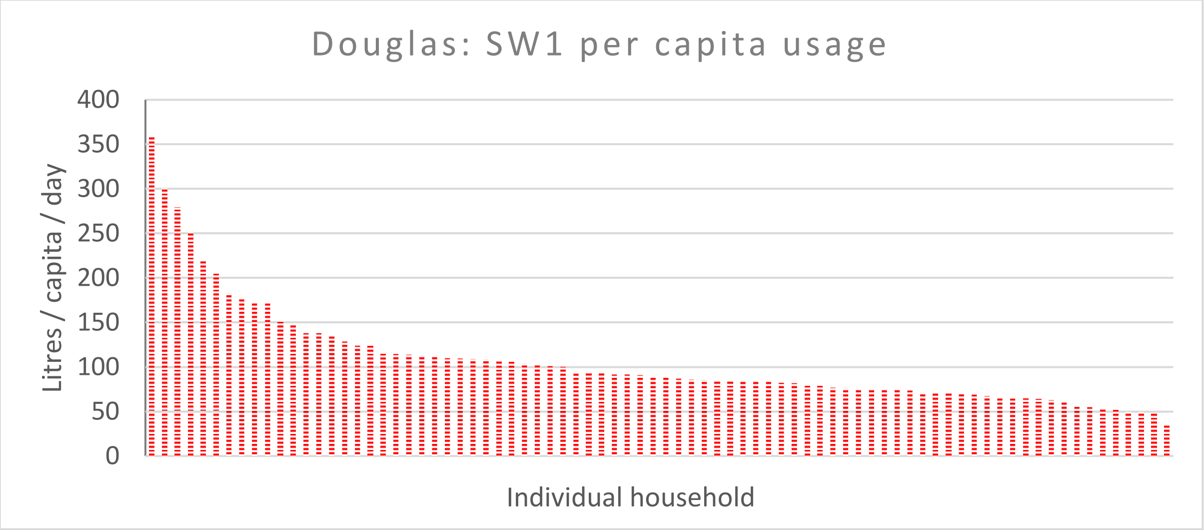

Figure 4.11 Per capita water usage for each household.

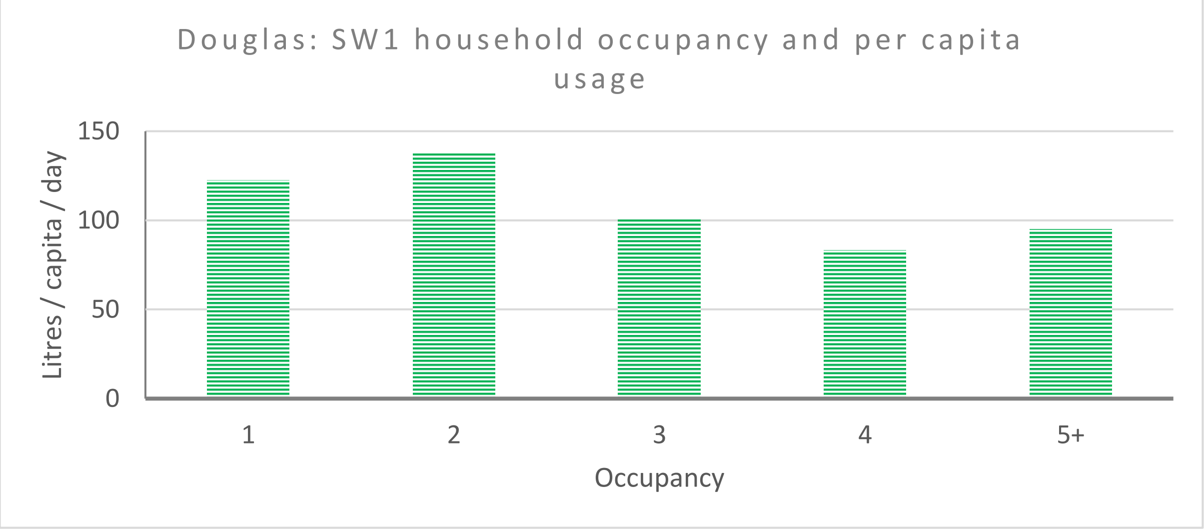

Figure 4.12 Household occupancy and per capita water usage.

Hourly meter data

It was initially envisaged that hourly data over the period of a week where households concurrently completed a water diary would yield information into household end-uses and identify reductions brought about through the installation of water saving devices.

Considerable gaps were however observed in the resulting hourly data. Upon correspondence with metering technicians, the gaps were found to be a result of an exceedance of meter memory during the study week. Once the memory is exceeded, the device cannot collect more data until it has been read and the data cleared. Meters would need to be read more frequently during the study week (to read and hence clear the meter memory) in order to obtain an unbroken record. Unfortunately, a substantial proportion of the hourly resolution data was not recoverable. For Douglas and Athenry, during SW1 there were just three and two complete days, respectively, where an unbroken hourly record is available. Importantly, the overall weekly consumption was still available (i.e. Monday – Sunday), meaning water usage for SW1 and SW2 can still be compared. However, the gaps in the hourly records greatly limit the potential usefulness of the data.

While it was envisaged that the hourly record would provide an insight into specific end-uses, this did not appear to be feasible during this study for several reasons. Firstly, the fragmented hourly record (2 and 3 complete days, respectively) provides a limited insight into household usage. The record does not account for any significant temporal variation from day to day or week to week. A longer unbroken record (i.e. a week or ideally longer) would be required to get an adequate and reliable insight into usage. Secondly, even with an unbroken record, hourly resolution is unlikely to be sufficiently granular to provide insight into specific end-uses. Hourly resolution provides 24 water usage data points for a single day. However, in reality, water usage appliances are often used a considerable number of times each day. Furthermore, this usage is often concentrated into a small number of hours (i.e. the morning and evening).

For instance, for a household of four occupants (two adults and two children) if both parents are working and both children are in school, the majority of usage is likely to occur in the morning and evening, before and after work/school, respectively. For an average evening, water consumption may arise from cooking, toilet/sink usage, washing machine and dishwasher usage and up to as many as four showers. Separating each hourly usage figure into the various end-uses is not feasible. While the water diary has recorded appliance usage, it has not recorded the time of usage, or the duration of usage (e.g. for shower or tap). The coarse nature of hourly data is highlighted by previous studies (e.g. Mayer et al., 2004; Liu et al., 2010) that have used smart metering to identify household end-uses. This research has used meters that log flows every 10 seconds and are capable of storing 15 days of consumption data. This smart research should be considered for future work in Ireland, and is outlined in Section 5.3.

While specific appliance usage cannot be accurately determined by this current research, the hourly data is still assessed. As presented in Figure 4.13, hourly usage varies considerably between houses. For most houses, daily consumption starts from approximately 06:00 am, with usage peaks throughout the day. Of note, however, is the number of houses that use substantial quantities of water during the night. Low levels of consumption at night may arise due to toilet and sink usage. Additionally, some people may start certain appliances (e.g. dishwashers and washing machines) before they go to bed. However, larger night time usage may be unexpected. While these hourly trends may be explainable by householder practices (which could be identified with consultation) it may also help identify areas of abnormal usage, leaks and/or potential areas for conservation.

An apparent bimodal distribution of water usage (i.e. two periods of peak usage during a given day) in some houses (n = 9) is illustrated in Figure 4.14. For these houses, usage peaks are seen in the morning and evening, with little or no usage during the day. As discussed previously, this is likely due to householder behaviour. As occupants are potentially outside of the household during the day (e.g. at work, school etc.), water usage is concentrated into the morning and evening times. In contrast, Figure 4.15 illustrates scenarios where household water usage does not belong to a distinct bimodal distribution, with consumption evident throughout the day.

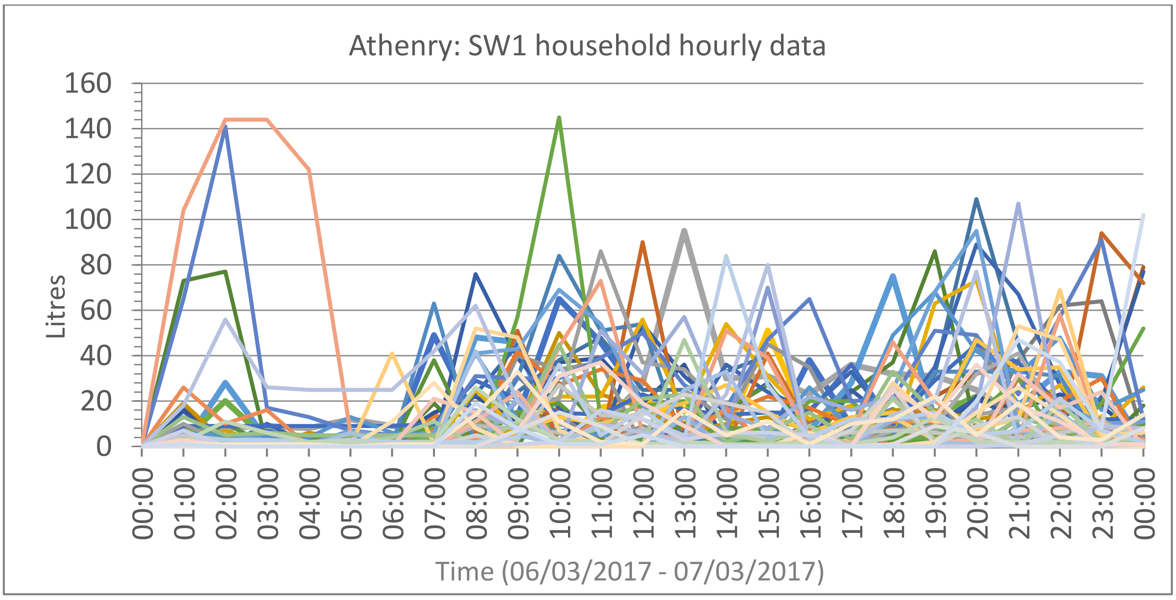

Figure 4.13 Hourly water usage data over a period of one day for n=60 houses in Athenry.

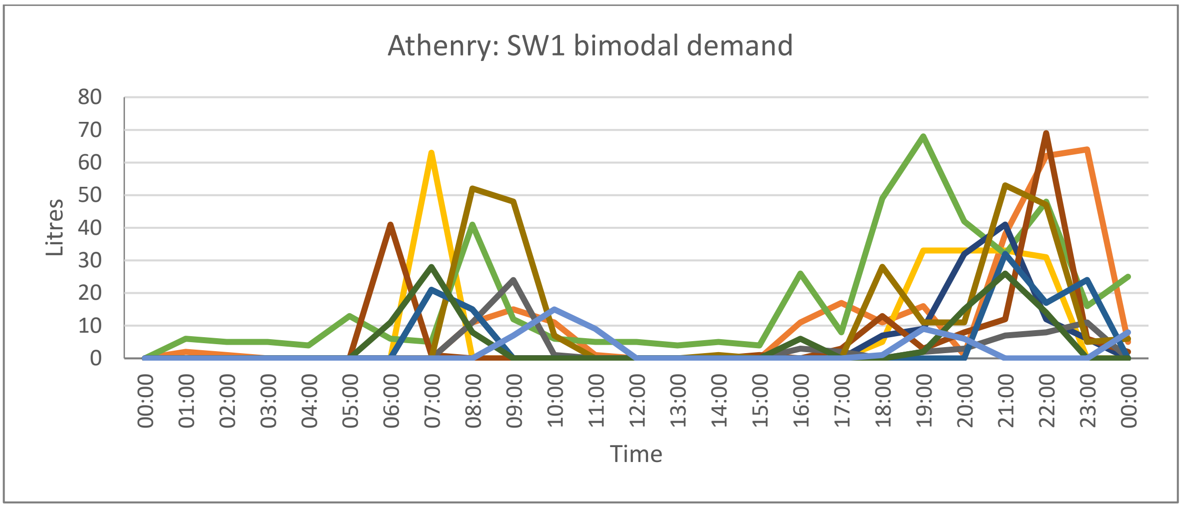

Figure 4.14 Bimodal usage apparent over 24 hours in a number of study houses.

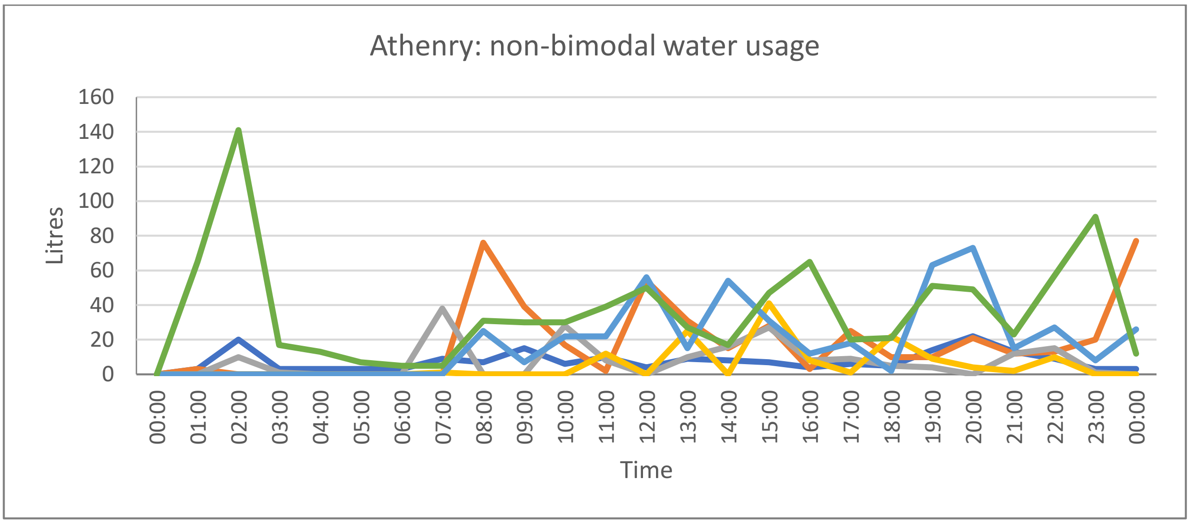

Figure 4.15 SW1 hourly data with consumption evident throughout the 24-hour period.

In summary, hourly data does hold potential value for understanding household water usage and can be valuable tool in order to identify peak times of usage. Any further research that intends to collect and utilise hourly meter data must consider the limited meter memory. Meters would have to be read more frequently to clear the meter memory and ensure an unbroken record. Finally, while hourly data is useful, finer resolution would provide greater opportunity to elucidate end-uses and any potential reductions brought about by the installation of water saving devices.

4.4 SW1 Water Diary: appliance usage

The water diary completed during SW1 provides a valuable insight into appliance usage and water end-uses in the home. Comprehensive data pertaining to water appliance usage is not readily available in Ireland. Previous research has used estimates based on various inferences (Dubber and Gill, 2013).

The usage of each appliance is presented on a household basis. Note, while these results provide an insight into appliance usage in Irish households, care must be taken when interpreting these results due to the relatively small sample sizes. The following usage is based on 42 and 53 households in Athenry and Douglas, respectively (i.e. the number of houses that returned the SW1 water diary).

Dishwasher

Dishwasher usage varied considerably between households (Figure 4.16 and 4.17). Thirty households in total (15 in Athenry and 15 in Douglas) do not use a dishwasher. On average the dishwasher was used 3.4 and 4.1 times per household per week in Athenry and Douglas, respectively. In terms of per capita usage, a dishwasher was used 0.16 (Athenry) and 0.19 (Douglas) times per capita per day.

As discussed in Section 2.3, there is common belief that a dishwasher uses more water than washing dishes by hand. This is often not the case, as dishwasher efficiency has improved in recent decades and the relative consumption of these appliances will depend on the respective ages of the washing machine versus the dishwasher in any individual household. Consequently, the houses that do not use a dishwasher may use more water. However, the water consumed during dish washing is likely to depend on the household and their practices. For instance, a dishwasher usage depends on the specific settings used, while the water consumed during hand washing dishes will depend on whether the tap is left running etc. Unfortunately, no information was available on dishwasher efficiencies, but more generic information has been provided in Section 2.3 previously.

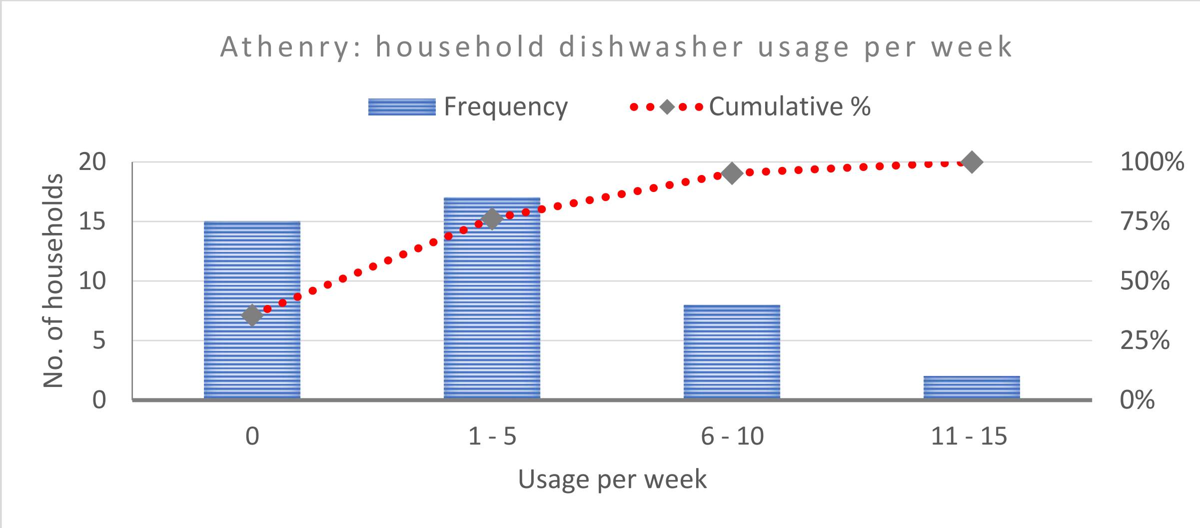

Figure 4.16 Dishwasher usage per week in Athenry.

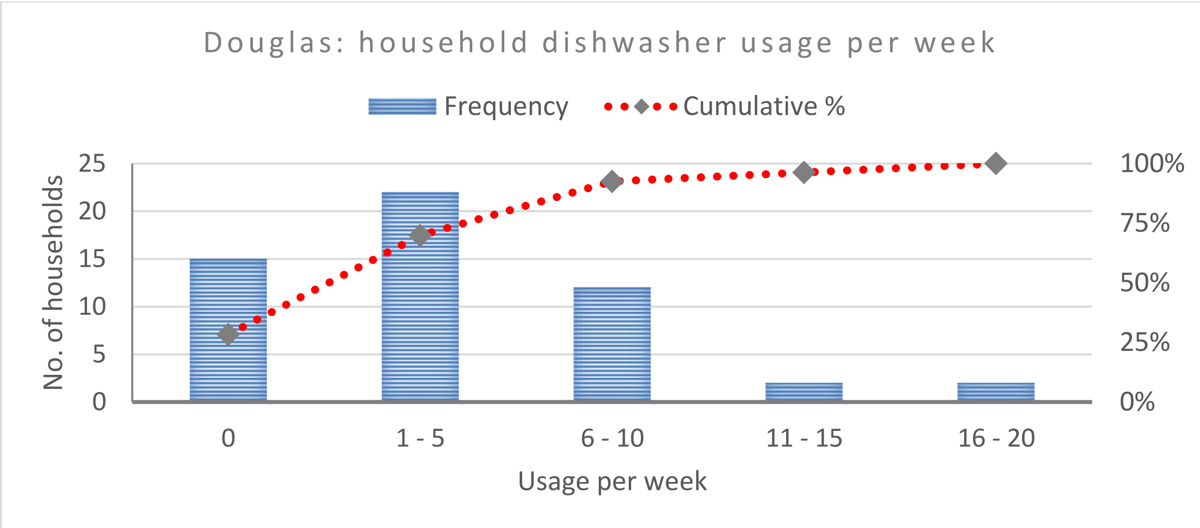

Figure 4.17 Dishwasher usage per week in Douglas.

Washing machine

With the exception of four houses in Athenry, all houses included in the study used a washing machine during the study week. Significant variation was again seen between houses (Figure 4.18 and 4.19). On average, houses used the washing machine 5.8 and 6.6 times per week in Athenry and Douglas, respectively. Per capita daily usage (0.3) was the same in both Athenry and Douglas. Again, unfortunately no information was available on washing machine efficiency. As with dishwashers, water usage depends on the specific settings used (but again more generic information has been provided in Section 2.3 previously).

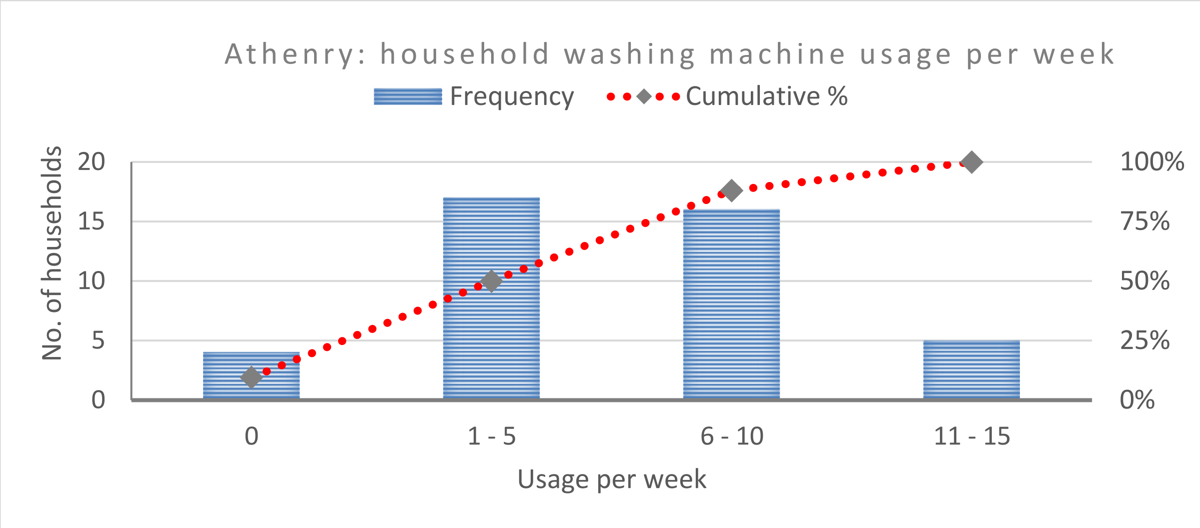

Figure 4.18 Washing machine usage per week in Athenry.

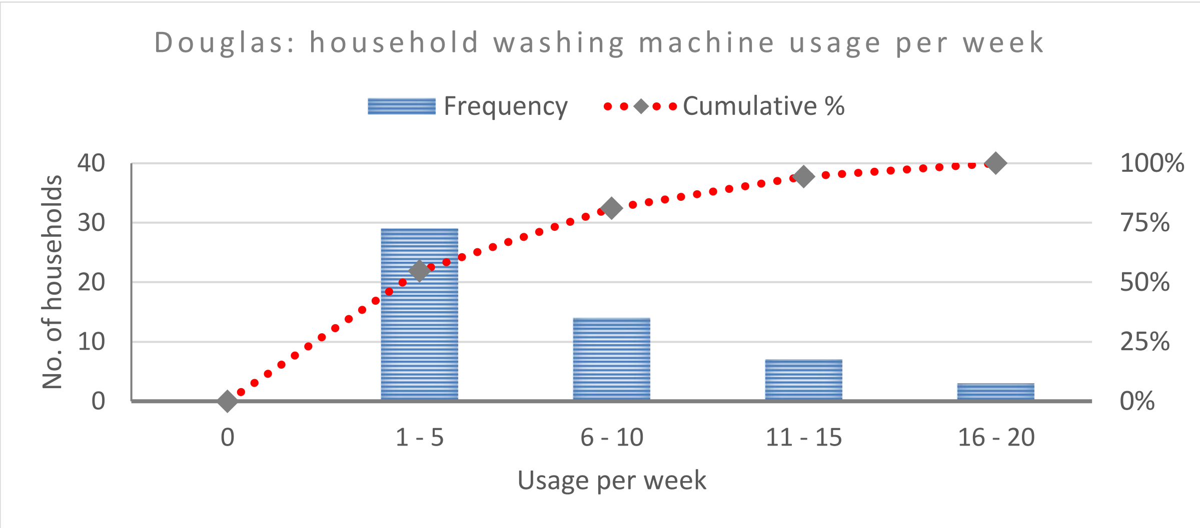

Figure 4.19 Washing machine usage per week in Douglas.

