



Draft Water Resources Management Plan 2019

Technical Report - Demand for water



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1. Introduction

This technical report sets out our approach to deriving robust resource zone level¹ forecasts of demand for water², including how we will help manage that demand now and in the future in our draft Water Resource Management Plan 2019 (WRMP19). Our approach to forecasting and managing demand in future has been informed by what customers, stakeholders and regulators have told us, including during our pre-consultation activities. Our demand forecasts adhere to the guiding principles and the Water Resources Planning Guideline³ and this report aims to demonstrate the way in which we have consistently applied the latest methods and national best practice. The key components of demand for water to be forecasted⁴ from a “base year” to the end of the planning period⁵, as in Section 5 of the Water Resources Planning Guideline, are shown in Figure 1.

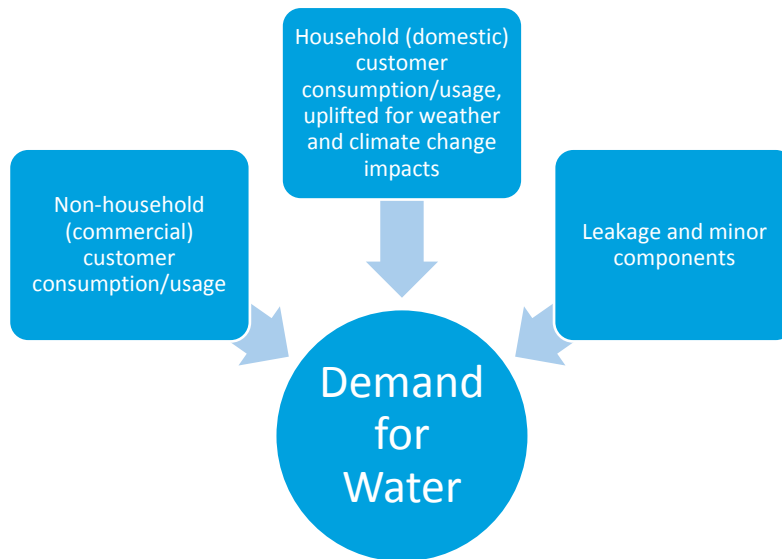


Figure 1 Building the WRMP19 demand forecast

Therefore, we require an understanding of:

1. Household (domestic) customer consumption/usage, hereafter referred to as “household consumption”, including the benefits of demand management and uplifted for climate and weather impacts (i.e. reflecting “dry” weather conditions)
2. Non-household (commercial and industrial) customer consumption/usage, hereafter referred to as “non-household consumption”, including the benefits of demand management
3. Leakage⁶
4. Any other losses or uses of water, such as water taken unbilled, known as “minor components”

Also, as with any long-term forecast, there is inherent uncertainty. Therefore, the understanding and representation of this uncertainty is as important as the central forecast, forming a key input to target headroom assessment and demand scenarios. Upon final adoption of WRMP19, we will continue to track, monitor and report demand on an annual basis as part of the Annual Water Resources Management Plan review process.

¹ As well as at Demand Monitoring Zone (also known as Distribution Monitoring Zone) level to support resilience assessments that use “peak” type uplifts. We currently have 33 Demand Monitoring Zones.

² The treated, or “potable”, element of which is known as “distribution input”. However, the term “demand for water” is sometimes expanded to cover “non-potable demand” (covered in Section 9) as well.

³ Water Resources Planning Guideline (Environment Agency, 2017)

⁴ For the “baseline” scenario, before any strategic choices (e.g. around leakage) are taken, and “final planning” scenario, where the benefit or impact of any strategic choices are included

⁵ Our demand forecast “base year” is 2015/16 for the draft Water Resources Management Plan and the planning period is to, at least, the year 2044/45

⁶ Water leaks from our network of pipes and customer supply pipes

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1.1 Resource zones

Following our WRMP19 Water Resource Zone Integrity review, as documented in our *Draft WRMP19 Technical Report - Supply forecasting*, we have four resource zones:

- The Strategic Resource Zone (sometimes abbreviated to “SRZ”), a combination of the old Integrated and West Cumbria Resource Zones as defined in the 2015 Water Resources Management Plan (WRMP15). This reflects completion of the Thirlmere transfer scheme by March 2022 (2022/23), and supplies over 98% of customers;
- The Barepot Resource Zone (sometimes abbreviated to “BRZ”), a newly created resource zone containing industrial customers on non-potable supplies⁷ (covered in Section 9.2);
- The Carlisle Resource Zone (sometimes abbreviated to “CRZ”); and
- The North Eden Resource Zone (sometimes abbreviated to “NERZ”).

1.2 Historic trends, WRMP15 review and key changes for WRMP19

As shown in Figure 2, large leakage reductions in the 1990’s, as well as metering and water efficiency activity, have contributed to demand for water being significantly lower than in the recent past.

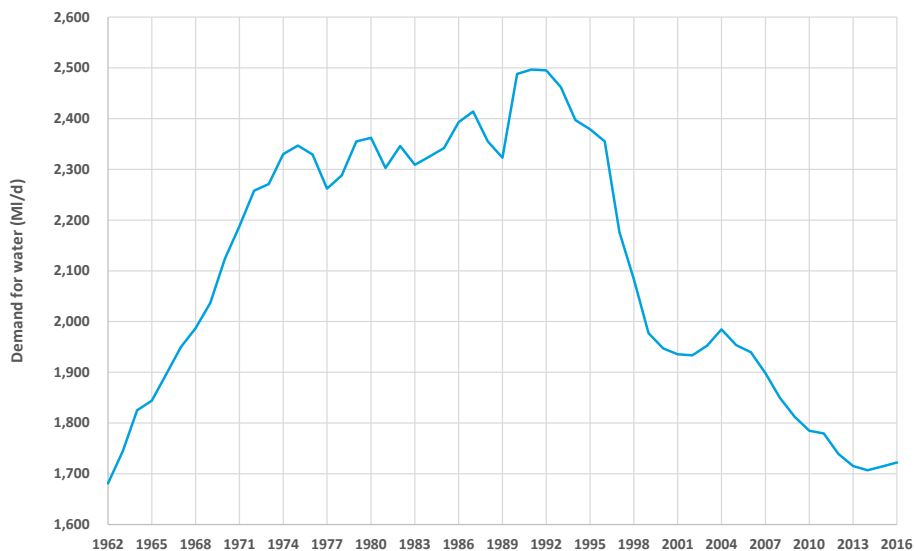


Figure 2 Annual average demand for water back to 1962

As mentioned in Section 4.3.8 of our *Draft WRMP19 main report*, year on year the demand for water can fluctuate and in the last few years we have seen slight increases in demand, as shown in Figure 3.

⁷ Although, in the WRMP process, non-potable water supplied is taken away from available supply, this report discusses non-potable supply from the customer perspective and, therefore, refers to it as “non-potable demand”. It’s also worth noting that raw water and potable imports and exports are covered in the *Draft WRMP19 Technical Report - Supply forecasting*.

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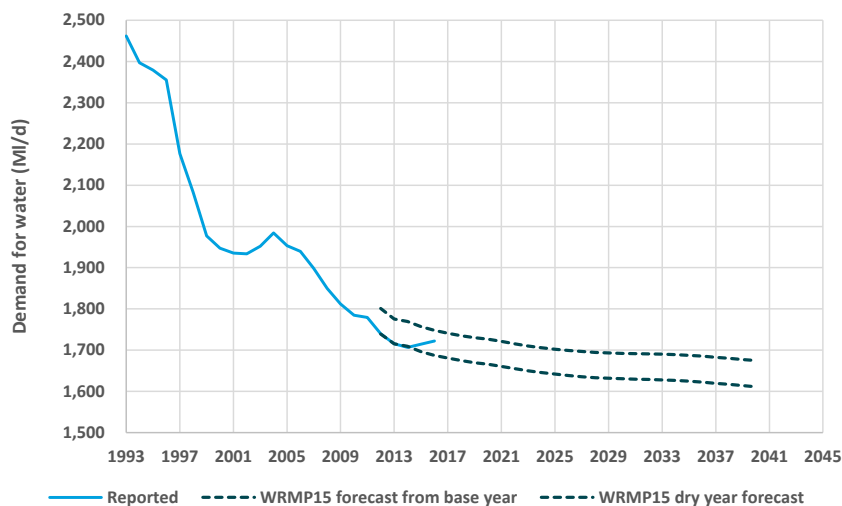


Figure 3 Reported demand for water shown with our WRMP15 forecasts

From Figure 2 and Figure 3, it is clear that there are year on year fluctuations in demand for water, due to factors such as weather. However, in the last few years we have seen slight increases in demand for water (similar to those previously observed between 2001 and 2005 on the graph). While our forecasts aim to account for the long-term trend and take account of plausible uncertainty in target headroom within our planning process, we are alert to the fact that this could be the start of an upward trend. This is a key reason for reviewing our WRMP on a regular basis and we will continue to monitor demand for water, assessing it against our demand forecast, as part of our annual review process.

For WRMP19, the overall reduction in demand for water has not only influenced the starting point of our demand forecast, via the use of this data to inform the base year, but also helps inform the forward look. Table 1 shows this and other key changes made for WRMP19.

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Table 1 Key changes to approaches and methodologies for WRMP19

Change ID	Change	Rationale	Key section
DFM1	Used data from Regulatory Reporting 2015/16 for base year data ⁸	Reported data, measured where possible, should always form the basis of any demand forecast	1.2.1
DFM2	Based our forecast population and property figures on local plans published by Local Authority Districts and Unitary Authorities	In line with the guidance from the Water Resources Planning Guideline and the WRMP19 Methods – Population, Household Property and Occupancy Forecasting UKWIR report (UKWIR, 2015)	2.1
DFM3	Remodelled the uptake of the Free Meter Option (sometimes referred to as “FMO”) and included the uncertainty around the benefit, in terms of consumption reduction, in target headroom.	Following feedback from the Environment Agency and the findings in our previous annual reviews, when comparing actual levels to our forecast levels	2.2.6 and 10
DFM4	Remodelled household consumption	In line with the guidance from the WRMP19 Methods – Household Consumption Forecasting, previously Demand Forecasting Methods UKWIR report (UKWIR, 2015)	2.4
DFM5	Remodelled non-household consumption	To reflect the latest economic position and sectoral trends	3.3
DFM6	Reassessment of the Economic Level of Leakage (ELL) and Sustainable Economic Level of Leakage (SELL)	WRMP15 advice item and further feedback from the Environment Agency around incorporating the findings of the SELL recommendations report, as well as our own methodological improvements	4.3
DFM7	Remodelled the relationship between weather variables and consumption of water	In line with updated UKWIR guidance and utilising the latest capabilities of the Met Office	7.1.2
DFM8	Revised our design “dry year”	Following a WRMP15 advice item and further feedback from the Environment Agency	7.1.3

1.2.1 Key base year data

Table 2 shows the key components of demand for the base year of our demand forecast.

Table 2 Key components of demand from Regulatory Reporting 2015/16 Table 10b in megalitres per day (Ml/d)

Component	Strategic	Carlisle	North Eden	Region
Unmeasured household consumption	592.0	10.5	1.2	603.7
Measured household consumption	265.1	3.7	0.5	269.3
Unmeasured non-household consumption	9.1	0.2	0.1	9.4
Measured non-household consumption	352.2	6.9	1.2	360.3
Total leakage	443.5	5.9	2.6	452.0
Minor components	26.8	0.4	0.2	27.5
Demand for water	1688.8	27.5	5.8	1722.1

In our region, 51% of demand for water is from households, 21% is from non-households and 28% is related to leakage and minor components. These proportions have been relatively consistent since the large leakage reductions in the 1990’s.

1.2.2 Key new research projects for WRMP19

Table 3 shows a list of the demand related UKWIR projects carried out to inform WRMP19 and, specifically, what components or elements of our WRMP they have informed or impacted. A full list of all demand related UKWIR projects can be found in Appendix E.

⁸ For the revised draft of our WRMP19, we will likely update the base year to 2016/17

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Table 3 Demand related UKWIR projects carried out to inform WRMP19

Year	Manual/report name	Manual/report reference	Key components/elements that are informed/impacted
2015	WRMP19 Methods – Population, Household Property and Occupancy Forecasting	15/WR/02/8	Deriving population, household property and occupancy forecasts (see Section 2.1)
2015	WRMP19 Methods – Household Consumption Forecasting, previously Demand Forecasting Methods	15/WR/02/9	A key change for WRMP19 and informed the choice of approach for household consumption forecasting (see Section 2.4.1)
2015	Economics of Supply Pipe Leakage	15/WM/08/56	Informed our assessment of customer supply pipe repair policy (see Section 4.2)
2016	Integration of Behavioural Change into Demand Forecasting and Water Efficiency Practices	16/WR/01/15	Informed our customer behaviour, occupancy and ownership survey (see Section 2.1.3 and 2.4.3)
2016	WRMP 2019 Methods – Decision Making Process: Guidance	16/WR/02/10	Informed the thinking for our WRMP19 problem characterisation and approach selection documented in our <i>Draft WRMP19 Technical Report - Options appraisal</i>
2016	WRMP 2019 Methods – Risk Based Planning	16/WR/02/11	Informed the thinking for our WRMP19 problem characterisation and approach selection, documented in our <i>Draft WRMP19 Technical Report - Options appraisal</i>
2017	Consistency of Reporting Performance Measures - Leakage	17/RG/04/5	Informed our approach to leakage convergence (see Section 4.8)

2. Household consumption

This section covers how we have derived our forecast of measured and unmeasured household consumption, including the incorporation of the benefits of customer metering and our water efficiency activities.

2.1 Population, properties and occupancy

This section covers how we have derived our WRMP19 population and property forecasts to ensure we support the growth predicted by Local Authority Districts and Unitary Authorities within our region, in line with Defra’s guiding principles⁹. Throughout this section, we refer to two main types of population and property forecast, as shown in Table 4.

Table 4 Types of population and property forecast

Forecast type	Description
Trend-based	Replicates the latest subnational population projections ¹⁰ , including those for the Welsh Government, from the Office for National Statistics (sometimes referred to as “ONS”). The trend-based population forecast is reconciled to the latest mid-year population estimates ¹¹ and the forecast horizon is extended beyond the projection horizon (of 2039) to match the WRMP19 planning period. This population forecast, as well as information from the latest Department for Communities and Local Government (sometimes referred to as “DCLG”) household projections ¹² , forms the basis of the trend-based property forecast.
Plan-based	This property forecast uses future housing growth evidence from the Local Development Plans of just over 50 Local Authority Districts and Unitary Authorities (sometimes referred to as “LADUA”), as well as 3 National Park Authorities (sometimes referred to as “NAP”). For years beyond each Local Development Plan period, the annual housing growth reverts to the trend-based forecast. In terms of population forecasting, the plan-based forecast is informed by the trend-based forecast, but assumes a higher net in-migration, in line with the increased number of properties being forecast in the Local Development Plans. Our engagement with Local Authority Districts and Unitary Authorities is documented in 2.1.1 and a full list of the Local Authority Districts and Unitary Authorities in our region can be found in Appendix G.

For each of our resource zones with household (domestic) customers, we have:

1. Derived a trend-based population and property forecast, as described in Table 4;
2. Engaged with Local Authority Districts and Unitary Authorities (see Section 2.1.1) and collated the available data from the property forecasts in Local Development Plans, to form the basis for a plan-based population and property forecast;
3. Engaged with and sought endorsement from our household customer retail team (known as “Domestic Retail”), including the review of several household property forecasting assumptions (see Section 2.1.2), against the trend-based/plan-based forecasts;
4. Derived an occupancy forecast informed by Department for Communities and Local Government projections and a household customer behaviour, occupancy and ownership survey for the our region (see Section 2.1.3);
5. Carried out an assessment of our unallocated population, such as irregular migrants¹³ and short-term residents. Although, as discussed in Appendix B, we use per household consumption (PHC), rather than per capita consumption (PCC), in our Water Balance, so the impact of this population on reported levels of household consumption is likely to be minimal, only warranting sensitivity testing of our household consumption forecast (see Section 2.6); and

⁹ Department for Environment, Food & Rural Affairs (abbreviated as “Defra”) Guiding principles for water resources planning (published in May 2016)

¹⁰ At the time of writing, this was the 2014-based subnational population projections (published in May 2016). It’s worth noting that the 2016-based national population projections (published in October 2017), which will eventually inform the 2016-based subnational population projections, estimate lower population growth than the 2010-based, 2012-based and 2014-based population projections.

¹¹ At the time of writing, this was the 2015 mid-year population estimate (published in June 2016)

¹² At the time of writing, this was the 2014-based household projections (published in July 2016)

¹³ Typically refers to migrants in a country who are not entitled to reside there, either because they have never had a legal residence permit or because they have overstayed their time-limited permit.

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6. Assessed the ranges/uncertainty (see Section 9).

2.1.1 Engagement with Local Authority Districts and Unitary Authorities

We have worked with Edge Analytics and CBRE Ltd to ensure we are using the most up-to-date information from Local Development Plans. We have been through a stringent process of reviewing the available data for all the Local Authority Districts and Unitary Authorities in our region (see Appendix G for the full list). This data has formed the basis to our plan-based property and population forecast.

We also engage with Local Authority Districts and Unitary Authorities on a business as usual basis and have used this opportunity to provide updates on our progress with WRMP19.

2.1.2 Household types and property forecasting assumptions

This section covers the occupied household types we base our household consumption forecast around, as shown in Table 5, and some key household property forecasting assumptions, as shown in Table 6.

Table 5 Occupied household types with key information

Household type	Description and key information
Unmeasured	At present, the majority ¹⁴ of households in our region do not have a water meter, however the number of unmeasured households is expected to reduce markedly as customers continue to opt to be measured. There will also be a net reduction due to demolition or conversion.
Measured (Metered When Built Pre 2010)	Households built between 1989/90 and 2009/10 that were compulsorily measured.
Measured (Metered When Built Post 2010)	Households built after 2009/10 that were compulsorily measured, but have also been designed to be water efficient, as required under Part G of the Building Regulations.
Measured (Optant)	Households where the customer(s) have opted to be measured. We have offered a Free Meter Option (FMO) scheme for households since April 2000, in accordance with the Water Industry Act 1991. The forecast numbers of optants across the region are shown in Section 2.2.6.
Demand Management	About 4000 households that owned garden sprinklers were compulsorily measured during the 1995/96 drought, but this programme was discontinued as it was seen as a “tax” on honest customers who informed us that they owned a garden sprinkler and was not an economic supply-demand measure.

Table 6 Household property assumptions, with a description for each

Household property forecasting assumption name	Description
Deletions	Household properties that have been demolished or are forecast to be demolished in the WRMP19 planning period.
New household connections	Household properties that are forecast to be connected in the WRMP19 planning period.
Void or voids	Unoccupied or empty household properties or household properties that are forecast to become unoccupied or empty in the WRMP19 planning period.

Deletions have been forecast based on our latest best estimate for 2016/17. Over the longer term, we have forecast unmeasured household deletions to reduce, as the outright number of unmeasured household properties decreases, and measured household deletions to increase as there are more measured household properties, due to new connections and the impact of the Free Meter Option (see Section 2.2.6).

In line with the Water Resources Planning Guideline, our forecast of new household connections has currently been informed by the plan-based property forecast. However, as shown in Figure 4, the plan-based property forecast creates a large peak in new household connections.

¹⁴ At 2015/16, regional metering penetration (excluding voids) was around 40%

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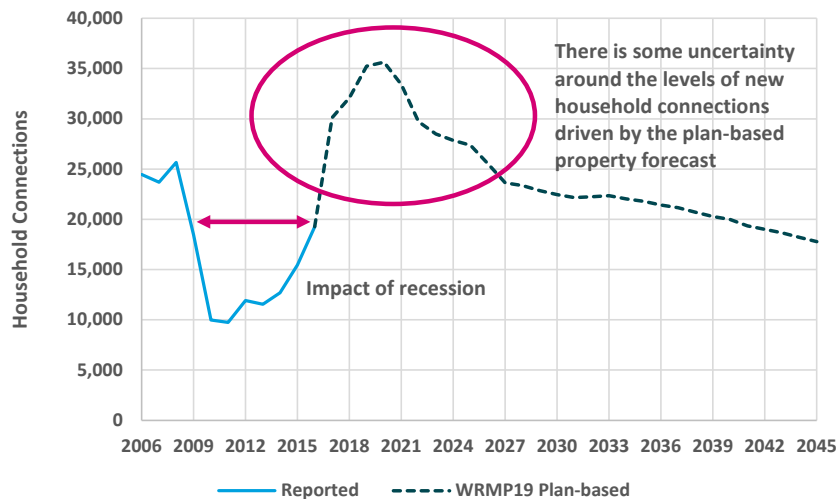


Figure 4 Reported new household connections, with the plan-based forecast of new household connections for WRMP19

Whilst being based on Local Authority Districts and Unitary Authorities plans for the future, there is uncertainty in whether this level of household new connections will be achieved, given we have not seen similar levels for many years¹⁵. This is not so much of an issue for the longer term forecasting used for the WRMP, but for shorter term forecasting this creates a potential issue. Therefore, for our next business plan (covering 2020/21 to 2024/25), we are reviewing the profiling of the plan-based forecast to ensure the level of household new connections is sensible, based on historic data and forecast achievable levels, using information from the house building industry. We may look to utilise this profiled plan-based forecast for the revised draft of our WRMP19.

For the last 5 years, approximately 6% of unmeasured household properties have been classified as void. This is forecast to increase to just over 9% in the next few years, due to a full verification of occupier details, and we have forecast this percentage to be maintained though the WRMP19 planning horizon. Similarly, over the same period the average percentage of measured household properties classified as void has been approximately 4%. We have forecast this to increase slightly, due the verification mentioned previously, and remain at this level for the WRMP19 planning horizon.

2.1.3 Occupancy and household size

Occupancy rates are informed using two main sources of information:

1. A household customer survey, discussed fully in Section 2.4.3, to inform the base year occupancy for different household types (see Table 5 for the different household types) and information from our last four occupancy surveys is used to verify occupancy rate forecasts; and
2. The most recently published Department for Communities and Local Government headship rates¹⁶ inform our forecast of occupancy rates and, therefore, assumptions around the change in household size.

The occupancy rates for the different household types from our last four occupancy surveys are shown in Figure 5. There has been a decline in all occupancy rates signifying a regional change in household size, due to, for example, the development of large blocks of flats in the population centres that tend to have a lower occupancy.

¹⁵ On reviewing data back to the late 1990's, the highest level of new household connections has been just over 25,000 in 2007/08.

¹⁶ At the time of writing, these were the Department for Communities and Local Government headship rates from the 2014-based household projections (published in July 2016)

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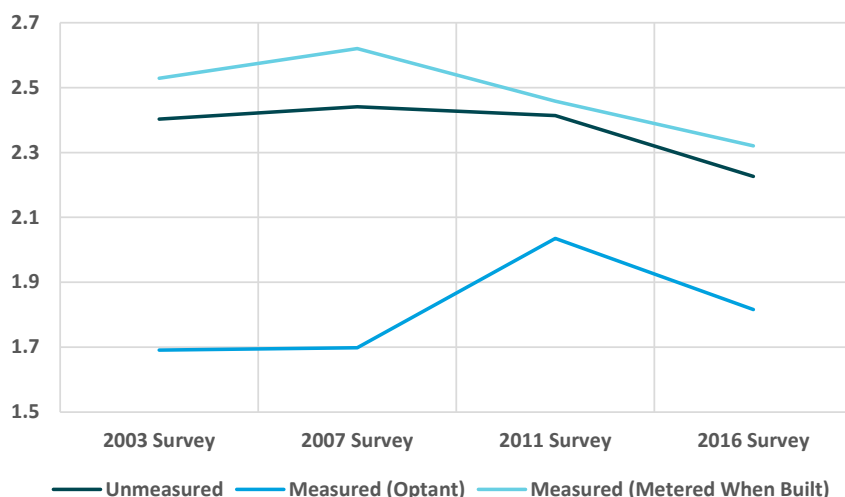


Figure 5 Household occupancy rates from our last four occupancy surveys

The occupancy rates from our 2016 household customer survey for WRMP19 are shown in Table 7 and are broadly consistent across all our resource zones.

Table 7 Household occupancy rates from our WRMP19 Household Customer Survey

Resource Zone	Unmeasured	Measured (Optant)	Measured (Metered When Built)
Strategic Resource Zone	2.3	1.8	2.4
Carlisle Resource Zone	2.2	1.8	2.3
North Eden Resource Zone	2.2	1.8	2.3
Region	2.2	1.8	2.3

2.1.4 Forecast

Figure 6 shows the reported total population and household properties (excluding voids) for our region, as well as our different forecasts to 2044/45, including:

- The forecast from our previous WRMP, “WRMP15”; and
- The plan-based and trend-based forecast, created for WRMP19 and discussed above.

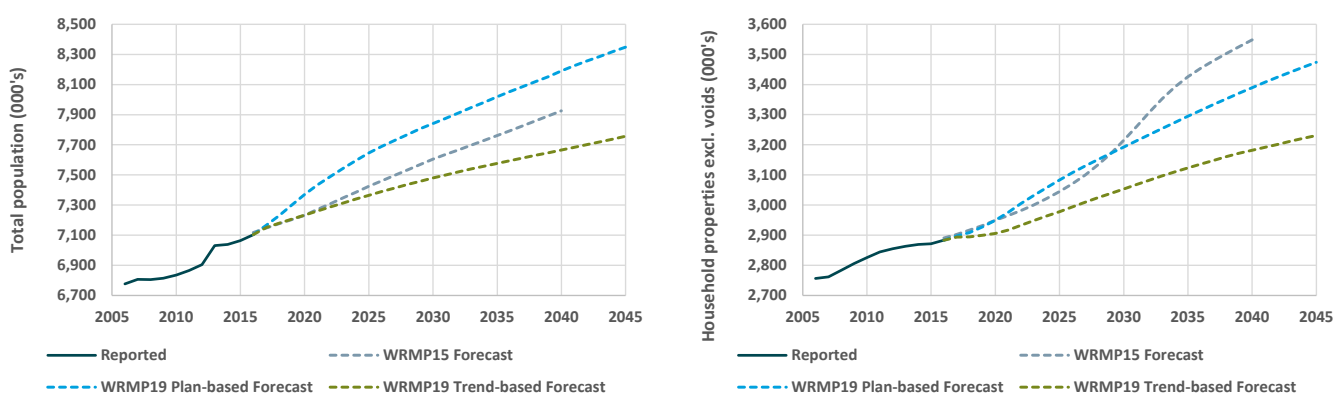


Figure 6 Reported and forecast total population¹⁷ and household properties to 2044/45

Table 8 shows the reported and plan-based scenario data broken down by resource zone.