Kitchen sink tap

Kitchen sink usage during the study week is presented in Figures 4.20 and 4.21. On average, households in Athenry and Douglas used the kitchen sink tap 56 and 78 times per week, respectively. Daily per capita usage was 2.9 in Athenry and 3.8 in Douglas. While kitchen sink usage and the flow rate is known (from the water audit), the specific water volume of water used is difficult to estimate as the length for which tap was used is unknown.

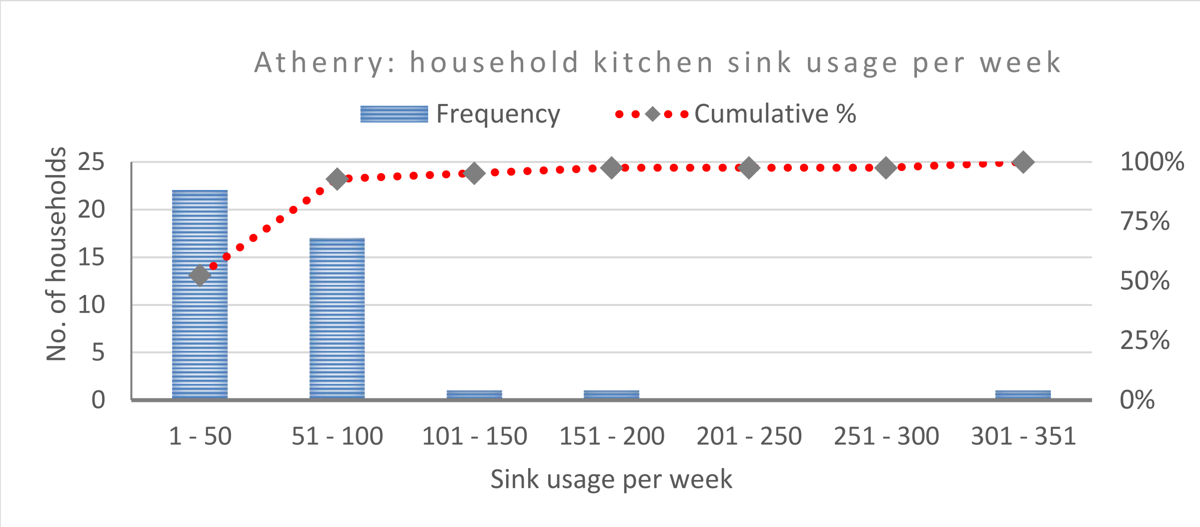

Figure 4.20 Kitchen sink usage per week in Athenry.

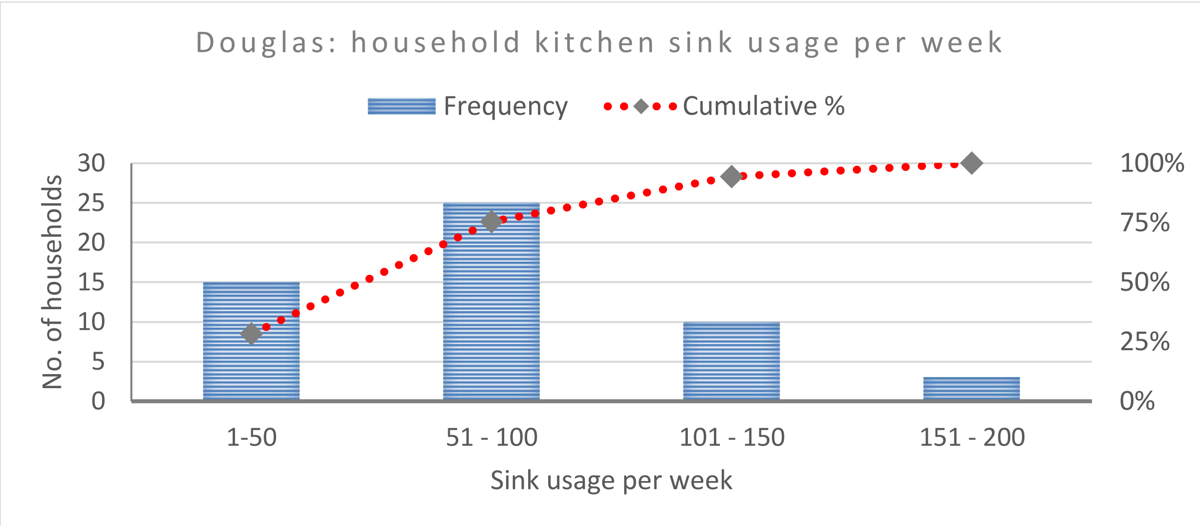

Figure 4.21 Kitchen sink usage per week in Douglas.

Toilets

The number of toilets in each household and the amount of flushes per week are shown in Figure 4.22 – 4.25. The number of toilets in the household is important as it governs how many water saving devices are required, and hence the investment needed by the householder. The number of flushes per week varies greatly. On average household's use 84 and 97 flushes per in Athenry and Douglas, respectively. Per capita daily usage ranged from 4.4 in Athenry to 6.7 in Douglas.

Unlike the sink tap usage, the volume of water used during each flush is constant (unless a dual flush toilet is in use), hence the potential for savings is easier to calculate (see Section 4.6). It should be noted that only 2 houses in the study (both in Athenry) had dual flush toilet systems installed.

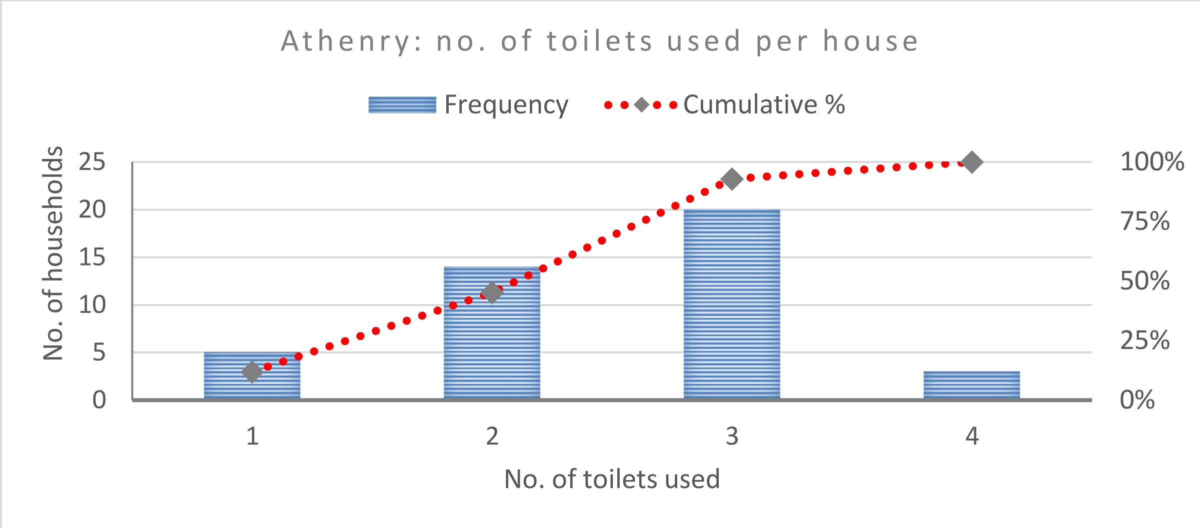

Figure 4.22 Number of toilets used per week in Athenry.

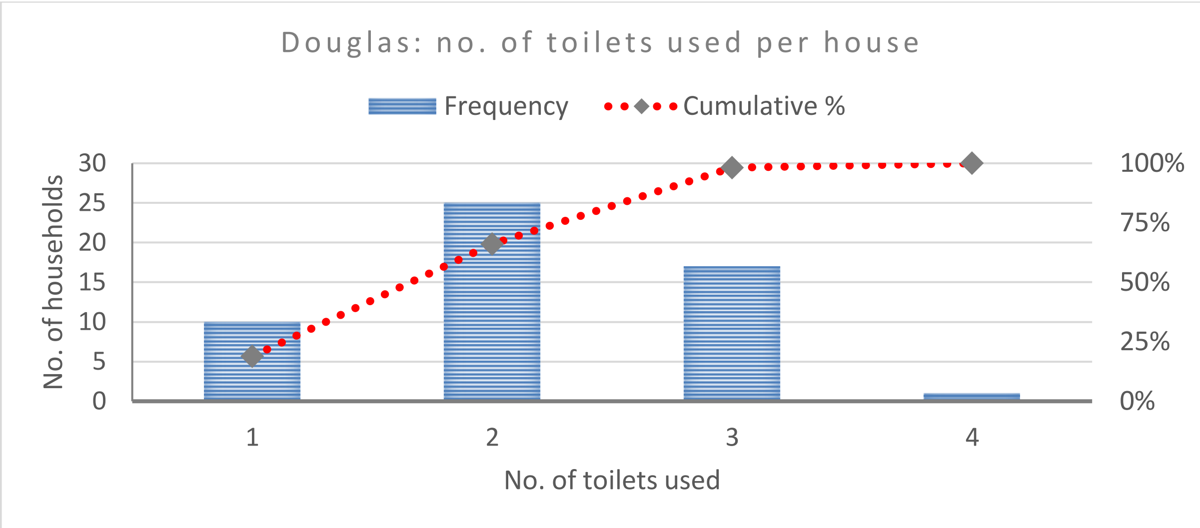

Figure 4.23 Number of toilets used per week in Douglas.

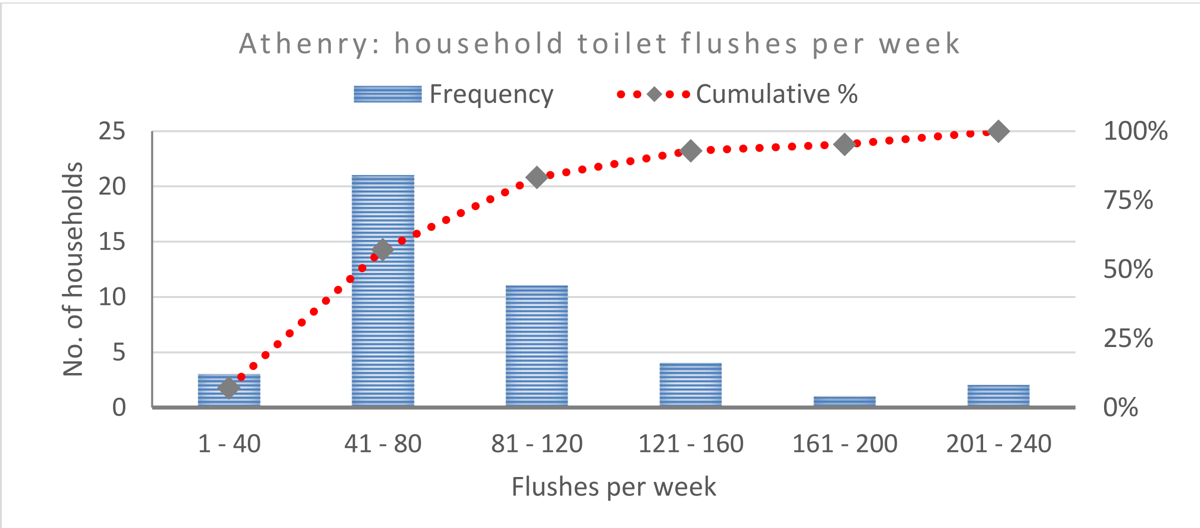

Figure 4.24 Number of toilets flushes per week in Athenry.

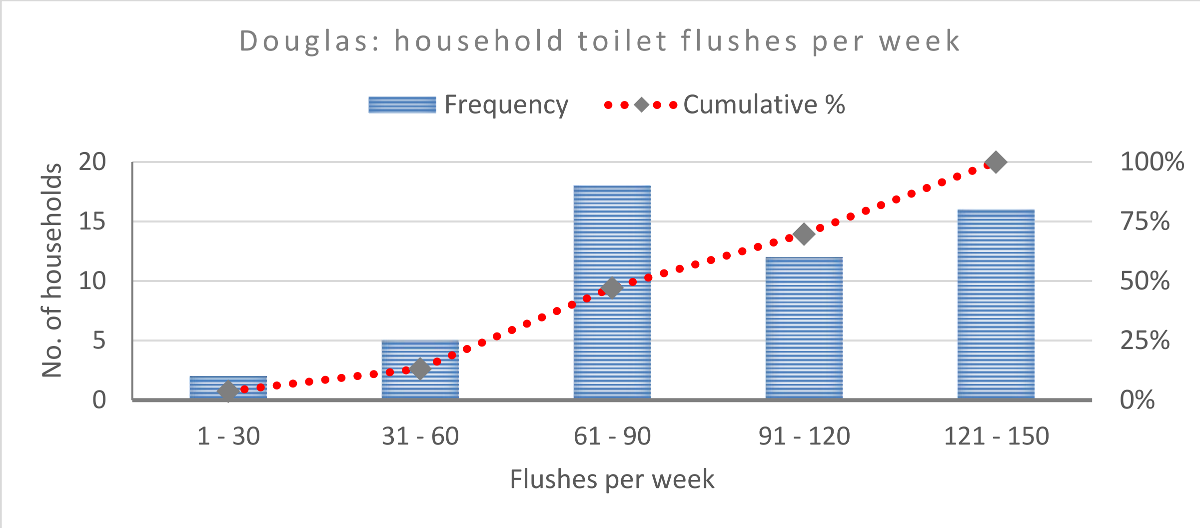

Figure 4.25 Number of toilets flushes per week in Douglas.

Showers and bath

The number of showers in each house and the weekly usages are shown in Figures 4.26 – 4.29. The majority of houses use one shower, while a small number of houses have either two or three in regular use. As the majority of households use just one shower the installation of a single water saving device (e.g. low flow shower head or Amphiro meter) could offer considerable savings with a short payback period. Note, any reduction in water usage during showering also offers notable savings in household energy bills.

The average daily per capita shower usage was identical for both Athenry and Douglas (0.63). Of note is the number of households that use baths per week. While the majority of houses prefer to use showers, 17 households in Athenry and 13 houses in Douglas (most of which households contained children) use a bath at least once per week (see Figure 4.30 and 4.31). This suggests that appreciable savings would be attainable for a number of houses by switching from using a bath to using a shower.

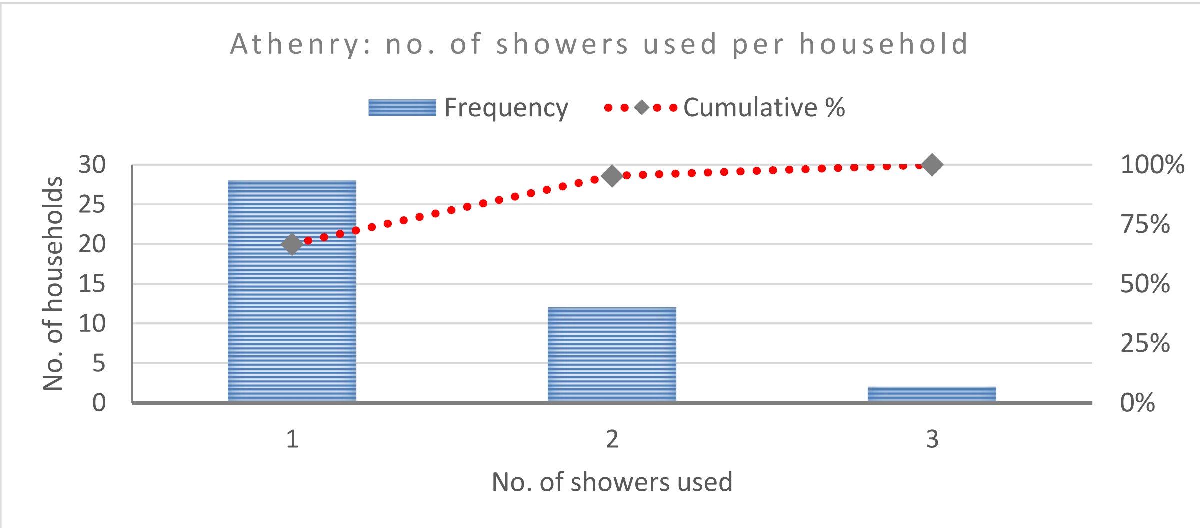

Figure 4.26 Number of showers per week in Athenry.

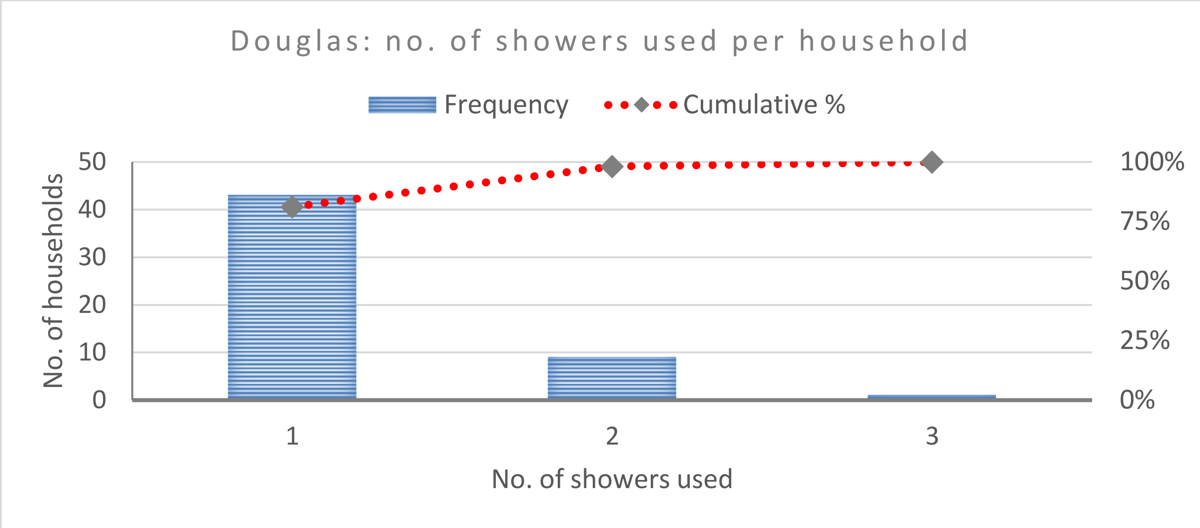

Figure 4.27 Number of showers per week in Douglas.

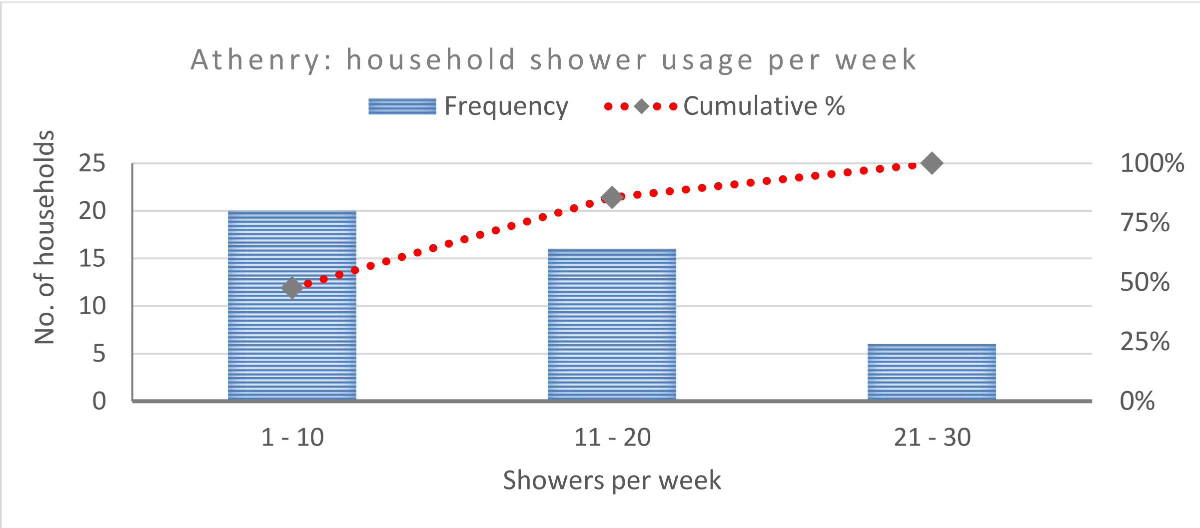

Figure 4.28 Showers usage per week in Athenry.

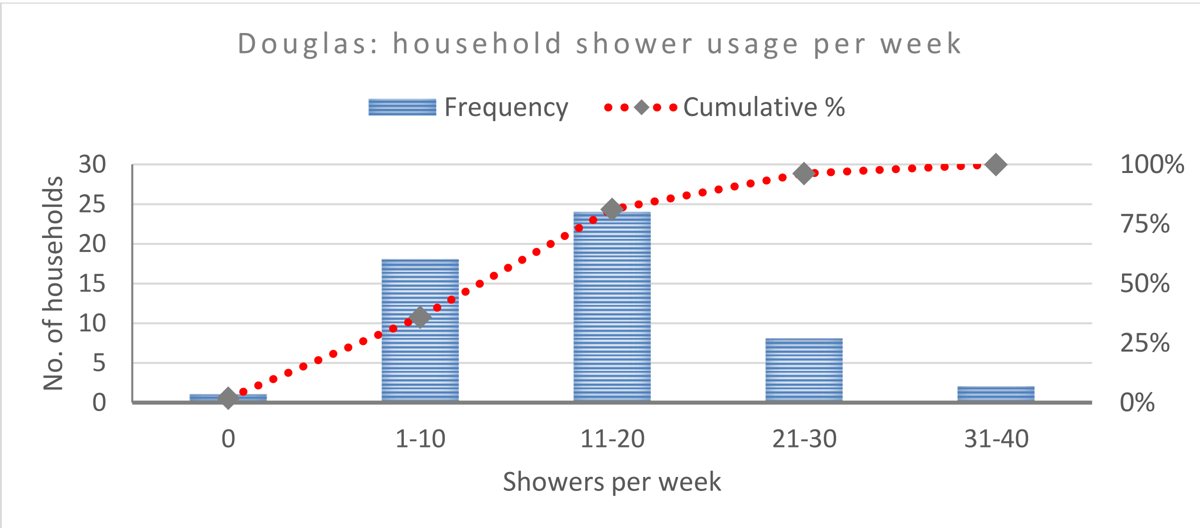

Figure 4.29 Showers usage per week in Douglas.

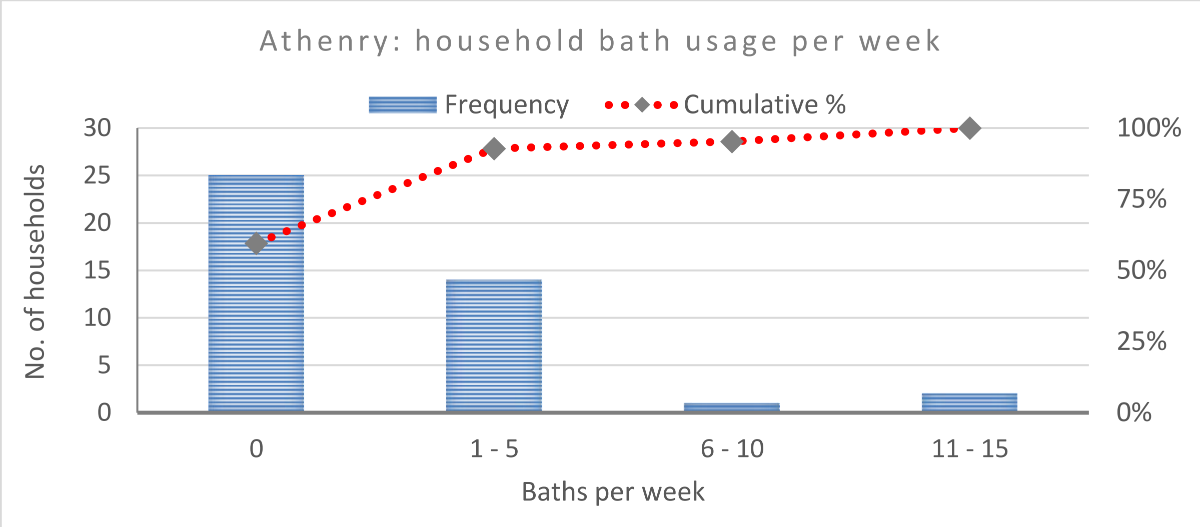

Figure 4.30 Bath usage per week in Athenry.