¹⁷ Of which around 90% is household population, the rest falls into measured non-household and unmeasured non-household population

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Table 8 Reported¹⁸ and plan-based population and household property forecast by resource zone to 2044/45

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Total population	6,980,386	7,301,526	7,551,216	7,732,309	7,906,330	8,075,297	8,198,640
Household population	6,219,119	6,434,497	6,667,802	6,867,349	7,086,126	7,318,565	7,504,470
Household properties (excl. voids)	2,831,157	2,921,682	3,049,635	3,152,639	3,251,837	3,343,179	3,408,719
Household occupancy	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Carlisle Resource Zone							
Total population	109,469	117,287	123,395	128,284	130,955	132,873	133,820
Household population	99,853	106,140	112,723	118,328	121,998	125,026	126,161
Household properties (excl. voids)	46,632	48,745	51,843	54,512	56,402	57,779	58,515
Household occupancy	2.1	2.2	2.2	2.2	2.2	2.2	2.2
North Eden Resource Zone							
Total population	13,746	14,619	15,202	15,661	16,011	16,213	16,264
Household population	11,666	12,396	13,049	13,592	14,031	14,343	14,492
Household properties (excl. voids)	5,415	5,651	5,945	6,183	6,367	6,500	6,560
Household occupancy	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Region							
Total population	7,103,601	7,433,432	7,689,812	7,876,254	8,053,296	8,224,384	8,348,723
Household population	6,330,638	6,553,033	6,793,575	6,999,270	7,222,155	7,457,934	7,645,123
Household properties (excl. voids)	2,883,204	2,976,077	3,107,423	3,213,335	3,314,606	3,407,458	3,473,793
Household occupancy	2.2	2.2	2.2	2.2	2.2	2.2	2.2

Full details of our forecast population, number of properties and occupancy by property type and resource zone can be found in Appendix H.

2.2 Customer metering and tariffs

In line with The Water Resources Management Plan (England) Direction 2017, this section covers our estimate of the number of household (domestic) properties which will become metered during the WRMP19 planning period. It also covers our estimate of the reduction in household consumption, as a result of the increase in the number of properties becoming metered.

In AMP7 (covering 2020/21 to 2024/25) we are planning to spend circa £75m on the installation of meters on new developments, for customers that opt to have a meter fitted under our Free Meter Option (FMO) scheme and maintenance of our existing meters. It should be noted that a part of our business planning process this number may change to revised draft plan, and is provided here as an indication of current estimates.

2.2.1 Background

We recognise the important contribution of economic customer metering and tariff actions in achieving and maintaining an adequate supply-demand balance in each of its four water resource zones. It plays a key role in our demand management plans.

Effective metering contributes to the overall reduction in consumer demand and plays a key role in the WRMP. Compulsory metering of new premises was introduced in 1990 after the introduction of community charge and the cessation of applying rateable values. The Water Industry Act 1999 gives customers the right to opt to have a water meter fitted for free: this is often called the “Free Meter Option”. Our Free Meter Option policy was introduced in April 2000 and it we have committed to fit a meter where it is reasonably practicable and not unreasonably

¹⁸ It's worth noting that we have applied the updated WRMP19 occupancy rates to 2015/16 for consistency

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expensive to do so. If meter fit is not possible we will bill the customer based on an assessed charge. The assessed charge requirements are stated in the charges scheme and are based on type of property (detached, semi or other), or we have a single person tariff if the customer lives alone (in any type of property).

2.2.2 Metering policy drivers

There are three main drivers for our metering policy:

- Regulatory and policy;
- Business; and
- Customer and stakeholder.

Regulatory drivers

The following legislation sets out our requirements to maintain customer meters and provide customers with the option to be metered:

- Water Industry Act 1991 section 144A, Right of consumer to elect for charging by reference to volume;
- Water Industry Act 1991 section 45, Duty to make connections with main;
- Water Industry Act 1991 section 55, Supplies for non-domestic purposes; and
- The Water Resource Management Plan (England) Direction, Defra 2017

Business drivers

- Ensuring our water resources are sustainable and resilient by creating a financial incentive for customers to reduce demand;
- Improved accuracy of calculated leakage volume, by increasing the number of metered customers. An improvement in the accuracy of consumption volumes will improve the accuracy of the water balance and hence the calculation of leakage. Better information will inform the assessment of the economic level of leakage as well as operational targeting of leak detection and repair resources. A better estimate of leakage enables targeted leakage reduction; and
- Customer engagement associated with meter installation, which can help to highlight the benefits of water efficiency to customers.

Customer and stakeholder drivers

- Demonstrating responsible stewardship of the water and wastewater networks we operate;
- Listening to what our customers and stakeholders tell us through the Customer Experience programme, which helps us to become the North West's leading service provider; and
- Aiming to achieve our objectives without adding to the burden on household budgets.

2.2.3 The requirement for metering

Studies into the savings achieved from metering have shown varied degrees of benefits. The long-term effects must be considered, as savings may not be sustainable over a long period. Experts previously thought that there was a “bounce back” associated with metering, i.e. the benefit of metering being reduced over time. However, our studies of optant properties have shown no evidence of “bounce back”.

We focus on metering customers because:

- Reducing demand can help to improve security of supply and reduce the impact on the environment through lower abstraction;
- Metering and reducing water use can help cut greenhouse gas emissions associated with abstracting, supplying water, treating water and wastewater, and heating water in homes and businesses;
- Metering gives us better information about customer water use and can help plan and operate our networks more efficiently, whilst reducing losses and leaks;
- Metering provides customers with accurate information about their water use and allows them to be billed on the amount used. This can be a key element in behaviour change as rateable value or assessed charges do not encourage water efficient behaviour;

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- Metering programmes can consider both current and future opportunities for variable tariffs; and ensure that people who are unable to afford their bills are protected through appropriate tariffs;
- Where we install meters we can ensure a range of water efficiency measures are put in place to enhance the benefits of metering;
- Opportunities to link smart metering for water and energy could be applied to all large scale metering programmes as a Smart Water Industry architecture is defined and implemented. Until such time, our position is to continue with automatic meter reading (AMR)¹⁹ in its current form, using walk/drive by technology, until such time as energy smart metering is rolled out nationally. Please refer to Section 11 for more details on innovation projects we are planning in the area of smart metering; and
- Customers save not only on their water bills, but also on their energy usage. It is, therefore, an overall financially attractive option for many customers. There are also benefits to the environment from reduced carbon emissions.

There are, however, additional factors which we have to take into consideration when reviewing our approach to metering:

- Not all customers will benefit financially from being on a meter, those with a large household who are currently on a low rateable value may not benefit;
- There are cost implications of increased numbers of customer meters that need to be reflected in business planning;
- There is a general customer apathy to metering, despite the potential financial benefits it could bring; and
- The North West is not classified by the Environment Agency as water stressed area, which means we have no legal right introduce compulsory metering policy.

2.2.4 Current metering policies

It is widely accepted that customers with a meter use less water than those without one. Several studies have evaluated the effect of metering on water consumption confirming that this is the case. Results from key studies can be found in Appendix D. Metering is also an opportunity for customer engagement, which if sustained, can be useful for promoting water efficiency. Metered customers are able to review the impact of their behaviour on their bills, and metering also gives us the opportunity to use flexible tariffs based on consumption patterns. “Paying for what you use” is a well-supported principle.

Our metering aims are to:

- Maximise the cost effectiveness of customer metering and tariffs to assist in achieving and maintaining adequate supply-demand balances, in accordance with the UKWIR / Environment Agency national best practice methodology “Economics of Balancing Supply and Demand”;
- Carry out action plans that are consistent with national best practice; and
- Target demand management activities in those water resource zones where supply-demand deficits exist or are anticipated to occur in the near future where it can be identified that customers will realise the benefits of taking up metering opportunities.

Our metering policy is to:

- Meter all new household properties. Our policy for new build is to install meters in an above ground location (internally, or in a wall mounted meter box that allows easy access to read the meters for both the customer and the company). All new meter installations are AMR enabled;
- Provide a Free Meter Option scheme for household customers. Since April 2000 we have actively promoted this scheme to customers. Our preferred meter location position is inside a property and all meters are AMR enabled;
- Meter all new non-households;

¹⁹ Automatic meter reading (AMR) enable to obtain meter readings remotely, without gaining access to property. Most of our AMR meters are read every two weeks using devices attached to council bin wagons.

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- Replace any faulty household and non-household meters;
- Offer unmeasured household customers an alternative choice of tariff (i.e. assessed charges) in the small number of instances where metering is not practically possible (circa 15%);
- Accurately read all household water meters with the use of AMR, where AMR meters are installed;
- Meter existing unmeasured non-households where possible. All industrial premises and the majority of commercial and public service premises are already metered following a programme in recent years to compulsorily meter all non-households where practical. Each year we still undertake a number of compulsory meter installations, these are usually from properties that have been altered or merged. Those that remain un-metered tend to be relatively small water users where the installation is either not possible or disproportionately costly; and
- Have the majority of industrial and commercial customers, who consume over 20 Ml per annum, on enhanced AMR to enable remote automated meter readings and updated data every 15 minutes to monitor usage via a web portal service.

To improve our efficiency we are currently assessing the most cost effective ways of reducing the length of time a customer will be required to wait for a meter. We will test working to different levels of service during peak times (March – June) and during off peak times where volumes of work are reduced.

Our policy is to always try to install a water meter internally, at the point of the initial survey and we forecast c.60 per cent of meters will be installed in this location. If no internal installation is possible, e.g. in case where the meter may cause customer issues due to aesthetic or other operational reason, we will look to install a water meter externally, ordinarily in the public footpath. If an underground meter box has previously been installed at the premises (e.g. due to previous service renewal activity), this will always be considered as the first point of installation.

All water meter installations will be Automated Meter Read (AMR) equipped to allow greater frequency of data collection and more efficient meter reading. More granular data will also help us identify when customers' consumption changes or "leak alarms" are triggered so we can proactively notify customers of the changes. AMR will also help to reduce the number of estimated bills customers receive and will play a key role in leakage detection as the availability of frequent data and alarms allows leaks to be detected earlier than when a bill is generated.

Other metering policies have been considered but have not justified implementation to date, in some cases due to the constraints of the Water Industry Act 1991.

We are currently trialling a new metering proposition – the "price promise". It has been developed on the back of research we have done recently and "Tell Me" emails (see Section 2.3.1), which showed that customers worry that they may end up paying more for their water if they change to a meter, even though they may be better off. The new proposition was developed to overcome this barrier.

With the price promise if customers aren't saving money once the meter's been fitted, we will only charge them what they are currently paying on a fixed annual bill. We'll apply this automatically so there is no need for the customer to contact us. We'll do this for two years and during this time customer can choose to switch back to a fixed annual bill if they think they won't be better off on a metered charge. We're also trialling the price promise together with an installation of water efficiency devices at the point of meter installation to further enhance customer experience, water efficiency behaviour and financial savings for customers.

2.2.5 Current performance

We continue to measure all new households and non-households, and under our Free Meter Option scheme household customers can opt for a meter. Each year, in June, we report our performance against forecasts in the

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annual updates of our water resource management plan (published as the Annual Water Resources Review²⁰). Table below shows the new number of new properties and the uptake under our Free Meter Option scheme over the last five years.

Table 9 Historical metering performance

Property type	2012/13	2013/14	2014/15	2015/16	2016/17
New households	11,560	12,677	15,451	19,273	19,947
Household optants	48,437	43,734	40,102	27,197	32,447
New non-households	719	668	690	719	793

We have made significant improvements to our free meter offer; in particular we have:

- Employed agents trained in the free meter installation process, and made improvements to contractual arrangements with the supplier we use to carry out meter installs which has helped us to significantly improve the speed of installation and reduce drop off rate (the number of customers that resign from the installation);
- Promoted the Free Meter Option within normal billing contacts, including promotion on all envelopes used during our main billing;
- Targeted 55,000 customers to promote metering via a range of media (email, letter, text) where we believe these customers would be better off with a meter; and
- Promoted our Free Meter Option across the region on a series of 25 billing roadshows and carried out 28,000 Town Action Plan Affordability visits to promote all of the customer assistance schemes we currently have available, which includes the Free Meter Option.

We continue to offer an extended period of 24 months for all customers to switch back from being metered to unmetered. This gives customers time to decide whether they will benefit from being on a metered tariff. Details on the projections of meter penetration are described in Section 2.2.6.

2.2.6 Free Meter Option forecast

We have worked with Artesia Consulting to model the uptake of the Free Meter Option to ensure that we have a realistic and robust view of the potential numbers of customers who would be willing to opt for a meter each year. This involved the analysis of large amounts of data and exploration of several different modelling techniques²¹, with the resultant regional forecast shown, with historically reported numbers of meter optants, in Figure 7.

²⁰ <https://www.unitedutilities.com/corporate/about-us/our-future-plans/water-resources/>

²¹ Including survival type models, logit and logit (regression) models

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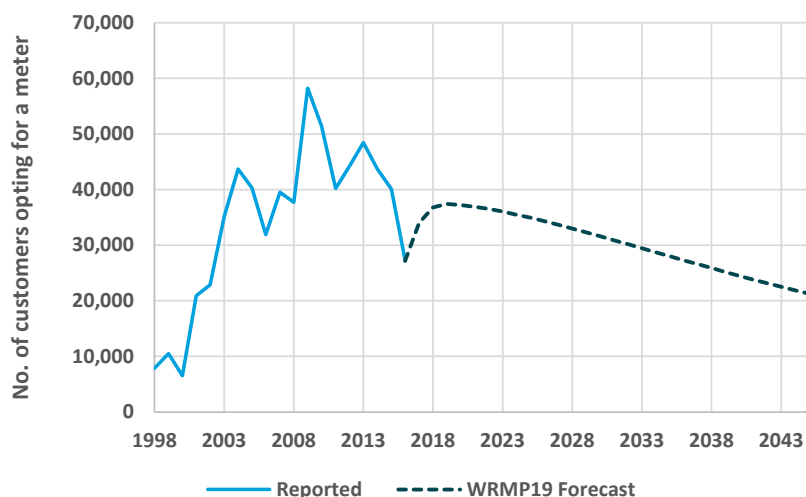


Figure 7 Reported and forecast number of customers opting each year

As with demand for water, there are year on year fluctuations in the number of customers opting for a meter. This is driven by factors such as population age and dynamics, as well as economic factors such as unemployment. The decline in customers opting over the planning horizon is due to an ever shrinking base of unmeasured customers. Table 10 shows how this forecast looks by resource zone.

Table 10 Forecast number of meter optants by resource zone

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone	26,822	36,576	33,998	30,583	26,989	23,533	20,973
Carlisle Resource Zone	347	294	301	293	280	264	253
North Eden Resource Zone	28	24	22	20	19	18	17
Region	27,197	36,895	34,321	30,896	27,288	23,815	21,243

We represent the benefits of metering using a “property swap” method, where the property moves from the unmeasured housing stock into the measured (optant) housing stock. Figure 8 shows the impact of this movement, along with the metering of newly built household properties, on metering penetration in our region and the reduction in household consumption associated with it.

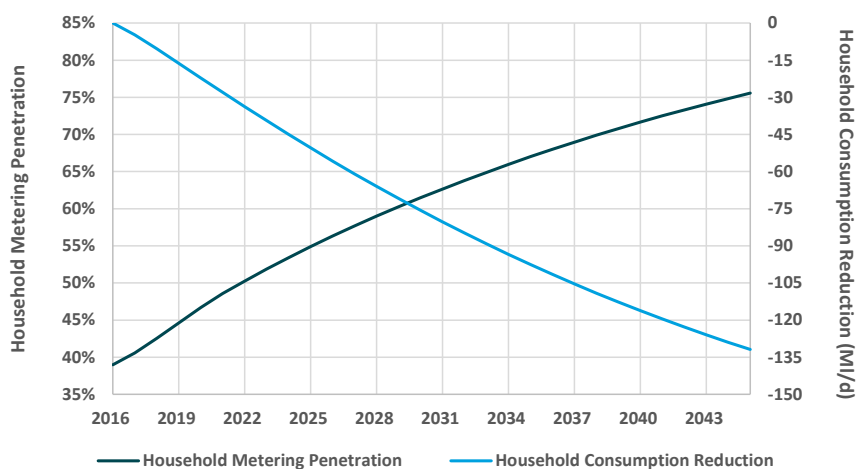


Figure 8 The forecast impact of metering penetration on household customer consumption

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2.2.7 Automated Meter Reading (AMR)

With the continual growth of metering and automated meter reading (AMR) stock throughout AMP5 (covering 2010/11 to 2014/15) and AMP6 (covering 2015/16 to 2019/20), we developed and implemented a unique approach for reading AMR enabled meters by working in partnership with Local Authorities within our region. To date we have installed over c.650 data collection devices on Local Authority refuse vehicles and currently have the ability to read over 400,000 water meters each week through using data signals collected from water meters as refuse vehicles collect household waste. We are continuing to roll-out AMR enabled meters to new and replacement meter installations, and are continuing to work with councils within our region to further grow our 'passive' meter reading solution. This development follows the successful piloting of a small trial undertaken on 7,000 properties in 2013.

Data collected from the water meter includes meter readings, stopped meter alerts and leakage alerts. Alongside the installation of data loggers and AMR meters, we have developed a web based portal to allow call agents to better handle customer contact and billing queries from customers who have AMR enabled water meters.



Figure 9 AMR portal – example screenshot

We also proactively inform customers where we identify a leak, and inform them of their potential increase in bill due to the presence of the leak. We are also planning provision consumption of data to customers in the form of a web application and/or smart-phone application and also to make this data visible in our 'My Account' customer portal.

2.2.8 Tariffs

Our current charges are to set to be consistent with our revenue controls published by Ofwat on 12 December 2014, and are prepared in accordance with its legal obligations.

Charges are set in accordance with the general charging principles of:

- Fairness and affordability;
- Environmental protection;
- Stability and predictability; and
- Transparency and customer-focused service.

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The charges for water services can be summarised as follows:

- Unmeasured charges – a standing charge for water plus charges based on a charging value (a rateable value or a charging value assessed from a business rateable value);
- Assessed charges – for customers who would like to have a meter but it is not possible, a fixed charge is applied based on property type or occupancy for a single occupier;
- Measured household charges – a combination of standing charges, a fixed charge and volumetric charges for water and sewerage services;
- Measured non-household charges – a combination of standing charges, a fixed charge and volumetric charges. Different volumetric charges apply for different categories of non-household customers, based on the volume of water used (Select 50, Select 180, Select 750 and Select Plus); and
- Non-potable volumetric charge – supplies of non-potable water for non-domestic purposes are charged a standing charge and a volumetric charge.

A number of schemes exist to support vulnerable customer groups, such as:

- Watersure – intended to support customers that have a low income and use higher than average amounts of water due to a large family or medical conditions. The scheme allows the customer to pay a charge based on the average annual household bill;
- Help to pay scheme – developed to help eligible household customer who are entitled to receive Pension Credit to pay their water bill, based on a fixed charge; and
- Support tariff – designed for customers on low income who are struggling to pay their water bill, based on a fixed charge (six different levels of fixed charge).

Customer tariff actions

For AMP7 (covering 2020/21 to 2024/25), our charges will be set to be consistent with U UW’s revenue controls as per the PR19 final determination to be published by Ofwat. This includes the introduction of a separate control for water resources, which should help deliver resilient water resources for customers and the environment in the long-term.

We will continue to review all charging policies annually and monitor the developments of tariffs in the industry and other industries were applicable. We will continue to review the effectiveness of alternative tariffs for different groups of customers and explore innovative approaches for charging, including exploring opportunities to encourage the better use of water:

- considering offering developers discounted infrastructure charges for water efficient connections; and
- trialling a basis of charge for non-household sites with rainwater harvesting systems which use rainwater for flushing toilets etc., but where the overflow does not flow to sewer.

2.3 Engaging with the retailer and household demand management

This section describes our approach in helping manage customer consumption in households. It has been written in partnership with our household customer retail team to ensure a consistent forecast and the delivery approach between our WRMP and the retail section of our business plan.

2.3.1 Water efficiency in households

As a water company we have a statutory duty to promote the efficient use of water as required by the Environment Act 1995 and the Water Industry Act 1991.

We consider it a priority to engage at an early stage with customers and stakeholders, so future options or schemes can be developed with their views and interests taken into consideration. We have carried out research (described in more detail below) with our customers to understand who our audience is (for water efficiency messages), how water use varies across life stages and what the key influences are on water use behaviour as well as motivations for saving water.

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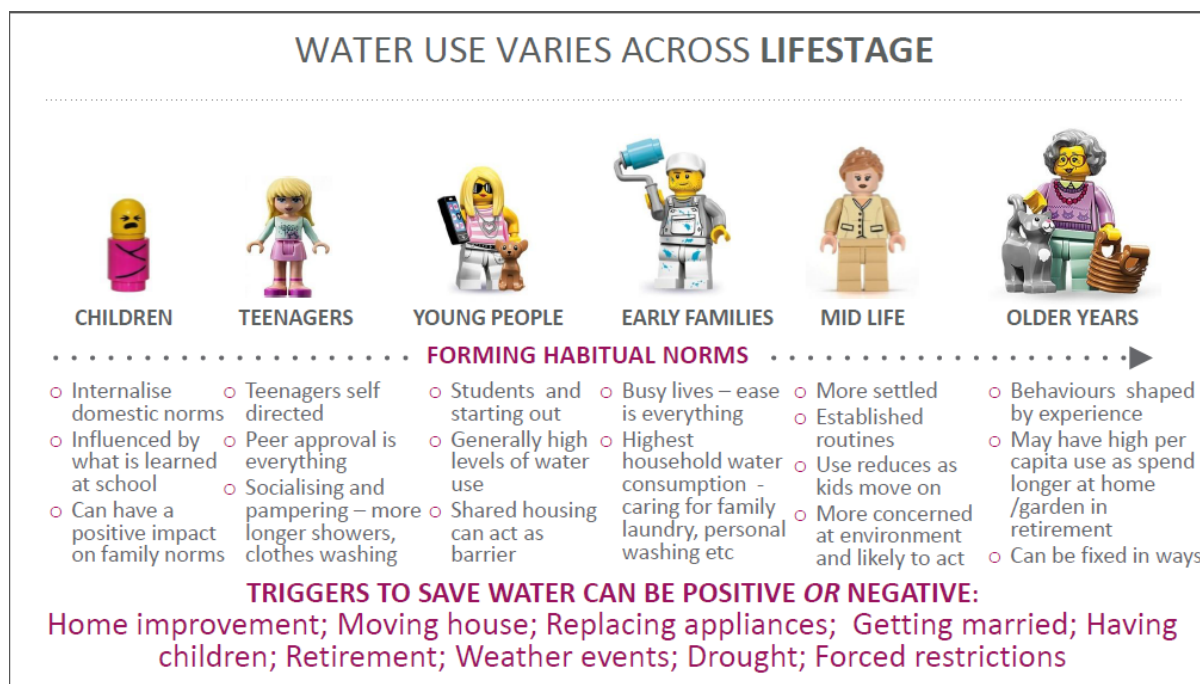


Figure 10 Customer segmentation

We recognise the important contribution water efficiency actions have in achieving and maintaining an adequate and sustainable supply-demand balance in each of our water resource zones. Although there are no mandatory water efficiency targets imposed by Ofwat since 2015/16, in our demand forecast we have committed to continue to achieve, as a minimum, an annual saving of 1 litre per property per day²² through the planning horizon.

We have a number of policies that impact directly on the water efficient behaviour of our customers. These include policies related to water efficiency, supply pipe repairs and replacement, sustainability and carbon emissions, and a Free Meter Option scheme.

Building on previous activities we continue to:

- Supply free, easy to install water efficiency devices which can be ordered via agents, online or picked up at events we attend (for example Trafford Armed Forces day, Disability Awareness day in Warrington, Tatton Flower Show and many more);
- Run our education programme for primary schools across the North West. The workshop is extremely interactive and covers a number of topics from Key Stage 2 Science and Geography such as the water cycle, water safety, what not to flush and water efficiency. At the end of the workshop each child is provided with a pack that contains a booklet reiterating the important messages, a set of water efficiency trump cards and a toothy timer to encourage them to turn off the tap while brushing their teeth; and
- Carry out free visits to customers' homes to fit free water efficiency devices.

²² To this we apply a decay rate or half-life of two and a half years to represent factors, such as the deterioration in water efficiency products over time.

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Figure 11 Products used in our water efficiency education programme

In 2017, we also ran a roadshow during main billing (February/March), holding events in town centres and shopping centres across the region to offer customers an opportunity to speak to us and ask any questions about their bills. We discussed tariffs that may be available to specific customers and promoted water efficiency and free water saving devices to help customers reduce their water and energy bills to help them save money. This was popular with customers and we plan to run this again during main billing.

In 2016/17, an initiative called “Tell Me” was introduced which encourages agents to highlight any issues they come across, feedback from customers, or ideas for improvement in Customer Services. The points raised are reviewed by our Customer Services Director who then ensures they are actioned. As a result of this there have been a number of issues resolved and new initiatives put in place to improve customer service and this will continue going forwards. For example we received customer feedback about our metering information and we used this to change website customer journeys, and in the development of the price promise proposition (refer to Section 2.2.4 for more detail).

Table 11 below shows the savings made through various water efficiency activities and products distribution since 2015.

Table 11 Water efficiency savings since 2015

Water efficiency activity	Number	Saving (Ml/d)
Cistern devices distributed to customers	67860	0.72
Water efficiency customer self-audits	242,792	2.06
Water butts distributed to customers	2582	0.01
Water Efficiency Education Programme, pupils visited	18,431	0.87
Other promotional events	3,168	0.02
Crystal packs / water sticks distributed to customers	4256	0.00
Retrofit devices distributed to customers	153,871	2.20
Total	492,960	5.88

We are mindful that in order to maintain the long term forecast we need to keep our approach fresh. We are constantly looking for ways to enhance our offering to customers through research and partnership working. We have recently undertaken research into attitudes towards water efficiency and metering to inform a joined up communications strategy for water efficiency, metering and water demand using segmentation to target groups of customers with tailored messaging, this includes community groups. The aim of the research was to understand the benefits, barriers and motivations to desired behaviours and willingness to act to achieve greater water efficiency.

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We worked with groups of customers and undertook qualitative research which included four co-design workshops to explore reactions to initial propositions; and a quantitative survey with 1,200 face to face interviews to identify priorities.

The research showed that attitudes to water are deeply ingrained and water is seen as a basic human right. There is low interest for most people unless supply is threatened, most use water freely and without thought, however most people do not set out to consciously waste water. Metering is the biggest influence on attitudes and behaviours and the main motivation for saving water is cost saving. The main barrier to saving water is subconscious habits that prevent action and for unmetered customers the barriers to saving water outweighs the benefits and perception that, with the amount of rainfall in the North West, water cannot possibly be scarce. To change behaviour, we need to increase benefits, reduce the barriers to saving water and increase environmental awareness.

The recommendations from the research and strategy work include:

- Targeting specific audiences with priority behaviours and driving motivation by making it easy to act whilst reframing water saving tips, tools and gadgets to focus on personal benefits;
- Making saving water personal with reports on usage for metered customer which shows water saving;
- Engaging communities of interest and making valuing water as social as possible through education, workplace advocates and community outreach around water resources; and
- Working with partners to collaborate to achieve shared goals.

In seeking to identify effective methods for future use, we trialled a whole community approach in a Cumbrian town to roll out a programme of home water audits to reduce water use in households in the local area. The key objectives of the trial were to:

- Raise awareness of the campaign and embed key messages;
- Create community ownership of action among the people of the town; and
- Encourage residents to sign-up for a free home check.

We have identified and contacted 24 community organisations out of which 11 agreed to support the campaign. Unfortunately, while community networks were happy to support the campaign, securing deep commitment was a challenge. Three potential community delivery partners were approached, however none of these could commit to recruiting members to undergo training to enable them to cascade the campaign messages to peers within the timescales. We therefore adapted the delivery method to place more responsibility on street teams, however the lack of any committed community partners clearly reduced the impact of the campaign and made it hard to explore the impact of a whole community approach to saving water.



Figure 12 Promoting water efficiency at local events

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Figure 13 Examples of our marketing material

We are using feedback from the research and activities to refresh and update our messaging and marketing material. We are also using it to update the design and content of our bills, this includes information that is tailored to the customer, based on information we hold on them and covers water saving advice and information about meters.

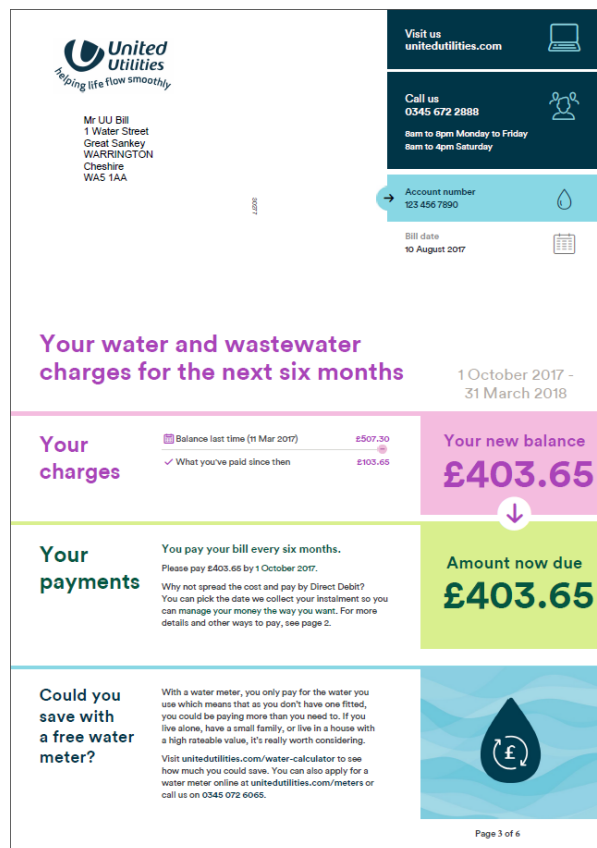


Figure 14 New bill format, with visible water meter promotion

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Save money on your bills

Our number one tip for saving money: use water wisely

Saving water around the home and garden is good for the environment and your bank balance too.

As you have a water meter, your bill is based on how much water you use so getting handy with your H₂O will reduce your bills. Not letting taps run, having showers instead of baths, using watering cans in your garden – these small savings soon start to add up over the year.

Using less water can also have a positive effect on your energy bills too. This is because a lot of ways you use water in the home involves heating the water before use – such as washing machines, baths, dishwashers, showers and water for cleaning. So a few simple tweaks to how you use water in the home can see your energy bills tumble.

For lots of hints and tips on how to use water wisely in the home please visit unitedutilities.com/watertight

Take advantage of our fantastic freebies

We have some fantastic devices that will help you save water and money, and what's more, they're completely free. From shower regulators to two minute toothy timers, just visit unitedutilities.com/watertight to find out more and order yours today.

4

Knock £5 off your bill every year with Direct Debit

Why not pay your bill in smaller chunks over the year by setting up a Direct Debit? It's better than having to pay your bill in one lump sum and we'll even knock £5 off your bill every year for paying in this way.

You can choose when to pay – weekly, fortnightly or monthly – and we'll automatically take your payments from your bank account meaning you can get on with the fun stuff. Set up yours today by calling 0345 672 2999 or visit unitedutilities.com/directdebit

Check for leaks

As you pay for all the water you use, it makes sense not to let it leak away. Check overflows (which are those pipes that stick out through the outside walls of your house) to see if any water is dripping out of them. And check your toilet too – modern toilet cisterns tend to overflow into the toilet bowl rather than outside.

We also provide a leak repair service for your water supply pipe (this is the pipe that brings water into your home from our water main in the street). This pipe is your responsibility but if you find it's leaking we may be able to fix it for free and refund you for the cost of the water you've lost. Find out more at unitedutilities.com/bursthome

Get discounts for drainage

Part of your bill pays for us to remove all that lovely rainwater that falls on your home. But if your home isn't connected to the public sewer to drain away this rainwater (for example, it drains to a soakaway instead), we can reduce your bill. For more information and to download a claim form visit unitedutilities.com/surface-water-drainage

5

Figure 15 New bill insert, showing water efficiency messages

We are also incorporating behavioural economics and trialling activities and communications to further understand what is most successful in reducing water use by changing behaviour.

We continue to develop our digital strategy to widen our reach with customers and increase the channels we use to communicate which is more inclusive of our younger customers. This has included the introduction of web chat, improvements to My Account and launch of a customer app. It has also incorporated wider use of social channels for promotion of water efficiency items which link directly to the online ordering facility for free pack devices.

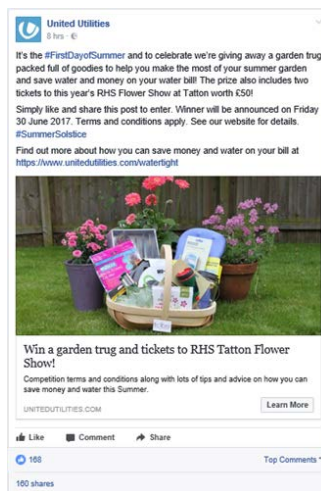


Figure 16 Examples of our digital campaigns

As we develop the digital channels we are also currently planning a yearlong trial, which is due to start in January, 2018 to provide water use data to approximately 100,000 customers via the app. The aim of this is to give customer

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greater control of their water use and their bills. We will be trialling a number of interventions with customers via the app to help customers reduce their water use through behavioural change.

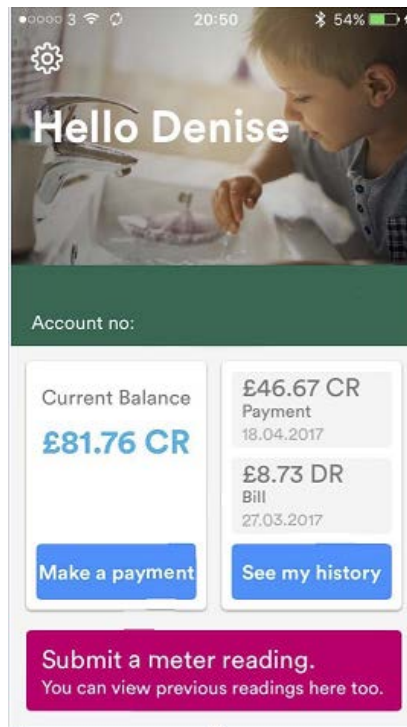


Figure 17 UU app screen shot

We have also changed our web analytics package to be able to improve reporting on visitors to the website and to allow continuous improvement on the content and customer journeys on our website. For example, we can track customer journeys and see where users drop out before completing the action and can make changes where this commonly happens. This was used on the metering pages and content was updated.

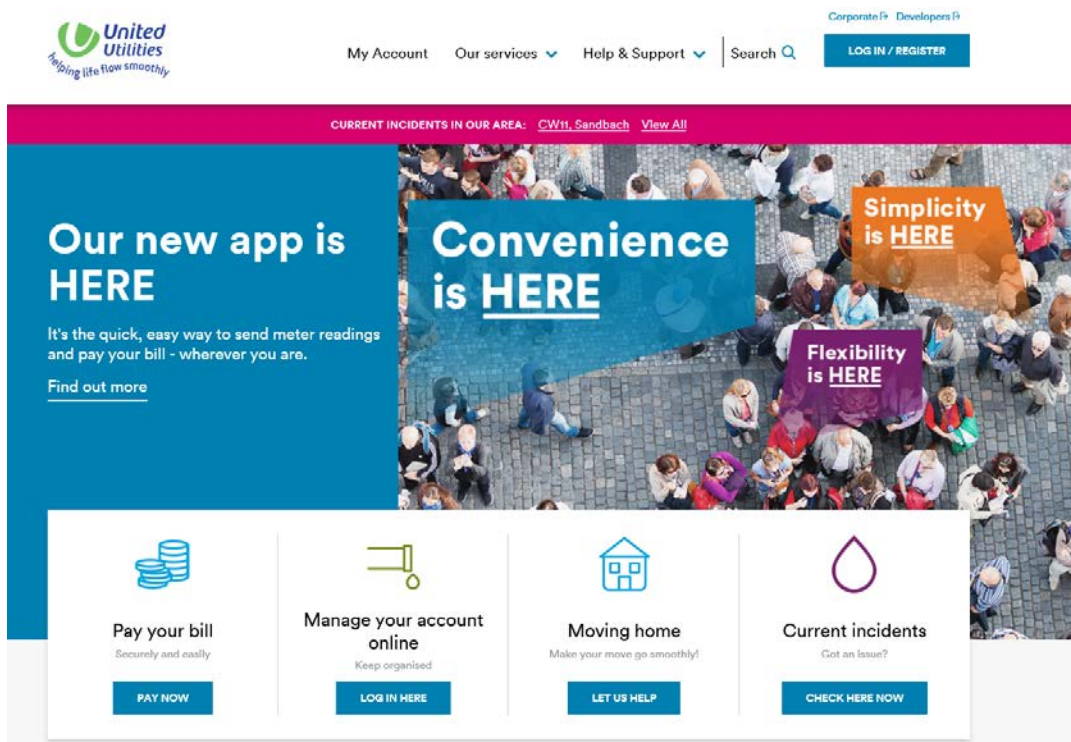


Figure 18 Our new website

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We are also trialling a new metering proposition ‘the price promise’ (see Section 2.3.1 for more detail) which includes water efficiency devices fitted free of charge. The aim of it is to help customers save even more money on their bill and to encourage them to change their behaviour to reduce their water use.

We have developed a number of water efficiency options for inclusion in the supply-demand forecast. The costs and benefits of these options were assessed using actual company data wherever possible. Full assessment of the social and environmental costs was completed for any option that passed the primary screening process and these costs were accounted for in the option appraisal process. Further detailed on the options assessed as part of this process are included in *Draft WRMP19 Technical Report – Options identification*. Water efficiency options are fully considered as part of appraising options for inclusion in our preferred plan (*Draft WRMP19 Technical Report – Options appraisal*).

Sustainable economic level of water efficiency (SELWE) programme in West Cumbria

This WRMP19 is based upon a future Strategic Resource Zone following the delivery of the Thirlmere transfer project by March 2022. As explained in the *Draft WRMP19 Technical Report – West Cumbria legacy*, we will continue to apply the existing demand management commitments in this zone based on WRMP15 until the new Strategic Resource Zone is formally adopted in the Annual WRMP process.

As part of WRMP09, we included additional water efficiency activities in West Cumbria, which was also continued in WRMP15. The annual SELWE target of 0.066 Ml/d has been included in the baseline demand forecast for the WRMP15. We have over achieved this target each year since 2015.

Due to sensitive nature of the environment in West Cumbria and pressure to reduce abstraction from Ennerdale as far as practicable we are committed to continue to deliver enhanced level of water efficiency in West Cumbria until the delivery of the new Thirlmere pipeline.

We will continue to:

- Attend local events where we will distribute water efficiency devices and provide advice on how to save water;
- Organise water efficiency give away days through local supermarkets; and
- Promote our Free Meter Option.

2.4 Forecasting method

2.4.1 Forecasting methods review

In our WRMP19 initial ‘problem characterisation’²³, as documented in our *Draft WRMP19 Technical Report - Options appraisal*, all of our resource zones were considered to be of “low level concern”, based on complexity factors and strategic needs. However, when large scale water trading was considered in the Strategic Resource Zone, the level of concern moved to “moderate”.

At WRMP15, we used micro-component analysis²⁴ to model and forecast household consumption. For WRMP19, in line with UKWIR guidance²⁵, we carried out a household consumption forecasting methods review with Artesia Consulting in July/August 2016. The main observation from this review was that regression modelling and micro-component analysis were suitable approaches for all resource zones. The simpler macro-component analysis approach was also a potential for low level concern resource zones. However, as micro-component analysis, which we used at WRMP15 and which has been used in the UK water industry for many years, scored comparably well for

²³ This is a term used in WRMP19 UKWIR industry methodologies, whereby companies consider the risks and complexity of their resource zones to target the most appropriate approaches plan decision-making and appraisal methods.

²⁴ Sometimes abbreviated to “MCA”, this is modelling changes in sub-components of household water consumption, for example water used by toilet flushing, showers, baths, washing machines, dishwashers, or external water use (including garden watering).

²⁵ WRMP19 Methods – Household Consumption Forecasting, previously Demand Forecasting Methods (UKWIR, 2015)

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the low level and moderate level concern resource zones, this supported its continued use for the WRMP19 household consumption forecast.

2.4.2 Applied method

As discussed, we have applied micro-component analysis, which is calculated by multiplying estimates²⁶ of the ownership, frequency of use and amount of water per use of water using appliances (known as “micro-components”), with:

- Base year (and forecast) appliance ownership, generally being informed by a customer survey (see Section 2.4.3); and
- Base year (and forecast) frequency of appliance use and amount of water per appliance use, generally informed by industry-wide evidence/predictions (e.g. the UK Government Market Transformation Programme) and some more specific research (see Appendix E).

We have followed the guidance in the Water Resources Planning Guideline²⁷, which requires water companies to prepare a table of micro-component water consumption for unmeasured households and measured households for each resource zone. We have compiled the data in the categories shown in Table 12.

Table 12 Categories of water using appliance or “micro-component”, with our assumed key driver and mapping to the Water Resources Planning Guideline (WRPG) categories

Our categories of water using appliance or “micro-component”	Key driver (person or property)	WRPG category
Toilet	Person	WC flushing
Washing Machine	Property	Clothes washing
Electric Shower	Person	Personal washing
Mixer/pumped shower	Person	
Bath	Property	
Hand basin	Person	
Kitchen Sink Use (with dishwasher)	Property	Dishwashing
Kitchen Sink Use (no dishwasher)	Property	
Dishwasher	Property	
Hosepipe	Property	External use
Garden sprinkler	Property	
Miscellaneous	Property	Miscellaneous (internal) use

We have undertaken a separate micro-component analysis for each of the household types shown in Table 5. We have, therefore, identified different Ownership (**O**), Frequency (**F**) or Volumes (**V**) values for different house types to take account of the different characteristics and the effect of metering on water use rates. The average daily water use by an appliance in a particular type of home can be calculated as:

$$\mathbf{O * F * V}$$

- Where:
- O** = estimated percentage of houses that own the appliance (%)
 - F** = estimated average frequency of use (uses per day)
 - V** = estimated average volume per use (litres per use)

²⁶ Therefore, have a degree of uncertainty

²⁷ Water Resources Planning Guideline (Environment Agency, 2017)

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As shown in Table 12, we've assumed a key driver for certain appliances, based on our understanding certain water using appliances are used. Therefore, in some cases **F** is assessed as the frequency of use per person and in some cases it can be assessed as the frequency of use per household property, in which case an average occupancy is then used to convert it to frequency of use per person. The total per capita consumption (l/hd/d) is calculated as the sum of micro-component volumes:

$$O * F * V \text{ for baths} + O * F * V \text{ for showers} + \text{etc.}$$

Total per capita consumption values are individually calculated for each year.

2.4.3 Customer survey

In consultation with DJS Research Ltd and using the standard UKWIR questionnaire²⁸ as a starting point, we designed a questionnaire to be used to survey over 2000 household customers²⁹ across our resource zones. The survey questionnaire was shared with YourVoice³⁰ (previously referred to as our "Customer Challenge Group" or "CCG") and the Environment Agency, with all comments being incorporated before the survey was undertaken.

Participant data was used to allow us to attain a spread of customer types according to resource zone, household type and metered status.

Table 13 Number of household customers surveyed

	Strategic Resource Zone	Carlisle Resource Zone	North Eden Resource Zone
Number of household customers	1488	499	95

As well as informing our occupancy rates, this survey helped us understand the ownership and frequency of use of water using appliances. Examples of the results for ownership are shown in Figure 19 and Figure 20.

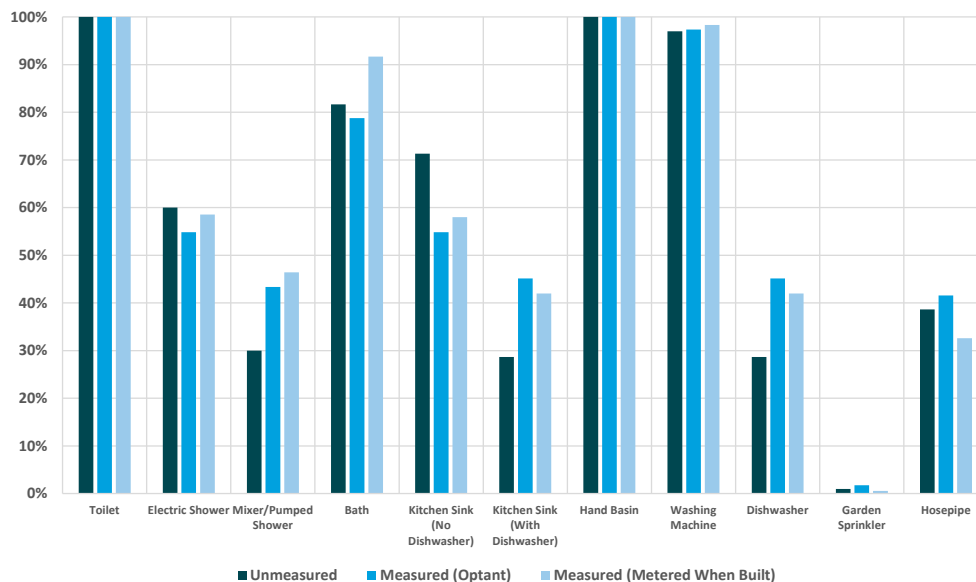


Figure 19 Ownership of different water using appliances in our Strategic Resource Zone

²⁸ UKWIR longer form questionnaire from the Integration of Behavioural Change into Demand Forecasting and Water Efficiency Practices (UKWIR, 2016)

²⁹ Surveys were carried out by telephone and 2,082 customers were surveyed in total

³⁰ <https://www.unitedutilities.com/corporate/about-us/performance/yourvoice/>

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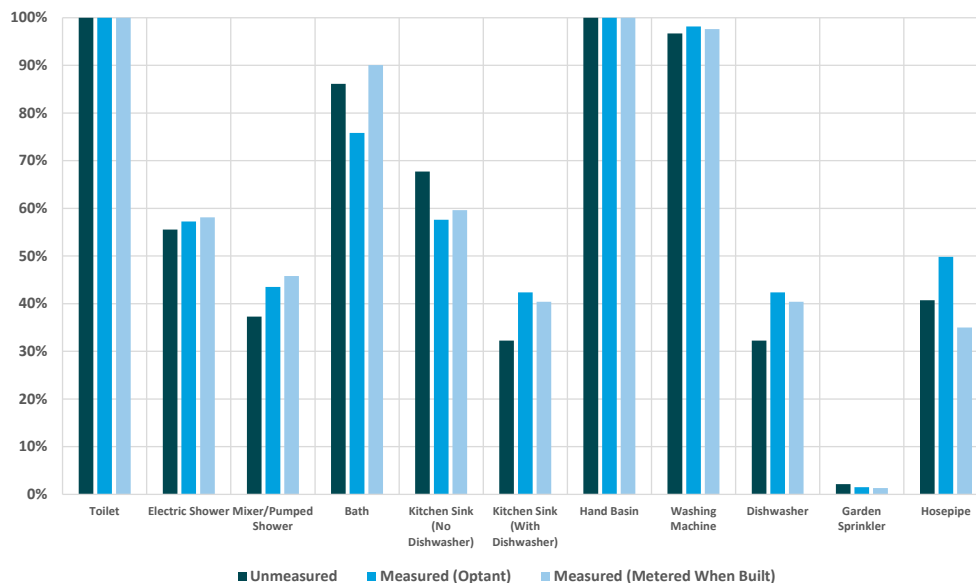


Figure 20 Ownership of different water using appliances in our Cumberland Resource Zones (Carlisle and North Eden)

2.5 Central forecast from the base year

Table 14 shows our central forecast of measured and unmeasured household consumption for each resource zone from the base year of 2015/16. The increase in measured household consumption is due customers moving into new properties in our region as well customers opting for a meter, which also results in a decrease in unmeasured household consumption.

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Table 14 Our central forecast of measured and unmeasured household consumption for each resource zone, prior to the application of any demand uplifts to account for climate change and weather variation

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Measured household consumption (Ml/d)	265	333	395	448	497	543	576
Unmeasured household consumption (Ml/d)	592	517	454	396	346	303	273
Total household consumption (Ml/d)	857	850	849	844	844	846	849
Measured per household consumption (l/prop/d)	240	234	230	226	224	223	223
Unmeasured per household consumption (l/prop/d)	343	345	342	338	335	333	331
Average per household consumption (l/prop/d)	303	291	278	268	259	253	249
Measured per capita consumption (l/h/d)	118	113	110	107	105	103	102
Unmeasured per capita consumption (l/h/d)	149	148	148	148	147	147	147
Average per capita consumption (l/h/d)	138	132	127	123	119	116	113
Carlisle Resource Zone							
Measured household consumption (Ml/d)	3.7	4.7	5.7	6.6	7.2	7.8	8.1
Unmeasured household consumption (Ml/d)	10.5	9.7	9.2	8.6	8.1	7.6	7.2
Total household consumption (Ml/d)	14.2	14.4	14.9	15.2	15.3	15.4	15.3
Measured per household consumption (l/prop/d)	234	233	231	228	226	224	222
Unmeasured per household consumption (l/prop/d)	340	341	339	335	332	329	327
Average per household consumption (l/prop/d)	304	296	287	279	271	266	262
Measured per capita consumption (l/h/d)	110	108	106	104	103	102	102
Unmeasured per capita consumption (l/h/d)	158	156	156	156	156	155	155
Average per capita consumption (l/h/d)	142	136	132	128	125	123	121
North Eden Resource Zone							
Measured household consumption (Ml/d)	0.5	0.6	0.7	0.8	0.8	0.9	0.9
Unmeasured household consumption (Ml/d)	1.2	1.1	1.1	1.0	1.0	1.0	0.9
Total household consumption (Ml/d)	1.7	1.7	1.8	1.8	1.8	1.8	1.8
Measured per household consumption (l/prop/d)	240	239	236	234	232	231	230
Unmeasured per household consumption (l/prop/d)	354	357	354	352	350	348	346
Average per household consumption (l/prop/d)	311	304	296	290	285	280	278
Measured per capita consumption (l/h/d)	111	108	107	105	104	103	102
Unmeasured per capita consumption (l/h/d)	165	163	163	162	161	161	161
Average per capita consumption (l/h/d)	144	139	135	132	129	127	126
Region							
Measured household consumption (Ml/d)	269	338	402	455	505	551	585
Unmeasured household consumption (Ml/d)	604	528	464	406	355	311	281
Total household consumption (Ml/d)	873	866	866	861	861	863	866
Measured per household consumption (l/prop/d)	240	234	230	226	224	223	223
Unmeasured per household consumption (l/prop/d)	343	345	342	338	335	332	331
Average per household consumption (l/prop/d)	303	291	279	268	260	253	249
Measured per capita consumption (l/h/d)	118	113	110	107	105	103	102
Unmeasured per capita consumption (l/h/d)	149	148	148	148	148	147	147
Average per capita consumption (l/h/d)	138	132	127	123	119	116	113

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In terms of average per capita consumption in our region, we currently benchmark as being around industry average when looking across the water industry as a whole³¹. We are committed to working with our household customer retail to continue to reduce average per capita consumption, utilising metering (as discussed in Section 2.2) and innovative water efficiency initiatives (as discussed in Section 2.3).

2.6 Scenarios and sensitivity

Following an audit of our household consumption forecast model by Artesia Consulting in July 2017, our model was stated as being comprehensive, in that it:

- Includes ownership (O), volume per use (V) and frequency of use (F) data for 12 micro-components, that when summed give the per household consumption for the resource zone being analysed;
- Is built at household level and includes micro-components (toilets, shower use and wash basins) that vary with occupancy, a similar approach to the Artesia Consulting per household consumption models;
- Varies frequency of use by occupancy, an important consideration;
- Is segmented by each resource zone and by property type, with each property type having separate assumptions relating to ownership, volume per use and frequency of use; and
- Uses ownership data derived from a customer survey, with volume per use and frequency of use being derived from industry standard data.

We were recommended to carry out two sensitivity tests and these were:

- The benefit of the Free Meter Option, considering the NERA study³² and the impact of the Free Meter Option on unmeasured occupancy; and
- Testing different micro-component rates of change, guided by the rates of change being used by Artesia Consulting.

These two sensitivity tests had a material impact on the household consumption forecast, as shown in 21, representing an inherent uncertainty in forecasting and warranting inclusion in the target headroom assessment so that this is appropriately factored into the supply-demand balance. This is documented further in Section 9 and in *Draft WRMP19 Technical Report - Target headroom*.