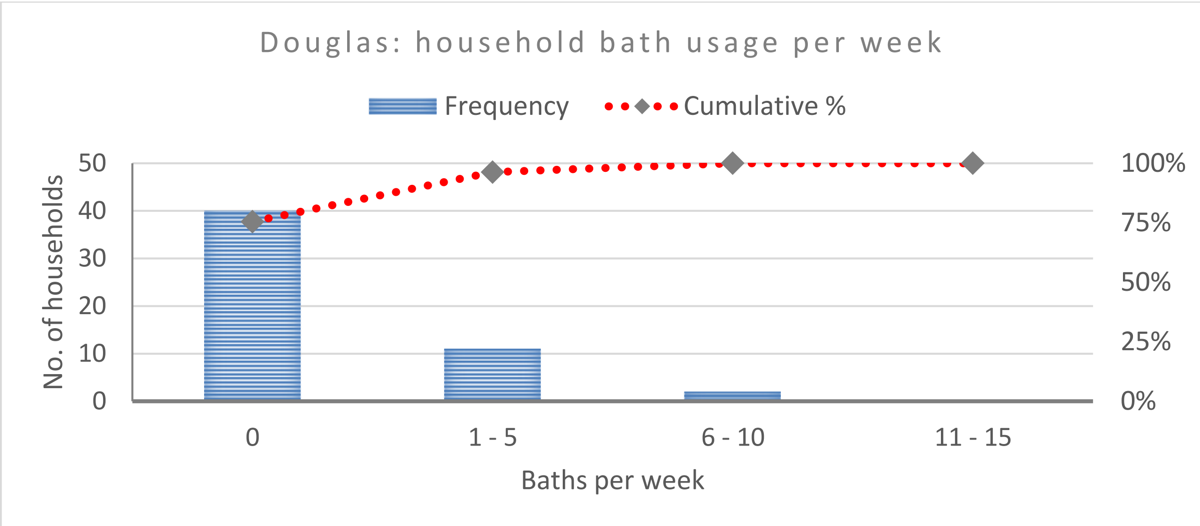

Figure 4.31 Bath usage per week in Douglas.

Sinks

The number of sinks in each house and the weekly usages are shown in Figures 4.32 – 4.35. On average, houses in Athenry used a sink 89 times per week, while houses in Douglas used the sink 107 times during the study week. There were approximately 5 uses per capita per day in both areas. As discussed with respect to kitchen sinks, the volume of water used during each tap "usage" was not identifiable in this current research. Nonetheless, savings would no doubt have been realised, where flow regulators or aerators are installed.

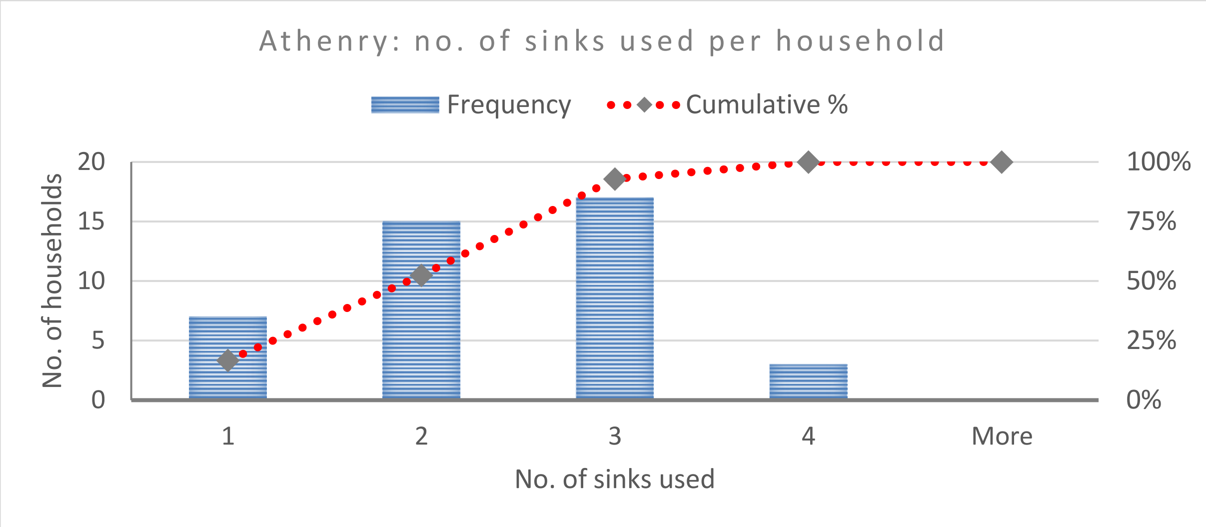

Figure 4.32 Number of sinks used per week in Athenry.

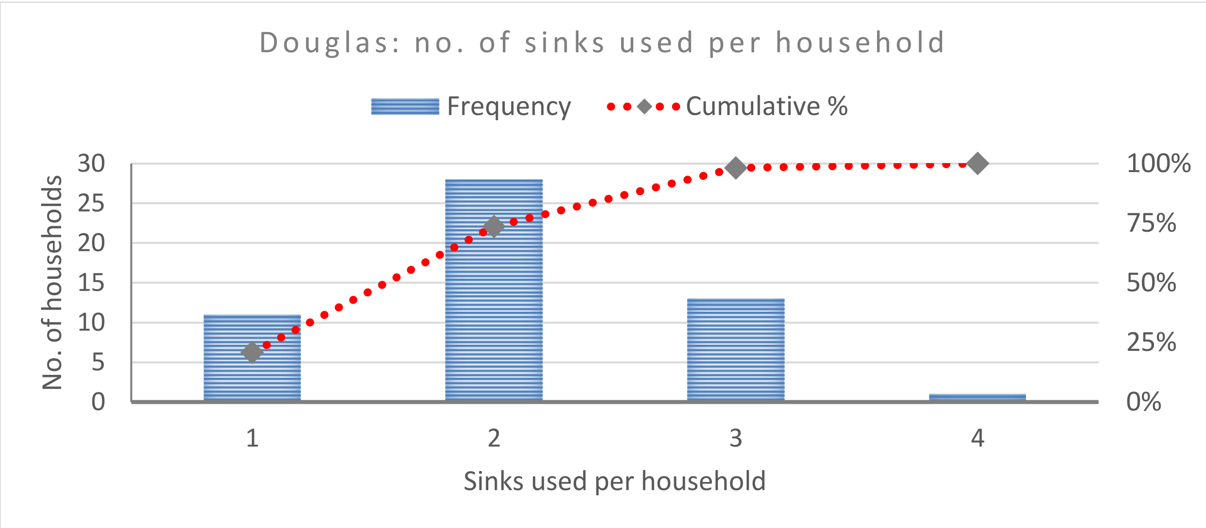

Figure 4.33 Number of sinks used per week in Douglas.

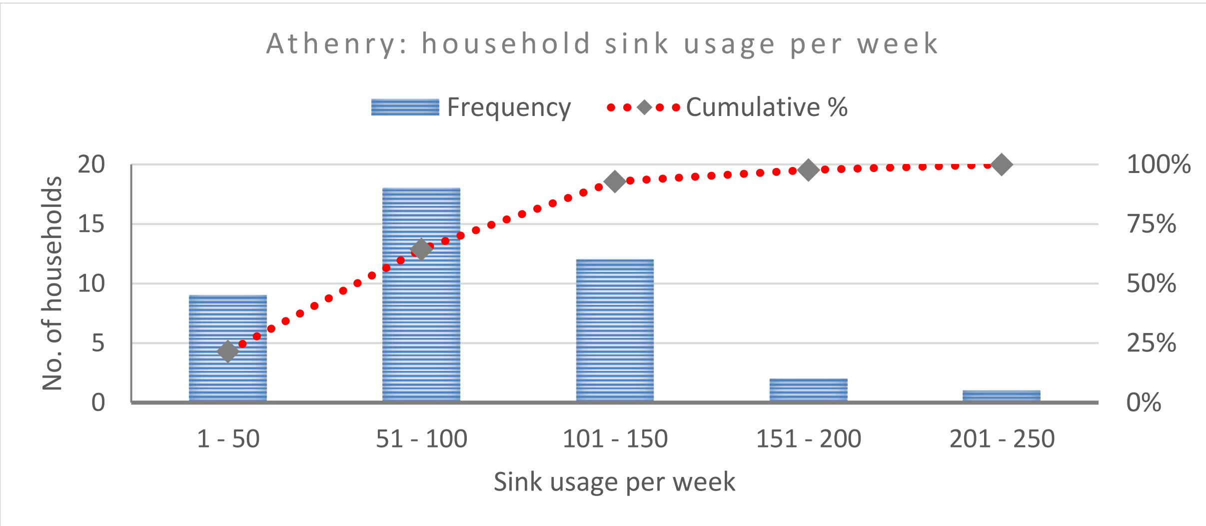

Figure 4.34 Sink usage per week in Athenry.

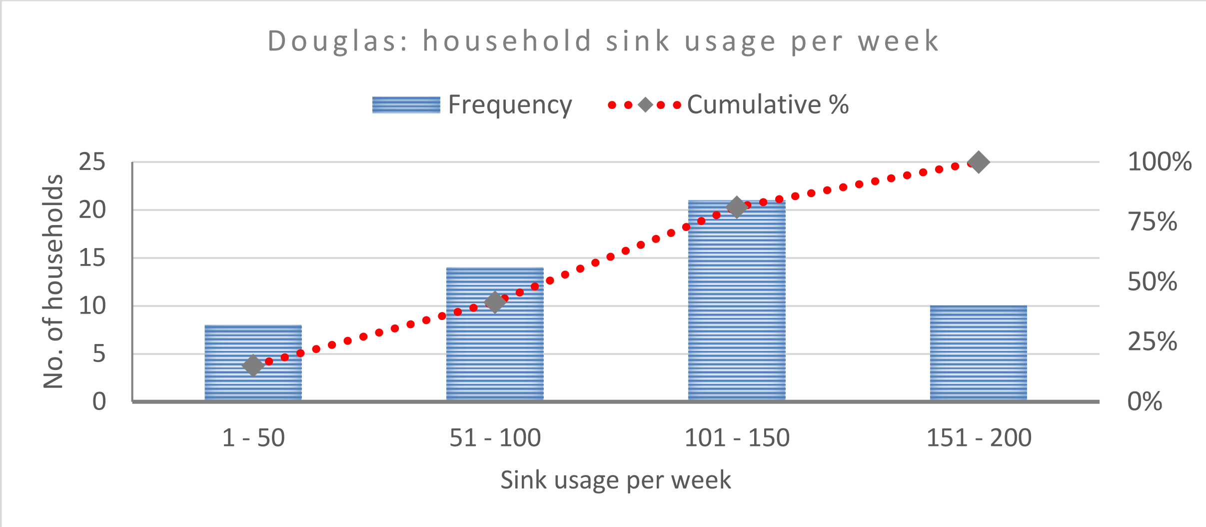

Figure 4.35 Sink usage per week in Douglas.

4.5 Audit and device installation

As outlined in Section 3.1, a water usage audit was carried out by an independent contractor in participating houses. The flow rates for household appliances were measured and water saving devices were fitted where suitable. The following section provides a summary of the household devices audited and the associated flow rates. This data provides a unique insight into water usage appliances in Ireland, and hence the potential scope for the installation of water saving devices. The reduction in flows rates measured on-site following the fitting of the devices also shows clearly that, if these devices are used appropriately, they can assist in water conservation measures.

Note, while 144 houses initially agreed to participate in the research, several refused the water audit and/or the installation of water saving devices (see Table 4.3). These houses provide little value to the analysis and hence have been removed from the following summary. This left 48 households in Athenry and 64 households in Douglas it the study at this stage. The proportion of refusal should however be used to inform any future research, as larger sample sizes would be required to provide more robust data analysis and derived conclusions. The water saving devices installed during the research are outlined in Figures 4.36 and 4.37. The specific distribution of devices installed in each of the houses is illustrated in Appendix 2.

Table 4.3 Proportion of houses that refused an audit and/or the installation of water saving devices.

	Athenry	Douglas
No. of houses called to by contractor	63	81
No. of houses that refused audit and/or the installation of water saving devices	15	17

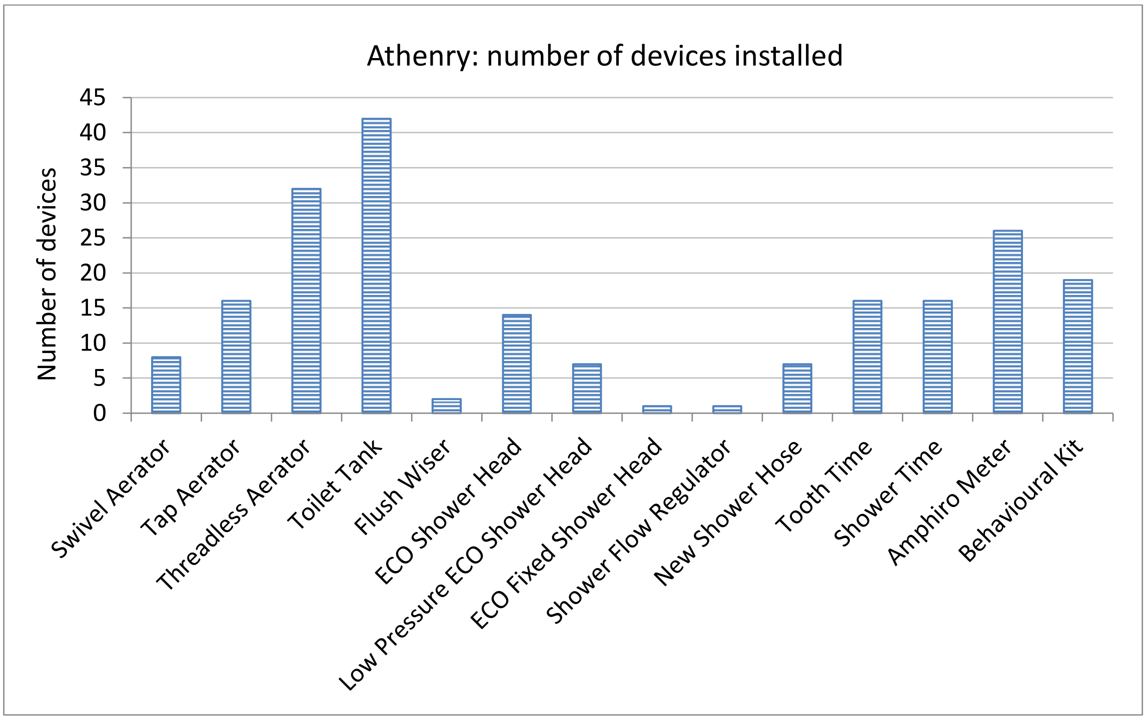

Figure 4.36 Number of water saving devices installed in 48 participating households in Athenry.

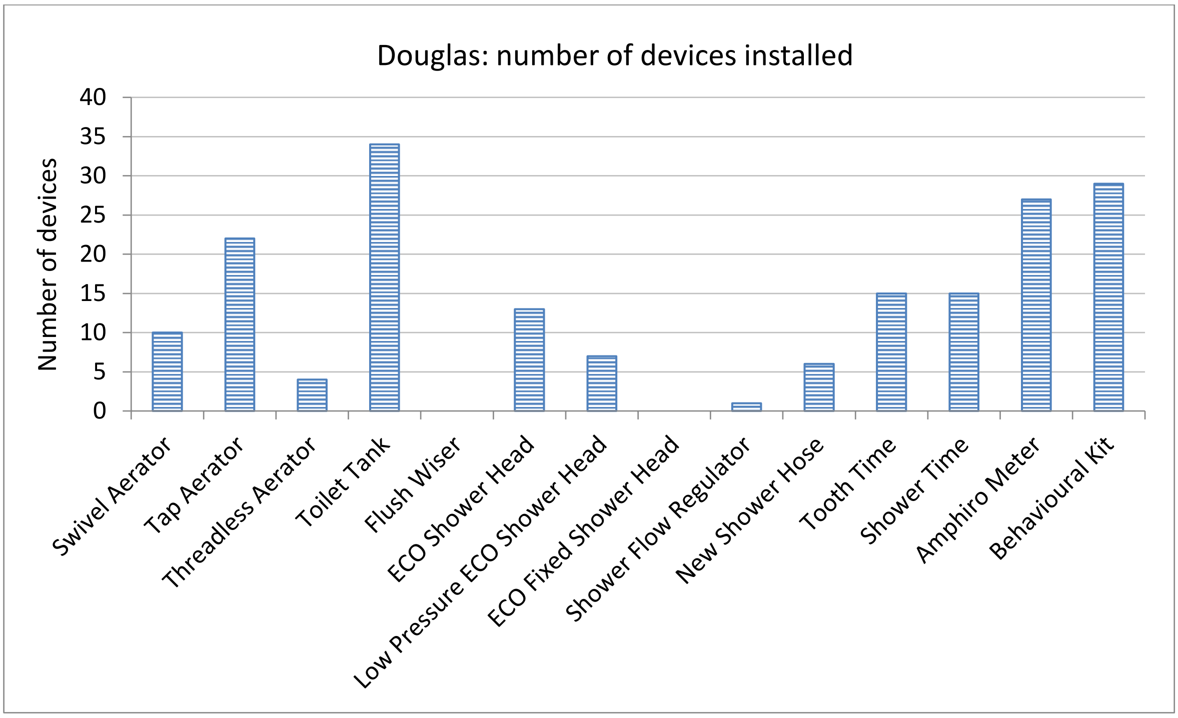

Figure 4.37 Number of water saving devices installed in 64 participating households in Douglas.

Kitchen sink

A summary of the findings from the audit of kitchen taps in Athenry and Douglas is presented in Table 4.4. Average, median, maximum and minimum flow rates are notably similar between Douglas and Athenry. The large range in flow rates between houses suggests that there is scope for an improvement in kitchen tap efficiency in a large number of homes.

Table 4.4 Summary statistics for kitchen tap flow rates measured in audited houses (litres/minute).

	Athenry	Douglas
Mean flow rate	15.8	15.2
Median flow rate	16	16
Max. flow rate	22	25
Min. flow rate	8	8

For the taps that were fitted with water saving devices, Table 4.5 illustrates the initial flow rates, the devices installed, the flow rates post installation and the percentage reduction. The swivel aerator was fitted to 18 taps and brought about an average reduction in flow of 45%. The ordinary tap aerator was fitted to eight taps and brought about a similar average flow reduction of 45%. Significant reductions are observed.

Table 4.5 Initial flow rates of kitchen taps fitted with water saving devices, the flow rates after installation and the percentage reduction (flows in litres/minute).

Household	Initial flow rate	Swivel aerator fitted	Tap aerator fitted	Flow rate after	% reduction
1	13	1	0	8	38
2	15	1	0	7.5	50
3	14	1	0	8	43
4	15	1	0	8	47
5	15	1	0	8	47
6	16	1	0	7.5	53
7	12	1	0	7	42
8	16	1	0	8	50
9	12	1	0	7.5	38
10	22	1	0	8	64
11	16	1	0	8	50
12	12	1	0	8	33
13	12.5	1	0	7.5	40
14	15	1	0	7	53
15	15	1	0	8	47
16	11	1	0	7.5	32
17	13	1	0	8	38
18	15	1	0	7.5	50
19	15	0	1	7	53
20	10	0	1	7.5	25
21	16	0	1	7.5	53
22	12	0	1	7	42
23	12	0	1	7.5	38
24	17	0	1	7.5	56
25	13	0	1	7	46
Mean ±SD	***14.2 ±2.4***	-	-	***7.6 ±0.4***	***45.1 ±8.5***

Toilet

As discussed in Section 4.4, most houses use more than one toilet. Figure 4.38 illustrates the flush characteristics for all of the toilets audited as part of this research. Of the 122 toilets audited in Athenry (in 48 houses), just 13 were dual flush toilets. Of the 145 toilets audited in Douglas (in 64 houses), just 39 were dual flush toilets. In view of the relatively small number of dual flush toilets coupled with the number of single flush toilets that use 7 and 9 litres per flush, there is clearly scope for a reduction in flush volumes by the replacement single flush cistern with dual flush mechanisms.

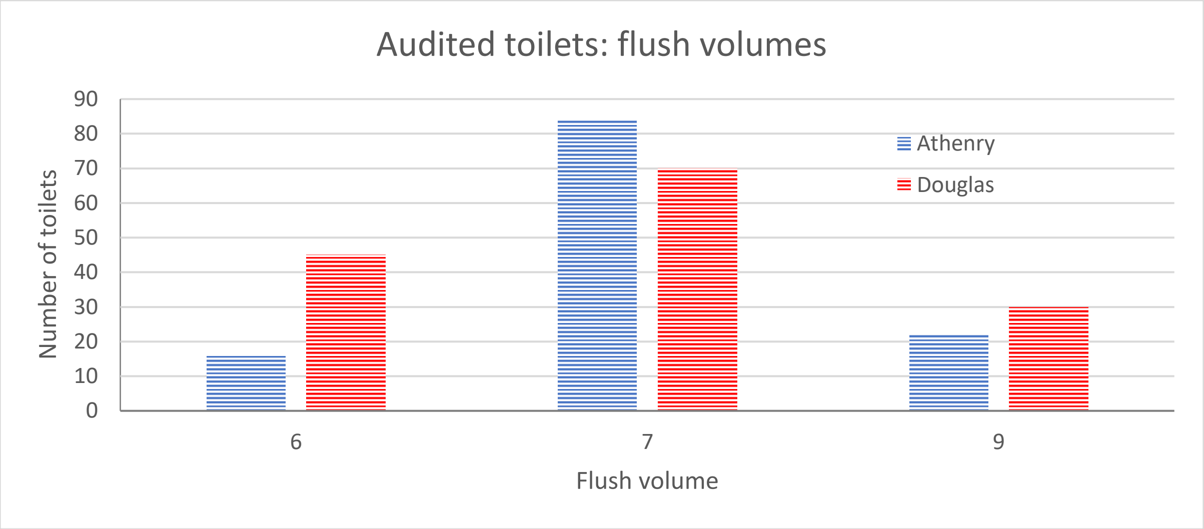

Figure 4.38 Flush volumes of toilets audited in Athenry and Douglas.

Flush wiser devices were installed in two separate houses. The devices reduced flush volumes from 9 L to 7.5 L in both houses. Toilet tanks were installed in 20 houses each in Athenry and Douglas. In total, toilet tanks were fitted to 42 and 30 toilets in Athenry and Douglas, respectively. Toilet tanks were installed in either 9 or 7 litre toilets (flush volume) and reduced water usage per flush by 1 litre (i.e. to 8 or 6 litres per flush, respectively).

Sink

As presented in Section 4.4, most houses have several wash basins which means there are several sets of taps in each house. Depending on the design, each sink may have two taps (i.e. an individual hot and cold) or a single tap (i.e. a mixer tap). This has obvious implications when installing water saving devices as it dictates the quantity of devices required. For the following review of audit results, flow rates are given on a per wash basin basis. Therefore, where an individual basin has two taps (i.e. individual hot and cold) a single average value flow rate is provided. Where there is a single mixer tap a single flow value is provided.

The audit assessed 125 and 140 basins in Athenry and Douglas, respectively. Summary statistics for the flow rates measured prior to the installation of water saving devices are provided in Table 4.6.

Table 4.6 Audit flow data for basin taps (litres/minute).

	Athenry	Douglas
Mean flow rate	11.2	10.5
Median flow rate	12	11
Max. flow rate	16	18
Min. flow rate	4	3.5

In total, 25 mixer taps were fitted with a tap aerator (see Table 4.7). On average, these aerators reduced flow by 62%. Individual savings ranged from 50 – 79%. Twenty basins with individual hot and cold faucets were fitted with thread-less tap aerators (i.e. each basin received two aerators each) (see Table 4.8). On average, these aerators reduced flow by 49% with individual savings ranging from 42 – 54%.

Table 4.7 Initial flow rates of mixer basin taps fitted with a tap aerator, the flow rates after installation and the percentage reduction (flows in litres/minute).