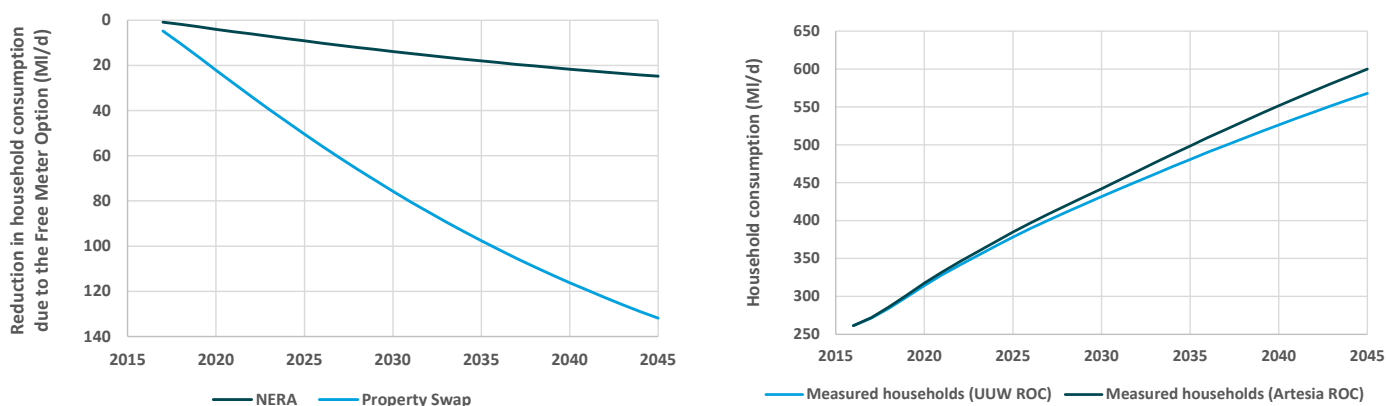


Figure 21 Sensitivity tests on the benefit of the Free Meter Option (circa. 100 MI/d difference by 2044/45) and different micro-component rates of change, guided by the rates of change being used by Artesia Consulting (circa. 30 MI/d difference by 2044/45)

³¹ Analysing data from <https://discoverwater.co.uk/amount-we-use>

³² The Impact of Household Metering on Consumption: Empirical Analysis (A Final Report for United Utilities Water) (NERA, 2003)

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We also carried out sensitivity tests around unallocated population (52,759 irregular migrants, short-term residents and people with second addresses), as discussed earlier, but the impact on the household consumption forecast was relatively minimal (circa. 6 Ml/d) and not considered to require inclusion in the target headroom assessment.

3. Non-household consumption

This section covers how we have derived our forecast of measured and unmeasured non-household customer consumption, including the incorporation of the benefits of customer metering and our water efficiency activities.

3.1 Eligibility review

From April 2017, non-household customers³³ were able to choose their water and wastewater retailer. As the incumbent water supplier or wholesaler, we are still responsible for delivering the water to the customer, continuing to forecast and plan for non-household customer consumption in our region.

In line with part 17C of the Water Industry Act 1991 and with Ofwat’s supplementary guidance on assessing whether non-household customers in England and Wales were eligible to switch their water and wastewater retailer, we carried out a full eligibility review in 2016. We worked with Sagacity Solutions Ltd, applying Ofwat’s guidance around “principle” or “predominant” use via these key principles:

- Properties or premises listed only on business rates were classed as non-household and are eligible to switch retailer;
- Certain properties listed on Council Tax, but billed as a non-household are eligible to switch retailer, including nursing homes, purpose built student accommodation and farms;
- It is the legal responsibility of the retailer to only provide services to non-household customers;
- We only have a licence to provide retail services to household (domestic) customers; and
- The eligibility of mixed usage premises was determined by principle or predominant water usage.

The final stage, if principle or predominant water usage could not be established, was to engage directly with the customer and carry out site visits to establish eligibility. The resulting property movements are shown in Table 15. The majority of movements related to smaller properties or premises, such as small shops, change of use and non-working farms. Therefore, the impact of the eligibility review on non-household customer consumption was minor, with no noticeable step change in the reported levels of consumption between 2015/16 and 2016/17.

Table 15 Movement of properties or premises from household to non-household and vice versa

	Active	Void ³⁴	Total
Previously classed as household, but now classed as non-household and eligible to switch retailer	475	1,282	1,757
Previously classed as non-household, but now classed as household and not eligible to switch retailer	1,467	134	1,601

3.2 Engaging with the retailer(s) and non-household demand management

The general duty to promote the efficient use of water under section 93A of the Water Industry Act 1991 applies to both the incumbent water supplier or wholesaler and the retailer. Through the WRMP19 process have engaged with non-household retailers, requesting information on planned water efficiency activities to allow us to detect any potential shifts in future non-household consumption. We have also noted that the largest non-household retailer operating in our region, offer a range of water efficiency services on their website and we will continue to work with all non-household retailers to help promote and potentially target water efficiency activity.

At this time, the non-household retail market in England is in its relative infancy, we have identified no tangible or quantifiable change in water efficiency practices. Therefore, for WRMP19, we have dealt with the impact of

³³ All business customers and public sector, charitable and not-for-profit organisations in areas of England and Wales served by water undertakers that are wholly or mainly in England.

³⁴ Unoccupied or empty properties

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competition on water efficiency using scenarios and sensitivity testing, discussed further in Section 3.5. We will continue to engage with non-household retailers throughout the WRMP process and in future planning cycles, as the market evolves.

3.3 Forecasting method

3.3.1 Measured

As at WRMP15, we have worked with Experian to understand how non-household consumption changes with economic trends by sector. For this, we use a modelled³⁵ relationship between historic³⁶ non-household consumption by sector and some key economic metrics, including:

- Total output in the non-service sector (measured using GVA³⁷), known as “output growth”; and
- Full-time equivalent employment in the service sector, known as “employment growth”.

We have also reviewed the customer segmentation, in line with the Water Resources Planning Guideline, choosing the continued use of Standard Industrial Classification (sometimes “SIC”) categories, as we have data by Standard Industrial Classification category reconciled to our Regulatory Reporting data back to 2003/04.

3.3.2 Unmeasured

During the 1990’s, we carried out an extensive programme of metering non-household properties, wherever practicable. Therefore, the number of properties remaining unmeasured is small³⁸ and shrinking as, each year, a small number of customers are converted to measured, where feasible. Consequently, this is a relatively small component of the non-household consumption forecast.

Water consumption by unmeasured non-households in the “base year” has been calculated from the number of properties and the estimated average consumption, based on data for similar properties that have been measured in the past. Forecast values have been based on the growth for measured non-households to ensure a consistent economic outlook.

3.4 Central forecast from the base year

Figure 22 shows our central forecast for measured and unmeasured non-household consumption over the planning horizon.

³⁵ Specifically, econometric models, which, in this case, aim to simplify the real world into a relationship between economic metrics or variables and consumption of water.

³⁶ Data from Regulatory Reporting, back to 2003/04

³⁷ Gross Value Added

³⁸ At Regulatory Reporting 2015/16, there were 14,730 unmeasured non-household properties and 154,262 measured non-household properties

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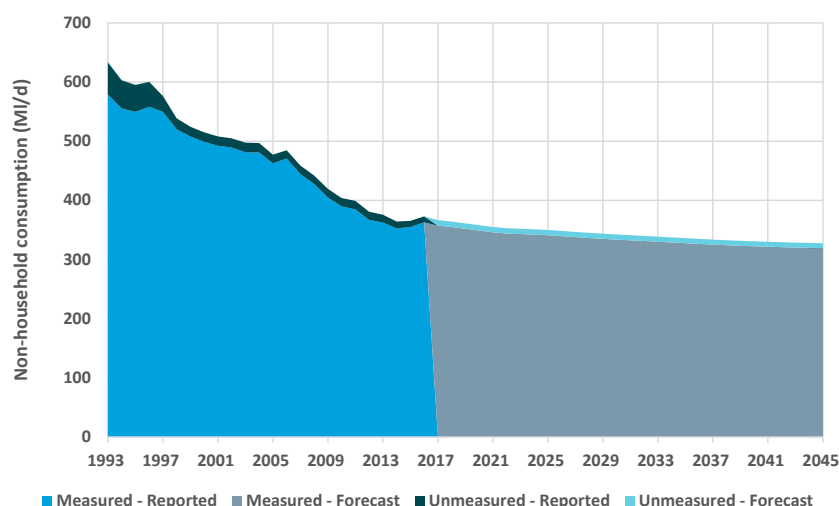


Figure 22 Reported and forecast non-household consumption

Table 16 shows this same forecast by resource zone to 2044/45.

Table 16 Reported and forecast non-household consumption by resource zone to 2044/45

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Measured non-household consumption	352	338	332	325	319	315	313
Unmeasured non-household consumption	9	9	9	8	8	8	8
Total non-household consumption	361	347	341	334	328	323	321
Carlisle Resource Zone							
Measured non-household consumption	6.9	6.5	6.2	6.0	5.8	5.6	5.5
Unmeasured non-household consumption	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total non-household consumption	7.1	6.7	6.4	6.2	6.0	5.8	5.7
North Eden Resource Zone							
Measured non-household consumption	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Unmeasured non-household consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total non-household consumption	1.3	1.3	1.2	1.2	1.2	1.2	1.1
Region							
Measured non-household consumption	360	346	339	332	326	322	319
Unmeasured non-household consumption	9	9	9	9	8	8	8
Total non-household consumption	370	355	348	341	335	330	328

In the following sections, we discuss how the different non-household sectors have influenced this forecast, with a full sectoral breakdown of the forecast shown in Appendix I.

3.4.1 Service sector

Despite the relatively strong employment growth seen in our region, water consumption in the service sector declined by 1.3% between 2011/12 and 2014/15. All service sectors, with the exception of the 'other services' sector³⁹, recorded a decrease in water consumption over the same period. Water efficiency appears to explain part of the decline, water efficient gains measured by water consumption per employed person indicates average water efficiency savings of around 2.6% per annum.

³⁹ This sector comprises establishments engaged in providing services not specifically provided for elsewhere in the classification system.

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The forecast reflects the increasing economic dominance of the service sector with more stable water consumption relative to the non-service sector. Water consumption in the service sector is set to decline by 4.2% in the next 30 years from 176 MI/d in 2014/15 to 169 MI/d in 2044/45. The non-household consumption in the service sector is expected to be 1.4% higher in 2039/40 compared to our WRMP15 forecast.

3.4.2 Non-service sector

Water consumption in the non-service sector has declined marginally since the WRMP15 study from 154 MI/d in 2011/12 to 150 MI/d in 2015/16, representing a 2.7% decline over the period. The relatively minor reduction can be explained in three parts:

- GVA growth for the non-service sector shows signs of stabilisation, remaining flat;
- After observing a period of significant water efficiency gains, identified in the WRMP15 study, the recent water efficiency gains measured by water consumption per unit of output indicates a 2.5% increase in the period (2011/12 to 2015/16), which translates to average water efficiency gains of around 0.8% per annum compared to the 3.1% estimated for the period between 2003/04 to 2011/12; and
- The real term water tariff increase has been low since 2009 by historic levels, which made water relatively less expensive and thus reduces some of the incentive to focus on water efficiency.

The downward trend in water consumption in the non-service sector will continue albeit at a slower pace. Water consumption is set to decline by 22.5% in the next 30 years from 150 MI/d in 2014/15 to 116 MI/d in 2044/45. The model predicts higher water consumption in the non-service sector compared to the WRMP15 forecast, resulting in water consumption that is 3.9% higher in 2039/40 than the WRMP15 forecast.

3.5 Scenarios and sensitivity

Figure 23 shows all the scenarios considered as part of our non-household consumption modelling.

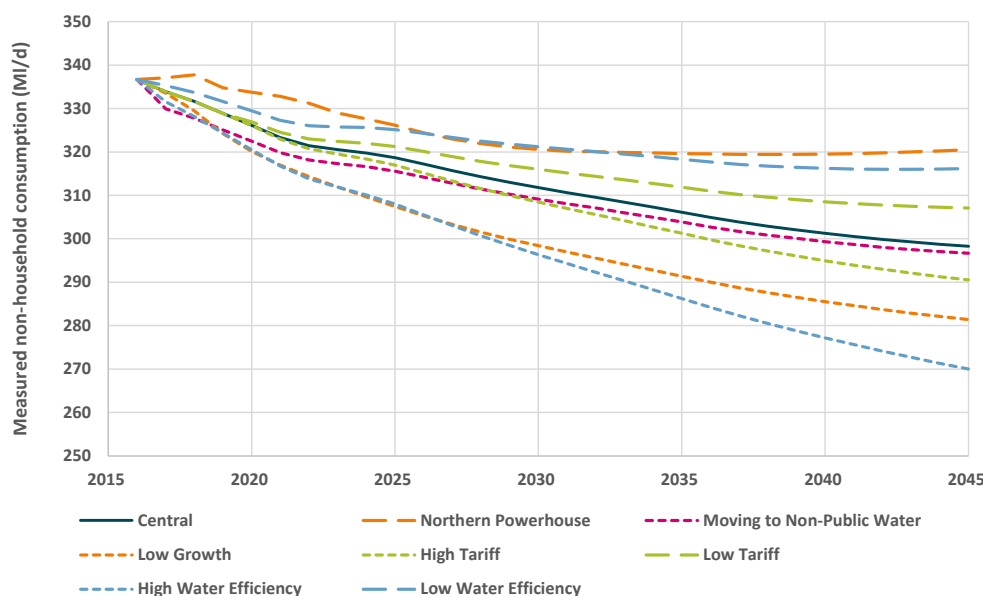


Figure 23 Scenarios considered as part of our non-household consumption modelling

The sections below describe the creation and reasoning behind each of these scenarios and Section 10 shows how we've included the uncertainty from these scenarios in the target headroom assessment.

3.5.1 Economic growth and the "Northern Powerhouse"

The "Northern Powerhouse" scenario assumes good early progress on negotiating new trade arrangements with the European Union (EU), perhaps similar to the existing European Economic Area (EEA) member status for the UK, but including a provision for some emergency brakes on migration. It also assumes promising initial discussions with other major trading partners such as the US, China and the Commonwealth countries, although actual deals would

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take longer to agree. In the medium to long-term, the UK economy will slowly return to long-term growth rates of 2.5% projected by the Office for Budget Responsibility (OBR) which is at the high-end of the UK's average long-term growth path. Further to this growth, the scenario envisages that the northern regions (North West, North East and Yorkshire & the Humber) undergo a period of economic transformation and fulfil the aspirations of the vision set out in HM Treasury analysis.

The "Low Growth" scenario assumes that negotiation with the EU has proved difficult, raising concerns for a possible 'hard-Brexit' and with the UK perhaps relying on World Trade Organization (WTO) rules to trade with the EU. This has led to a further fall of the value of sterling and the loss of consumer and business confidence which undermine both consumer spending and business investment. In this case, the UK could enter a period of recession for the next 12 to 24 months and permanently lower the nation's growth potential. The UK economy gradually emerges from the recession stabilising at a below trend growth trajectory until the end of the forecast period.

3.5.2 Water efficiency and tariff scenarios

The water efficiency scenarios explore the potential water efficiency benefits of increasing competition within the water industry, leading to savings for customers. The water efficiency benefit of increasing competition for our customers was calculated, based on a similar study conducted in Scotland, to be 1.08% per annum. We have applied this saving in the "High Water Efficiency" scenario to understand the potential impact. However, as noted in Section 3.1, the non-household retail market in England is in its relative infancy and we have identified no tangible change in water efficiency practices. Therefore, even though "High Water Efficiency" is the extreme of the potential lower measured non-household consumption scenarios, we used the "Low Growth" scenario to inform our target headroom assessment, as documented in Section 10.

3.5.3 Customers moving from and/or to non-public water source

As suggested by the Water Resources Planning Guideline⁴⁰, we examined the potential impact of customers substituting water from a public source to a non-public source or vice versa. The scenario was developed using results from a National Farmers Union (NFU) survey, related to the proportion of respondents that have active abstraction licences, as an indication of the potential scope for customers in the agricultural industry⁴¹ to access non-public water sources. The impact of this scenario in the context of other non-household consumption scenarios is relatively minor, as shown in Figure 23.

⁴⁰ Water Resources Planning Guideline (Environment Agency, 2017)

⁴¹ We also considered the power generation sector (for instance, Rookcliffe Power Station and Sellafield). However, our business as usual engagement has not highlighted this as a major issue.

4. Leakage

4.1 Background

Balancing the supply and demand of water is fundamental to our obligations to maintain a reliable supply to customers and to safeguard the environment. Leakage management contributes to the overall reduction in demand and plays a key role in reducing demand in the past and maintaining a supply-demand balance since the 1990s.

For the purpose of the WRMP, leakage is defined as loss of water from any point downstream of the distribution input meter at a Water Treatment Works, up to the internal stop tap in a customer property. This includes leakage from trunk mains and service reservoirs, known as upstream leakage. It also includes leakage from distribution pipes, connections to properties (communication pipes) and the associated customer supply pipes, known as supply pipe leakage (or customer side leakage). Raw water losses upstream of Water Treatment Works are considered separately.

Leakage management plays a key role in fulfilling the supply demand balance. Leakage reduction can be achieved incrementally and is one of the most flexible options considered in the WRMP as it can be scaled over time. In an uncertain future, incremental and flexible water resource solutions have an important value in terms of an alternative to the need for long-term fixed solutions. This will help us to be robust to the various risks and uncertainties such as the impact of climate change on the supply demand balance.

Figure 24 below shows the contribution of each of the components to the total leakage that is occurring on the distribution network.

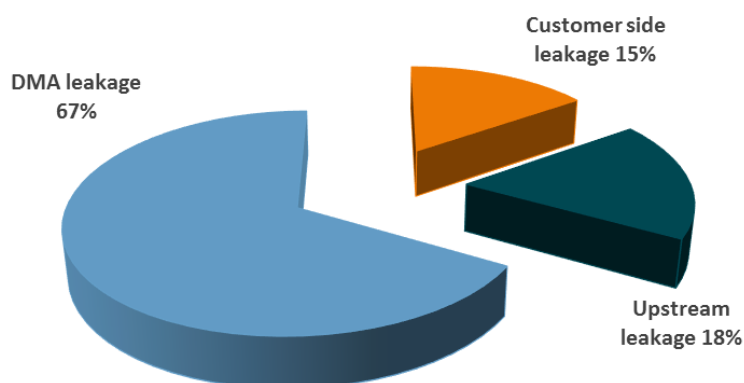


Figure 24 Leakage components 2016/17

As shown in Figure 25, we have significantly reduced leakage over the last 25 years, more than halving leakage from 945 MI/d in 1992/93 to 462 MI/d in 2007/08. Leakage has continued to decrease and, in 2016/17, we have achieved our lowest ever level of 439 MI/d, giving a three year average leakage of 448.2 MI/d. This has been achieved and maintained through expenditure on a combination of measures in accordance with national best practice. For example, we have:

- Installed a comprehensive network of over 2,500 district meters (cellular telemetry data loggers) that use GPRS technology to continuously monitor water use and leakage in each district of around 1,200 properties across the region;
- Installed over 4,000 pressure management valves and other pressure reducing methods to optimise water pressure across our distribution networks;
- Employed a large leak detection workforce of around 150 full-time equivalent personnel who have been trained and equipped with the latest leak detection techniques;

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- Provided a free telephone service for customers to inform us of leaks, and a free supply pipe repair service for households; and
- Maintained a sophisticated leakage information system that analyses 15-minute flow and/or pressure data from over 6,000 sites across the region. This identifies the areas where high leakage is occurring and directs our leak detection activities.

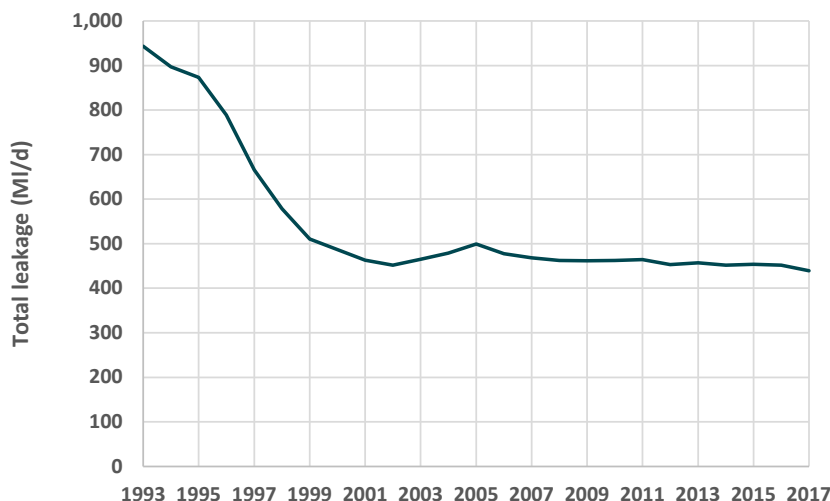


Figure 25 Leakage performance 1993 to 2017

Water companies have been working together, co-ordinated by Water UK, to improve the consistency of reporting of definitions of key measures of performance, so that performance can be compared between companies more easily.

This work is supported by Ofwat, the Environment Agency, Natural Resources Wales and the Consumer Council for Water; further information can be found [here](#).

Companies need to make changes to their current reporting to align with the new, more consistent, reporting definitions, and for some of these changes it will take some time to have robust data.

One of the measures of performance this applies to is leakage. Each company's draft Water Resource Management Plan explains how the company is implementing the new reporting definition for leakage and the extent to which it might impact on their future plans for balancing supply and demand for water. The change in reporting of leakage is purely a change in calculation; it does not affect the actual amount of water lost through leakage.

Each company will be making different changes to their current reporting to come into line with the more consistent definition, and so the impact will be different for each company. For us, the changes and their potential impact are explored below in Section 4.9.

4.2 Leakage management

At each price review we agree with Ofwat a leakage target which is derived using a combination of historic performance, economic appraisal and customer preferences. We employ best practice, follow UKWIR approved methodologies where appropriate and ensure that adequate resources are deployed to maintain our leakage levels below the agreed target. Leakage management is well governed with operational review on a weekly basis, water balance reporting on a monthly basis and management reviews on a monthly basis or more often if required.

We have achieved our regulatory leakage target for over 10 years, despite experiencing two severe winters in 2009/10 and 2010/11. This has been achieved by carrying out an extensive range of leakage control actions, at significant cost. We are continually striving to improve and ensure that we are operating as efficiently and effectively

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as possible. This meant that we have managed to achieve steady reductions in leakage over the past few years and our lowest ever leakage in 2016/17.

We are planning to maintain this lower level of leakage and have committed significant operational and capital resources to achieve this through:

- Maintenance of our existing district metered areas (DMAs);
- Widespread pressure management (region wide pressure management programme is being delivered in AMP6, covering 2015/16 to 2019/20);
- Good quality data and robust maintenance of our leakage management and information systems;
- Efficient leakage detections and repair using latest technologies;
- Replacement and refurbishment of poor performing mains;
- Providing free supply pipe repairs for domestic customers; and
- Rising customer and community awareness (Leakline campaigns).

There are currently three geographical Business Areas where leakage managers, leakage team leaders and analysts are responsible for targeting leakage detection resources as appropriate. In-house water network integrity inspectors, customer inspectors and asset inspectors work alongside dedicated contracted leakage staff to ensure integrated network management. A night leakage team operates across all areas. Water network engineers and technical specialist provide further support to operational leakage activities. Within the Water Network+ Strategy team we also have a full-time, committed resource, responsible for developing the Company's long-term leakage strategy, monitoring and reporting on leakage performance, carrying out economic appraisals of leakage, regulatory reporting to Ofwat and the Environment Agency and sharing best practice with other UK water companies.

District metered areas (DMA) leakage

Our network is divided into over 2500 district metered areas (DMAs) and around 4500 discrete pressure areas (DPAs, pressure managed sections of DMAs). DMAs are formed by dividing the network into manageable units covering between 900 and 2000 properties. This makes leakage targeting and burst localisation more efficient. Leakage levels for DMAs are calculated on a daily basis using the minimum night flow (MNF) method consistent with the industry best practice⁴².

Large customers that have a significant impact on the DMA's minimum night flow are continuously monitored to enable more accurate leakage estimation. Estimates of domestic and commercial use are determined by a thorough sampling and statistical methodology in line with UKWIR recommendations⁴³.

We use DPAs to manage pressure in our network as it is a proven method of reducing leakage and ensuring customers receive the right level of service. As part of AMP6 (covering 2015/16 to 2019/20), we are currently delivering a region wide pressure management programme which will significantly increase the number of properties within pressure managed areas. We will build around 800 new pressure management schemes and optimise just over 300 existing ones. Deployment of remote telemetry loggers since 2005 has significantly improved leakage and pressure monitoring.

We use Netbase, a sophisticated leakage management software widely used across the UK and internationally, to analyse data and monitor leakage performance. Netbase links to our corporate systems and brings together information on assets, areas and flow and pressure measurements and analyses the 15-minute flow and pressure data in each DMA and DPA on a daily basis. This enables rapid targeting of areas showing a sudden rise in the minimum flow. The application is also used to direct leakage reduction activities and report leakage and distribution input trends.

⁴² (UKWIR, 2011)

⁴³ (Water UK, 2016)

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Upstream leakage

We have the largest upstream network out of all UK water companies (this is the network between the distribution input meters and DMA meters). The identification and detection of non-visible leaks on trunk mains is more difficult than for local distribution mains. This is because larger pipe diameters absorb the noise generated by the leak more readily than smaller pipe diameters, thus hindering the leak detection equipment. To target leakage efficiently the upstream network is also divided into units which are called tiles. Each tile is continuously monitored using remote telemetry logged data. Metered data is analysed and validated each week by the Regional Upstream Losses Coordinator. This enables to identify and resolve data anomalies and target tiles for leakage detection.

We use a wide range of standard technologies and techniques for leak detection to maximise our effectiveness. These include:

- Sounding;
- Step testing (including mobile step testing devices);
- Zero pressure testing;
- Mass balance;
- Meter verification;
- Leak noise correlators;
- Ground noise microphones;
- Acoustic loggers; and
- In pipe acoustic sensors (e.g. WRc Sahara® device).

Large service reservoirs are monitored for overflows on a daily basis through telemetry alarms and can also be identified through routine analysis of the upstream tiles. We have an ongoing reservoir cleaning and maintenance programme where drop tests are undertaken and large reservoirs are also inspected for safety.

Customer side leakage

Supply pipe leakage can be considerable and recognising this, in May 1996 we were the first company to introduce a region-wide free repair service. We continue to operate the scheme in accordance with regulatory and customer expectations.

In 2011, we amended the terms of our free supply pipe repair offer to customers so it is no longer limited to one repair per year. Recognising the feedback from customers and relevant contact data, we set up a proactive customer contact team to keep customers informed, have a single point of operational response and ultimately resolve issues quicker so that leaks are not perceived to be left running for a long time. Each month we repair or replace on average 180 supply pipes. Customers can replace their lead supply pipe at their own cost and once the new pipe is installed by the plumber we will connect it and replace any remaining lead pipe beyond property boundary for free, subject to acceptance onto our Lead and Common Supply Pipe replacement (LCSP) scheme. Since privatisation we have replaced over 600,000 lead supply pipes (we estimated it to be half of all lead supply pipes). We are also actively mitigating public health risk from lead pipes by controlling plumbosolvency in our distribution network.