Area	Initial flow	Flow after	% reduction
Athenry	8	3.5	56
Athenry	8	3.5	56
Athenry	9	4	56
Athenry	15	3.8	75
Athenry	8	3.5	56
Athenry	7	3.5	50
Athenry	8	3.5	56
Athenry	9	4	56
Athenry	10	4	60
Athenry	9	3.8	58
Athenry	10	4	60
Athenry	12	3.5	71
Douglas	12	3.8	68
Douglas	6.5	3	54
Douglas	14	5	64
Douglas	8	4	50
Douglas	18	5	72
Douglas	9	4	56
Douglas	18	3.8	79
Douglas	12	3.5	71

Douglas	10	3.5	65
Douglas	8	4	50
Douglas	10	3	70
Douglas	7	3	57
Douglas	18	3.8	79
Mean ±SD	***10.5 ±3.4***	**3.8 ±0.5**	***61.8 ±8.8***

Table 4.8 Initial flow rates of basin taps fitted with thread less tap aerators, the flow rates after installation and the percentage reduction (flows in litres/minute).

Area	Initial flow	Flow after	% reduction
Athenry	12	6	50
Athenry	13	6.5	50
Athenry	16	8	50
Athenry	14	7	50
Athenry	12	6	50
Athenry	12	6	50
Athenry	12	6	50
Athenry	13	6.5	50
Athenry	16	8	50
Athenry	12	5	42
Athenry	14	7	50
Athenry	12	6	50
Athenry	12	6	50
Athenry	13	6.5	50
Athenry	16	8	50
Athenry	12	5	42
Athenry	14	7	50
Athenry	12	6	50
Douglas	12	6.5	54
Douglas	12	6	50
Mean ±SD	***13.1 ±1.4***	***6.5 ±0.8***	***49.4 ±2.6***

Showers

In total, 88 and 103 showers were audited in Athenry and Douglas, respectively. The types and numbers of showers encountered are illustrated in Figure 4.39. Electric showers were the most common type encountered in both areas, followed by electric pumped, bath tap mixer hose and pumped power. Reviews of the flow rates measured for each shower type (prior to the installation of water saving devices) are illustrated in Tables 4.9 and 4.10 (for Athenry and Douglas, respectively).

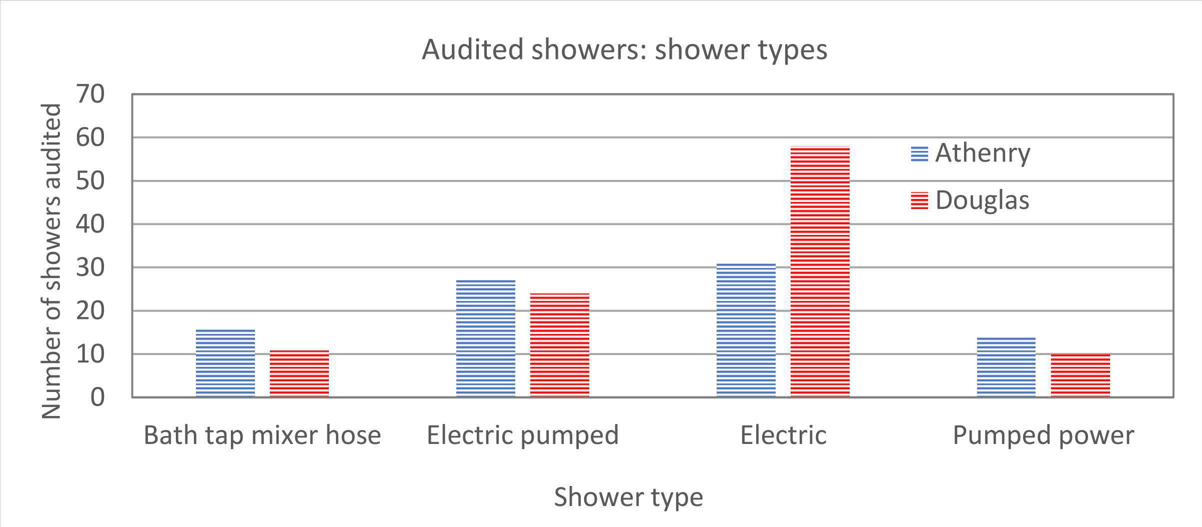

Figure 4.39 Types of showers audited during the research.

Table 4.9 Summary statistics for shower flow rates (Athenry).

	Flow rate (Litres / minute)			
Shower type	**Average**	**Median**	**Max**	**Min**
Bath tap mixer hose	7.3	7	15	4
Electric pump	11.4	12	16	7
Electric	7.3	7	9	6
Pumped power	13.7	14.5	20	5

Table 4.10 Summary statistics for shower flow rates (Douglas).

	Flow rate (Litres / minute)			
Shower type	**Average**	**Median**	**Max**	**Min**
Bath tap mixer hose	7.4	7.5	11.0	5.0
Electric pump	9.0	8.5	16.0	6.0
Electric	6.7	7.0	11.0	4.0
Pumped power	10.7	11.0	16.0	5.0

The number of water saving devices installed in showers was outlined in Figure 4.36 and 4.37. Note, the shower timer and Amphiro meter aim to influence user behaviour and hence a reduction in flow rate would not be expected. Flow rates were, however, measured after the installation of the various water saving shower heads and flow regulators. Flow rates before and after the installation of water saving devices are presented in Tables 4.11, 4.12 and 4.13.

The ECO shower head was installed in 15 and 13 houses in Athenry and Douglas, respectively. On average, the device reduced flow rates by 43%, with individual reductions ranging from 25 – 60%. The lower pressure ECO shower head was installed in six and five houses in Athenry and Douglas, respectively. On average, flow rates were reduced by 28%, with individual reductions ranging from 18 – 46%. Shower flow regulators were fitted in just two showers. While the flow regulator reduced flow rates by 58 and 38%, the small sample size must be appreciated.

Table 4.11 Initial flow rates of showers fitted with ECO shower heads, the flow rates after installation and the percentage reduction (flows in litres/minute).

ECO shower head installation			
Area	**Initial flow**	**Flow after**	**% reduction**
Athenry	15	7	53
Athenry	20	8	60
Athenry	16	7	56
Athenry	12	7	42
Athenry	15	7.6	49
Athenry	12	8	33
Athenry	8	6	25
Athenry	7.5	5.5	27
Athenry	13.5	6.5	52
Athenry	14	8.5	39
Athenry	13.5	6.5	52
Athenry	8.5	6	29
Athenry	14	7	50
Athenry	20	8	60
Athenry	14	7	50
Douglas	10	6.5	35

Douglas	10.5	7	33
Douglas	9	6.5	28
Douglas	9	6	33
Douglas	10	6	40
Douglas	9.5	6	37
Douglas	12	7	42
Douglas	11	6.5	41
Douglas	16	7.5	53
Douglas	11	6.5	41
Douglas	15	7	53
Douglas	13	7	46
Douglas	9.5	6	37
Mean ±SD	***12.4 ±3.2***	***6.8 ±0.7***	***42.7 ±10.0***

Table 4.12 Initial flow rates of showers fitted with Low Pressure ECO shower heads, the flow rates after installation and the percentage reduction (flows in litres/minute).

Low Pressure ECO Shower Head			
	Initial flow	**Flow after**	**% reduction**
Athenry	14	10	29
Athenry	7	5.5	21
Athenry	8	6	25
Athenry	8	6	25
Athenry	12	6.5	46
Athenry	12	7	42
Douglas	11	8	27
Douglas	7.5	6	20
Douglas	6.5	5	23
Douglas	8.5	7	18
Douglas	8	5.5	31
Mean ±SD	***9.3 ±2.4***	***6.6 ±1.3***	***27.9 ±8.5***

Table 4.13 Initial flow rates of showers fitted with shower flow regulators, the flow rates after installation and the percentage reduction (flows in litres/minute).

Shower flow regulator			
	Initial flow	**Flow after**	**% reduction**
Athenry	18	7.5	58
Douglas	16	10	38

4.6 Potential for savings

Previous EPA funded research outlined by Dubber and Gill (2013) estimated the potential savings attainable through the installation of water saving devices in Ireland. This research assumed an average per capita water consumption of 150 Lcd and used the breakdown of end-uses determined by Liu *et al.* (2010) (see Figure 2.3) to estimate the number of times various water appliances were used. For instance, Liu *et al.* (2010) found that approximately 28% of household water usage was used by flushing the toilet. Dubber and Gill (2013) assumed an average toilet flush to use approximately 9 L, and hence calculated that the average person uses the toilet 4.66 times per day.

The study was then able to assess the savings offered by various devices that reduced the flush volume of a toilet. This compares to the findings from this study which found the mean per capita daily toilet flushing frequency of 4.4 in Athenry and 6.7 in Douglas (with mean flush volumes of 7.2 and 7.1 litres respectively).

The findings from Dubber and Gill (2013), although useful and based on the best available data and estimates at the time, are approximate. The assumptions that were required by Dubber and Gill (2013) highlight the general lack of information regarding household water consumption and specific end-uses in Ireland. However, since the completion of the Dubber and Gill (2013) study, the data obtained from this research, coupled with improved household water usage data that has been brought about by the national domestic metering programme, has provided a greater insight into water and appliance usage in Irish homes. The research by Dubber and Gill (2013) was conducted prior to the installation of household water meters in Ireland, and hence, the estimate of 150 Lcd, although reasonable at the time, is now known to be an over estimation (see Section 2.2).

Furthermore, while Dubber and Gill (2013) had to estimate appliance usage based on UK studies and several inferences, the water diary developed as part of this study provides a direct indication into the frequency of appliance usage in Irish households. In addition, the audit data (see Section 4.4) provides an insight into the flow characteristics (i.e. water usage) of the appliances, which was also estimated by Dubber and Gill (2013).

The following section builds upon the work of Dubber and Gill (2013) and develops estimates that illustrate how much water the households that participated in this research could save by installing various water saving devices. Using flow data obtained by the household audit and appliance usage frequency obtained from the water diary, the following section calculates the volume of water used by appliances during SW1. The potential savings attainable through the use of water saving device are then calculated.

Note, potential savings can only be calculated for all suitable houses in the study that returned the first water diary and also agreed to a household audit: 35 and 49 households in Athenry and Douglas returned the diary and agreed to a water audit, respectively. For the houses that did not return the diary there is no data on their appliance usage, and for houses that refused the audit there is no data on appliance water usage.

The potential for savings are not easily determinable for all water usage appliances. For instance, savings achievable through the installation a device that reduces a toilet's flush volume (e.g. a toilet tank) are easily calculable as the toilet is used in distinct usage events. However, for kitchen or bathroom taps, potential savings are difficult to quantify. Firstly, the duration for which each tap is used is unknown, and will likely vary between each use. For instance, for a kitchen tap it may be used to fill the sink, fill a glass or to wash hands. While the water diary recorded the number of uses and the audit recorded the average flow rate, the duration of each use is unknown. Hence, the potential for savings cannot be reliably calculated. Note, the percentage flow reductions still provide an indication of the general reductions in usage.

The following section also assesses the monetary savings that can be achieved through installing water saving devices. These savings can be used to determine the payback period for investment in each device. Although water charges are currently suspended, previous rates were set at €1.85/m³ when a single service is used (i.e. either water supply or wastewater services) and €3.70/m³ where both water and wastewater services are used (Irish Water, 2017). Note both water and monetary savings are based on just one week's usage. This does not account for temporal variation in appliance usage from week to week.

Toilet Tank Bank

As discussed in Section 3.2, toilet tanks displace water from the cistern and can reduce flush volumes by up to 2 litres. Based on the toilet audit data (flush volume) and water diary returns (number of flushes), this section assesses the potential savings attainable through the installation of these displacement devices. Potential savings were calculated for a 1 litre reduction as this was deemed most suitable by the independent contractor.

Of the houses that returned the water diary and agreed to the audit, 4 (out of the remaining total of 48 in Athenry) and 18 (out of the remaining total of 48 in Douglas) were already using dual flush toilets (6 L), and hence are excluded from the dataset. As outlined by Dubber and Gill (2013) some consideration must be given to the toilet type and flush volume before a water saving device that reduces flush volume is fitted. A reduction in volume can lead to a higher possibility of restricted performance. Toilets may need to be cleaned more often, and, also if the technology is not appropriate (i.e. if the designs of flush valves and bowls are not adapted properly to the low flush volume), the need for double flushing might arise and the expected water saving would not be achieved (Dubber and Gill, 2013). Consideration must also be given to the effect of reducing flow volumes on the movement of the waste through pipes.

The volume of water used per day by the 31 households in each of the areas for toilet flushing is illustrated in Figure 4.40 and 4.41. These volumes are calculated based on the household's toilet usage (obtained from the water diary completed during SW1) and the audit data which outlines the flush volume used by each toilet in that household.

Based on toilet usage during SW1 and the audit data, the savings that would have been attained had a Toilet Tank Bank been fitted are presented in Table 4.14 and Figures 4.40 and 4.41. On average, based on these results, households would have saved 12 L and 13 L per day in Athenry and Douglas, equating to mean percentage reductions of 13.5 % and 13.4% respectively, through the installation of a Toilet Tank Bank. Savings naturally depend on how many times the toilet is flushed each day, with savings ranging from 31 to 3 L per day. Average per capita savings are 4 and 5 L/d for Athenry and Douglas, respectively.

Table 4.14 Savings attainable from a Toilet Tank Bank (Litres/day).

		Average	**Maximum**	**Minimum**
Per household	Athenry	12	31	5
	Douglas	13	21	1
Per capita	Athenry	4	10	2
	Douglas	5	10	0.8

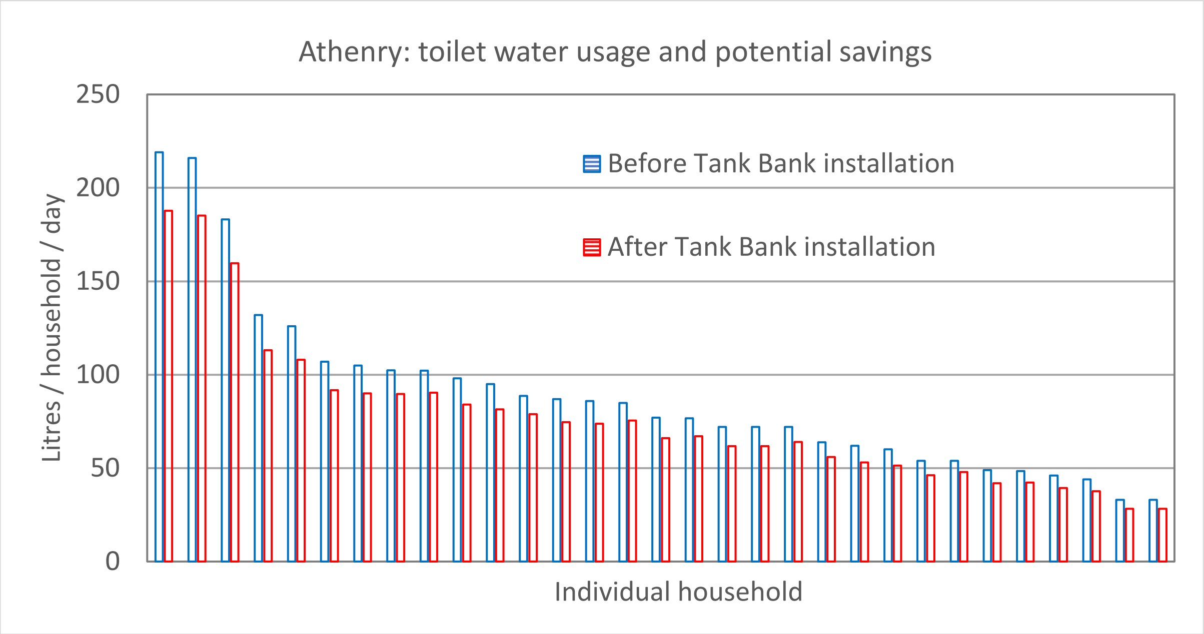

Figure 4.40 Water usage by toilets during SW1 and the potential savings attainable through the installation of water saving devices.

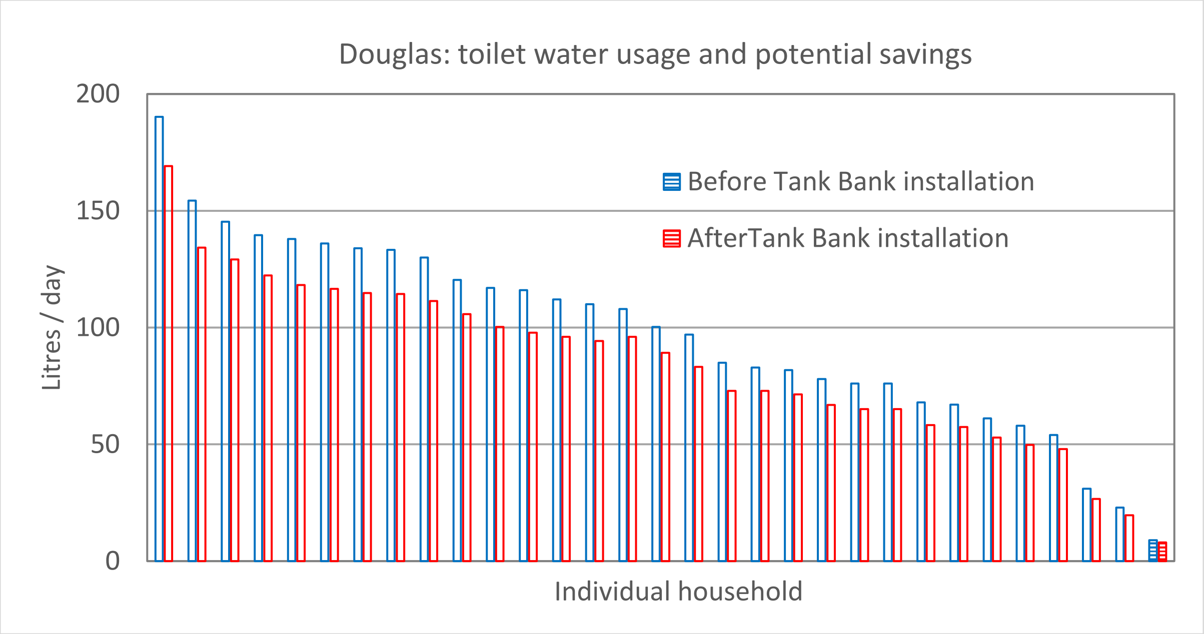

Figure 4.41 Water usage by toilets during SW1 and the potential savings attainable through the installation of water saving devices.

Assuming a water charge rate of €3.70 per m^3, and provided the flush volume is reduced by 1 L, the Toilet Tank Bank would save €0.0037 per flush. The unit price of the Toilet Tank Banks installed during this research was €5.99. The cost of installing Toilet Tank Banks, depending on whether there are one, two, three or four toilets in the household are shown in Table 4.15. Note, these costs of installation are based on the assumption that devices are installed in all toilets in the households. In practice, a Toilet Tank Bank may be fitted in a single toilet that is used the most. This would reduce the initial investment required and the payback period. However, to maximise savings these calculations are based on the assumption that all toilets are fitted with Toilet Tank Banks. Based on the savings (e.g. litres per day) calculated above and the cost required to install the Toilet Tank Bank, the average payback periods range from 299 to 465 days, respectively (Table 4.16).

In summary, the Toilet Tank Bank can offer notable savings in both water and monetary terms. Taking an average value for both Athenry and Douglas, the device would save a household 12.5 L per day, and have a payback period of 387 days.

Table 4.15 Costs of installing toilet tank banks.

Number of toilets	Cost
1	5.99
2	11.98
3	17.97
4	23.96

Table 4.16 Payback period for a toilet tank bank (day).

	Average	Maximum	Minimum
Athenry	465	1030	155
Douglas	299	985	83

Low flow shower heads

As presented in Sections 3.2, by reducing flow rates, low flow shower heads can reduce the volume of water used per shower. Based on the shower audit data (flow rate) and water diary returns (shower usage), this section assesses the potential savings attainable through the installation of these low flow devices. Note, these devices, of which there are a large number currently on the market, can reduce flow rates to variable extents depending on the specific household and its shower system. The following savings estimates are based on the low flow shower heads reducing shower flow to 7 L/min (based on the manufacturer's claims for the devices installed as part of this current research). Calculations are based on an average shower time of 7.16 minutes which was determined previously by Dubber and Gill (2013). For 7 and 21 houses in Athenry and Douglas, respectively, initial flow rates were already below 7 L/min, and hence low flow devices would not be required. These houses are omitted from the following analysis. This finding also indicates the value of having a water audit completed prior to the selection of any water saving devices.

The savings that would have been attained had a low flow shower head (that reduces flow to 7 L/min) been fitted are presented in Table 4.17 and Figures 4.42 and 4.43. On average, households would have saved 64 L and 37 L per day in Athenry and Douglas, respectively. Note, some houses in the analysis would not reduce consumption as initial flow rates were already low. In terms of per capita savings, average savings are 19 and 14 L/d for Athenry and Douglas, respectively.

Table 4.17 Savings attainable from a low flow shower head (Litres/day).

		Average	Maximum	Minimum
Per household	Athenry	64	306	1
	Douglas	37	276	1
Per capita	Athenry	19	76	1
	Douglas	14	138	0.25

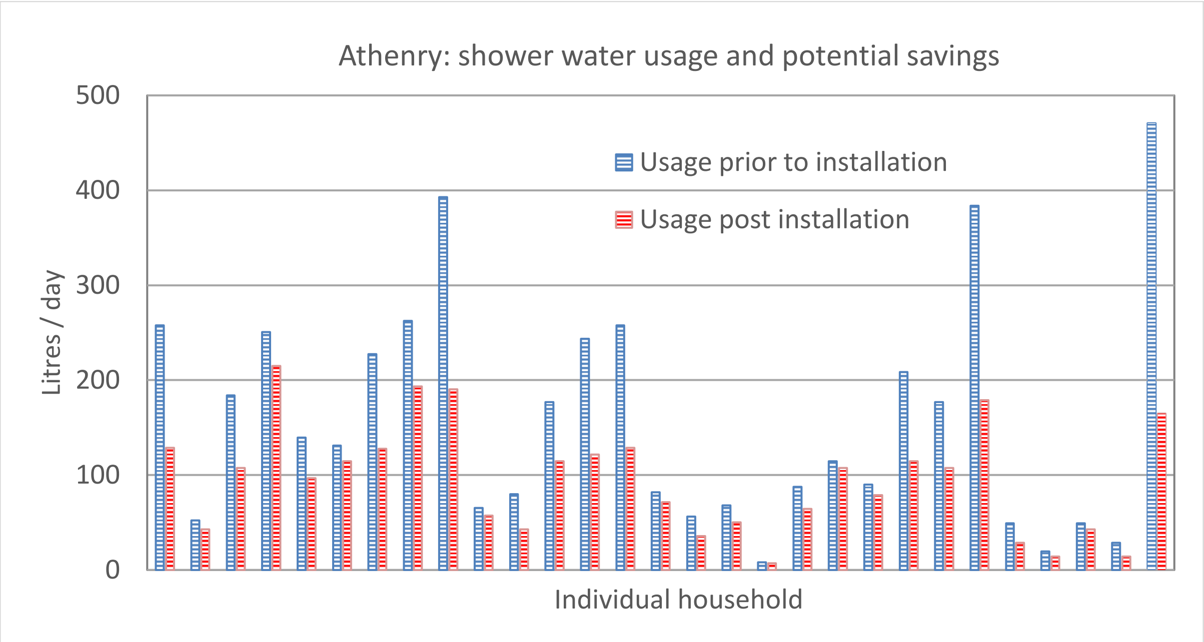

Figure 4.42 Water usage by showers during SW1 and the potential savings attainable through the installation of water saving devices.

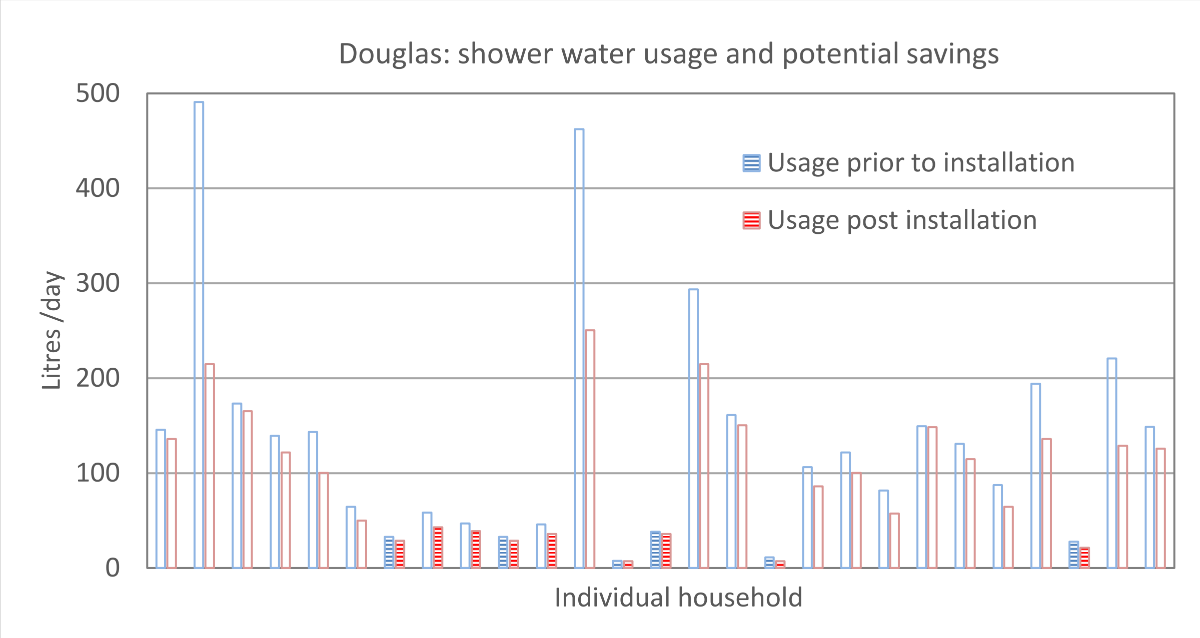

Figure 4.43 Water usage by showers during SW1 and the potential savings attainable through the installation of water saving devices.

Payback periods for the installation of these devices are presented in Table 4.18. Savings, and hence the payback period depend on the frequency of shower use and the initial flow rate prior to the installation of the low flow device. Payback periods also depend specifically on what device is installed and how many are required. This may be dictated by the shower type already fitted in the house. Payback periods will therefore differ substantially between houses. As with toilet savings, it is assumed that water saving devices are installed to all showers in the household. Again, in practice, a household could install just one device and ensure that all showers are taken using the low flow device. In, practice, however, this may not be possible.

Table 4.18 Average payback period for a low flow shower devices (days).

	Shower flow regulator	**Air Jet - hose head model and**	**Air Jet - fixed head model**
Cost (€)	9.78	39.98	45.45
Athenry	285	1166	1325
Douglas	553	2259	2568

As illustrated in Table 4.18, payback periods, in particular for the Air Jet models, are long. For the fixed head model in Douglas, the average payback period would be 11.4 years.

Reducing shower times

While water savings are attainable through reduced shower flow rates, savings would also be achieved by reducing shower duration. As outlined in Section 3.2, products such as shower timers and Amphiro meters encourage such reductions. While the success of these products is largely based on the householder's behaviour, the potential savings attainable can still be estimated. As the shower flow rate and number of showers taken per household per week is known, and assuming an average shower time of 7.16 minutes (based on Dubber and Gill, 2013) the savings attainable through a reduction in shower duration can be calculated.

The average reductions in water usage that would be attainable if shower times were reduced by one minute are shown in Table 4.19. On average, households would reduce shower water usage by 14%.

Table 4.19 Savings attainable from a toilet tank bank (Litres/household.day).

	Average	Maximum	Minimum
Athenry	19	1	66
Douglas	17	1	69

4.7 Water usage comparisons: before and after device installation

To assess the performance of the water saving devices installed, household water usage before and after the installation is compared. Comparisons are drawn between water usage during SW1 and SW2. While it was initially envisaged that comparisons could be drawn for individual days during these weeks, gaps in the record due limited meter memory means that only an overall weekly meter comparison is possible. However, this weekly comparison does not account for natural variability that may occur from week to week in usage, due to temporal changes in occupancy or behaviour, for example.

SW1 vs SW2

Comparisons of SW1 and SW2 water usage for Athenry and Douglas households are shown in Figure 4.44 and 4.45, respectively. Note, while 144 metered household were included in the study, for a comparison to be possible a household had to have agreed to have water saving devices fitted in addition to having valid SW1 and SW2 meter readings. Due to the limitations regarding the meter memory at the hourly setting and frequency of meter reading carried out during the trial, as well as the fact that many of the original households who signed up for the trial decided not to have any water-saving devices installed, comparisons can only be made for 36 and 59 houses in Athenry and Douglas, respectively.

As illustrated in Figures 4.44 and 4.45, water usage did not decrease for all houses from SW1 to SW2. For a considerable number of houses, water consumption was actually higher during SW2. Increases in consumption were apparent in 56% (n=20) and 36% (n=22) houses in Athenry and Douglas, respectively. The remaining houses showed a reduction in usage to varying extents. On average, for the 36 houses in Athenry, weekly consumption increased by 149 L, while in Douglas, there was an average reduction of 167 L.

The lack of any clear pattern with respect to changes water usage following the installation of the water saving devices across the households that remained in the trial through to its completion is considered to be mainly a function of the small sample size in conjunction with the short duration of the metering periods before and after device installation. It is likely that household water usage will vary considerably from week to week and so such comparisons on the basis of single two single weeks do not account for natural variability in usage. Such variability could be due to changes in occupancy (for example, short term such as visitors staying / leaving or more long term changes) or linked to changes in behaviour (for example, changes in work patterns, changes in pastimes such as taking up a new sport etc.). This natural variation is not accounted for when simply comparing SW1 and SW2. The efficacy of the water saving devices is therefore not distinguishable from natural variation, and hence limited conclusions can be offered.

As illustrated in Figures 4.44 and 4.45, for certain houses consumption increased/decreased significantly between SW1 and SW2. For instance, for a small number of houses, consumption more than tripled, while for others consumption reduced by a similar magnitude. While there may be several reasons for these changes, identifying the cause(s) is not possible using the current data. The low return rates of the first (SW1) and, in particular the second diary (SW2), means that for many houses, comparisons of appliance usage between SW1 and SW2 (a potential reason for increases/decreases between the two weeks) are not possible. Likewise, the fixing of leaks may account for some disparity, however this was not confirmed.

Note, in July 2016, during the initial household recruitment and survey phase of the research project, domestic water charges were suspended and a review has begun.

While difficult to accurately assess, it is possible that this suspension may have altered consumer attitudes, behaviours and hence the household water usage.

Finally, the results of this study does also raise the interesting question of individual's behaviour linked to perception of water consumption and whether this may result in a form of water usage homeostasis: i.e. consciously or subconsciously an individual may spend longer using certain devices (such as a shower) following the installation of a water saving device than before as they perceive that they are saving water, and yet the longer usage mitigates any significant benefits of the device. It is not possible identify such behaviour from the results in this study but could form the basis of an interesting future bespoke research project.

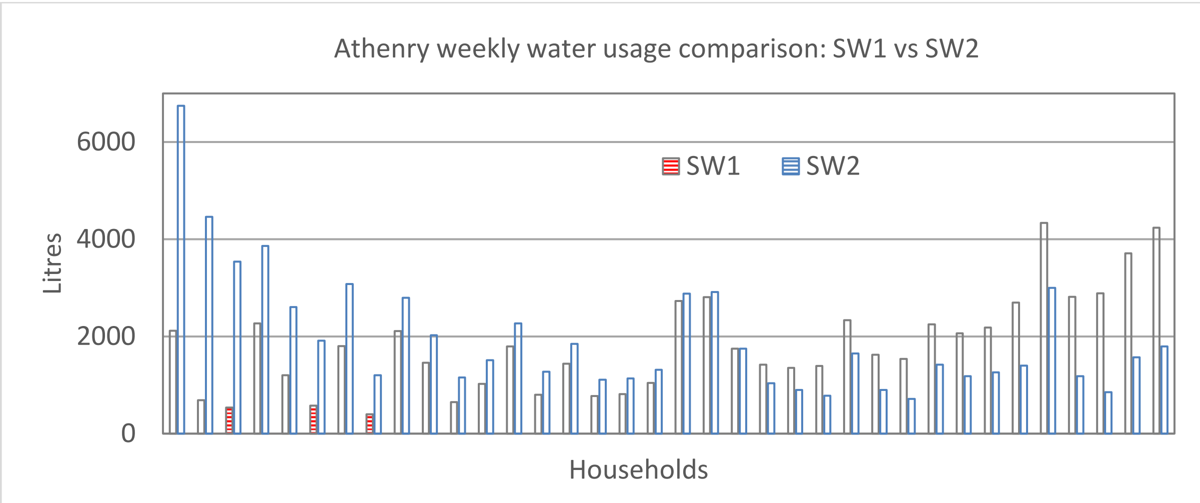

Figure 4.44 Comparison of household water usage between SW1 and SW2 (i.e. before and after the installation of water saving devices).

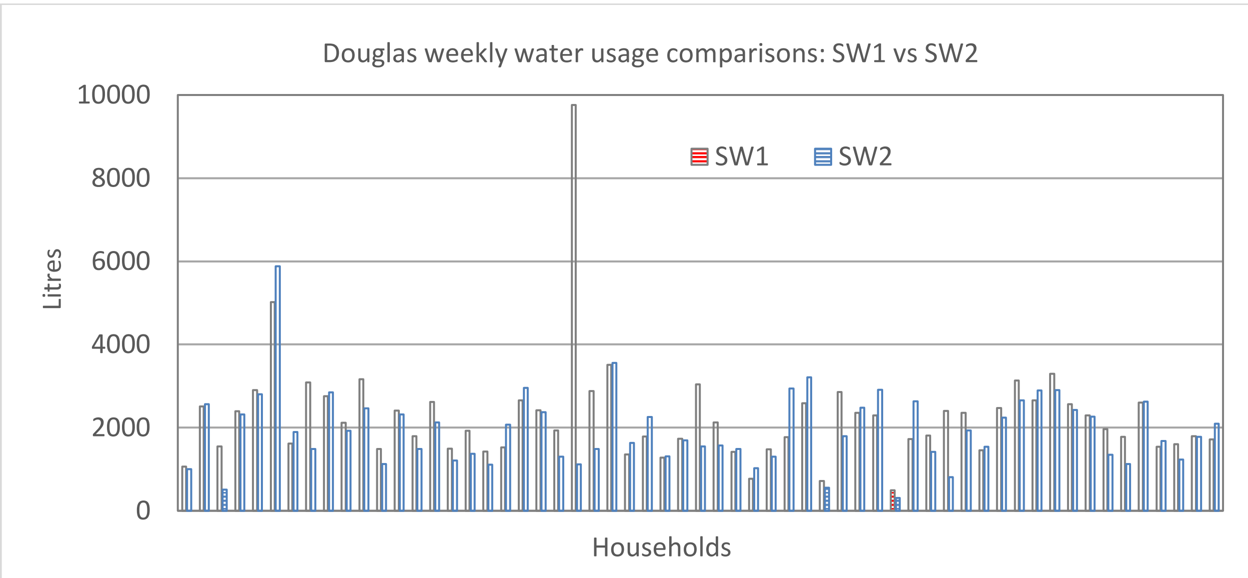

Figure 4.45 Comparison of household water usage between SW1 and SW2 (i.e. before and after the installation of water saving devices).

5. Summary and conclusions

5.1 Water saving device efficiency

Through the use of household water diaries, improved meter resolution and household water audits carried out before and after the installation of water saving devices, this research has provided useful insights into water usage in Irish households and the potential for savings through the installation of water saving devices.

The water diaries have provided valuable information with respect to appliance usage and water end-uses in the home. For example, the average appliance usage frequencies per week are given in Table 5.1 for a range of appliances.

Table 5.1 Average weekly frequency of appliance use per house and per capita in two study areas.

	Athenry		Douglas	
	per house	per capita	per house	per capita
Dishwater	3.4	0.16	4.1	0.19
Washing machine	5.8	0.3	6.6	0.3
Kitchen tap	56	2.9	78	3.8
Toilet flushes	84	4.4	97	6.7
Shower	1.4	0.63	1.2	0.63
Sink use	89	~5	107	~5

The household audit and device installation process has also provided a realistic assessment of the existing flow rates of household appliances being used as well as the reduction in flows that were made where water saving devices could be fitted (as well as providing an indication of the suitability of existing houses for such retrofits). Hence, this data provides a unique insight into water usage appliances in Ireland, and hence the potential scope for the installation of water saving devices.

For example, the mean kitchen tap flow rates measured in the audited houses were 15.2 L/min (Athenry) and 15.8 L/min (Douglas): the installation of swivel tap aerators to these provided an average reduction in flow of 45%. Equally, the mean flow rates for basin taps were 10.5 L/min (Athenry) and 11.2 L/min (Douglas): tap aerators on mixer taps reduced flow by 62%, whilst thread-less tap aerators on individual hot and cold faucets reduced flow by 49% on average.

For toilets, just 13 out of the 122 toilets audited in Athenry and just 39 of the 145 toilets audited in Douglas were dual flush toilets indicating that there is considerable scope for a reduction in flush volumes in typical Irish households. The flush wiser devices reduced flush volumes from 9 L to 7.5 L in the two houses in which they were fitted. The toilet tanks reduced water usage per flush by 1 litre per flush in the 72 toilets in which they were fitted.

Finally, electric showers were the most common type encountered in both areas, followed by electric pumped, bath tap mixer hose and pumped power. Reviews of the flow rates measured for each shower type (prior to the installation of water saving devices) are given in Table 4.10. Where the ECO shower head was installed it reduced flow rates by an average of 43% (ranging from 25 – 60%). The lower pressure ECO shower head was installed on fewer houses and achieved an average flow rates reduction of 28% (ranging from 18 – 46%). Shower flow regulators were fitted in just two showers and reduced flow rates by 58 and 38 respectively.

Since the completion of the Dubber and Gill (2013) study, the data obtained from this research, coupled with improved household water usage data that has been brought about by the national metering programme, has provided a greater insight into water and appliance usage in Irish homes. For example, based on these results, households would have saved on average 12 L and 13 L per day in Athenry and Douglas, respectively, through the installation of a Toilet Tank Bank. Equally, households would have saved on average 64 L and 37 L per day in Athenry and Douglas, respectively using low flow shower heads.

However, whilst reductions in household water usage would be expected after the installation of water saving devices, reductions in usage were not evident statistically from a comparison of the high resolution data collected in SW1 and SW2. This is likely due to the relatively small sample sizes and the short duration over which the comparisons were made. For example, just 32 households returned the second water diary (10 in Athenry and 22 in Douglas), representing a 22% return rate. Further limitations are discussed in Section 5.2 which can all be used as valuable lessons and experience upon which to base any future water consumption studies.

5.2 Limitations

1. Sample sizes. In view of the number of variables that may potentially influence water usage (household occupancy, social demographics, attitude to water conservation, lifestyle etc.) coupled with the number of water saving devices that exist (and hence the various combinations with which they can installed in each house) considerably larger sample sizes would be required. Larger sample sizes would improve the power of statistical analysis and in turn the confidence with which conclusions and recommendations can be made regarding water conservation practices and policies.

2. Limited meter memory and reading frequency. While the initial research proposal had intended on the use of hourly meter data from two seven-day periods (before and after the installation of water saving devices and in parallel with the completion of water diaries), the meter memory proved inadequate to provide this data based on a frequency of meter reading carried out during the trial. This lead to considerable data gaps, hence, limiting analyses and findings. Meters would need to be read more frequently during the study week (to read and hence clear the meter memory) in order to obtain an unbroken record.

3. Monitoring duration. While monitoring (water diary completion and enhanced meter mode) was conducted over two 7-day periods, more frequent monitoring would be desirable, for example, at least four 7-days periods across the year prior to and across the year following device installation. Increased monitoring before and after the installation of water saving devices would facilitate more powerful comparisons and a more reliable assessment of the potential for water conservation. Increased monitoring would also allow for an assessment of water usage patterns and, for instance, how it can vary temporally (i.e. between summer and winter).

4. High-resolution data. While the enhanced meter mode provides usage data on an hourly basis, improved resolution would be required to accurately identify water end-uses within each household. This has been successfully achieved and is discussed below in relation to recommendations for future research.

5. Water diary accuracy. The nature of the water diary means that its accuracy is dependent on householder participation and commitment. The reliability of the appliance usage cannot be guaranteed.

6. Appliance water usage. While the use of appliances such as washing machines, dishwashers and toilets may use a relatively consistent volume of water each use, the volume used by taps and showers depends on the duration of use and the strength of the flow (which may differ between uses). Therefore, estimating the volume of water used by taps and showers based on the water diary results is not practical. Consequently, estimating the effectiveness of water saving devices fitted to taps and shower heads is challenging. For instance, offsetting behaviour may be nullifying their purpose.

7. Distribution of water saving devices. Water saving devices were not installed in a systematic manner. Devices were installed depending on household appliance suitability and the availability of the devices (constrained by the research budget). In many instances, households were fitted with more than one water saving device. Given that several different types of devices were installed, there was a large number of potential combinations of devices that each house could (and did) receive. For instance, one house may have received an Amphiro meter, a tap aerator and two toilet tanks, while another house may have received an Amphiro meter, a flush wiser device and a low flow shower head (see Appendix 2).

   As the devices have not been systematically installed, attributing any water savings to an individual device is not possible and hence the performance of each type of device cannot be determined. This has greatly limited the inferences that can be drawn from the findings. This study has shown however, that the suitability of any device for retrofit installation is clearly very household specific depending on plumbing etc. but has also indicated the value in carrying out a water audit, prior to the installation of any device.

5.3 Recommendations for further research

While limitations were apparent in this current study, these provide useful guidance and direction for future research. Recommendations for further research include:

1. Increased sample sizes: Further research into the effectiveness of water saving devices would require considerably larger sample sizes.
2. Water diary design: Improvement of the household water diary would facilitate more accurate insights. For instance, information regarding the time and duration of appliance usage (i.e. showers and taps) would provide information regarding householder behaviour and water usage.
3. Systematic installation of devices: The distribution of water saving devices needs to be informed by sound experimental design developed by a scientist and/or statistician.
4. Enhanced smart metering: While this research has assessed the potential use of the smart metering capabilities of currently installed Irish water meters, limitations were encountered with respect to meter memory, which was found to be insufficient with respect to the reading frequency available. Improved meter memory would be required for further research.
5. Water meter data resolution: As discussed above, improved meter data memory would be required to gain further insight into household water usage. In addition to increased memory, improved meter resolution would provide considerable opportunities for further research, including specific end-use water monitoring and being able to assess whether householders exhibit any offsetting behaviour whereby appliances fitted with water saving devices start to get used more often, for example.

Giurco *et al.* (2008) provides a comprehensive review of the approaches and technology available for residential water usage research. With particular relevance to this current research, Giurco *et al.* (2008) outlines approaches that be can be taken to identify specific water ‘end uses’ in each household. This “end-use based monitoring” refers to water use measurement that separates volumes of water used by each fixture or appliance in a given house. This ability to distinguish between different end-uses enables the characterisation of when each appliance is used and how much water it consumes.

End use data can be obtained by metering specific appliances or by installing smart metering systems which collect sufficient information for each water use event (e.g. flow and pressure). Selecting the most suitable approaches method(s) for a specific study will depend on several factors, including the objective of the research and the resources available. Plans must be tailored to meet the case specific constraints. For instance, when selecting a methodology for data capture there is often a trade-off between cost and reliability of data, and hence, Giurco *et al.* (2008) state that the more sophisticated (and hence accurate) methods tend to rely on technological approaches using smart meters and data loggers.

Giurco *et al.* also provide an insight into the technological methods available for data capture (metering) and data analysis (software). With respect to data capture standard market water meters often yield data that it too coarse for end-use studies, and hence upgrades to smart meters capable of producing high resolution data is required. Once this high-resolution data has been logged, data analysis technologies can then be used to assist in the processing and interpretation of raw data into meaningful information about end-uses. Data analysis tools include software packages such as Aquacrafts's TraceWizard© and WRc's Identiflow®.

Numerous studies have used smart metering and software approach to elucidate household water end-uses (Loh and Coughlan, 2003; Willis *et al.*, 2010; Beal and Stewart, 2011; Stewart *et al.*, 2013; Willis *et al.*, 2013 and more). A schematic layout of the process used by Beal and Stewart (2011) and Willis *et al.* (2013) is outlined in Figure 5.1. As illustrated, the smart meter was used to record high resolution water usage, with flows logged at 10 seconds intervals (in contrast to the hourly data attained during this current research). Using the Trace Wizard software, the volume of water used by each appliance was determined.

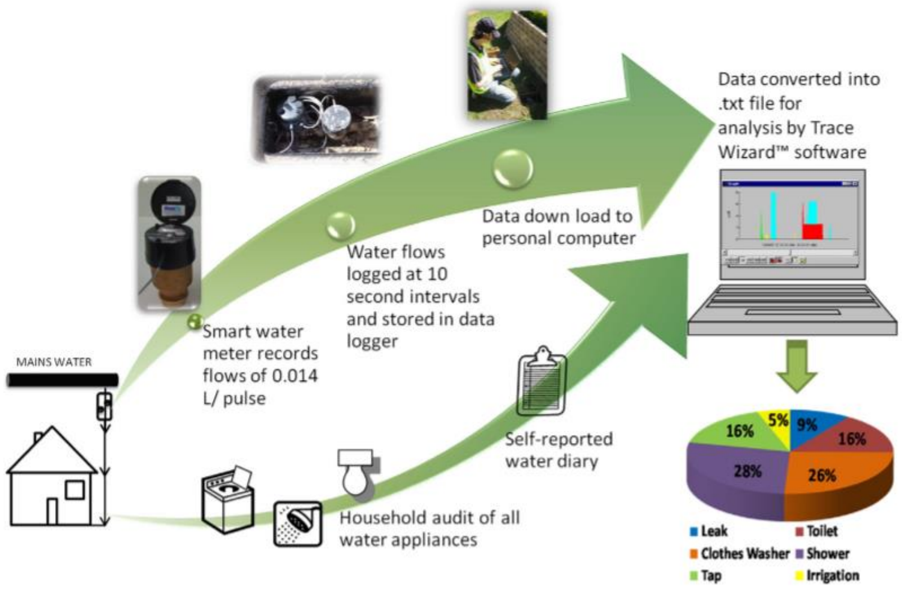

Figure 5.1 Water end-use identification using smart metering and Trace Wizard software (from Willis *et al.*, 2013).

An example of an output from Trace Wizard is shown in Figure 5.2. The blue peaks in Figure 5.2 show the volume of water used by the washing machine. The machine shown here has two primary cycles (wash and rinse) and a number of extractor/spin cycles before and after the rinse cycle. The red peak is a shower running simultaneously with the clothes washer. A toilet flush is green and hand taps are in yellow.

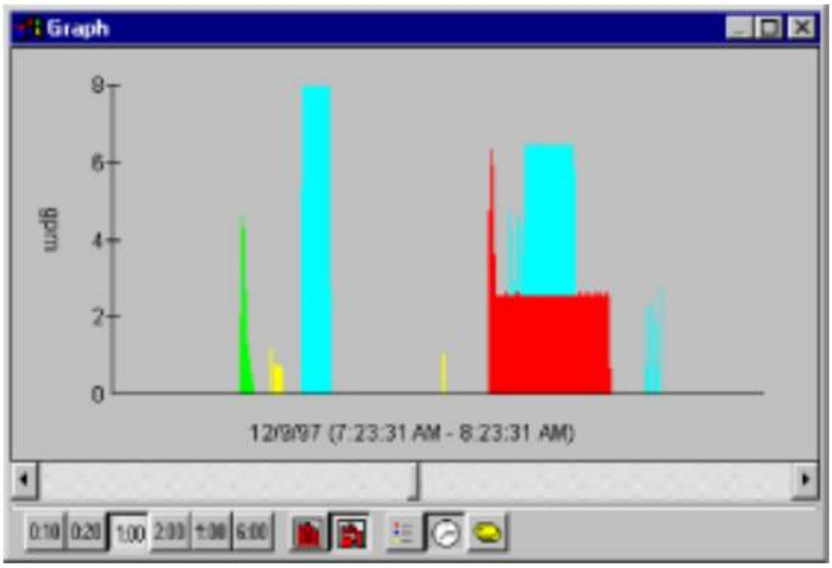

Figure 5.2. Example output from Trace Wizard software (from Giurco *et al.,* 2008).