We provide a freephone 'Leakline' service for customers to report leaks. The service is actively promoted through telephone directory entries, information leaflets, customer billing information and our website, where a leak can also be reported using an online form <https://www.unitedutilities.com/help-and-support/got-a-problem/report-a-leak/report-a-leak-form/>. Over 50% of leaks repaired by us each year are reported by customers.

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Following the recommendation of the recent UKWIR report on the economics of supply pipe losses⁴⁴ we commissioned a project to explore the impact of changing our current policy on supply pipe repairs. The optimal approach, taking account of social and environmental costs, is to maintain our current policy for both household and non-household properties. The model was also used to test a number of scenarios for inclusion in the water resource management plan option identification process⁴⁵, these are:

- Introduction of proactive monitoring;
- Replace rather than repair supply pipes for household; and
- Offer a free repair policy for non-households.

4.3 Economic appraisal of leakage

The primary objective of the economic appraisal is to determine the economic level of leakage required to provide reliable supplies to customers at least-cost over a 25-year planning horizon. The long-run economic level of leakage is defined as the point at which the net present cost of providing an additional unit of water through leakage reduction to balance supply and demand is equal to the net present cost of providing the same unit from alternative options (such as water supply schemes or demand management measures). The inclusion of externalities such as social, environmental and carbon costs enable a sustainable economic level of leakage (SELL) to be derived.

We have followed the “best value” supply-demand planning approach recommended in the latest UKWIR guidance⁴⁶. This approach aims to provide the most cost effective and sustainable long term solution. It is based on a combination of core methods which seek to minimise the net present value of the cost of all the investment required to maintain a supply-demand balance over the 25 year period, augmented with extended methods to ensure best value for customers and environment. Leakage reduction options form a key part of the appraisal process, whether this be to meet a supply-demand deficit, meet customer and stakeholder expectations or benefit the environment. More detail on how we considered leakage reduction options can be found in *Draft WRMP19 Technical Report - Options appraisal*.

Full account has been taken of the Ofwat Leakage Methodology Review (the “Quinquartite” Reports)⁴⁷ and subsequent guidance. In particular, the principles detailed in the report on *Providing best practice guidance on the inclusion of externalities in the ELL calculation*⁴⁸ and the recommendations in “*Review of the calculation of sustainable economic level of leakage and its integration with water resource management planning*” (SMC, 2012)⁴⁹ have been followed to establish a sustainable economic level of leakage.

⁴⁴ (UKWIR, 2015)

⁴⁵ (Crowder Consulting, 2016)

⁴⁶ (UKWIR, 2016), (UKWIR, 2016)

⁴⁷ (Ofwat, 2007)

⁴⁸ (Ofwat, 2008)

⁴⁹ (SMC for EA, Ofwat, Defra, 2012)

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Table 17 Short run ELL and SELL

		Strategic	Carlisle	North Eden	Region
PR19	ELL (MI/d)	471.5	7.4	2.9	481.8
	SELL (MI/d)	453.5	6.8	2.8	463.2
PR14	ELL (MI/d)	671.5	7.8	2.9	682.9
	SELL (MI/d)	595.9	7.2	2.6	605.7

The main reason for the significant reduction in ELL and SELL between PR19 and PR14 is exclusion of repair costs when producing the active leakage control (ALC) curve⁵⁰. This is based on the assumption that the natural rate of rise in leakage (NRR)⁵¹ is a function of infrastructure condition and is not significantly impacted by reducing or increasing leakage levels, i.e. the same number of leaks has to be repaired each year just to counteract the NRR, irrespective of the absolute level of leakage.

Following the recommendations of the SMC report, we have improved our model so that now pressure management and mains rehabilitation are also incorporated into the analysis. This ensures that the benefits of the various leakage management options are not double counted.

The ELL model was used to develop a number of leakage reduction options for inclusion in the option appraisal process (please see our *Draft WRMP19 Technical Report - Options appraisal*). The costs and benefits of these options were assessed using actual company data, keeping it consistent with the ELL assessment. Full assessment of the social and environmental costs was completed for each option and these costs were accounted for in the option appraisal process.

4.3.1 Sensitivity analysis of the SELL

There is an inherent uncertainty in all of the ELL/SELL analysis components as there is a level of estimation in each one. Analysis was carried out to examine the sensitivity of the leakage profile to a number of key components of the ELL analysis. Figure 26 below shows results for the Strategic Resource Zone.

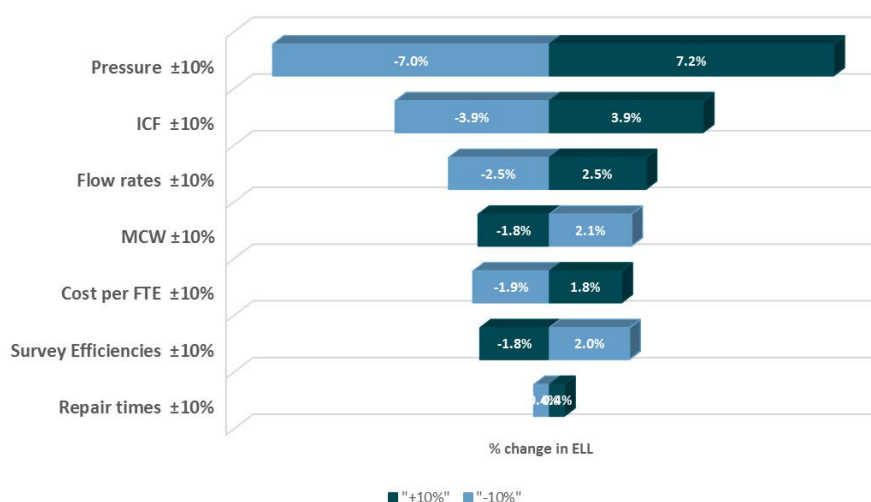


Figure 26 Sensitivity analysis of the SELL

⁵⁰ Active leakage control curve (ALC) is showing the relationship between leakage and cost

⁵¹ NRR is the rate at which leakage would rise if no proactive leakage detection was carried out

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The ELL is most sensitive to changes in pressure and policy minimum. For example, a 10% increase in pressure would increase the ELL by 7%. A 10% increase in policy minimum would have similar effect of the ELL, causing a 6% increase. A 10% increase in marginal cost of water has no significant impact on ELL causing only 1.8% decrease. This is due to total cost curve being relatively flat around the minimum point.

4.3.2 Upper and Lower bands for ELL and SELL

A Monte Carlo simulation was used to assess the upper and lower bands for ELL and SELL.

A set of confidence levels was set for the 7 components identified in the sensitivity analysis. This was done using internal subject matter expertise, accounting for the amount of data used when deriving the particular component, difficulty level of the analysis and the amount of validation required in the assessment.

Table 18 90% confidence limits

Component	90th CL%	Reason
Pressure	1%	Data mostly based on logged data, robust validation processes in place.
Infrastructure condition factor (ICF)	2%	Output from the minimum historic analysis, a lot of data inputs so potential errors, also estimation involved but the analysis is robust and a lot of validation is carried out.
Flow rates	5%	Output from NRR analysis, reliant on accuracy of burst data and leakage detection data, a lot of data cleansing required. The analysis is very subjective at individual DMA level.
Marginal cost water (MCW)	2%	Obtained from Production Planning, validated data set, data improved a lot over the past few years, since Production Planning initiative was launched.
Cost per Full Time Equivalent (FTE)	2%	Subject to various assumptions, especially for the managerial time allowance.
Survey efficiencies	10%	Very difficult to estimate, as assumes that survey in a particular DMA will always take the same amount of time, and this is not the case in practice. Therefore, large uncertainty band.
Repair times	5%	Derived as part of the NRR analysis using data extracted directly from SAP. Reliant on very accurate logging of burst types etc., therefore some assumption had to be made to group bursts in categories required for the analysis.

A normal distribution was applied to each component using the confidence limits above. A Monte Carlo simulation was run on the ELL model, randomly selecting each component from its distribution. The results below are based on 1000 simulations and show upper and lower bands based on 90% confidence limits.

Table 19 Upper and lower band for ELL and SELL

WRZ	ELL (MI/d)			SELL (MI/d)		
	Central	Upper	Lower	Central	Upper	Lower
Carlisle	7.4	7.7	7.1	6.8	7.1	6.6
North Eden	2.9	3.0	2.8	2.8	2.9	2.7
Strategic	471.5	486.8	456.3	453.5	467.6	439.5
Company	481.8	497.4	466.2	463.2	477.6	448.8

The figure below shows an example of a normal distribution of ELL and SELL for Strategic resource zone (shown as histogram and as continuous distribution).

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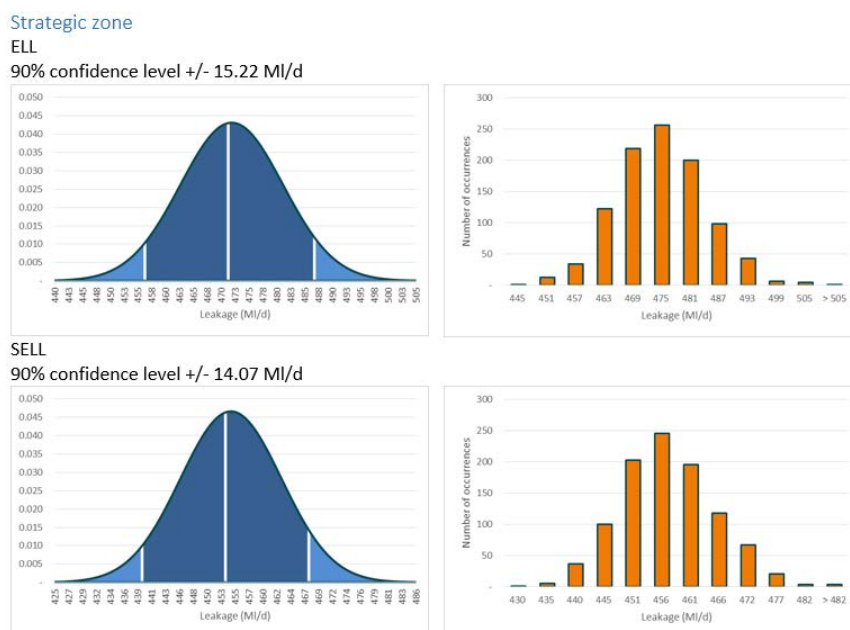


Figure 27 Normal distribution of ELL and SELL

4.4 Risks and uncertainties

There are a number of risks and uncertainties surrounding the economic level of leakage appraisal. The analysis is very complex and requires a lot of data inputs that can themselves carry a high level of uncertainty, for example leak flow rates, survey efficiencies and repair times have to be derived at a resource zone level while in real life each leak will be different, detection efficiency will vary at DMA level and estimate of repair time relies on accuracy of the job management system. For more detail on the economic appraisal of leakage please refer to Appendix A.

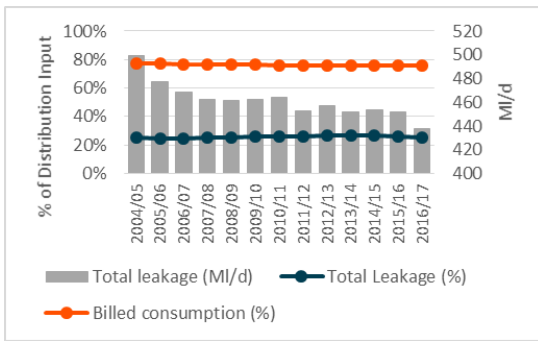
4.5 Benchmarking

Due to the wide range of systems and the different statistics available, benchmarking leakage performance is challenging and subject to misinterpretation. This section aims to walkthrough the different comparisons made in the UK and elsewhere.

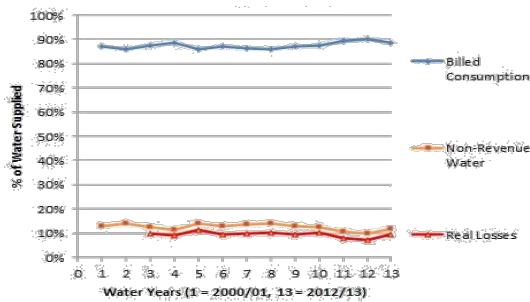
Although, there is a wide range of leakage performance indicators in use e.g. % of system input, per km of mains, per km of system (mains + services), per connection, per billed property – none of these provide an equitable means of comparing leakage between systems and countries. Due to underlying differences in the components of leakage and influential parameters such as pressure, leak run times and meter penetration, different statistics can show individual systems, companies/utilities or countries to perform differently relative to their peers. For example, urban areas with high consumption tend to favour “leakage per property” while areas with low property density turn to “per km of main”. % of system input can mask true level of leakage reduction as it is also heavily influenced by consumption, please see Figure 28 below.

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Left: In the last twelve years our total leakage – in MI/d - has been reduced by 12%. However, this has been matched by a fall in consumption, and hence system input, so leakage as percentage of system input has remained constant. This shows why reporting leakage in % is a poor incentive on performance and can be misleading.



Below left: Yarra Valley Water faced a severe drought in the 2000s, forcing them to take the multiple steps to improve their water efficiency. Non revenue water was cut by 75% (as shown on the chart).



From Lambert (n.d.)

Below right: Yarra Valley Water’s successful water efficiency measures meant that percentage losses remained constant.



From Lambert (n.d.)

Figure 28 Leakage reported as a percentage of water supplied hides holistic management of limited water resources

The recently published EU Reference Document ‘Good Practices on Leakage Management’⁵² provides a recent evidence-based ‘fit for purpose’ review of the leakage performance indicators for different objectives. These are shown in Figure 29 below.

OBJECTIVE	GOOD PRACTICE PERFORMANCE INDICATOR FOR LEAKAGE, FIT FOR PURPOSE						
	Volume per year	litres/ service connection	m ³ /km mains	litres/ billed property	% of System Input Volume	% of Water Supplied	Infrastructure Leakage Index, with Pressure
SET TARGETS AND TRACK PERFORMANCE, FOR AN INDIVIDUAL SYSTEM	YES, for large systems	YES*	YES*	YES (UK)	NO	NO	Only if all justifiable pressure management completed
TECHNICAL PERFORMANCE COMPARISONS OF DIFFERENT SYSTEMS	NO	NO	NO	NO	NO	NO	YES
DRAW GENERAL CONCLUSIONS FROM SINGLE OR MULTIPLE SYSTEMS	NO	NO	NO	NO	NO	NO	YES, together with other context factors

* Choose services connection density > 20/km; if not, choose mains; or base choice on country custom and practice

Figure 29 Leakage performance indicators fit for purpose⁵³

Infrastructure Leakage Index (ILI) is listed as the only indicator suitable for comparisons of different systems. It was developed by the International Water Association (IWA) Task Force in 1999 and quickly became popular in countries

⁵² (EU, 2015)

⁵³ (EU, 2015)

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such as Australia, New Zealand, AWWA (North America), and is now widely calculated and increasingly adopted throughout Europe and internationally (Austria 2009, Croatia 2009, Denmark 2014, Germany due 2017/18, Italy 2016, and Malta 2003)⁵⁴. The advantage of using ILI for company comparisons is that it allows to account for all 4 key parameters influencing leakage i.e. pressure, number of connections, meter location, mains length, whereas the indicators mentioned in the beginning of this section are limited to only one parameter.

Due to UK water companies having limited data on number of connections, as regulatory reporting in the UK uses billed properties, the assessments of ILI might not be fully representative and can make international comparisons less meaningful. Another factors that can contribute to less meaningful comparison are, for example:

- Company size (generally European utilities are a lot smaller and it would be extremely difficult, impossible even, to find a utility in Europe of similar size to ours); and
- Meter penetration (with the UK having the second lowest meter penetration in Europe).

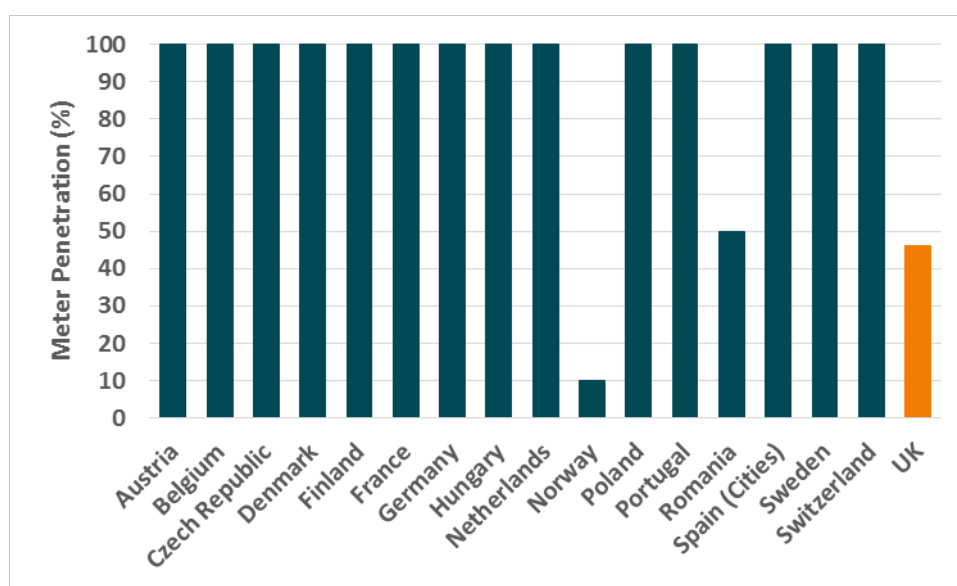


Figure 30 Meter penetration in European countries⁵⁵

Figure 31 below shows how we compare with individual utilities in other countries⁵⁶ using ILI as performance indicator. Our current estimate of ILI is significantly below the average calculated using data for utilities in countries included in the graph below. Our estimate of ILI is at similar level if compared to other large European Economies such as Germany or France. Note, that the data presented for each individual country reflects anonymous utilities in that area included in the report, therefore in some cases individual countries will appear more than once on the graph.

⁵⁴ <http://www.leakssuite.com/welcome/>

⁵⁵ http://www.harvesth2o.com/rainwater_harvesting_UK.shtml and Ofwat

⁵⁶ http://www.miya-water.com/user_files/Data_and_Research/miyas_experts_articles/2_NRW/06_International_Benchmarking_of_Leakage_from_Water_Reticulation_Systems.pdf, anonymous data for individual utilities in other countries

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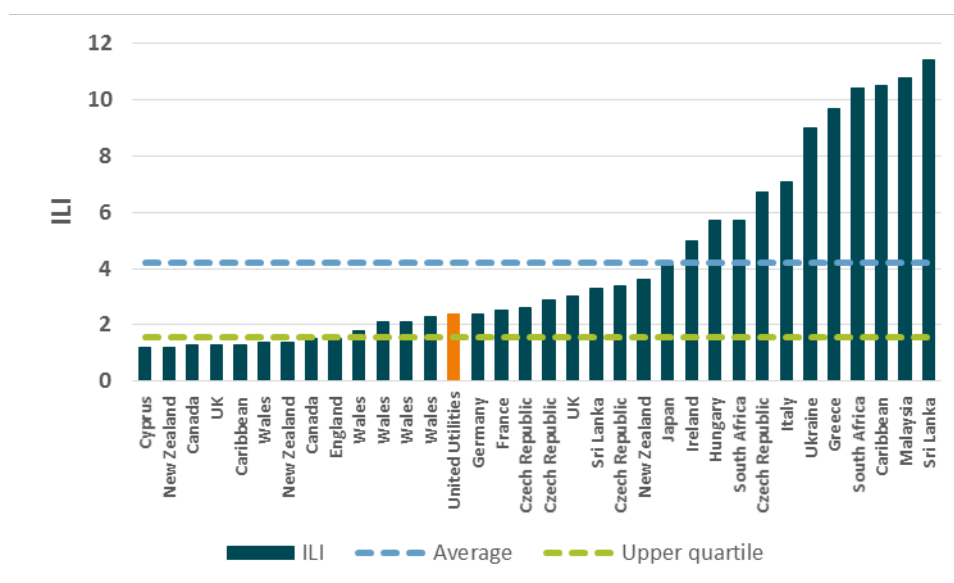


Figure 31 International ILIs⁵⁷

For national comparisons, Ofwat historically used combination of two leakage performance indicators, leakage in litres per property and leakage in cubic meters per kilometre of main. This was done with a view that scoring companies using a combination of these two KPIs will remove some of the bias that can potentially be introduced if using only one. The graph below shows how we compare to other water companies using 2016/17 reported leakage⁵⁸ and how our position will change following the delivery of AMP7 (covering 2020/21 to 2024/25), AMP8 (covering 2025/26 to 2029/30) commitments, as well as those in future AMP periods (to 2044/45). Dashed lines on the graph represent lines of equal leakage equivalent to good, average and poor infrastructure condition factor (ICF) respectively.

It is worth noting that, generally, companies closer to the origin on the graph below are the ones facing deficits currently or in the very near future. This means that the for the last two AMP periods, or potentially for longer, they have been focusing their efforts on increasing meter penetration (some companies have been granted right to universal metering) and leakage reduction. Historically, our supply-demand balance position has not resulted in deficits to address for the majority of the region, and we have consistently achieved or outperformed our regulatory targets agreed with Ofwat at the last two periodic reviews.

As mentioned in Section 4.7 below, we are mindful that we have to balance any leakage reduction aspirations against customer affordability and other business priorities, we have therefore gone for a phased approach. This pace will enable the business to adjust to delivering the proposed scale of leakage reductions, ensuring that we take advantage of innovation and emerging technologies, which should make achieving reductions more affordable and efficient over time as part of the most cost-effective long-term plan. Achieving our commitment over the planning horizon will move us closer to the industry average. Our future leakage plans are outlined in Section 4.7.

⁵⁷ ILI for United Utilities was calculated as ratio of distribution losses to unavoidable annual real losses (UARL) using FY17 data

⁵⁸ Data from <http://discoverwater.co.uk/>

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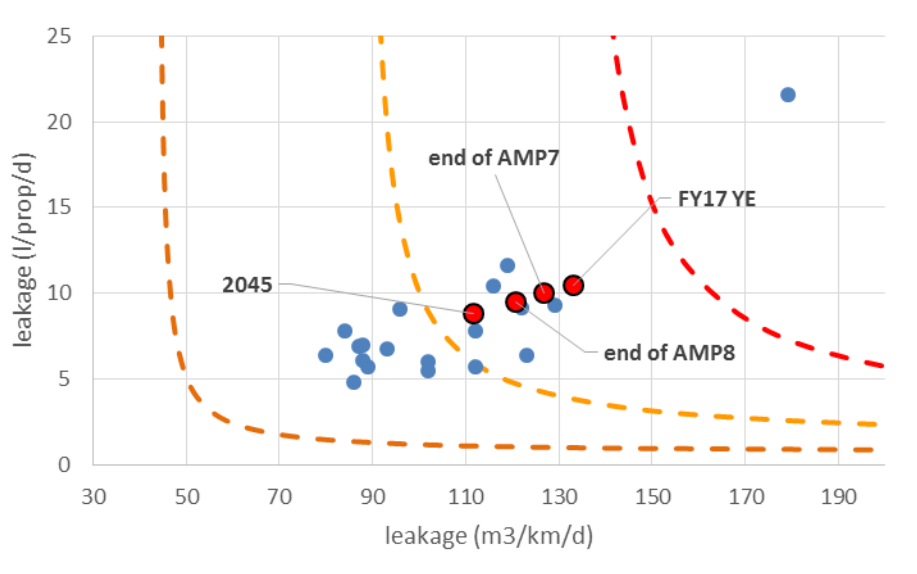


Figure 32 Industry comparison leakage per km vs. leakage per property⁵⁹

4.6 Current performance and “base year” total leakage

We have followed the WRMP guidelines and Ofwat PR19 methodology⁶⁰ in determining our “base year” leakage position. Due to our current leakage levels being significantly below the short-run SELL, which has been calculated at 463.6 MI/d, and the current regulatory target of 462.7 MI/d, we have used a three-year rolling historic average to represent “base year” total leakage. This means that even before a further consideration of leakage reductions as a key strategic choice in this plan (see Section 4.7), our leakage commitment going forward would be just over a 14 MI/d reduction from that in WRMP15.

Table 20 below shows our leakage performance for the last 3 years⁶¹ and “base year” total leakage.

Table 20 Annual leakage performance at Company level

	2014/2015	2015/2016	2016/2017	“base year” ⁶²
Total leakage (MI/d)	453.6	451.9	439.2	448.2

The calculation of leakage levels is fully consistent with current best practice such as the Demand Forecasting Methodology⁶³, Managing Leakage 2011⁶⁴ and Best Practice for Supply Pipe Leakage Assessment⁶⁵.

The best practice is to estimate leakage using two nationally-agreed methods, the integrated flow approach (‘top down’) or the minimum night flow approach (‘bottom up’). We use both methods and demonstrate a robust water balance through the reconciliation of the two estimates of leakage. This is explained in detail in Appendix B.

⁵⁹ Discover Water, FY17 data, <https://www.discoverwater.co.uk/leaking-pipes>

⁶⁰ (Ofwat, 2017)

⁶¹ Data from Regulatory Reporting Table 10

⁶² This assumption is based on direction from Draft water resources planning guideline (November 2015) and PR19 consultation (July 2017) requirement to report leakage using 3-year rolling average. Base year leakage is calculated as an average between 2014/15 and 2016/17, including 2016/2017 will align it with demand forecast for the revised draft Water Resource Management Plan. Use of the 3-year average was also chosen on the grounds that existing policies or commitments are defined at regional level, this ensures we bake in current improved performance in the baseline, and that year-on-year sensitivity on the final number due to weather conditions is reduced

⁶³ (UKWIR/NRA, 1995)

⁶⁴ (UKWIR, 2011)

⁶⁵ (UKWIR, 2005)

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4.6.1 Water resource zone level “base year” total leakage

The table below shows our AMP6 (2015-2020) forecast from WRMP15 and our leakage performance over the last 3 years at water resource zone level.

Table 21 Annual leakage performance at water resource zone level

Total leakage (MI/d)	AMP6 forecast	2014/2015	2015/2016	2016/2017	“base year”
Strategic	441.9	445.4	443.5	430.8	439.9
Carlisle	4.8	5.6	5.9	5.3	5.6
North Eden	2.0	2.6	2.6	3.1	2.8

The “Base year” for the Cumbrian zones is also calculated as a 3-year rolling average, which gives higher leakage level than the current WRMP15 forecast.

Our network is split into 34 Demand Monitoring Zones. When comparing leakage performance across our Region, Carlisle is a frontier of all our rural zones, with total leakage expressed in both l/prop/d and m3/km/d well below industry average⁶⁶.

The WRMP15 forecast for North Eden is based on historic reported performance in 2003/04. However, we have made significant improvements in the way we collect and process data since, making leakage estimates more robust. Latest review of minimum historic carried out by Crowder Consulting shows that current forecast is basically equal to the revised policy minimum (see Figure 33 below), making it practically impossible to maintain. It should also be noted that North Eden is a small but very rural zone, with only 17 properties per km (Company average is 89 properties per km). This makes leakage detection very challenging.