This smart metering and end-use monitoring offers substantial insights into household water usage and behaviour. This approach would be particularly useful in the context of this current research as it could be used to facilitate the evaluation of water saving devices (i.e. end-use analysis before and after installation), as well as people's behavioural responses. Although costly, this approach would overcome many of the constraints encountered during this current research and should be considered for future research proposals.

In addition to these recommendations which are mainly based on the experience of the current study, any future research study should also include data that could help to provide further insights into the likely drivers of water consumption behaviour as examined in the initial B&A research carried out on this project entitled, *"Attitudes to Water Conservation"*. As per the original B&A research survey, such a study would require a high number of participating householders in order to derive statistically robust conclusions, and should be structured such that it could yield variables in relation to behaviour versus attitudes (and their likely drivers), the acceptance and impact of water-saving devices, and an assessment of the motivations to conserve water between different household groupings. A list of subjects is suggested (as follows) which could be linked with the actual consumption data during any future study.

- General attitudes to water conservation versus actual water consumption: for example, acceptance levels of water wastage from different appliance types (e.g. kitchen sink versus showers), response level to leaks, conscious water / energy conservation habits (such as waiting for full load before using dishwashers / washing machines etc.).

- Effect of housing size and family structure / life stage (singles / young families / older families / empty nesters etc.) on household consumption (and conservation).
- Spatial impacts on consumption (for example, rural vs urban); temporal impacts on consumption (for example, difference between seasons).
- Impact and sensitivity of householders to different incentives to conserve water – financial, peer pressure, conservation agendas etc.
- Characterise the water consumption between distinctive / differentiating water use experiences in the home: for example, habitual water uses (for cleaning, toilet flushing etc.) vs water uses associated with a quality experience (such as a shower).
- Group householders into the three generic categories - principled leaders, price conscious followers and disengaged – from an initial behaviour and attitude survey and compare the difference is in their appliance usage as well as overall consumption.
- Acceptance of the different water saving products by householders (for example, are they happy with the reduced flow and pressure outputs from tap aerators or low flow showers once installed), as well as an assessment of their ease of adoption / uptake.

Finally, such research should also focus on the best means of communicating the results of any future findings to the general population, aspects of which again were covered in the B&A *"Attitudes to Water Conservation"* report.

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Appendix 1 – Water diary

Household I.D: XXXXXXX

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Water Diary

Device: Bath [Tick each time the device is used (✓)]

Sun 5th	Mon 6th	Tues 7th	Wed 8th	Thurs 9th	Fri 10th	Sat 11th	Sun 12th

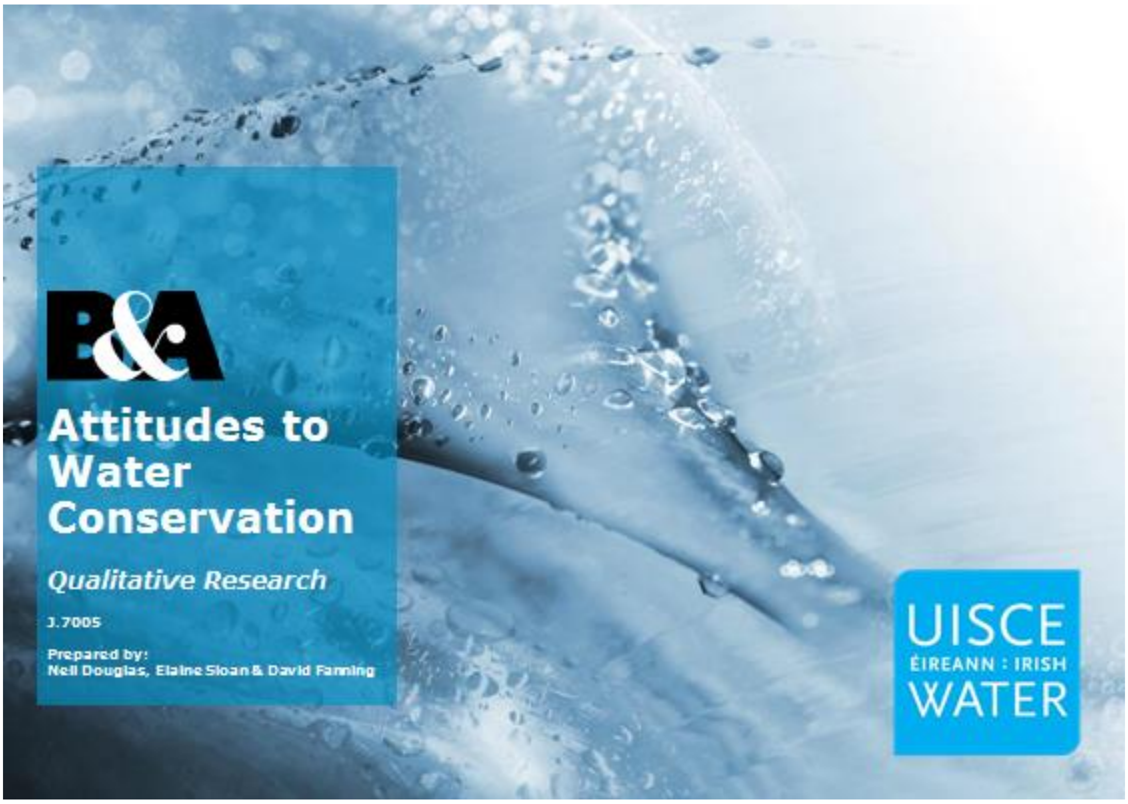
Appendix 2 – Water saving device installation record

Household ID	Swivel Aerator	Tap Aerator	Thread less Aerator	Toilet Tank	Flush Wiser	ECO Shower Head	Low Pressure ECO Shower Head	ECO Fixed Shower Head	Shower Flow Regulator	New Shower Hose	Tooth Time	Shower Time	Amphiro Meter	Behavioural Kit
54918			6	3						1	1	1	1	
50986			6	2			1				1	1	1	
50900		1				1			1				1	1
50912														1
50487			6	3									1	
50531				3									1	
50940				3							1	1		
50292														1
51526	1	2		1							1	1		
50746													1	1
50459	1					1				1	1	1	1	
50526				4		2				1	1	1	1	
50969														1
50447													1	1
51352		4		3		1							1	
50637													1	1
54917														1
50668					1									
51464					1									
50765			6	2										
50054													1	1
54915							1							
51436														1
50556				1										
51054														1
50638				1			1				1	1	1	
51514		1		1									1	
50708		1		2							1	1	1	
50461						1	1			1			1	
51188				2			1			1	1	1		
50164													1	1
51482														1
51221	1	2				1	1				1	1	1	

51268	1	2		1		1				1	1	1		
50406	1		6								1	1	1	
50574							1							1
51444													1	1
50983				3										
51011				2							1	1	1	
51439														1
50744						1					1	1	1	
51315	1							1						
51159													1	1
51013			2	1										1
54922	1	1				2					1	1	1	
50558		2		3		1							1	1
50013	1					1				1	1	1	1	
50295				1		1								
53584		1		1		1							1	
53158														1
53583													1	1
53546													1	1
51868													1	1
52017														1
52823													1	1
52277		2		1							1	1		
53997	1						1			1			1	
52993		1												1
54913														1
54910						1							1	1
53525		1		1		1					1	1	1	
52971		1												1
53058			2	2		1								
53098		1		1										
53007		2												
52678	1			2		1				1			1	
52421	1			1		1								
52185			2											
52666														1
51845	1						1						1	1
52081							1						1	1
53794		1		2						1	1	1	1	
53361							1			1				
52970	1					1					1	1	1	
52267														1
51848		1		1							1	1	1	
52739		1		2										
52269		1		3		1				1	1	1		
54007													1	1

52760				3							1	1		
50134													1	1
53218				1							1	1	1	
51878	1										1	1	1	
53006		2				1								
52445													1	1
52075				1		1					1	1		
52930				1										
53595													1	1
51911				1					1		1	1		
51917														1
52703	1	1		2		1								
52488	1			2										
54133				1		1					1	1		
53729														1
53698		1		1							1	1	1	
53066	1			1			1				1	1		
52983														1
51952													1	1
52626													1	
54136														1
52154	1	1		1							1	1	1	
51877													1	1
52940													1	1
54088		1		1		1								
54923							1							1
52591		1					1			1				
52975		1		1										
53307														
53919													1	1
52100														1
51923														1
53561		1												

Appendix 3 – Behaviour & Attitudes Limited - *Attitudes to Water Conservation*



Research objectives

Core objectives

- To understand Irish people's current attitudes and behaviours towards conservation in their household.

Areas covered

- General attitudes to water usage and conservation.
- Existing conservation activity.
- Develop insights about where people see water wastage in the home.
- Identify which incentives may impact on water conservation.
- Understand the impact that water conservation grants may have on raising awareness of conservation.
- What is the impact of lifestage on consumption behaviour.
- Understand the level of effort consumers are prepared to undertake to conserve water and to change their habits.
- Identify if there is a relationship between newer housing stock and more efficient plumbing in homes.

Research Methodology

Extended Groups

Grp	Gender	Social Class	Life stage	Meter /Unmeter	Usage Level	Property Type	Location	Date /Exec
1*	Mix	BC1	Singles/ no kids	Meter	L	Apartments	Dublin	4/2 ND
2	Mix	C2D	Couple no kids (DINKY)	Unmeter	-	Apartments	Cork	3/2 ND
3*	Male	BC1	Young family	Meter	M	Bungalow	Naas	2/2 DF
4*	Female	C2D	Young family	Unmeter	-	Detached/Semi	Sligo	3/2 DF
5	Male	BC1	Older family	Unmeter	-	Bungalow	Sligo (rural)	3/2 DF
6	Female	C2D	Older family	Unmeter	-	Detached /Semi	Naas	2/2 DF
7	Male	C2D	Empty nester Older single /couple	Unmeter	-	Mix	Dublin	4/2 ND
8*	Female	BC1	Older retirees Single/couple	Meter	M	Mix	Cork	3/2 ND

Mix of combo and single service customer in metered groups

In-home depth interviews

Dpt	Gender	Social Class	Life stage	Meter /Unmeter	Usage Level	Property Type	Location	Date /Exec
1	Male	C2D	Singles no kids	Unmeter	-	Apartment	Dublin	26/1 DF
2	Female	BC1	Couple No kids (DINKY)	Meter	L	Apartment	Cork	28/1 DF
3	Male	C2D	Young family	Unmeter	-	Suburb bungalow	Cork	28/1 DF
4	Male	BC1	Young family	Meter	H	Satellite town Detached/ Semi	Ballinasloe	28/1 ND
5	Female	C2D	Young family	Unmeter	-	Rural bungalow	Balbriggan	27/1 ND
6	Male	BC1	Older family	Meter	H	Suburb 2 storey	Dublin	26/1 DF
7	Female	C2D	Older family	Unmeter	-	Satellite town Detached/ Semi	Ballinasloe	28/1 ND
8	Male	BC1	Older family	Meter	H	Rural Detached/ Semi	Balbriggan	27/1 ND
9	Male	BC1	Empty nester	Meter	L	Rural mix	Sligo	2/2 DF
10	Female	C2D	Empty nester	Unmeter	-	Suburban mix	Dublin	26/1 ND

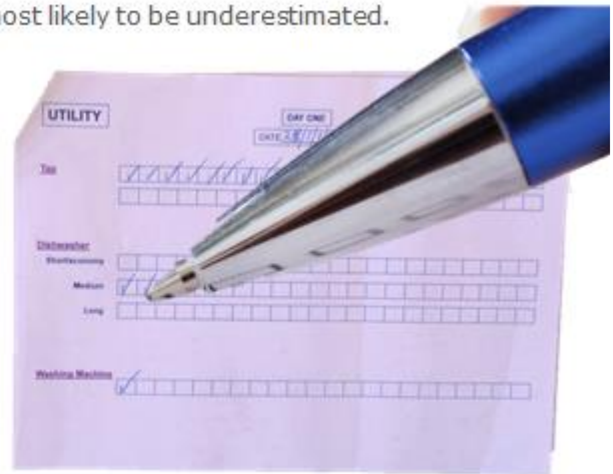
2. Pre-Task exercise & Sample differences

A note on pre-task activity for the groups

6

Effectiveness of pre-task method

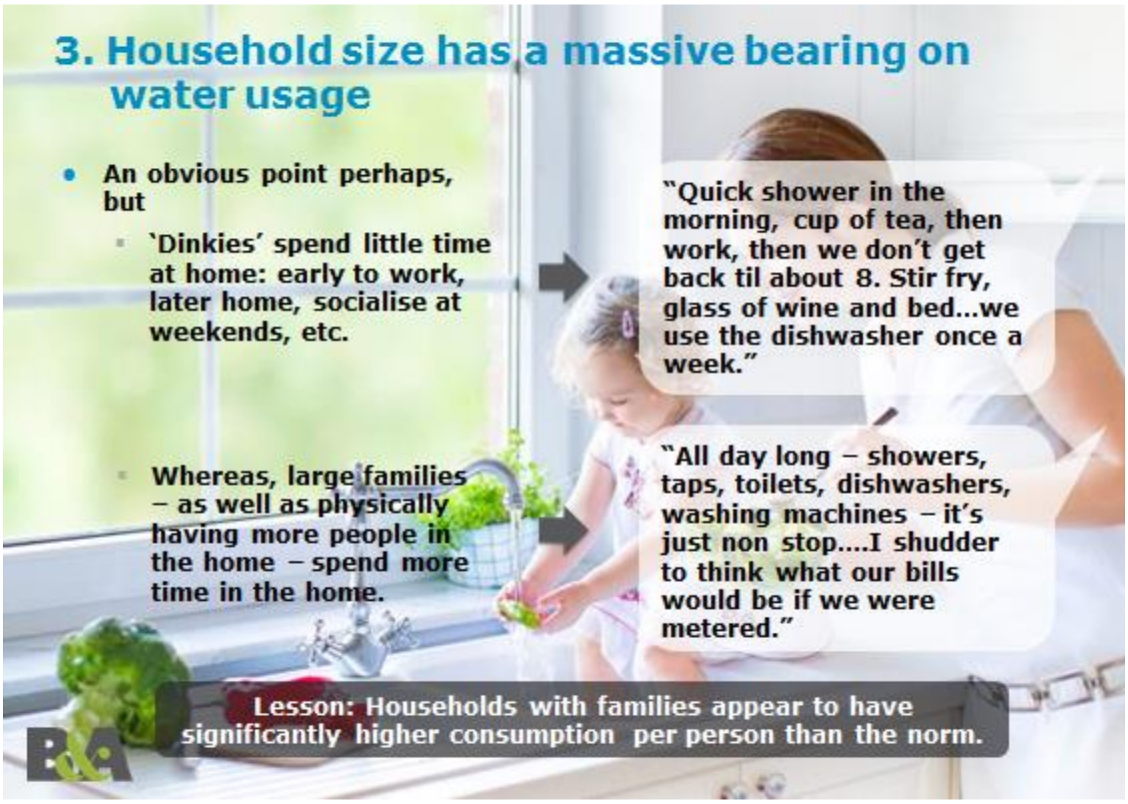
- Marginally better compliance with sheet per device approach over booklet per room (albeit on a small sample).
- Gaps/errors most likely with visitors in house and/or where other household members less involved/motivated.
- Multiple small usage occasions most likely to be underestimated.



7


1. We waste more water than we think we do
Widespread sense that the exercise highlighted to respondents – and other family members – just how much water their household wastes.
"I honestly thought we were good, that we were careful about it…but it was just tick, tick, tick all week! I mean, I'm sure we missed ticks too – I know it's not an exact science – but even at that, tick, tick, tick all day!"
Lesson: When people reflect on their behaviour there is general acceptance that a lot of household water is wasted.


2. Kitchen sink and showers are the two major areas where people feel that water is wasted
Kitchen sinks
In almost constant use at times for a variety of reasons
Drinking, washing hands/vegetables, general cleaning, etc.
More functional usage.
Shower
Particularly, in large households – almost constant use in the morning.
Older men especially contrast today's 'obsessive' showering regime with 'weekly bath' habit of yesteryear.
More emotional usage.
Lesson: Both are key wastage 'hotspots', but the triggers for usage are quite different – more functional in the context of kitchen taps; more emotive for showers ('pampering').
9


3. Household size has a massive bearing on water usage
An obvious point perhaps, but
'Dinkies' spend little time at home: early to work, later home, socialise at weekends, etc.
Whereas, large families – as well as physically having more people in the home – spend more time in the home.
"Quick shower in the morning, cup of tea, then work, then we don't get back til about 8. Stir fry, glass of wine and bed...we use the dishwasher once a week."
"All day long – showers, taps, toilets, dishwashers, washing machines – it's just non stop....I shudder to think what our bills would be if we were metered."
Lesson: Households with families appear to have significantly higher consumption per person than the norm.


4. Primary school kids good; teenagers bad
"I spent the first ten years trying to get them into the shower, and the next ten trying to get them out. The 16 year old is the worst – she takes three showers a day I'm not joking. Half hour in the morning, half hour when she comes in from school and another one when she goes to bed. She looked horrified when I told her about water conservation even though she's supposedly all about saving the world...."
Lesson: Education about water wastage and conservation needs to begin in primary school – by secondary school any environmental concerns are counterweighted by more profound concerns about body consciousness and image..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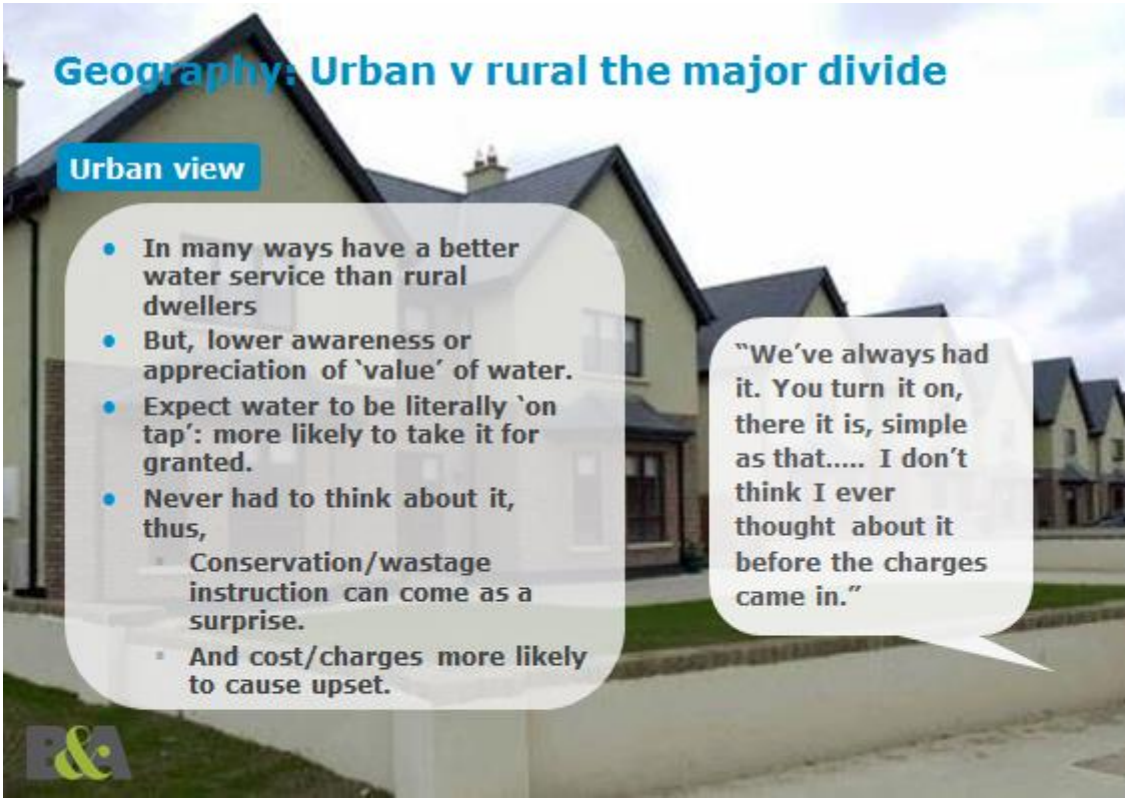
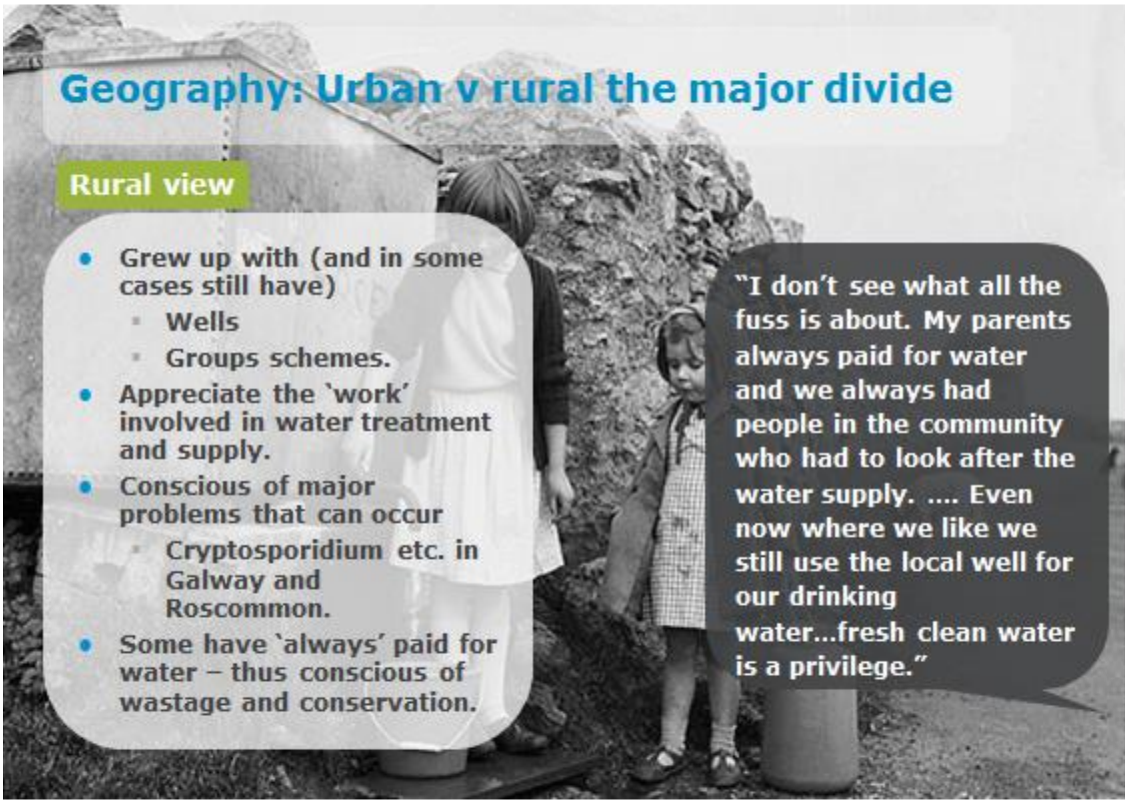
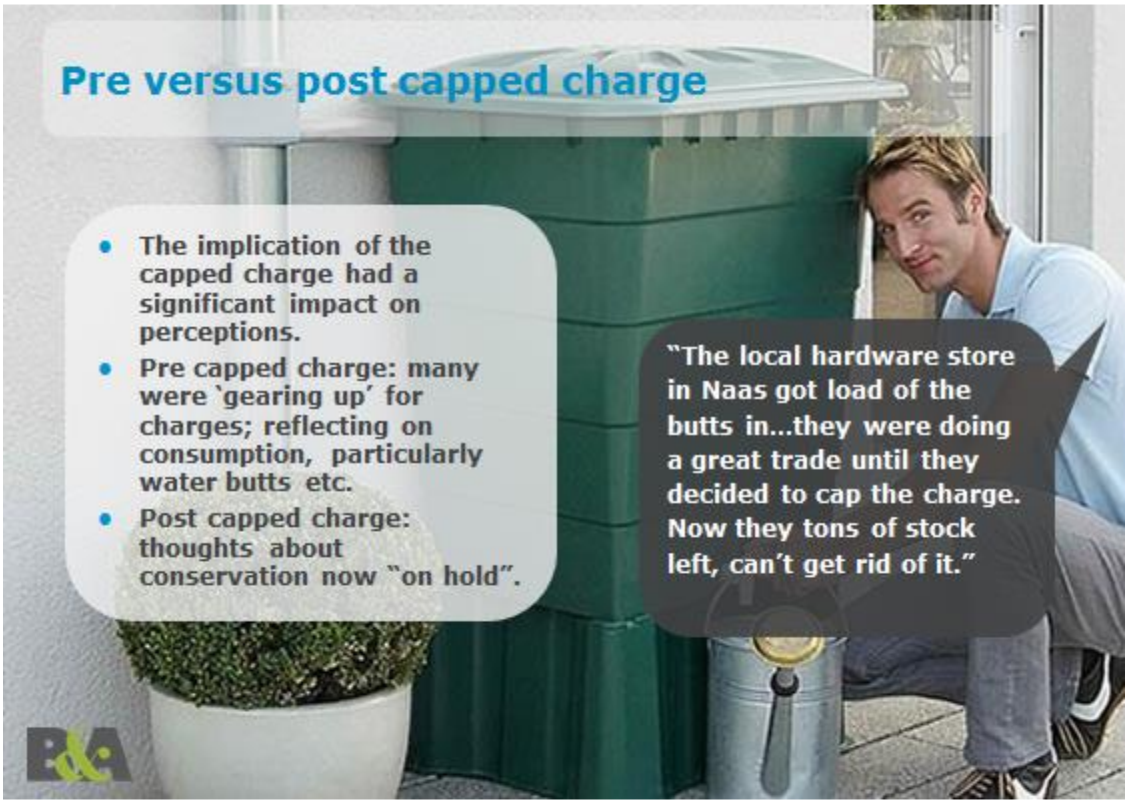

Geography: Urban v rural the major divide
Urban view
In many ways have a better water service than rural dwellers
But, lower awareness or appreciation of 'value' of water.
Expect water to be literally 'on tap': more likely to take it for granted.
Never had to think about it, thus,
Conservation/wastage instruction can come as a surprise.
And cost/charges more likely to cause upset.
"We've always had it. You turn it on, there it is, simple as that..... I don't think I ever thought about it before the charges came in."


Geography: Urban v rural the major divide
Rural view
• Grew up with (and in some cases still have)
▪ Wells
▪ Groups schemes.
• Appreciate the 'work' involved in water treatment and supply.
• Conscious of major problems that can occur
▪ Cryptosporidium etc. in Galway and Roscommon.
• Some have 'always' paid for water – thus conscious of wastage and conservation.
"I don't see what all the fuss is about. My parents always paid for water and we always had people in the community who had to look after the water supply. …. Even now where we like we still use the local well for our drinking water…fresh clean water is a privilege."


Pre versus post capped charge
• The implication of the capped charge had a significant impact on perceptions.
• Pre capped charge: many were 'gearing up' for charges; reflecting on consumption, particularly water butts etc.
• Post capped charge: thoughts about conservation now "on hold".
"The local hardware store in Naas got load of the butts in…they were doing a great trade until they decided to cap the charge. Now they tons of stock left, can't get rid of it."

Systemic leakage undermines conservation strategy

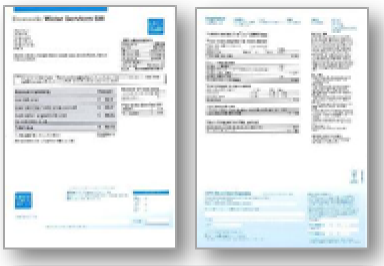
- Widespread impression emerges that the 'real' issue in water wastage in Ireland is systemic rather than household.
- Consistent reports of burst pipes and leaks in the mains, etc.

"Sure turning off the taps is only scratching the surface. It's the leaks in the system are the problem, not me."

Implication: Any communication from Irish Water around wastage/conservation needs to be in the context of how Irish Water are addressing the more fundamental, systemic problems.

Metered v non metered bills

Metered bills



- Low levels of attentive reading of bill.
- Many have not fully noticed or absorbed 'real' usage or charge.
- But, those who have
  - Start to reflect on their usage
  - Start to consider wastage.

Unmetered bills

- Very little close perusal of bill.

"I just look at the amount."

Those on metered bills are more likely to consider and reflect upon their water usage – but, could this be highlighted more prominently on bills?.

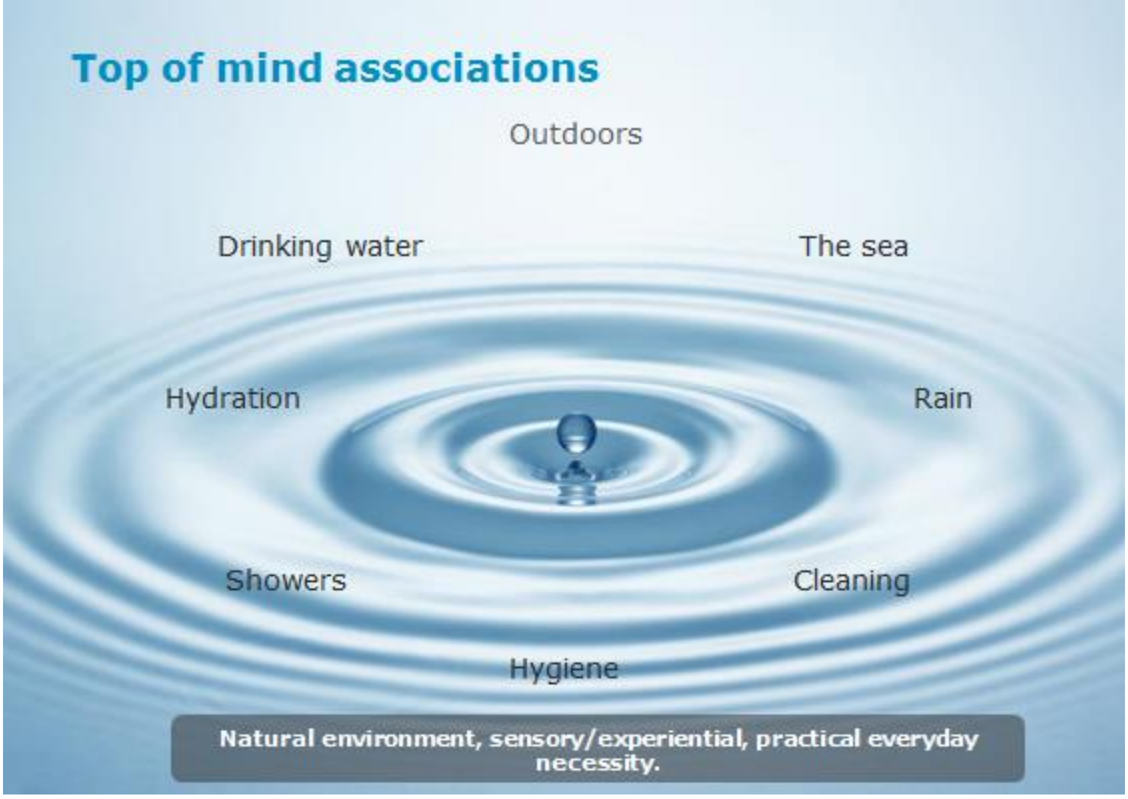
17

Sample differences: Lifestage

Singles/ No kids · Dinky	Young family	Older family	Empty nestor

• Low water usage: shower the main source of wastage.
• Broadly interested in environment.
• Limited specific focus on water conservation though.
	• Heavy water usage.
	• But, household can be influenced by primary school kids
	  • Food dudes
	  • Green schools.
	• Potentially a ready audience conservation/ wastage communications.
		• Very heavy water usage.
		• Teenagers especially can be heavy shower/washing machine users.
		• Financial incentive likely to be required to prompt real change.
			• Light water usage.
			• Generally more conscious of conserving resources: grew up in austerity.
			• Potentially open to communications messages.

B&A 18



Natural environment

Purity

- Connection with the outdoors.
- Rural locations.
- Empty landscapes.
- Bright reflections of light.

But also

- Dull, wet, water logged....lack of light.

Meaning:

- Simplicity
- A sense of 'return' or 'renewal'
- Cleansing/refreshment

But also,

- Depressing, limiting
- Reminder of global warming (and guilt).

Note, the absence of human interaction and the sense of connecting with something simple.

21

Natural environment

- While all understand water is treated before it arrives at their home, there is a tendency to forget/overlook this part of the process.
- Information about the **effort** involved in preparing water is **newsworthy** and **compelling**.

22

Experiential

Quality

- Focus often on **drinking and taste** properties first.
- **Hard/soft** (and impact on household appliances) occasionally mentioned.
- Pressure (stronger always better) sometimes referenced
  - Particularly with regard to **shower quality**.

Meaning:

- Strongest sense of connection and significance (centres on **showering**).
- Morning/evening '**ritual**'
  - Wake up
  - Wind down
  - **Reward**
  - Privileged **personal space**
  - Pampering

Note, the tendency to highlight distinctive/differentiating water experiences rather than frequent casual moments (like hand washing).

23

Experiential

- The most valued **experience** of water (shower length) may be difficult to target as it represents more than just hygiene
  - People may resent being asked to curtail this.
- More casual, even forgotten usage of water may be a more effective target (at least initially).

Everyday necessity

Habit

- Basic requirements
  - Tea/coffee/bottled water
  - Household cleaning
  - Dish/clothes washing
  - Toilet flushing
  - Food preparation
  - Hand washing.

Meaning:

- Essential to life (and quality of life)
- Assumed, background...forgotten?
- Linked with chores:
  - Partner
  - Removes dirt/waste

Despite importance to daily life, habitual behaviour AND role in waste removal results in usage amnesia.

Everyday necessity

- While habits are embedded behaviours, it may be possible to prompt at least reconsideration by drawing attention to **'unconscious'** bad habits.

Context is key to how water conservation is considered

Current climate
--> NO NEED

No link to usage
--> CAP AND POOR AWARENESS OF USAGE FIGURE

Weak link to green agenda
--> REPLENISHED NOT FINITE

Irish Water reputation
--> CYNICISM

Family history
--> INERTIA?

All of these contextual elements can undermine the potential effectiveness of a water conservation message.

28

Personal connection to avoiding wastefulness effective

Discomfort with casual waste

Immediate sense of relevance

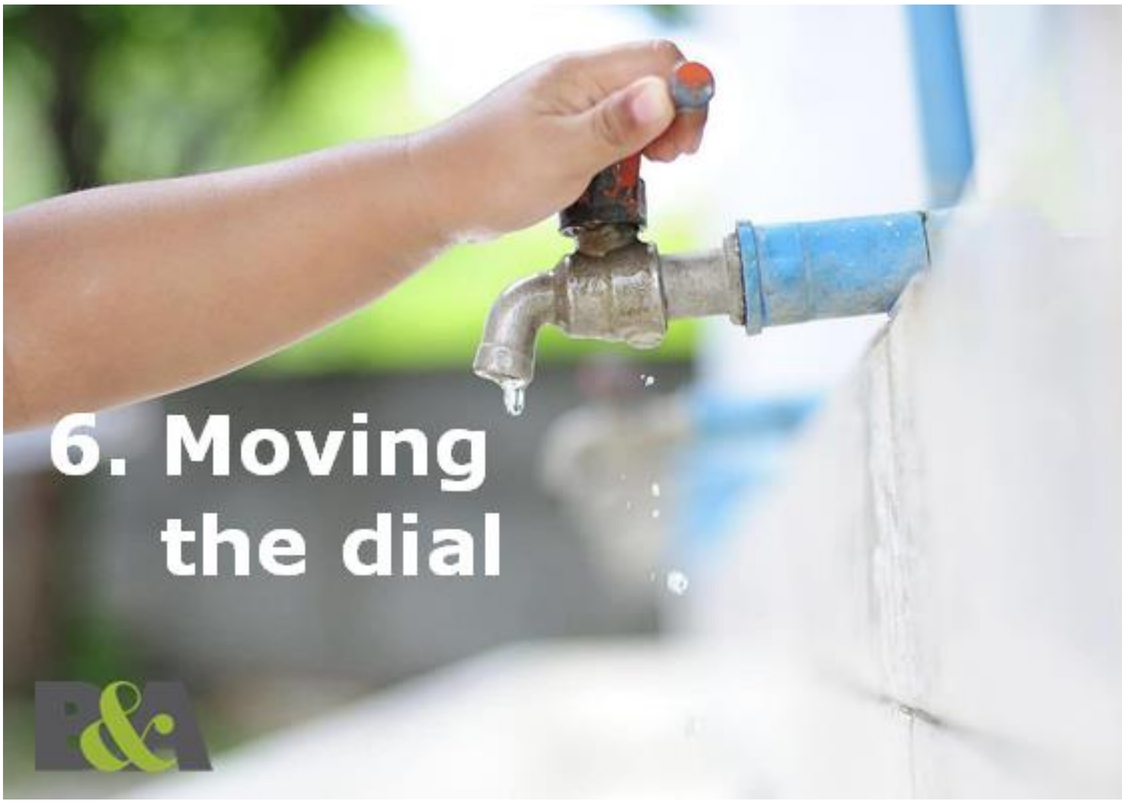
No requirement to link with 'greater good' nor 'incentive'

Recognition that it is easy to change

Hard to deflect relevance to other issues (leaks, metering, etc.)

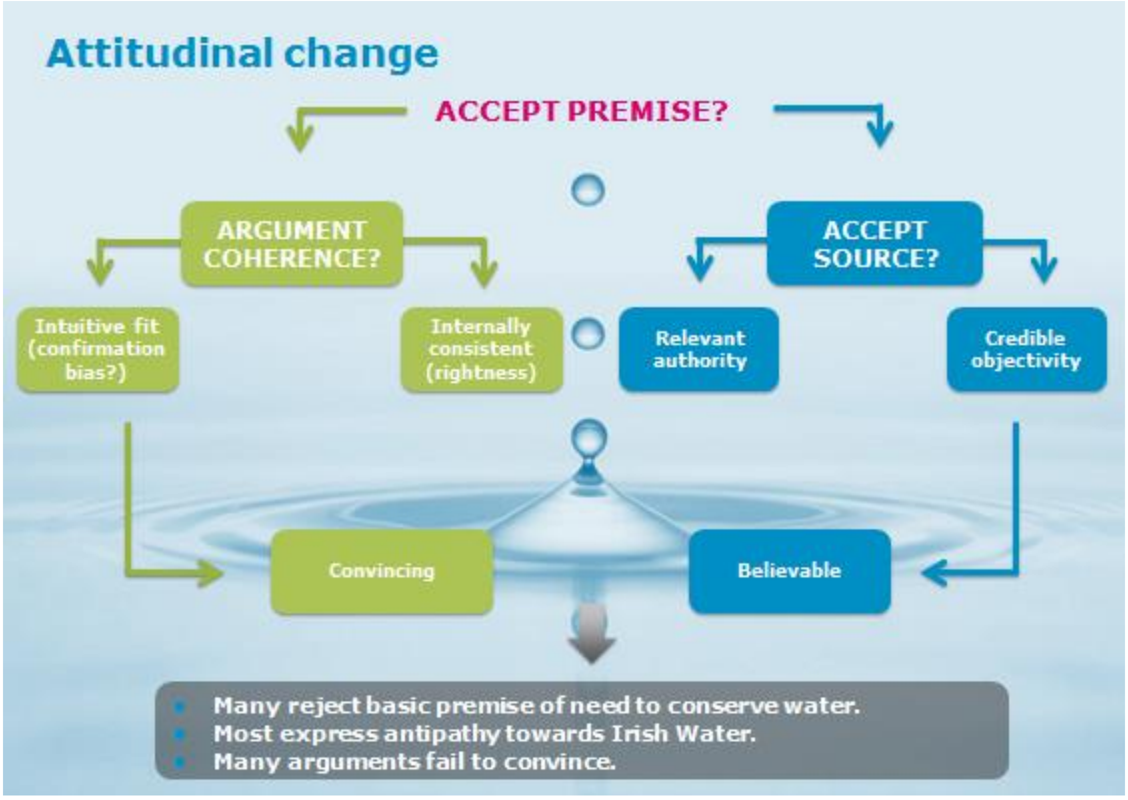
This operates on the level of 'common sense' and 'no brainer'. Key to establishing a positive and productive dialogue.

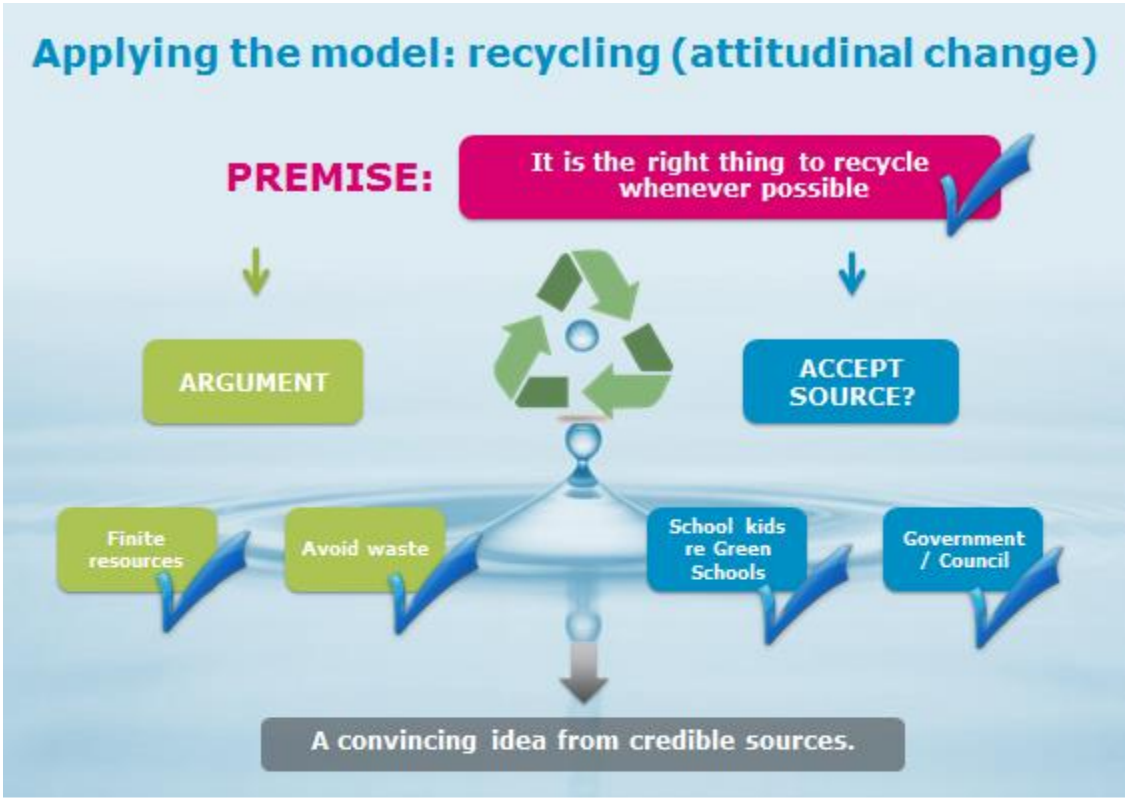
29

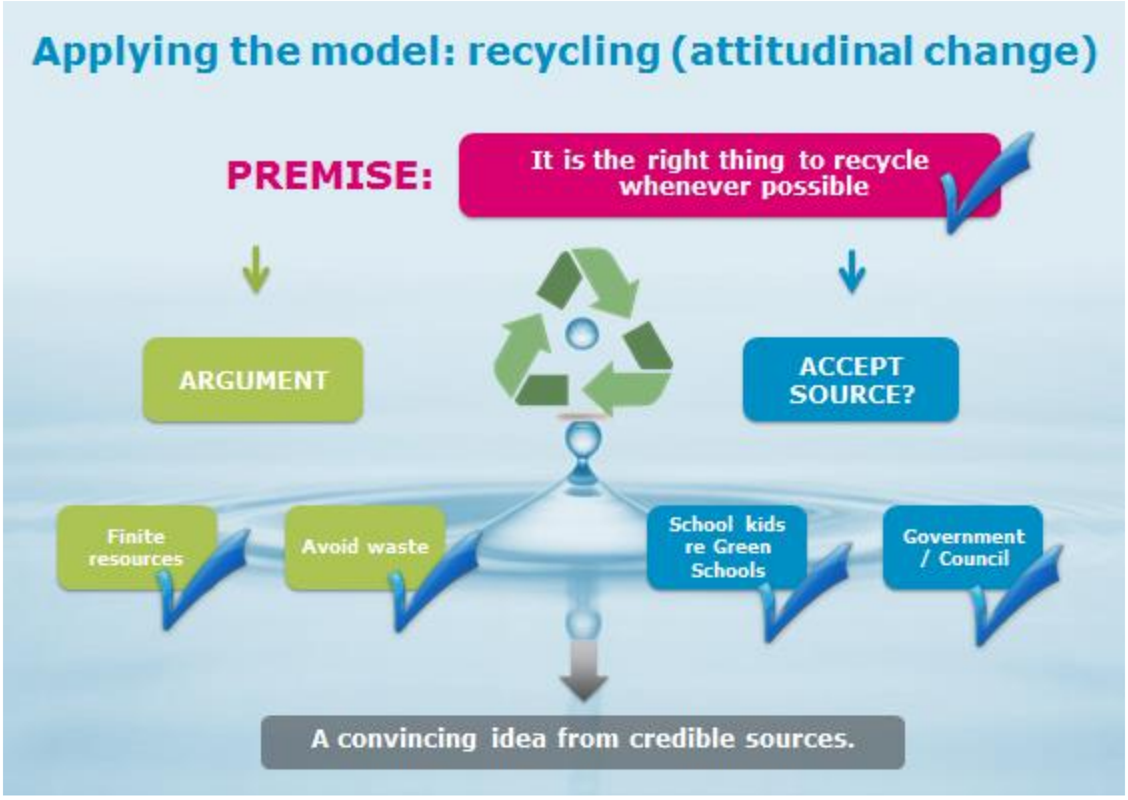


Moving the dial

- There is real need to engage the general public in order to shift both
  - **Attitudes** towards water usage and
  - **Behaviour** in the home.
- We need to understand what are the **triggers** and **barriers** to acceptance of the idea as well as the steps necessary to effect behavioural change.
- During the groups we received communication 'angles' and practical product interventions which helped uncover the most motivating territories.
- Before reviewing these we want to outline our analytical construct.


Attitudinal change
ACCEPT PREMISE?
ARGUMENT COHERENCE?
ACCEPT SOURCE?
Intuitive fit (confirmation bias?)
Internally consistent (rightness)
Relevant authority
Credible objectivity
Convincing
Believable
Many reject basic premise of need to conserve water.
Most express antipathy towards Irish Water.
Many arguments fail to convince.