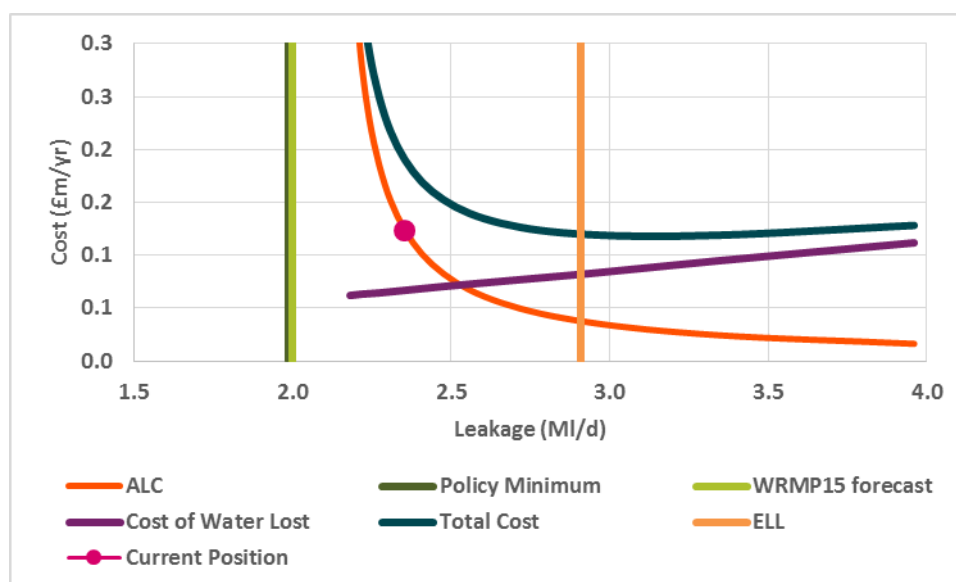


Figure 33 Total cost curve and ELL for North Eden

We have decided to use this review and set an achievable forecasts, noting that the new forecasts are still below the economic level of leakage for both zones. This ensures appropriate incentive on our performance.

⁶⁶ Carlisle: 92.0 l/prop/d, 4.4 m3/km/d; Industry average: 107.0 l/prop/d, 8.2 m3/km/d; based on FY17 data from <https://www.discoverwater.co.uk/leaking-pipes>

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We will continue our efforts in all Cumbrian zones and continue to report on all leakage and demand related activities in the water resource management plan annual reviews. Delivery of AMP7 (covering 2020/21 to 2024/25) leakage reduction, as described in the following sections, will be one of our biggest challenges in the coming years and we have to ensure that our resources are deployed in the most efficient way to maximise the benefits, where there is potential for further reductions and where they can be achieved and maintained.

The current leakage levels used in this appraisal are consistent with those completed annually as part of our regulatory reporting process and consistent with leakage levels reported in annual reviews of the water resource management plan. Detail on the water balance calculations, definitions of the components and an outline of the assessment approach are explained in detail in Appendix B : Water Balance.

4.7 Leakage forecast and setting stretching targets

Our current leakage levels are significantly below the short-run sustainable economic level of leakage, which has been calculated at 463.2 Ml/d. This demonstrates that further leakage reduction in itself is not economic or self-financing through reduced water production costs, prior to taking account of the wider value customers place on reducing leakage. For more detail on the economic appraisal of leakage please refer to Appendix A.

Regulators and government outline leakage as an area of focus, for example, in their guiding principles Defra states:

“We want to see the downward trend for leakage continue and you must consider leakage management fully as an option to balance supply and demand. We expect you to ensure that total leakage does not rise at any point in the planning period.... Challenging leakage objectives should be informed by your customers’ views on leakage and also be based on the potential for innovation in future.”

Various pieces of customer research carried out for WRMP19 and PR19 suggest that leakage reduction is high priority for our customers, and there is willingness to pay in this area. By way of examples, in customer research carried out for us by Verve (Water Talk Customer Panel survey, completed in June 2017), customers rank the importance of leakage reduction highly against other services areas. Leakage reductions are ranked below ‘providing safe, clean drinking water’ and ‘providing a reliable water/wastewater service’, yet higher than a range of other service areas. Similarly, a customer panel survey carried out for us by Verve also suggests that 93% percent of customers think that we should do more to reduce leakage. Stakeholders similarly see leakage reductions as an important priority area of focus in the water resource management plan. The full detail of our customer and stakeholder engagement is included in *Draft WRMP19 Technical Report - Customer and stakeholder engagement*.

Although, from economic point of view further leakage reduction is not cost-beneficial based on SELL, and our baseline supply-demand balance does not indicate any deficits in the planning horizon, it is clear that customers place an inherent value on the benefits of leakage reduction. We acknowledge that customers, stakeholders and regulators feel very strongly about reducing leakage, and that leakage levels are a perception issue for the industry. There is a potential that the industry wide drive for leakage reduction, aside from the environmental benefits, will also boost the need for innovation in leakage management enabling new technologies to become cheaper and more readily available.

However, we also have to be mindful that we have to balance cost of the potential reduction with customer affordability and investment in other business priorities in water and waste water services, especially as we are in a surplus position. Therefore, we extensively explored a range of scenarios to define an appropriate pace of change, also recognising that further innovation in the future has the potential to make reductions more affordable. Furthermore, we recognise that given our historic supply-demand balance position it will take time for the business to adjust to delivering the scale of leakage reductions that we are seeking and therefore we have gone for a phased approach to ensure cost-effectiveness and allow for exploration of more innovative solutions determined through our options identification process.

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After thorough analysis, as well as careful consideration of all the factors, we are proposing a 30 MI/d reduction in AMP7 (covering 2020/21 to 2024/25), 20 MI/d reduction in AMP8 (covering 2025/26 to 2029/30) and further 30 MI/d reduction by 2044/45. These reductions are from WRMP base year leakage of 448.2 MI/d. This equates to achieving a 17% leakage reduction from our current commitment of 462.7 MI/d by 2044/45 and is outlined in the table below.

Table 22 Forecast leakage reductions up to 2044/45

	2020/21	2024/25	2029/30	2044/45
Total leakage (MI/d)	448.2	418.2	398.2	368.2
% reduction from AMP6 commitment	3%	10%	14%	20%
% reduction from dWRMP19 baseline	0%	7%	11%	18%

Figure 34 shows historical leakage performance, scenario selected for final planning and how it relates to our current commitment. The long-term position is subject to review in future planning cycles as the supply-demand balance position evolves along with changes in technology.

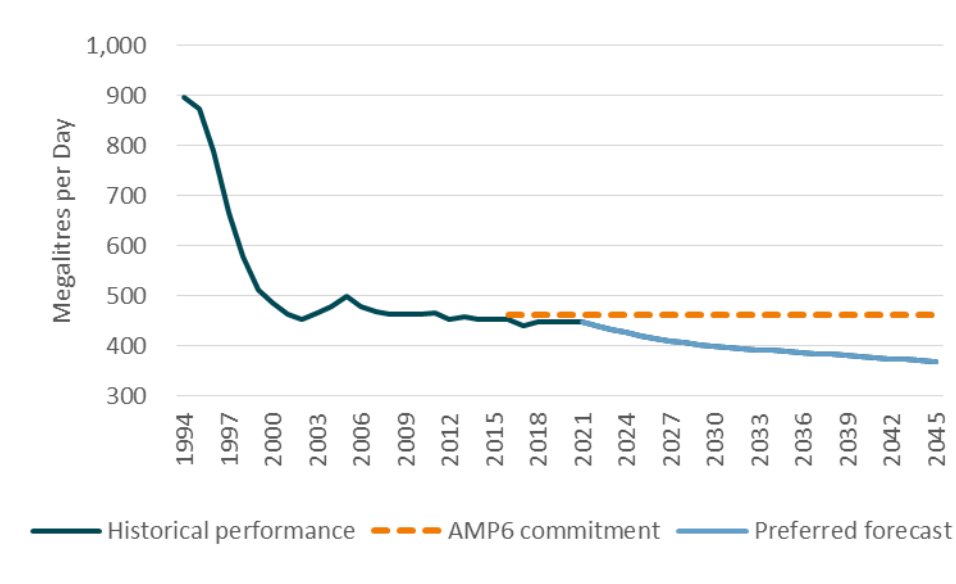


Figure 34 Historical performance and leakage forecasts up to 2044/45

This proposal is a key strategic choice in our plan for consultation, and Section 6.2 of the *Draft WRMP19 main report* summarises the reason for this proposal. Further detail on the scenarios tested and the cost-effectiveness of the selection is presented in *Draft WRMP19 Technical Report – Options appraisal*.

4.8 Delivering enhanced leakage reduction

We have aspirations to reduce leakage in the long-term as defined in the previous section. To do this cost-effectively our plans seek to apply innovations, which have been identified through our options identification process. In the guidelines it states “...[if] you have future leakage reduction ambitions, but do not necessarily know how to achieve these. If this is the case you should demonstrate that you are actively investigating how to achieve these ambitions”, and this section outlines our plans to progress in this area.

In order to achieve significant leakage reductions included in our demand forecast we will increase our find and fix resources to levels estimated by the ELL model. This will enable us to make the required transition in AMP7 (covering

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2020/21 to 2024/25). In the longer term, the scale of the step-change in leakage levels requires us to work differently and seek new innovations (beyond just increasing “find and fix” resources), particularly if it is to be delivered in a way that is affordable to customers.

Through a review of policy minimum we have identified over 200 DMAs with recoverable leakage i.e. DMAs where there is a potential to go beyond current lowest achieved night lines. We will carry out a detailed review of these DMAs to better understand the underlying data and challenge the achieved minimum night flows where appropriate.

For example, as part of our third-party options engagement and business innovation processes we have identified a potentially promising new technology to tackle customer side leakage. This would seek to use a non-intrusive device to identify properties with potential customer side leakage and a specialist contractor to repair or replace customer supply pipe, or resolve any issues with internal plumbing. We are awaiting a final proposal and if the business case can be made, trials will be commissioned in the near future. If the outcome is positive the technology will be rolled out from 2020. It should be noted that as with all innovation, in reality this may not prove effective or we may identify alternative ways of achieving our desired performance outcomes.

We have also done research into the benefits of using permanent acoustic loggers. We are considering trialling this technology in several district meter areas. It can take up to 6 months for the loggers to be fully calibrated and for the algorithms to be adjusted to minimise the number of false positives alarms. It is, therefore, likely that the full benefits of this technology will not be available until beginning of 2019 at the earliest.

4.9 Leakage convergence

In May 2015, the Water UK Board issued Terms of Reference for a project on “Consistency in Performance Measures”. The main purpose of this work was to facilitate consistent and comparable reporting for leakage, sewer flooding and interruptions to supply. This resulted in a new methodology for leakage calculation being published in April 2017. All water companies will have to report leakage using this new methodology from April 2021 and run parallel shadow reporting from April 2017 to enable new converged leakage figure being used for setting targets and performance commitments for AMP7 (covering 2020/21 to 2024/25).

We have held an internal workshop to assess the impact of this new methodology on our reported leakage levels, identify gaps in our process and understand areas where more work is required for us to be compliant with this new methodology. Although, some of the requirements relate to changes in computational procedures and can be implemented fairly easily within our leakage management software, due to our current procedures, it is not possible to fully apply these retrospectively.

Our initial assessment showed an approximate 5% increase in total leakage reported for FY17 (April 2016 – March 2017). However, due to limitations mentioned in the paragraph above, this is subject to change as further improvements are delivered throughout AMP6 (covering 2015/16 to 2019/20). In line with the guidance, we have therefore opted for a scenario approach in order to understand the impact of the leakage convergence on our supply demand balance and option appraisal process. The future level of proposed leakage reductions outlined in our plan based on the current reporting method will be relative to any revised baseline, and thus will not change.

The table below shows 3 scenarios that have been assessed.

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Table 23 Leakage convergence scenarios

Scenario	Total Leakage (MI/d)	% change from base	PHC (l/prop/d)	% change from base
Base	439.2	-	305	-
Scenario 1	462.6	5%	301	-1.3%
Scenario 2	452.2	3%	302	-0.7%
Scenario 3	470.0	7%	299	-1.7%

As required by the guidelines, we have produced a detailed plan of investigations that need to take place in order for us to understand the efforts and expenditure required to meet the requirements of the new methodology. These are set out in the RAG status table in Appendix C.

As shown on Figure 35 below, the overall impact of the convergence on the value of distribution input is not significant. There was, therefore, no material impact on the choice of options for the preferred plan. More detail can be found in our *Draft WRMP19 Technical Report - Options appraisal*.

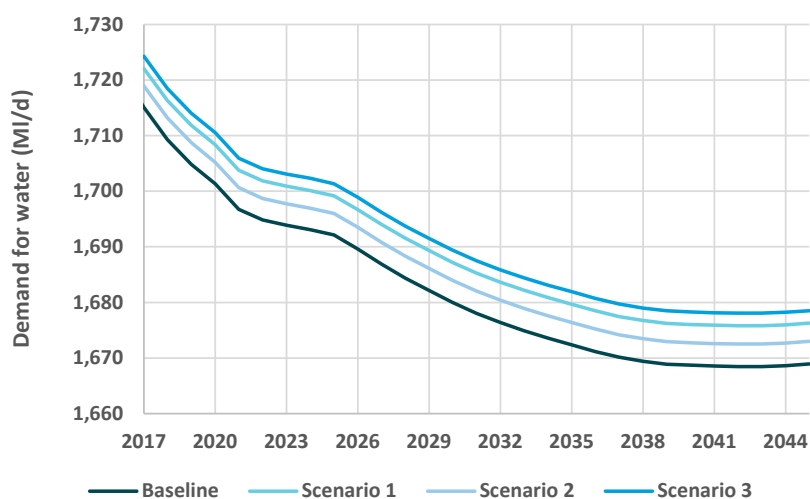


Figure 35 Leakage convergence scenarios impacting forecast demand for water

It is important to note that the range of uncertainty could potentially be greater than in the scenarios above. Significant work is on-going to enable us to achieve compliance with the new guidance by the end of this AMP period (by March 2020). One of the improvements we are currently assessing is the impact of fast logging on the assessment of household night use and unmeasured household consumption estimates (method recommended in the new guidance⁶⁷). Results of the trial were not available at the time of producing this report, but can potentially have a significant impact on our reported leakage and consumption figures. The assessment will be completed and included in the demand forecast updated for the revised draft WRMP19.

⁶⁷ (Water UK, 2016)

5. Minor components

The minor components of the water balance are shown in Table 24.

Table 24 Minor components of the water balance

Component	Definition (from our Regulatory Reporting Methodology)
Distribution system operational use	Water knowingly used by a company to meet its statutory obligations, particularly those relating to water quality. This includes, amongst other things, service reservoir cleaning, mains flushing/air scouring, swabbing, draining networks, discharges to control pH or other chemical parameters.
Water taken legally unbilled	This should include all water supplied to customers for legitimate purposes which is unbilled. It can include public supplies for which no charge is made (some sewer flushing etc.), uncharged church supplies, fire training and fire-fighting supplies where these are not charged irrespective of whether or not they are metered.
Water taken illegally unbilled	Illegally taken water, reported and included in the water delivered total and based on actual occurrences using sound, auditable identification and recording procedures. In 2012/13, the method and quantities of water taken illegally unbilled were subject to a detailed review by Atkins Limited, on our behalf. From year to year are adjusted based on information from our revenue assurance activities and records of water use that is unbilled. Regulatory Reporting is subject to a fully auditable process and subject to robust governance procedures.

As at WRMP15, to forecast minor components we have kept them consistent with the base year data. However, as an improvement for WRMP19, we have assessed the potential uncertainty around the base year data using the maximum and minimum reported value over the last 5 years. This has been used to inform our target headroom assessment, as noted in Section 10.

6. Overall baseline and final planning demand forecast from the base year

Table 25 shows the baseline demand forecast from the base year for all resource zones, broken down to show the different components of demand for water and how they are forecast to move over time. This is prior to the application of any demand uplifts to account for climate change and weather variation. These uplifts are discussed further in Section 7.

Table 25 Baseline demand forecast from the base year for all resource zones (in megalitres per day)

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Measured household consumption	265	333	395	448	497	543	576
Unmeasured household consumption	592	517	454	396	346	303	273
Measured non-household consumption	352	338	332	325	319	315	313
Unmeasured non-household consumption	9	9	9	8	8	8	8
Total leakage	444	440	440	440	440	440	440
Minor components	27	27	27	27	27	27	27
Total demand for water	1,689	1,664	1,656	1,645	1,638	1,635	1,636
Carlisle Resource Zone							
Measured household consumption	3.7	4.7	5.7	6.6	7.2	7.8	8.1
Unmeasured household consumption	10.5	9.7	9.2	8.6	8.1	7.6	7.2
Measured non-household consumption	6.9	6.5	6.2	6.0	5.8	5.6	5.5
Unmeasured non-household consumption	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total leakage	5.9	5.6	5.6	5.6	5.6	5.6	5.6
Minor components	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total demand for water	27.5	27.1	27.3	27.4	27.3	27.2	27.0
North Eden Resource Zone							
Measured household consumption	0.5	0.6	0.7	0.8	0.8	0.9	0.9
Unmeasured household consumption	1.2	1.1	1.1	1.0	1.0	1.0	0.9
Measured non-household consumption	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Unmeasured non-household consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total leakage	2.6	2.8	2.8	2.8	2.8	2.8	2.8
Minor components	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total demand for water	5.8	5.9	6.0	6.0	6.0	5.9	5.9
Region							
Measured household consumption	269	338	402	455	505	551	585
Unmeasured household consumption	604	528	464	406	355	311	281
Measured non-household consumption	360	346	339	332	326	322	319
Unmeasured non-household consumption	9	9	9	9	8	8	8
Total leakage	452	448	448	448	448	448	448
Minor components	27	27	27	27	27	27	27
Total demand for water	1,722	1,697	1,690	1,678	1,671	1,669	1,669

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Table 26 shows this same table with our proposed leakage reduction targets, as discussed in Section 4.7, and the impact that has on demand for water.

Table 26 Final planning⁶⁸ demand forecast from the "base year" for all resource zones (in megalitres per day)

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Measured household consumption	265	333	395	448	497	543	576
Unmeasured household consumption	592	517	454	396	346	303	273
Measured non-household consumption	352	338	332	325	319	315	313
Unmeasured non-household consumption	9	9	9	8	8	8	8
Total leakage	444	440	406	388	378	368	360
Minor components	27	27	27	27	27	27	27
Total demand for water	1,689	1,664	1,622	1,593	1,576	1,563	1,556
Carlisle Resource Zone							
Measured household consumption	3.7	4.7	5.7	6.6	7.2	7.8	8.1
Unmeasured household consumption	10.5	9.7	9.2	8.6	8.1	7.6	7.2
Measured non-household consumption	6.9	6.5	6.2	6.0	5.8	5.6	5.5
Unmeasured non-household consumption	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total leakage	5.9	5.6	5.6	5.6	5.6	5.6	5.6
Minor components	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total demand for water	27.5	27.1	27.3	27.4	27.3	27.2	27.0
North Eden Resource Zone							
Measured household consumption	0.5	0.6	0.7	0.8	0.8	0.9	0.9
Unmeasured household consumption	1.2	1.1	1.1	1.0	1.0	1.0	0.9
Measured non-household consumption	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Unmeasured non-household consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total leakage	2.6	2.8	2.8	2.8	2.8	2.8	2.8
Minor components	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total demand for water	5.8	5.9	6.0	6.0	6.0	5.9	5.9
Region							
Measured household consumption	269	338	402	455	505	551	585
Unmeasured household consumption	604	528	464	406	355	311	281
Measured non-household consumption	360	346	339	332	326	322	319
Unmeasured non-household consumption	9	9	9	9	8	8	8
Total leakage	452	448	414	396	386	376	368
Minor components	27	27	27	27	27	27	27
Total demand for water	1,722	1,697	1,656	1,626	1,609	1,597	1,589

⁶⁸ In the context of national water trading, this table relates to the "non-trading pathway". For more detail on the "trading pathway", see our *Draft WRMP19 Technical Report - Options appraisal*.

7. Demand uplifts and dry year demand forecast

7.1 Dry year uplift and weather patterns

The sufficiency of our supply-demand balance is most critical in prolonged “hot” and “dry” periods. In such conditions availability in our water sources is reduced and higher consumption occurs, due mainly to the much increased watering of gardens. The Environment Agency requires water companies to report on dry year demand⁶⁹, generally explained as a period of low rainfall and “unconstrained” or “unrestricted” demand.

7.1.1 Weather in a dry year

The severity of “hot”, “dry” weather such as that which occurred in the summer of 1995 occurs relatively infrequently. For example, the summers of 1976 and 1984 were similarly hot and dry, as demonstrated by Table 27.

Table 27 Comparison of weather data recorded at Manchester Airport for hot, dry summers⁷⁰

Parameter (covering May to August)	1976	1984	1995	2003
Total Rainfall (mm)	158.8	116.4	130.5	239.2
Average temperature (°C)	20.7	19.5	20.8	20.1
Days with temperature above 22°C	50	44	49	38
Days with temperature above 25°C	29	12	31	14
Maximum temperature (°C)	32.2	29.4	31.7	32

It was the dry autumn and winter of 1995/96 following the hot, dry summer that made the 1995/96 drought more prolonged than previous drought events. This can be seen in the daily maximum temperatures recorded at Manchester Airport in 1995, as shown in Figure 36. The summer of 2003 was significantly hotter and drier than average in North West England, with particularly high temperatures experienced in early August. This resulted in elevated demand for water as confirmed by our household water consumption monitors.

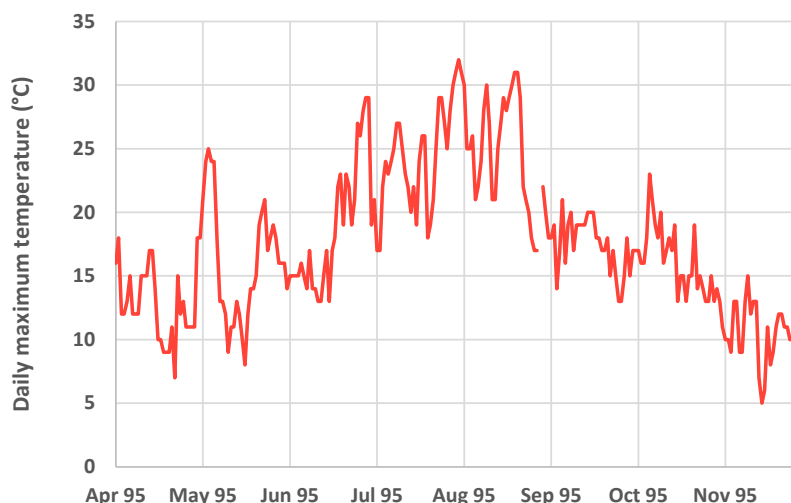


Figure 36 Daily maximum temperatures at Manchester Airport April to December 1995

7.1.2 Modelling the impact of weather on demand for water

At WRMP15, we worked with the Met Office on an innovative way of understanding the impact of weather on demand for water. This involved the use of their Demand-WIM (Weather Intelligence Model), which can determine relationships between demand for water and weather parameters⁷¹. The demand for water, attributed to these

⁶⁹ Full term is “dry year annual average”

⁷⁰ All data have been provided by the Met Office

⁷¹ Sometimes termed “weather variables” or “weather observations”, this refers to the record of, for example, the maximum temperature each day

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weather parameters is termed “weather dependent usage”. The Demand-WIM was calibrated to weather parameters, such as air temperature and rainfall, using around 10 years of data on demand for water.

Another key finding from this work was that, although some elements of non-household consumption are likely to increase during dry weather (e.g. due to watering of golf courses, sports pitches, gardens of non-household premises etc.), the analysis concluded that no significant weather signal could be identified in non-household consumption. Therefore, any increase in weather dependent usage is attributed solely to household consumption and this component is uplifted as such.

For WRMP19, we have worked with the Met Office again and the Demand-WIM has been revisited, including an assessment of spatial variability, a full data update and a recalibration of the model. On testing there were six weather parameters that clearly showed a relationship to demand for water and these were:

- Maximum daily temperature;
- Minimum daily temperature;
- Percentage of resource zone, across which rainfall occurred (key to understanding spatial variability);
- Three day average temperature;
- Three day average rainfall; and
- Soil moisture deficit.

Figure 37 clearly shows how the relationship between maximum daily temperature and demand for water is used to model a much increased weather dependent usage on “hotter” days.

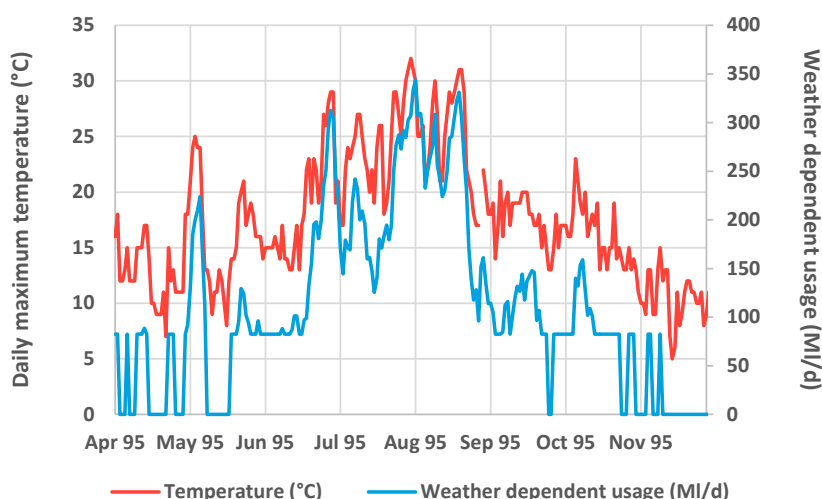


Figure 37 Daily maximum temperatures at Manchester Airport April to December 1995, with modelled weather dependent usage from April to December 1995

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7.1.3 Our design dry year

At WRMP15, we used the weather dependent usage seen in the summer of 1995/96 (adjusted to remove the impact of the hosepipe ban⁷²) to define the dry year. An advice item in the Environment Agency Advice Report on our WRMP15 referred to our choice of dry year as risk-averse and said that, for WRMP19, we should review the approach of using a drought year as our dry year.

Our rationale at WRMP15 was that the baseline supply availability in the regional supply-demand balance for the WRMP is defined by a drought year, namely 1984. We also account for the benefits of a temporary use ban, previously “hosepipe ban”, when defining that supply availability. Therefore, it seemed appropriate to “align” supply availability and demand for water to account for drought years. Although, admittedly different specific years.

Following the advice item, along with WRMP19 pre-consultation feedback and further discussions with the Environment Agency, we gave further consideration to a percentile approach, utilising the output from the Demand-WIM. On discussion with the Met Office and with other water companies, we consider a percentile approach to be a justifiable, based on two major advantages:

1. Choosing a percentile from a statistical distribution allows us to align risk across our WRMP and is less dependent on the characteristics of a single year; and
2. The 95th percentile weather dependent usage falls between 1984 (the year that influences our baseline supply availability in the regional supply-demand balance) and 1989 (a dry year in which we were able to maintain supplies without a hosepipe ban⁷² because of our integrated water supply network).

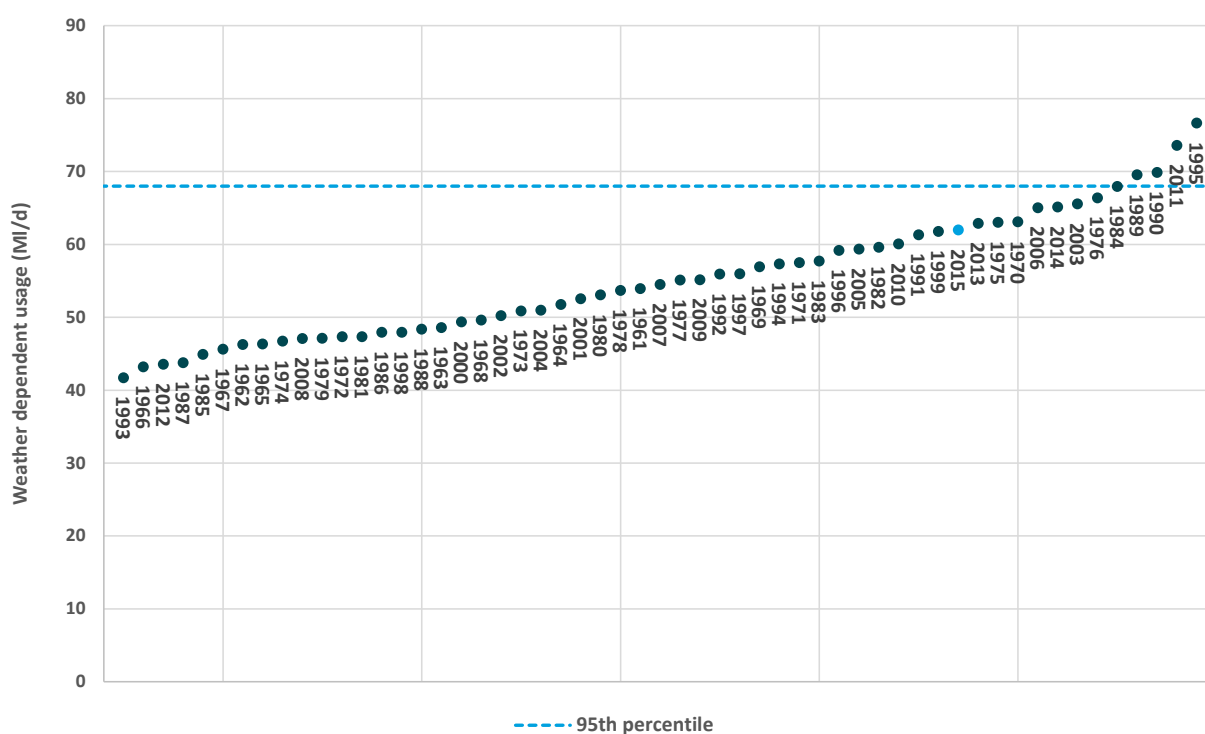


Figure 38 Modelled weather dependent usage for each year⁷³ with a full set of available weather data

Using the 95th percentile weather dependent usage, leads to a 1% uplift⁷⁴ on the household consumption forecast from the base year (“2015” on Figure 38).

⁷² Now referred to as a “temporary use ban”

⁷³ On this chart, for example, 2015 refers to the financial year 2015/16, as the key period for weather dependent usage is the summer months

⁷⁴ With a modelled uncertainty of $\pm 3\%$

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7.2 Climate change demand uplifts

As the principal source of climate change demand uplift information, we have included the findings from the Impact of Climate Change on Water Demand UKWIR project⁷⁵ to determine the climate change uplift to apply to household consumption. The 50th percentile annual average estimated impacts, for the North West England river basin, from the Severn Trent Water relationship⁷⁶ have been included in our baseline “dry year” demand forecasts (50th percentile minimum deployable output estimated impacts have been included in our “critical period” forecasts for the Carlisle Resource Zone).

The uncertainty in the potential climate change impact on demand for water has been included as part of the assessment of target headroom (see Section 10).

7.3 “Critical period” and “peak” type uplifts

We use the term “critical period” to refer to the two to three month period where the key source(s)⁷⁷ in our more “flashy” resource zones⁷⁸ goes from full to emergency storage levels. This period is used to define a two to three month “peak” type demand, which could potentially coincide with the “critical” time for the water resources systems. For the Carlisle Resource Zone, the “critical period” relates to the drawdown of Castle Carrock Reservoir through 1976, a “critical” event for this water resources system. Using water resources models, we have calculated the critical period of this event to be 95 days (or around 13 weeks).

Using this critical period, we have derived a factor to uplift demand by comparing the average demand over the critical period with the average annual demand for water each year. Figure 39 shows this factor for demands back to 2000/01. This critical period is applied to dry year household and non-household consumption and, with leakage and minor components, this constitutes the critical period demand for water.

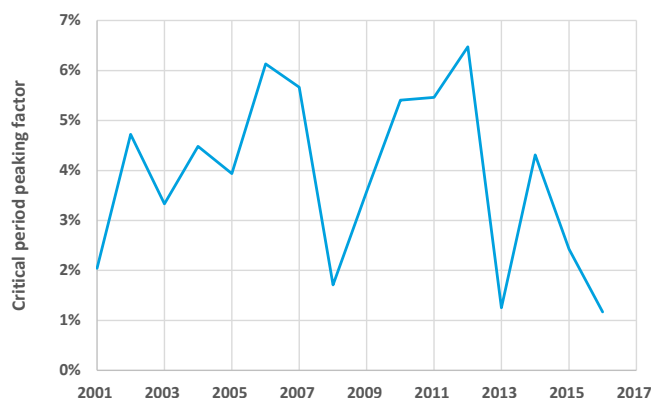


Figure 39 Carlisle Resource Zone “critical period” peaking factor for 2000/01 to 2015/16

Although they are not key for WRMP long-term supply-demand needs, peak type demands (e.g. “peak day”, “peak week”, “peak month”) are used in our asset planning, to ensure there is sufficient production (e.g. water treatment works etc.) and service reservoir capacity to meet demand peaks at local (or “sub-zonal”) level. This is a key part of our wider water supply resilience assessment and is covered further in our *Draft WRMP19 Technical Report - Water supply resilience*.

⁷⁵ Impact of Climate Change on Water Demand (UKWIR, 2013)

⁷⁶ The Impact of Climate Change on Water Demand UKWIR project provides a choice between the Thames Water model relationship and Severn Trent Water model relationship. At WRMP15, we chose the Severn Trent Water model relationship due to the close spatial location of our region to the Severn Trent Water region.

⁷⁷ Generally, the source(s) that defines deployable output and, therefore, supply capability

⁷⁸ Flashy refers to water sources that recede and recover in a short period of time and, at WRMP15, this would have referred to both the Carlisle Resource Zone and the West Cumbria Resource Zone

8. Overall baseline and final planning dry year demand forecast

Table 28 shows the baseline dry year demand forecast for all resource zones, broken down to show the different components of demand for water and how they are forecast to move over time.

Table 28 Baseline dry year demand forecast for all resource zones (in Megalitres per day)

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Measured household consumption	268	337	400	454	505	552	586
Unmeasured household consumption	598	523	459	402	352	308	277
Measured non-household consumption	352	338	332	325	319	315	313
Unmeasured non-household consumption	9	9	9	8	8	8	8
Total leakage	444	440	440	440	440	440	440
Minor components	27	27	27	27	27	27	27
Total demand for water in a "dry year"	1,697	1,673	1,667	1,656	1,651	1,650	1,651
Carlisle Resource Zone							
Measured household consumption	3.7	4.8	5.8	6.7	7.3	7.9	8.2
Unmeasured household consumption	10.6	9.8	9.3	8.7	8.2	7.7	7.3
Measured non-household consumption	6.9	6.5	6.2	6.0	5.8	5.6	5.5
Unmeasured non-household consumption	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total leakage	5.9	5.6	5.6	5.6	5.6	5.6	5.6
Minor components	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total demand for water in a "dry year"	27.7	27.3	27.5	27.6	27.5	27.4	27.3
Total demand for water in a "critical period"	29.1	28.7	28.9	29.1	29.0	28.9	28.8
North Eden Resource Zone							
Measured household consumption	0.5	0.6	0.7	0.8	0.8	0.9	0.9
Unmeasured household consumption	1.2	1.1	1.1	1.0	1.0	1.0	0.9
Measured non-household consumption	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Unmeasured non-household consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total leakage	2.6	2.8	2.8	2.8	2.8	2.8	2.8
Minor components	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total demand for water in a "dry year"	5.8	6.0	6.0	6.0	6.0	6.0	6.0
Region							
Measured household consumption	272	342	407	462	513	561	595
Unmeasured household consumption	610	534	470	412	361	317	286
Measured non-household consumption	360	346	339	332	326	322	319
Unmeasured non-household consumption	9	9	9	9	8	8	8
Total leakage	452	448	448	448	448	448	448
Minor components	27	27	27	27	27	27	27
Total demand for water in a "dry year"	1,731	1,707	1,701	1,690	1,684	1,683	1,684

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Table 29 shows the final planning dry year demand forecast for all resource zones, broken down to show the different components of demand for water and how they are forecast to move over time.

Table 29 Final planning⁷⁹ dry year demand forecast for all resource zones (in Megalitres per day)

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Measured household consumption	268	337	400	454	505	552	586
Unmeasured household consumption	598	523	459	402	352	308	277
Measured non-household consumption	352	338	332	325	319	315	313
Unmeasured non-household consumption	9	9	9	8	8	8	8
Total leakage	444	440	406	388	378	368	360
Minor components	27	27	27	27	27	27	27
Total demand for water in a "dry year"	1,697	1,673	1,633	1,604	1,589	1,578	1,571
Carlisle Resource Zone							
Measured household consumption	3.7	4.8	5.8	6.7	7.3	7.9	8.2
Unmeasured household consumption	10.6	9.8	9.3	8.7	8.2	7.7	7.3
Measured non-household consumption	6.9	6.5	6.2	6.0	5.8	5.6	5.5
Unmeasured non-household consumption	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total leakage	5.9	5.6	5.6	5.6	5.6	5.6	5.6
Minor components	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total demand for water in a "dry year"	27.7	27.3	27.5	27.6	27.5	27.4	27.3
Total demand for water in a "critical period"	29.1	28.7	28.9	29.1	29.0	28.9	28.8
North Eden Resource Zone							
Measured household consumption	0.5	0.6	0.7	0.8	0.8	0.9	0.9
Unmeasured household consumption	1.2	1.1	1.1	1.0	1.0	1.0	0.9
Measured non-household consumption	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Unmeasured non-household consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total leakage	2.6	2.8	2.8	2.8	2.8	2.8	2.8
Minor components	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total demand for water in a "dry year"	5.8	6.0	6.0	6.0	6.0	6.0	6.0
Region							
Measured household consumption	272	342	407	462	513	561	595
Unmeasured household consumption	610	534	470	412	361	317	286
Measured non-household consumption	360	346	339	332	326	322	319
Unmeasured non-household consumption	9	9	9	9	8	8	8
Total leakage	452	448	414	396	386	376	368
Minor components	27	27	27	27	27	27	27
Total demand for water in a "dry year"	1,731	1,707	1,667	1,638	1,622	1,611	1,604

⁷⁹ In the context of national water trading, this table relates to the "non-trading pathway". For more detail on the "trading pathway", see our *Draft WRMP19 Technical Report - Options appraisal*.

9. Non-potable demand

Although, in the WRMP process, non-potable water supplied is taken away from available supply, this section discusses non-potable supply from the customer perspective and, therefore, refers to it as “non-potable demand”. It’s also worth noting that raw water and potable imports and exports are covered in the *Draft WRMP19 Technical Report - Supply forecasting*.

As all our non-potable demand is from non-household customers, we worked with Experian to forecast non-potable demand using a similar economic output based approach as we’ve used for non-household consumption. We reviewed historic data, which indicated that the non-potable demand is mainly in three major sectors:

- ‘Paper (manufacture)’;
- ‘Fuel refining and Chemicals’; and
- ‘Rubbers, plastics and man-made materials (manufacture)’.

According to Experian forecasts, the output of all these three sectors are forecast to increase over the planning period and, therefore, the non-potable demand is forecast to increase accordingly.

9.1 Strategic Resource Zone

Following the approach outlined above, Figure 40 shows our forecasted non-potable demand for the circa. 50 non-household customers in our Strategic Resource Zone.

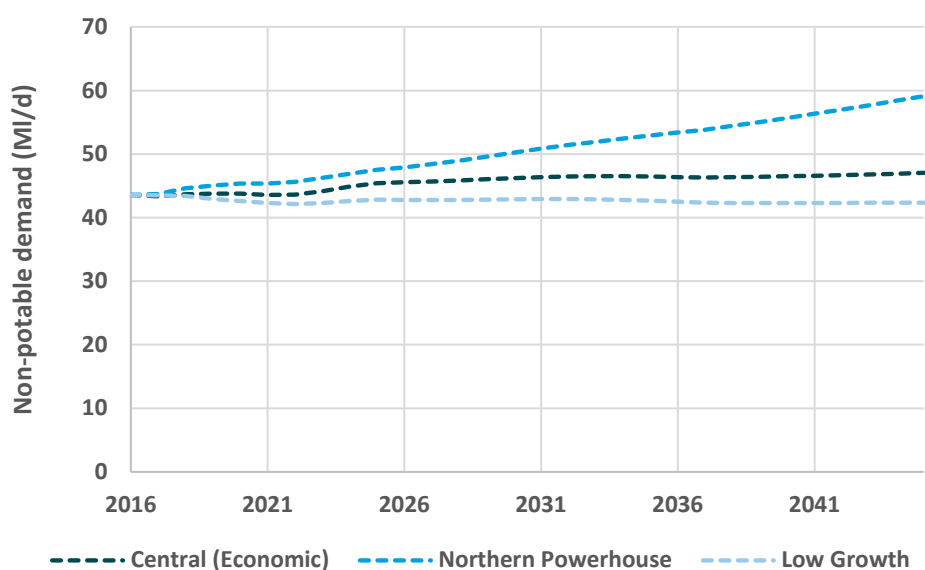


Figure 40 Forecast Strategic Resource Zone non-potable demand

9.2 Barepot Resource Zone

The results from the economic output based approaches for the generally indicate non-potable demand to be increasing in the Barepot Resource Zone. This is because the output of the industry sectors (or categories) that the customers in the Barepot area operate within are all forecast to increase over the forecast period and, therefore, the non-potable demand is forecast to increase accordingly. However, this assessment does not account for the future water needs of an individual customer and is best applied to a larger sample of customers, as in the Strategic Resource Zone. For this reason, the demand profile for the Barepot Resource Zone has been based on the supply agreement with the industrial customers. A flat demand of 26.9 MI/d has been applied over the planning period.

10. Allowing for uncertainty (target headroom and scenarios)

No forecasts can be totally accurate and include inherent uncertainty. For example, non-household consumption forecasts are dependent upon economic growth that is subject to significant uncertainty over the planning horizon. In part, this is why WRMP are reviewed every 5 years, supported by an annual review process. However, it is also important and appropriate to reflect this uncertainty either in target headroom (informed by sensitivity tests, where appropriate), and/or through the scenarios or plan testing framework. Figure 41 shows the overall range of uncertainty in our WRMP19 demand forecast.

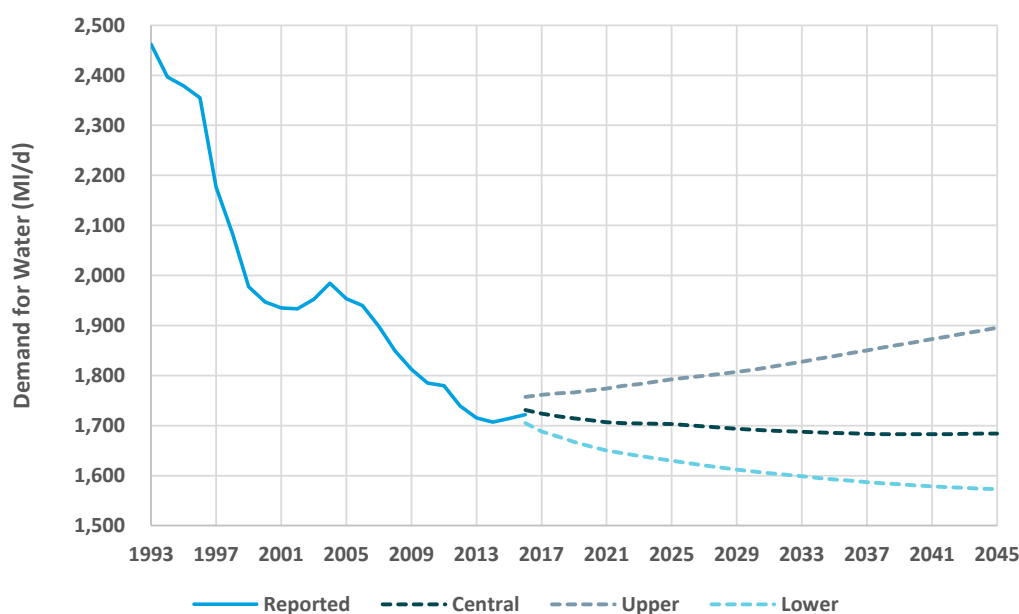


Figure 41 Reported regional demand for water, with the central forecast of dry year demand for water, as well as the upper (accounting for the “Northern Powerhouse” scenario, discussed in Section 3.5.1) and lower forecast of dry year demand for water⁸⁰

Table 30 documents the key demand influences or components, including the related uncertainties, as well as how they have informed the scenarios and target headroom.

⁸⁰ The different starting point for each forecast relates to the inherent uncertainty in the starting point, for example, the uncertainty in the dry year uplift that has been applied to demand for water

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Table 30 Key demand influences/components, related uncertainties and scenarios

Demand influence/component	Our approach at WRMP15	Our approach at WRMP19	Target headroom uncertainty or scenario
Base year data	In the Integrated Resource Zone, an allowance of up to $\pm 1\%$ of normal year demand (central forecast) was made to cover meter inaccuracies that may impact upon demand base data. For the smaller Carlisle, North Eden and West Cumbria Resource Zones, an allowance of up to $\pm 2\%$ was made.	In all resource zones, an allowance of up to $\pm 1.02\%$ (as documented in <i>Draft WRMP19 Technical Report - Target headroom</i>) of base year demand has been made to cover meter inaccuracies that may have impacted upon base year demand data. This is consistent with our Regulatory Reporting process.	D1
Population, property and occupancy forecast (impacts household consumption)	25% uplift and reduction on the population and property annual growth forecasts.	Upper forecast: Unmeasured occupancy increases, associated with the Free Meter Option (recommended from the Artesia Consulting review documented in Section 2.6) Lower forecast: Use of the “trend-based” population and property forecast (as documented in Section 2.1)	D2 and “Upper” (accounting for the “Northern Powerhouse”) and “Lower” demand scenarios
Household consumption	N/A	Upper forecast: Lower household consumption reduction, associated with the Free Meter Option and micro-component rates of change uncertainty (recommended from the Artesia Consulting review documented in Section 2.6)	D2 and “Upper” (accounting for the “Northern Powerhouse”) and “Lower” demand scenarios
Non-household consumption	The non-household low and high price forecasts were applied as these generated the highest and lowest level of demand from non-household customers.	Upper forecast: “Northern Powerhouse” high economic growth scenario (as documented in Section 3.5.1) Lower forecast: “Low Growth” economic scenario (as documented in Section 3.5.1)	D2 and “Upper” (accounting for the “Northern Powerhouse”) and “Lower” demand scenarios
USPL	N/A	N/A	N/A
Minor components	N/A	Upper forecast: 5 year maximum annual average value (as documented in Section 5) Lower forecast: 5 year minimum annual average value (as documented in Section 5)	D2 and “Upper” (accounting for the “Northern Powerhouse”) and “Lower” demand scenarios
“Dry year” uplift	Upper and lower bound “dry year” uplift factor applied to household demand	Upper bound dry year uplift factor (+3% from the central) and lower bound dry year uplift factor (-3% from the central) dry year uplift factor, provided by the Met Office and applied to household consumption.	D2 and “Upper” (accounting for the “Northern Powerhouse”) and “Lower” demand scenarios
“Critical period” uplift	N/A	N/A	N/A
Climate change uplift	The uncertainty in potential impacts on water demand, as represented by the lower and upper impacts derived from the Impact of Climate Change on Water Demand UKWIR project, was included	Upper forecast: 90 th percentile impact from the Impact of Climate Change on Water Demand UKWIR project ⁸¹ , was included Lower forecast: 10 th percentile impact from the Impact of Climate Change on Water Demand UKWIR project ⁸¹ , was included	D3 and “Upper” (accounting for the “Northern Powerhouse”) and “Lower” demand scenarios

More detail on our assessment of target headroom can be found in *Draft WRMP19 Technical Report - Target headroom*.

⁸¹ Impact of Climate Change on Water Demand (UKWIR, 2013)

11. Innovation projects

New technologies are continually being reviewed and implemented wherever there is scope to improve our efficiency. Innovation is inherent in what we do, and this can be seen through our evolving and improving demand forecasting approach each planning cycle. In this section we provide some key examples of other innovations related to demand and demand management that may inform our future plans and activities.

Connected homes and smart metering

We have been working with other organisations on options for establishing a water smart metering capability. To date, the focus has been on understanding the lessons learned from the energy sector as well as the advances already made by other water companies in this area. Through a series of trials we aim to unlock a number of benefits for customers, and maximise the value of smart metering for companies and customers that wish to pursue the technology. We also see merit in establishing a universal smart metering architecture for the industry.

Unlocking the value of new data flows enabled by smart meters could deliver substantial benefits, by for example putting customers in control of consumption and enabling more efficient solutions in areas such as water capacity and demand management.

Customer side leakage quantification trials

It has become apparent that technology is now in development in the marketplace to provide a battery-powered sensor, logging technology and an analytical method that enables flow past boundary boxes to be assessed in a non-intrusive way without a meter. We have identified five areas for investigation in order to understand the benefits of using this technology. This work has led to commissioning five pilot studies to:

- Show whether apparent DMA network leakage is actually consumption;
- Monitor flows on long services in rural areas/plastic pipes in others;
- Estimate the flow rate on suspected supply pipe leaks;
- Show flow patterns on a sample of industrial properties; and
- Monitor a sample of small area monitors to determine usage and leakage.

We have received some very useful insight into the characteristics of flows past customer stop taps and the variation in the behaviour between customers. Further work is required to develop and test a more cost effective way of carrying out surveys and speed up data processing.

Tackling customer side leakage club project

The prime objective of the project was to develop a methodology which can be applied routinely by water companies at an economic affordable cost to:

- Understand whether some of the flow into the DMA that we currently think is network leakage, is actually a combination of events beyond the customer stop tap i.e. genuine use, plumbing losses, and relatively small supply pipe leaks;
- Locate properties with continuous flow; and
- Understand the pattern of consumption in individual properties.

This project was carried in collaboration with five other water companies and was part funded by Innovate UK.

Save Water – in pipe assessment tool

The project is aimed to develop a technology to assess pipe condition in live mains.

This project is an example of how we collaborate with academia and other organisations to develop technology to answer some of our key challenges. Development of an in pipe assessment tool for use on "live" mains. The equipment will help determine mains in need of replacement prior to leaks breaking out. This will lead to a reduction in water losses and reduce interruptions to supply. Various techniques exist using cameras and ultrasonics to

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produce a "condition assessment", however the techniques do not produce the data equivalent to non-destructive testing (NDT) such as man entry into pipes or exposing pipes and testing from outside, both of which are time consuming and expensive.

This technology is still in development and the live trial is planned in the Cheshire area.

The SAVE Water project is a unique offering to the water industry not only in the UK but internationally. The technology derived from the project will be the first in-pipe assessment vehicle which will work in live conditions (no customer interruption) and deliver a full sensing package of optical and acoustic inspection while also carrying out a complete structural assessment of the pipe material and any associated linings, both factory and retrospectively applied. This technology builds on recent advances in live inspection equipment deployed in higher value industries such as oil and gas and is a much more affordable technology which will enable wide scale entry into the UK water sector. International exploitation is clearly identified and can be demonstrated by the consortium who have already entered international markets with other live in-pipe technologies.

This project is being carried out in collaboration with Liverpool John Moores University, Balfour Beatty and JD7.

Event Response planning (STREAM)

The project is aimed to understand whether we can improve on the length of time required to identify leaks in the network so that any disruption for our customers can be minimised or avoided completely. The work is carried out in collaboration with University of Exeter (WISE, Stream project).

The aim of this project is to develop an innovative and smart system to enhance operational efficiency and customer service. Building on from our in-house developed event recognition system (ERWAN) and using data from additional sources such as supervisory and control data acquisition (SCADA) systems and hydraulic simulation models, pressure and flow monitoring sensors and smart metering solutions (Automatic Meter Reading, AMR) to become more efficient at detecting changes in the network and locating where the event is so that it can be rectified before impacting the customer.

With increasing measurement points, the potential benefits of near real-time hydraulic models can be realised in which measured data is regularly streamed into a model to set and update simulation of boundary conditions. Pressure data has been found to be extremely useful in this case for model calibration and fault finding. Availability of a stream of continuously updating flow and pressure data enables calibration to current, rather than historic measurements, allowing a continuous and iterative process, and reflecting ever changing dynamics in the network caused, for example, by changes to valve positions, the timing of pump operations or the turnover rate of service reservoirs.

While various components of these areas of work have been proven at conceptual, and some even at prototype stage, the true potential and value will be realised when they are combined and delivered as part of an integrated, harmonious package. The fusion, integration and development of a systems approach will be at the heart of this research.

Event Management and Post Event Response Planning for Intelligent Water Networks

Collaboration with Sheffield University (Stream project)

Question this project is trying to answer: Can we develop a system that can plan the most effective and efficient response when an event happens in our water network?

The water industry in the UK and worldwide faces considerable challenges in making use of the real-time data that is collected in water distribution networks. The industry has a pressing need to use this data to improve response to various events in pipe networks (e.g. pipe bursts or equipment failures). We have developed, together with University of Exeter, the Event Recognition System (ERWAN), a novel technology that can detect and locate incidents

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and events in timely and reliable manner. What is currently lacking is the methodology for effective, optimised and automated response to these events.