Applying the model: recycling (attitudinal change)
PREMISE:
It is the right thing to recycle whenever possible
ARGUMENT
ACCEPT SOURCE?
Finite resources
Avoid waste
School kids re Green Schools
Government / Council
A convincing idea from credible sources.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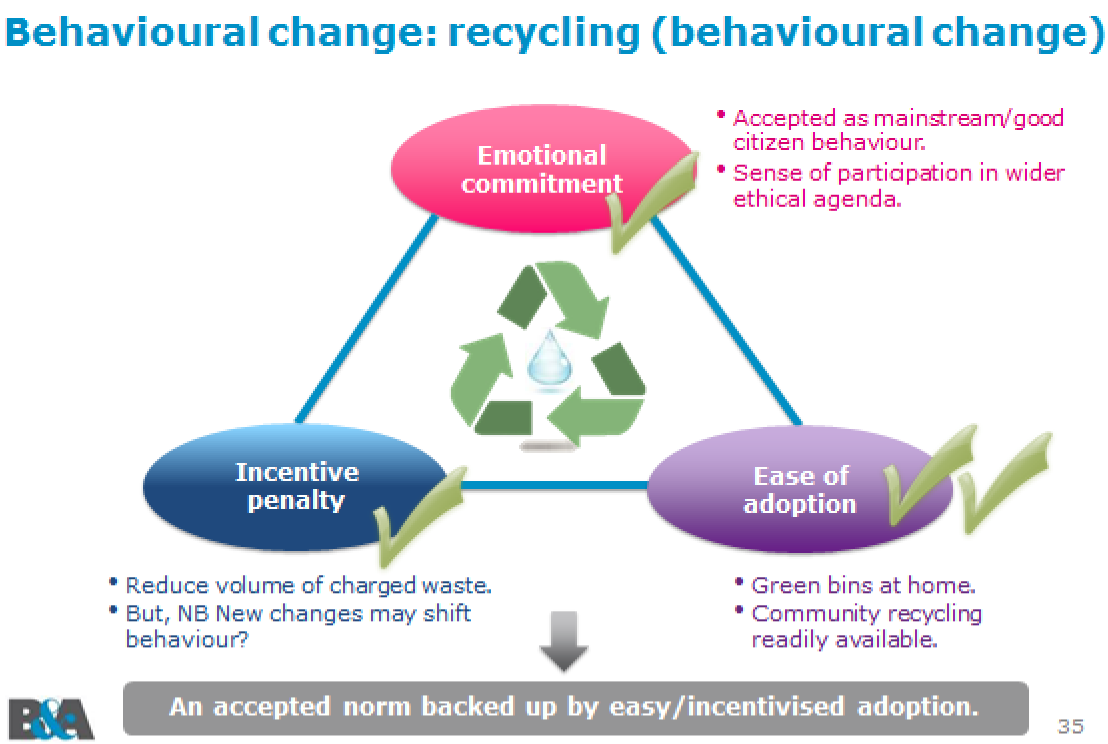
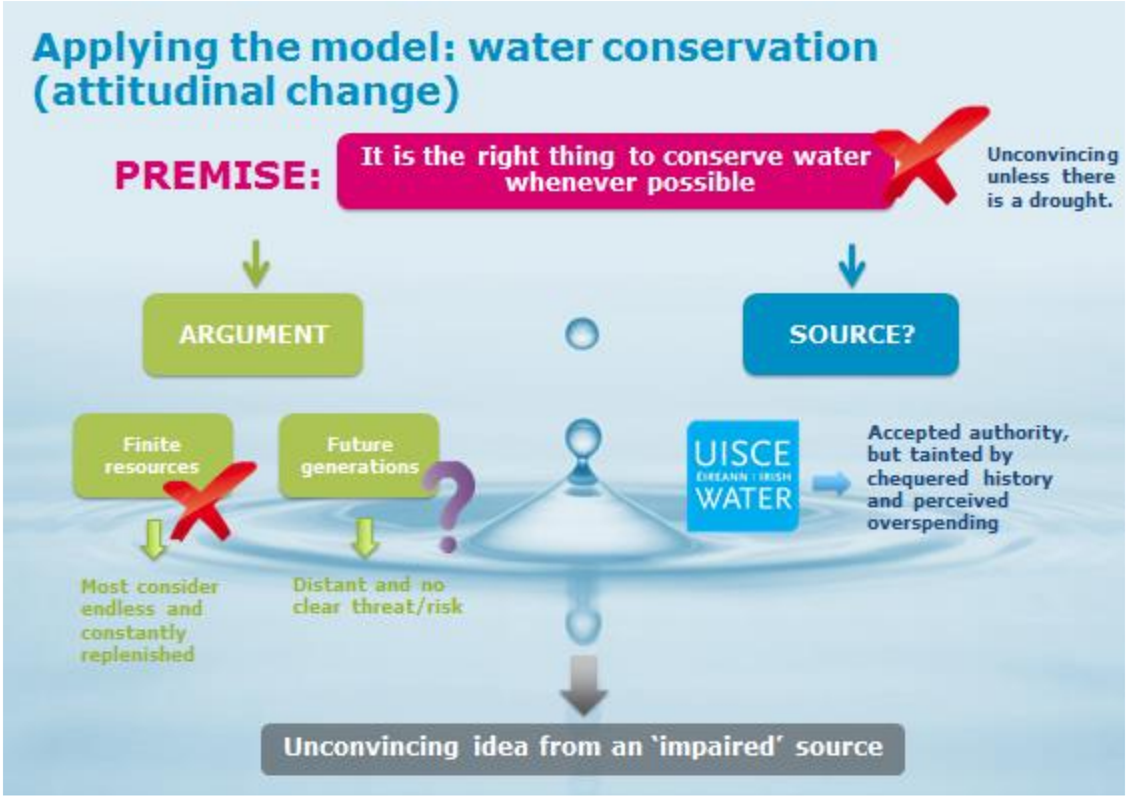
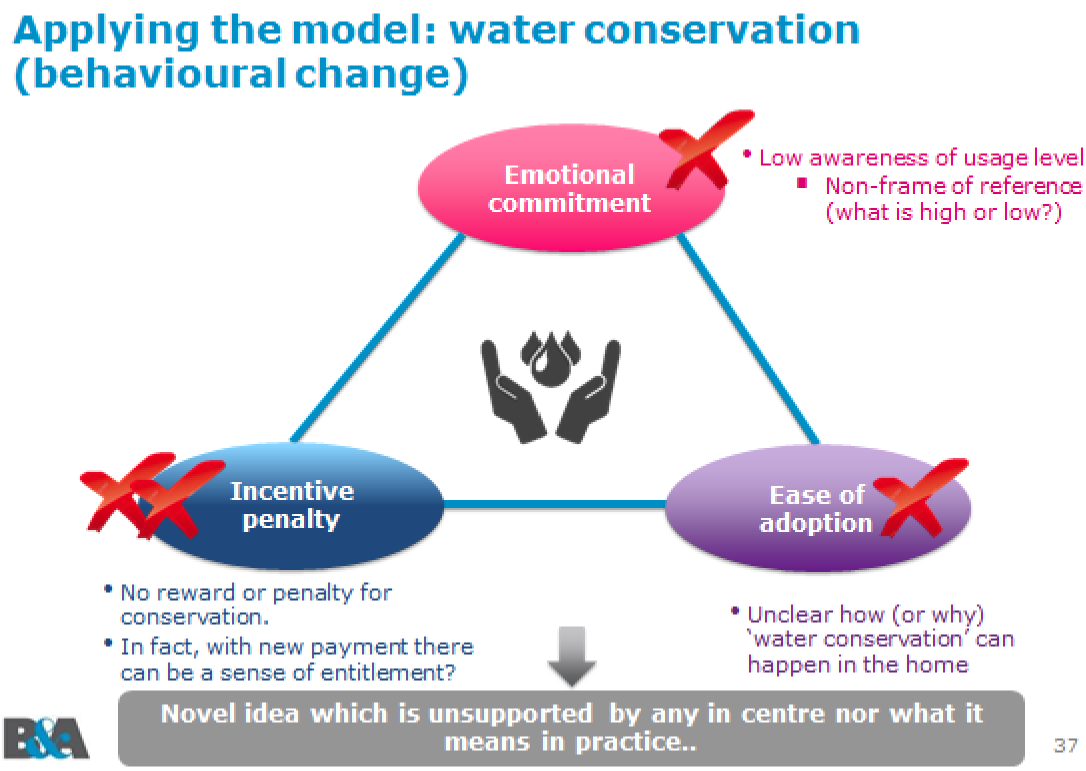
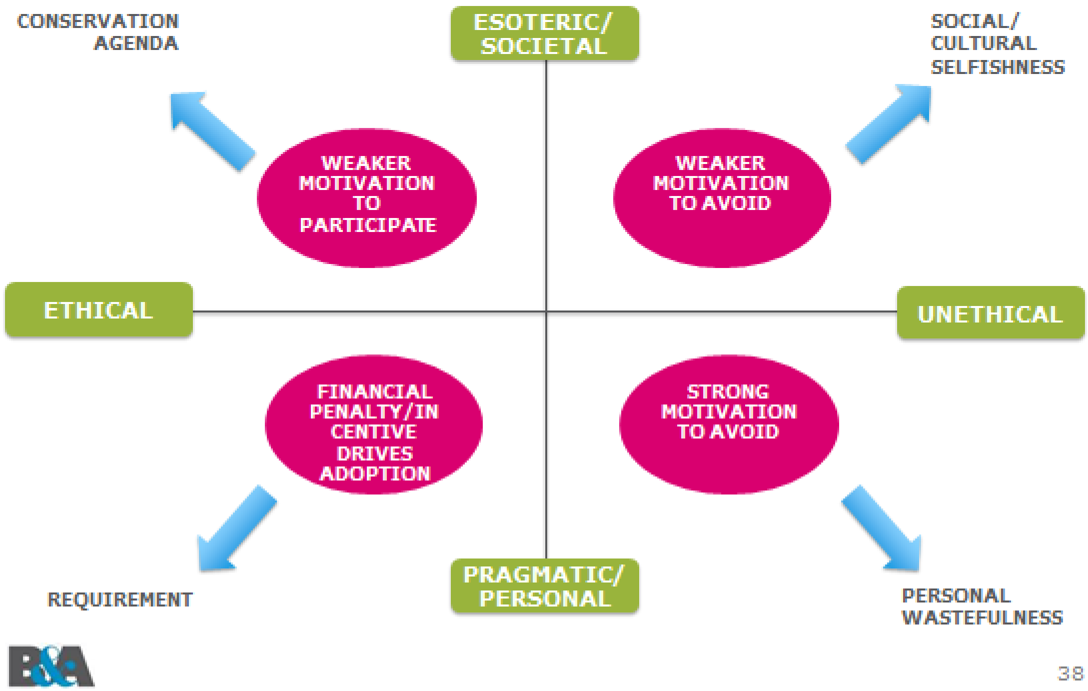

Behavioural change: recycling (behavioural change)
Emotional commitment
• Accepted as mainstream/good citizen behaviour.
• Sense of participation in wider ethical agenda.
Incentive penalty
Ease of adoption
• Reduce volume of charged waste.
• But, NB New changes may shift behaviour?
• Green bins at home.
• Community recycling readily available.
An accepted norm backed up by easy/incentivised adoption.
35


Applying the model: water conservation (attitudinal change)
PREMISE:
It is the right thing to conserve water whenever possible
Unconvincing unless there is a drought.
ARGUMENT
SOURCE?
Finite resources
Future generations
Most consider endless and constantly replenished
Distant and no clear threat/risk
UISCE ÉIREANN : IRISH WATER
Accepted authority, but tainted by chequered history and perceived overspending
Unconvincing idea from an 'impaired' source


Applying the model: water conservation (behavioural change)
Emotional commitment
• Low awareness of usage level
▪ Non-frame of reference (what is high or low?)
Incentive penalty
Ease of adoption
• No reward or penalty for conservation.
• In fact, with new payment there can be a sense of entitlement?
• Unclear how (or why) 'water conservation' can happen in the home
Novel idea which is unsupported by any in centre nor what it means in practice..
B&A
37

Motivational territories



Review of communication 'angles'

- Practical focus on volume of water can attract attention, but the basic **comparative construct** tends to be 'rejected' and/or 'unpicked'.
- Most directly question the validity of the comparison (not the same household size, number of residents etc.).
- Makes more sense if the relevant comparison is number of people in household rather than strict geographic areas.
- May potentially have relevance to communication with water bills.

1. **Localised** -
   Your household uses 500 litres of water every day, other similar households in your area use 250 litres per day.

Can cut through and provoke a response, but needs to be accurately connected to household size to potentially impact on behaviour.

40

Review of communication 'angles'

- Strong focal point created by practical focus on achievable goal (20 litres)
  - Converting this into methods of saving 20 litres could also help.
- However, most reject the argument that 'homes and businesses' can benefit
  - Inconsistent with household saving target (and commercially motivated as focus is on business).
  - Underlying premise is also not accepted (a finite resource where saving water will benefit the future)

2. **Community level (the positive) –**
   If every household in Ireland saved 20 litres of water a day this would provide capacity for new homes and business across Ireland for the future

Underlying argument does not support 'logic'.

41

Review of communication 'angles'

- Targeting daily waste seems much more practical and reasonable than the rather esoteric 'conservation' agenda.
- However, as before most reject the link with benefits to hospitals, schools and fire services.
  - While these are considered more altruistic than 'businesses' as the recipient of benefit most struggle to understand the link between less waste and the end benefit described.

3. Community level (the negative) – Every day households in Ireland waste many litres of water which could be directed to better use by our hospitals, schools and fire services

Waste is worthwhile focus, but again the underlying argument is not convincing.

B&A

42

Review of communication 'angles'

- While all recognise they are primed to respond to positive messages about Ireland – particularly through an international lens, there is some cynicism about Irish 'success' on reducing waste or recycling.
  - They see this as motivated by E.U. regulations and recycling incentives.
- Plastic bag tax is however seen as an example of Ireland adopting a leadership role
  - But, the catalyst for change in this case was the financial incentive – i.e. 15 cents.
- It proves the point that a penalty/incentive is required – not a sense of 'shared pride'.

4. National – Ireland is leading the way at a international level on reducing wastage, e.g. recycling and reusing materials, be part of the national initiative to reduce water wastage in your home and community today.

Even if more deftly expressed 'national pride' is not a strong enough to motivate behavioural change.

B&A

43

Review of communication 'angles'

- This statement is generally accepted due to its quite broad/non specific quality
  - It's better not to waste things.
- However, as before, many have difficulty accepting the link with
  - Improving supply for future generations.

6. Environment /Safeguarding our Future – using and wasting less water in our homes improves the supply of water for future generations.

Ultimately a little bland and lacks ability to attract attention or trigger reconsideration.

Review of communication 'angles'

- Consistently the most effective route (despite length)
  - Prompts **reconsideration** and **interest.**
- Newsworthy information which most find credible
  - Establishes clear sense of **value** for water coming out of a tap.
  - Contributes to a sense of **why** this is a limited resource.
  - Supports the sense of what Irish Water does.
- Cynicism expressed over "20 people": "20 plus consultants more like!"
- Practical reference to kettles and showers also humanises sense of **waste**
  - Proportionate to life/reasonable to change.

5. Wastage –
The water that is wasted every time a tap is left running, has been through a seven step treatment process, taking up to 5 days and involving 20+ people. It will take even more time and effort to treat the water that enters the wastewater network. In addition wasting water also wastes energy, every time we fill the kettle too much and every minute we leave the shower running until it heats up waste water and energy.

Value of water due to effort in its treatment makes intuitive sense AND establishes foundation for development of narrative from Irish Water.

Deconstructing wastage communication

7 Step Treatment

- Specifying number of days and people required has 'ring of truth'.
- Significant pause for thought as this information sinks in.
- Key to drawing attention AND establishing significance of wasteful behaviour.

Effort on waste water too

- Can be more difficult to comprehend:
  - And reminds some of waste water figure on their bill … surely this is not measured?
- Potential to remind people that all waste water is treated:
  - Perhaps better as a separate and more single-minded message as it can 'cloud' the issue here.

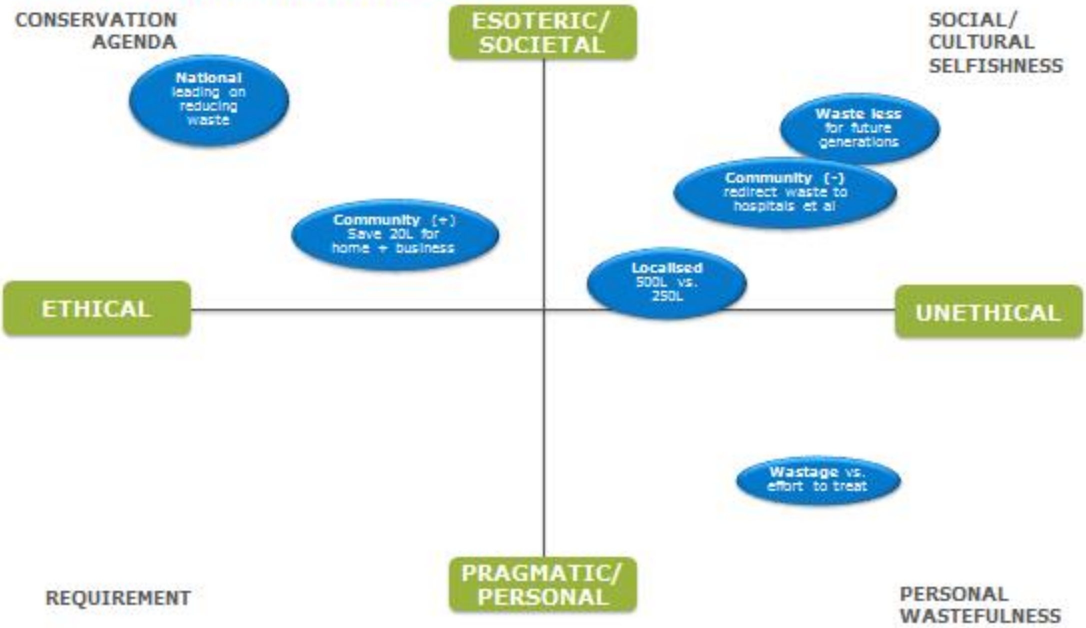
Tap running, kettle overfill, running shower

- Key component of this approach:
  - Connects message to personal experience.
  - Locates issue in a relevant, meaningful and intuitively acceptable way (most recognise themselves in the examples offered).
- Effective as it does not seem to preach but rather strikes a reasonable tone:
  - Silly not to comply, forgetful not **bad** behaviour in the frame.

B&A

46

Motivational territories



B&A

47

Review of products: Toilet bank

- Considered a practical intervention
  - Relatively easy to understand
  - Simple to install.
- Also, has the potential to signal Irish Water intentions in a positive way
  - Helping people save water (not charge them more).
- A few DIY adepts suggest a simple tweak to their ballcock or the use of a brick would result in the same thing (or putting a full bottle in the cistern).

49

Review of products: Tap aerator and regulator

Tap aerator

- Recognised by minority.
- Prompts interest as a contemporary and upscale device: *"soft water" "posh hotels"*.
- Minor query reducing speed of filling basin/kettle?

Tap regulator

- Reducing flow/pressure is understood to be the result of this device.
- Lower pressure is typically viewed as **'poor quality'** and undesirable.
- But, makes sense for heavy flow taps.

Some interest in both, but few feel they would retro-fit their taps without some financial incentive.

50

Review of products: Air jet shower and dual flush convertor

Dual flush convertor

- Some already have dual flush toilets.
- For those without this is rejected as
  - Complex
  - Risky (damage to toilet).
  - *"A drill? Are you serious? The mess!"*

Air jet shower

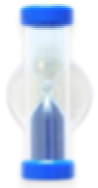
- Most express interest (assuming 'air jet' will increase sensation in a positive way).
- However, if this equates to reduced 'pressure' it is unlikely to be supported.
- One respondent had uninstalled an air jet shower due to poor flow: *"the girls couldn't get their conditioner out..."*

51

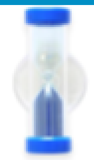
Review of products: Shower time and toothy timer

- Despite strong desire to limit teens time in shower, this would just act as a reminder. In fact, most want to preserve their personal time in the shower as special.
- 4 minutes also tends to be seen as impractical (too short especially for women with long hair); 5 minutes more practical in reality.
- Recognised as helpful for kids to encourage **length of brushing**.
- However, does not seem to relate to water usage (where turning off the tap rather than timing water use is key).

Shower time



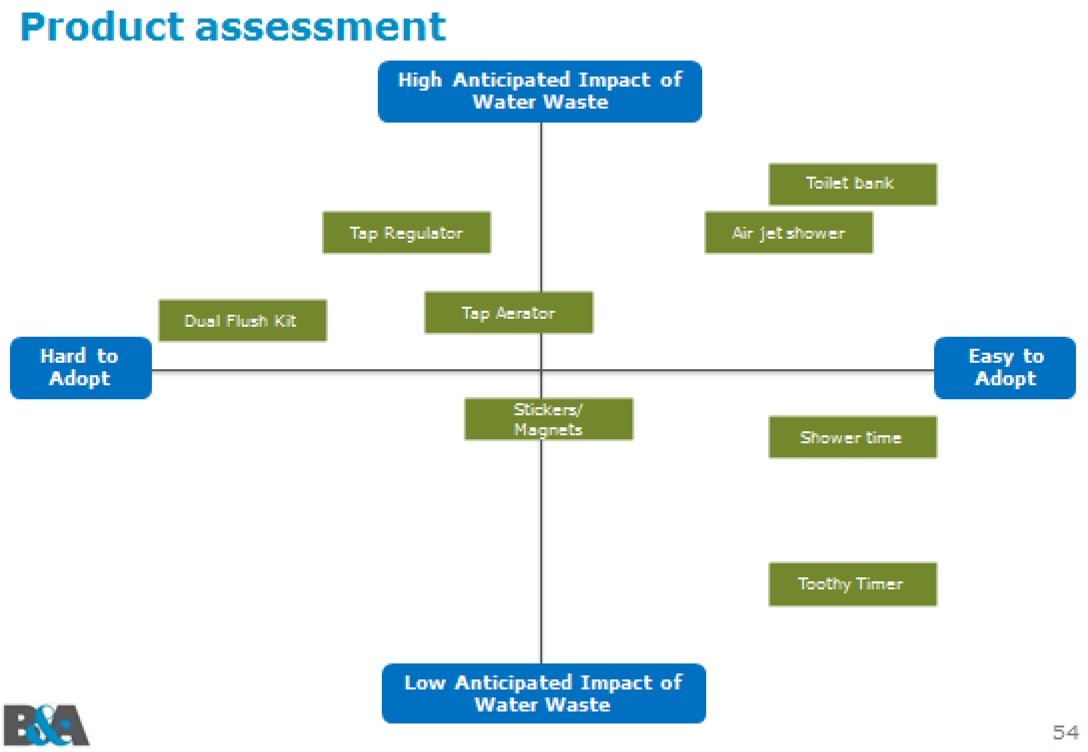
Toothy timer



Review of products: Stickers/magnets

- Several note the effectiveness of primary school initiatives where similar magnets/reminders come home (like Food Dudes).

- As part of a **school to home** campaign this may be worthwhile.
- However, many reject the idea of placing reminders around their house, disrupting their décor and sending a strange message to guests.
  - *"Fine in the 80's when we had rubbish furniture....but not now."*


Product assessment
High Anticipated Impact of Water Waste
Toilet bank
Tap Regulator
Air jet shower
Dual Flush Kit
Tap Aerator
Hard to Adopt
Easy to Adopt
Stickers/ Magnets
Shower time
Toothy Timer
Low Anticipated Impact of Water Waste
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9. Recommendations

Recommendations

- Several note the effectiveness of primary school initiatives where similar magnets/reminders come home (like Food Dudes).
- As part of a school to home campaign this may be worthwhile.
- However, many reject the idea of placing reminders around their house, disrupting their décor and sending a strange message to guests…
- What seems to be effective are small interventions in daily behaviour, particularly the 'unconscious' casual usage examples
  - Turning off the tap when brushing teeth is often offered as a learned shift in behaviour everyone accepts, and have adopted (or feel they ought to).
- Can we establish other small changes that can become a shift in habits?
  - These may seem like a small wins, but they are critical in beginning a positive dialogue.
- However, it is important to choose our battles.
- Many consider showers are a personal fixture in their day with more than just a functional role in terms of personal hygiene. Showers tend to have an **emotional significance** and many resent any attempt to say they should restrict their own habits.
  - Restricting their teenage kids maybe another matter!

B&A

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Recommendations

- At the macro level, certain concepts need to be established and built up over time. These should include:
  - The **effort** required in preparing water for human consumption.
  - Water conveyed as a **limited** resource for the country (not a constantly replenished supply) and how this impacts on development/future.
  - An indication of the timeline for linking usage to charges.
  - Providing a comparison with comparable households: e.g. typical households of two adults and two kids.
  - Translation of water usage into something more meaningful/relatable
    - On the bill cubic metres has little or no relevance to their sense of usage. Is there a different way to express this or provide a 'ready reckoner'? Can we make sure that the usage section is given more prominence?
    - Can we use physical references to bring usage to life? For example:
      - 'Households flush about a swimming pool of water every year?'
      - 'Washing a few potatoes under a running tap only takes 5 minutes. That is 20 litres of water'

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Building a positive identity

- Some of the most effective communication angles and conservation products also contribute to a more positive appreciation of Irish Water.
  - In fact, this should be considered in the way communications are developed (a negative view of Irish Water currently inhibits engagement with the message).
- There are several components to consider:

Water treatment .....effort

- People and time involved.
- Establishes sense of value.
- Avoid endlessly replenished notion.

Fixing the network.... industry

- Skilled engineers.
- Progress by area.
- Validates Irish Water contribution.
- Diffuses sense of no need to change personally because leaks are bigger problem.

Practical help to ...waste less

- Focus on practical steps in non contentious areas of usage (casual wastefulness).
- Establish memorable reference points (time and volume related). Both above the line and on bill.
- Support with advice, products.
- Utilise education route to home (as with Food Dudes).

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