The real-time event management and post event response planning technology developed in this project will provide an objective and scientifically sound methodology to increase efficiencies and demonstrate the benefits of optimised and automated event management ultimately enabling us to:

- Respond to customer issues quicker (contributing to an increase in customer satisfaction);
- Improve the ability of resources (planning responses to events better and optimal use of the resources available); and
- Reduce investment through quick and improved responses (contributing to a reduction in customer bills).

This technology also has the ability to be used across the UK and global water industry in the emerging smart water systems market.

The project will attempt to understand:

- What is the best way to respond to various events that may occur in a water distribution system? How can optimal operational interventions be identified and in a timely and automated way? What company data and resources (systems and people) need to be used in the process and how?;
- How should the identified response strategies be presented to the control room operator so that he/she can make an effective ultimate decision on how to deal with each event?; and
- What are the likely benefits and costs of new technology? How will the technology be effectively delivered in to the control room (people, processes and systems)?

Gas detection

CEO Challenge *“Improve our Customer Side Leakage (CSL) performance”*

The CEO Challenge were engaged to improve the current Customer Side Leakage. The team reviewed over 15 technologies that could be used to detect leaks. Subsequently, the team researched the capabilities of Gas Detection identifying success criteria to enable a trial which could comprehensively analyse the credentials of the product. The main benefits of the technology are increase in amount of leaks located, improved competency of UU employees and improved leak detection arsenal of UU employees.

Satellite imagery for leakage detection

We are currently trialling satellite technology that uses ground penetrating radar from Japanese satellite ALOS 2 to determine the spectral signature of chlorinated water just below the ground. The assumption is that this technology should help us to identify leaks quicker therefore significantly shorten current location times. The results of the trial should be available early in 2018.

Pressure management valves

As part of our continuing innovation we are now replacing the older generation of flow modulation units with the next generation. The new units give us added functionality that allows us to optimise remotely from an office based environment rather than having to travel to site, set up traffic management and lift lids to change the settings. There are also self-learning algorithms that utilise the recorded critical point data to allow for more accurate and calmer optimisation of the network. As well as this we are also installing closed loop control systems that maintain a set pressure at the critical point by sending live data back to the control unit on the pressure management valve and adjusting the outlet pressure accordingly. All this additional data that we are recording every 15 minutes is also utilised by our event recognition system to understand issues that may be occurring on our network before it impacts the customer. This data can then help them deploy a technician to site to rectify a potential issue without the customer ever being aware.

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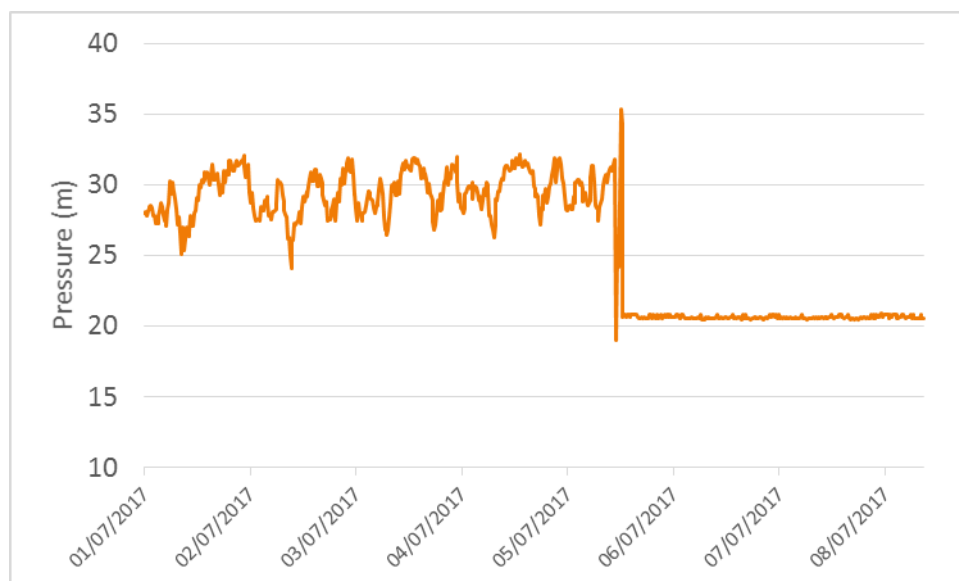


Figure 42 Pressure before and after optimisation

Network visualisation project

As part of our Intelligent Network management for Water (INMW) programme, we have developed a map based tool which takes data from a number of existing corporate systems to provide a single geographic view of network activities. The tool supports more informed customer calls, enables proactive network management both of which positively contribute towards our SIM and ODI targets. The project is currently being rolled out and we are in a process of developing an e-learning package to support the roll out. Figure shows feedback from users

I had an event in Stockport Friday. We were tankering into district, to make the Tankers last a bit longer we reduced the pumping pressure .

I used AquaVista to monitor the customer call for poor supply helping me determine what pressure I need to pump at or if to increase.

Worked great better than having to make multiple phone calls to events

Network Customer Inspector

It's a great system that brings so many systems together in one place for our inspectors on site and back in the office. It will help inspectors learn their districts and widen their understanding of flow in Water Networks. A great addition

Service Delivery Manager

Aquavista seems to be a system that could actually deliver everything it promises. It appears that the right people have been in place to develop and deliver it.

NCI / Service Delivery Manager

Figure 43 INMW Network visualisation

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Appendix A: Economic appraisal of leakage

Method

We have developed a model that finds the minimum cost of operating a network by optimising active leakage control (ALC), pressure management and mains rehabilitation using a direct optimisation formulation. The leakage level at this minimum cost is equal to the short run ELL and the marginal cost-benefit of the selected leakage reduction schemes is equal to the marginal cost of water. This method ensures that the benefits of each the interventions are not double counted.

Each Water Resource Zone (WRZ) is assessed separately and the results amalgamated to provide company level short run ELL and short run SELL.

The diagram below shows an overview of the process adopted for this assessment, which maps to the following description of activities / approach. The methodology, assumptions, data and calculations used in the model was subject to an external review and assurance.

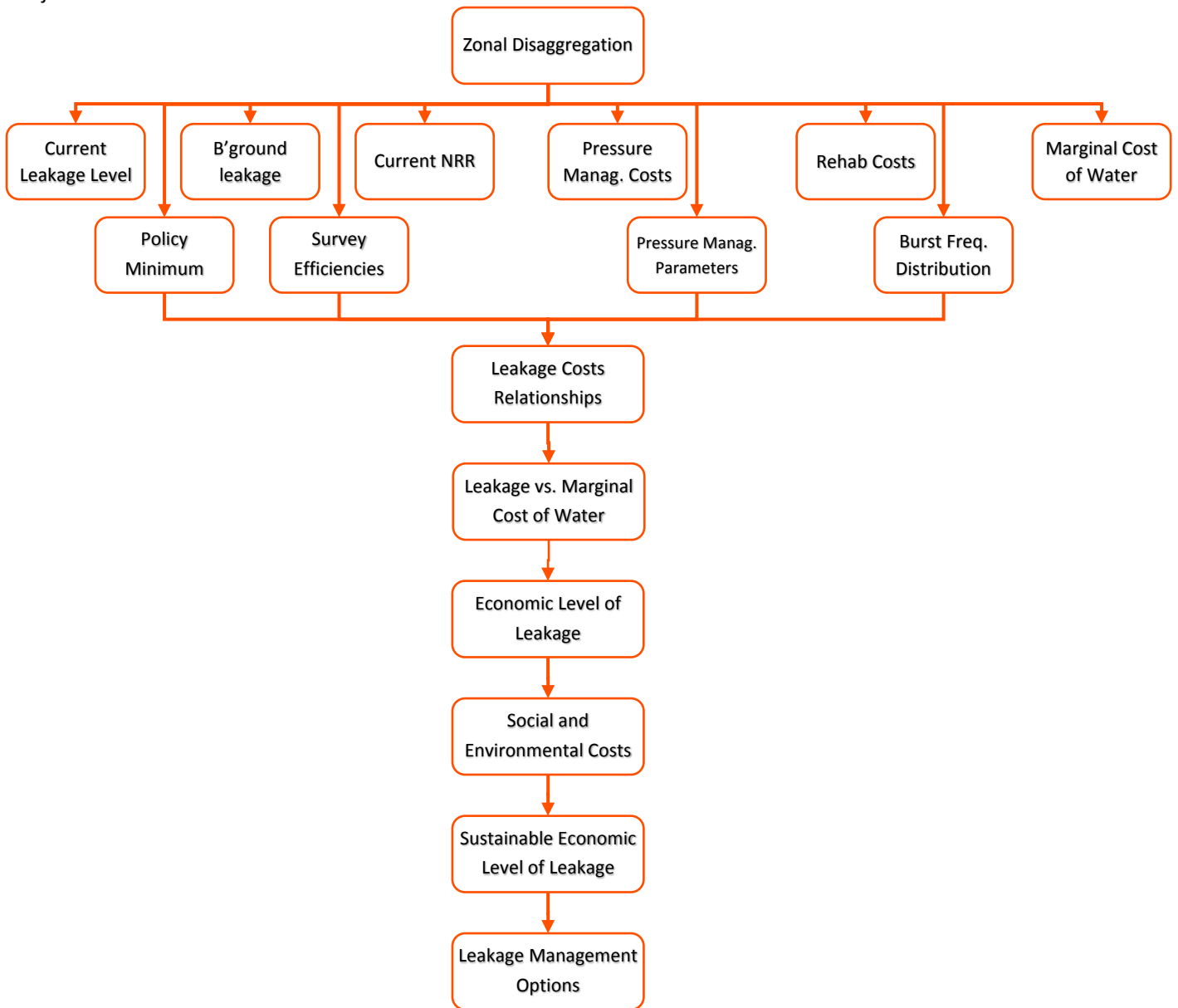


Figure 44 Process Overview

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Zonal disaggregation

We currently have four Water Resource Zones (WRZ's), of which the Integrated Resource Zone is the largest, covering approximately 95% of water supply in the area. The completion of the Thirlmere Transfer in 2022 will result in merging West Cumbria with the Integrated Zone. We are now calling this the Strategic Resource Zone to draw distinction with the previous zones. For more details please refer to Section 3 of our main WRMP document.

The UKWIR/Environment Agency definition of a WRZ (UKWIR/Environment Agency Definitions of Key Terms for Water Resources Practitioners) is as follows:

“The largest possible zone in which all resources, including external transfers, can be shared and, hence, the zone in which all customers will experience the same risk of supply failure from a resource shortfall”

Water saved by leakage control in one zone cannot be used to supply customers in a different resource zone. Therefore we address the supply-demand balance and the ELL separately in each WRZ as it is the most appropriate level and is consistent with regulatory reporting requirements

Current leakage levels

DMA leakage

We have over 2800 DMAs covering 99% of properties. Each DMA has monitored net flows. We use Netbase leakage management software to monitor and manage leakage levels in DMAs. Therefore, Netbase was used as a primary source of information on DMA leakage and characteristics for this study. Netbase follows methods outlined in Managing Leakage⁸² to calculate leakage at DMA level.

The minimum night flow (MNF) is calculated as a fixed one hour average flow between 03:00 and 04:00 using the DMAs net flow (calculated as the difference between the flows at the inlet and outlet meters, using 15-minutes raw data). If there is a logged user within the DMA, then its data is subtracted from the net flow before the MNF is derived. From this net MNF value the night use allowances for household and non-household properties are then deducted to provide a night leakage value for the DMA. To arrive at the daily leakage value a DMA specific hour to day factor is applied (hour to day factors are routinely reviewed by our leakage analysts). Where data was missing or a DMA was not operable the leakage values are estimated based either on the DMA's previous operable data or the zonal average figures.

We carry out a full water balance reconciliation each financial year for Regulatory Reporting purposes. For this assessment, current position (i.e. leakage level and operating costs) was derived using last 3 to 5 years of data.

Trunk main and service reservoir losses

Following recommendations in the SMC report⁸³, we have used tile analysis to estimate the level of trunk mains and service reservoir losses. We have made significant investments in our upstream infrastructure and production planning processes and through this achieved substantial reductions in our upstream leakage over the past few years. Our current levels of upstream losses are lower than estimates derived using burst and background estimation method used in the last assessment.

The tile balance approach consists of using actual meter data to calculate DMZ and Aqueduct losses. One of the big advantages of this method is that it allows UU to actively target areas where real losses occur. The burst and background estimation (BABE) method just gives the company one figure and doesn't give any indication of where the losses actually occur.

⁸² (UKWIR, 2011)

⁸³ (SMC for EA, Ofwat, Defra, 2012)

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Policy minimum

The 'current policy minimum' is defined in the Tripartite Report⁸⁴ as the lowest level of leakage which can be achieved through intensive active leakage control using conventional active leakage control methods, 'current' technology and 'reasonable' effort. Policy minimum is one of the most critical aspects in establishing the economic level of leakage.

Policy minimum is calculated as background leakage plus leakage from customer reported burst plus leakage from detected bursts as they await repair plus trunk main and service reservoir losses. There is also a variable amount of unreported (detected) leakage that can be identified through additional effort in active leak detection.

It is not possible to operate at the policy minimum leakage as it would require leakage in all DMAs to be held constantly at the lowest level ever achieved. The policy minimum represents a theoretical minimum level of leakage that could only be achieved under the current policy if infinite resources were deployed on active leakage control.

All components of policy minimum leakage levels, except for trunk main and service reservoir losses, were assessed in 2016 using the analysis period April 2011 to March 2015. The methodology for assessing policy minimum has not changed since the previous ELL assessment.

Background leakage

Background leakage is the collective sum of numerous minor leaks and seepages from valves, joints, hydrants, stop-taps, meters and other fittings. These leaks rarely exceed 100 l/hr and are not normally individually identifiable from DMA night flow measurements.

Background leakage was derived from actual minimum historic night flows, i.e. the lowest net night flow achieved between January 2015 and December 2015 for each DMA. A statistical routine was used to eliminate erroneous data and manual checks were carried out on the results to ensure correctness. This approach is consistent with Tripartite⁸⁵ guidance. Background losses at resource zone level are calculated as the sum of the values from individual DMAs.

Table 31 Background leakage

Resource Zone		Strategic	Carlisle	North Eden	Region
Background leakage PR19	MI/d	207.5	3.0	1.4	211.9
	l/prop/d	64.8	54.6	203.0	64.9
Background leakage PR14	MI/d	202.9	2.8	1.2	206.9
	l/prop/d	63.3	51.8	181.1	63.4

Background leakage has risen very slightly from 63.3 l/prop/day to 64.8 l/prop/day since the PR14 review. The level of background leakage is expected to rise over time with a strategy of maintaining serviceability across the distribution network, as new development increases the length of network overall, and new pipes are not free of background leakage, with joints being a particular problem.

⁸⁴ (Water Research Centre for Ofwat, EA and Defra, 2002)

⁸⁵ (WRc, 2002)

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Natural rate of rise (NRR)

The natural rate of rise of leakage is the rate at which leakage would rise if no proactive leakage detection was carried out. Proactive leakage detection has to be carried out in order to hold leakage at a defined level. The natural rate of rise of leakage the predominant driver in assessing the cost of proactive leakage detection. The assessment of the natural rate of rise of leakage is therefore critical.

The NRR was derived separately for each DMA by analysing the rise of the minimum night flow values between periods of leakage detection using the same date range as for the analysis of background leakage. This methodology follows best practise defined in the UKWIR report on Natural Rate of Rise in Leakage⁸⁶. DMA specific NRR values and estimates of background leakage were then used to derive a set of best estimates of the company specific unreported and reported burst flow rates.

Table 32 Natural rate of rise of leakage

Resource Zone		Strategic	Carlisle	North Eden	Region
NRR PR19	MI/d/yr	204.9	2.5	2.0	209.4
	l/prop/d/yr	64.0	45.1	296.6	64.2
NRR PR14	MI/d/yr	167.4	4.2	1.6	173.2
	l/prop/d/yr	52.3	77.6	228.1	53.7

Table 33 Average leak flow rates

Resource Zone		Strategic	Carlisle	North Eden	Region
NRR PR19	l/hr	1,115	1,092	2,063	1,113
NRR PR14	l/hr	961	1,300	994	958

Trunk main and service reservoir losses (upstream losses)

Trunk main losses and service reservoir losses have been provided by our Upstream Losses Co-ordinator and are based on FY16 reported figures.

Figure 45 Upstream losses

Resource Zone		Strategic	Carlisle	North Eden	Region
Upstream losses PR19	MI/d	81.1 ⁸⁷	0.8	0.3	80.1

⁸⁶ (UKWIR, 2005)

⁸⁷ Includes aqueduct losses

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Components of policy minimum

Figure 46 shows each component of leakage expressed as a percentage of the total leakage. It can be seen from the chart that the percentage of unreported leakage is the highest in the Strategic Zone at 38%. Strategic and Carlisle zones have similar levels of background leakage, at around 57%, while background leakage in North Eden is slightly higher at 63%. Level of reported leakage is the highest in North Eden at just over 5% and around 3% in the remaining two resource zones.

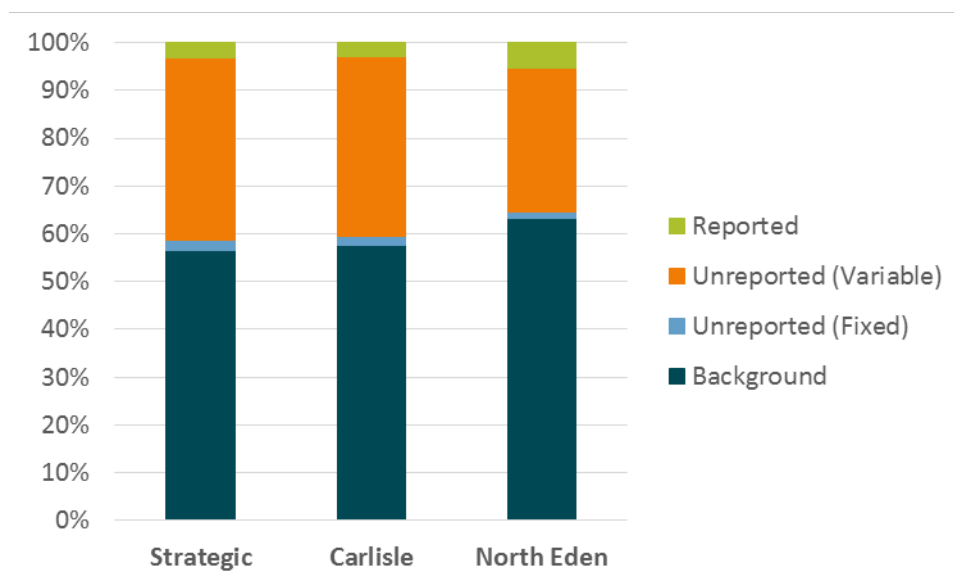


Figure 46 Components of total leakage

Regionally the policy minimum leakage is 232 MI/d, which is equivalent to 71 l/prop/d⁸⁸.

Table 34 Policy minimum

Resource Zone		Strategic	Carlisle	North Eden	Region
Policy Minimum PR19	MI/d	226.9	3.2	1.5	231.6
	l/prop/d	70.8	59.0	224.4	70.9
Policy Minimum PR14	MI/d	234.0	3.3	1.7	239.0
	l/prop/d	73.0 ⁸⁹	60.7	252.6	74.0

Survey efficiencies and leakage detection costs

We have a mixture of internal leakage detection resources and external contractors, the split is approximately 23%:77%. The leakage detection rates were derived using data provided by RPS, Amey and an internal performance team. In the model a weighted average of the three derived survey rates is used.

Using provided information a set of assumptions was made to group individual survey records into detection campaigns. A relationship between the duration of a campaign and recent DMA characteristics i.e. mains length and property counts was established and calibrated against the actual data in order to find the best set of coefficients that were then used by the ELL model to estimate intervention times.

⁸⁸ Does not include upstream losses

⁸⁹ Calculated as a weighted average using PR14 data for Integrated Zone and West Cumbria Zone

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This analysis was carried out assuming that on average 35% of DMA is surveyed each time. This is to reflect our leak detection strategy which is to leave the area once bursts are identified and move to another area.

The leakage detection resource costs have been based on a rate per day. The costs have been based on the following elements:

- ALC framework cost (this accounts for on cost to cover national insurance, pension, overtime, van and equipment);
- Allowances for managerial costs (our internal Operations and Asset Management costs, including on-cost); and
- An assessment of productive days taking into account statutory holidays, annual leave, sickness, training and weekends.

Pressure management costs and parameters

We have a wide pressure management programme being delivered in AMP7. Data on all schemes, including the costs and the benefits, was collected from the Engineering team. The benefit from each identified scheme was translated into weighted pressure reduction in terms of property meters. Based on this data, a relationship between the number of schemes and equivalent reduction in pressure where derived for each Water Resource Zone. Calibration with the actual data was carried out in order to determine a set of coefficients to describe the relationship used by the model. Figure 47 below shows an example relationship between number of schemes and reduction in pressure expressed in property-meters.

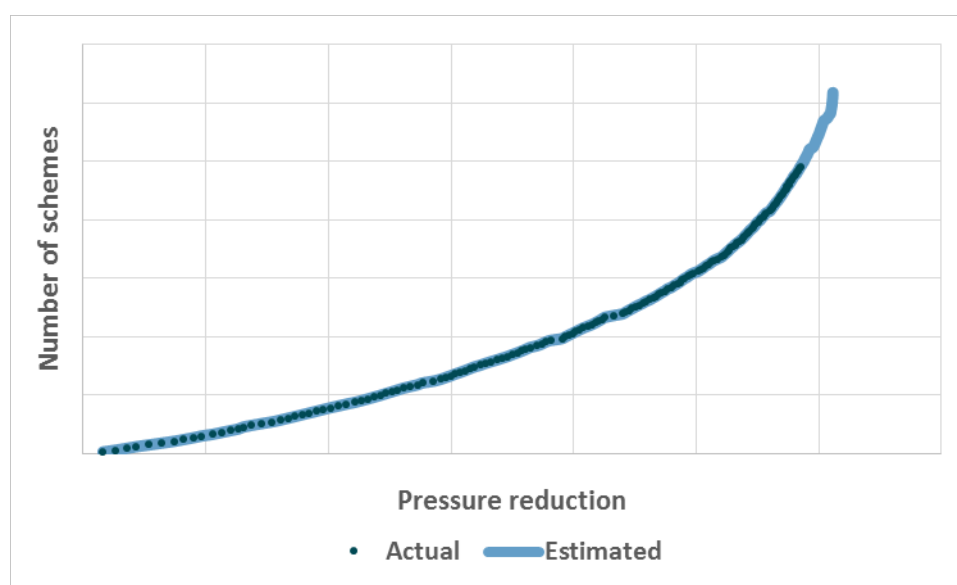


Figure 47 Pressure reduction relationship

Implementation of new and the optimisation of existing schemes have been modelled separately because of the significant difference in their cost and benefit relationship. An annualised costs for implementation of a new scheme and optimisation of an existing scheme were calculated using the unit costs (including: design/confirmation, construction, logger, installation/commissioning, mechanical costs), discount period and discount rate.

In order to include these relationships in the ELL model and assumption was made on the number of schemes that will be delivered in AMP6 to ensure the model does not overestimate the potential for pressure reduction available in AMP7.

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Mains rehabilitation costs and parameters

For mains rehabilitation for leakage reasons to have any chance of being cost effective it is essential that refurbishment is targeted at individual pipe lengths rather than total DMA rehabilitation. We have therefore created cohorts of pipes within our Discrete Pressure Areas (DPAs) based on material type. Bursts have been associated with these cohorts and the cohorts have been sorted in descending order of burst frequency. This data was used to develop a relationship between burst frequency and length of pipe cohort on the assumption that rehabilitation of a particular cohort would reduce the overall system burst frequency by the average number of bursts assessed for that cohort accounting for residual burst frequency in newly laid mains. Figure 48 below shows an example relationship between length of rehab and burst frequency. As visible on the graph, there is a tipping point at which burst frequency actually starts to increase with increasing length of rehab. This is due to accounting for residual burst frequency in newly laid mains in the analysis.

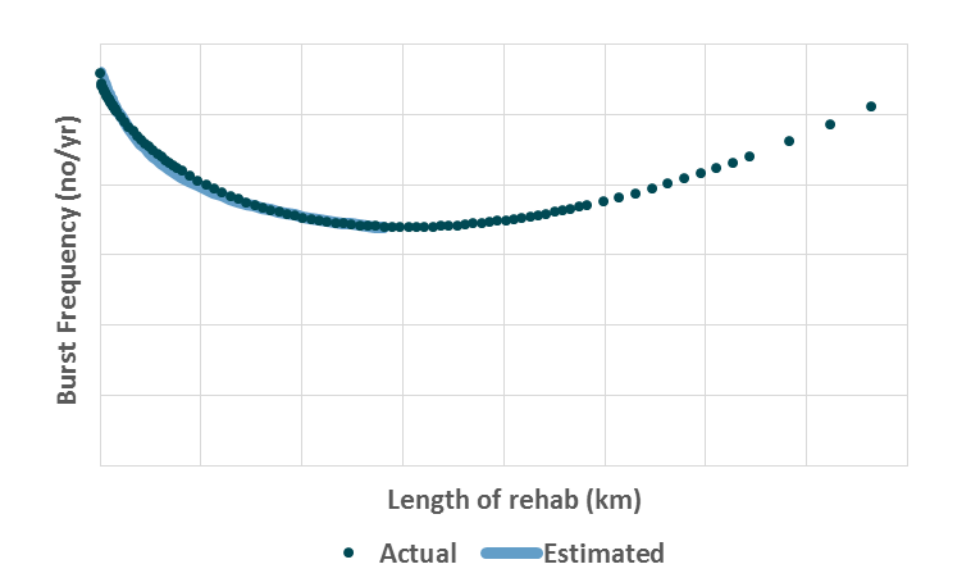


Figure 48 Mains rehabilitation relationship

Burst frequency distribution

The burst frequency distribution analysis was undertaken as part of the NRR analysis. A cut of all burst repair jobs that occurred between 2012 and 2015 was loaded into Netbase and assigned to DMAs using co-ordinates. This data provided, amongst other things, the type of repair job, whether it was reported or detected and the dates the leak was raised and repaired. Figure 49 shows the percentage distribution of each burst type. There is a similar proportion of mains bursts in Strategic and North Eden zones, at around 35%. Carlisle is slightly lower at around 30%. Proportion of supply pipe bursts is the lowest in North Eden at 17%, and at around 25% in the other two zones. Carlisle and North Eden have similar proportion of communication pipe bursts at around 50%. Proportion of communication pipe bursts is approximately 10% lower in the Strategic zone.

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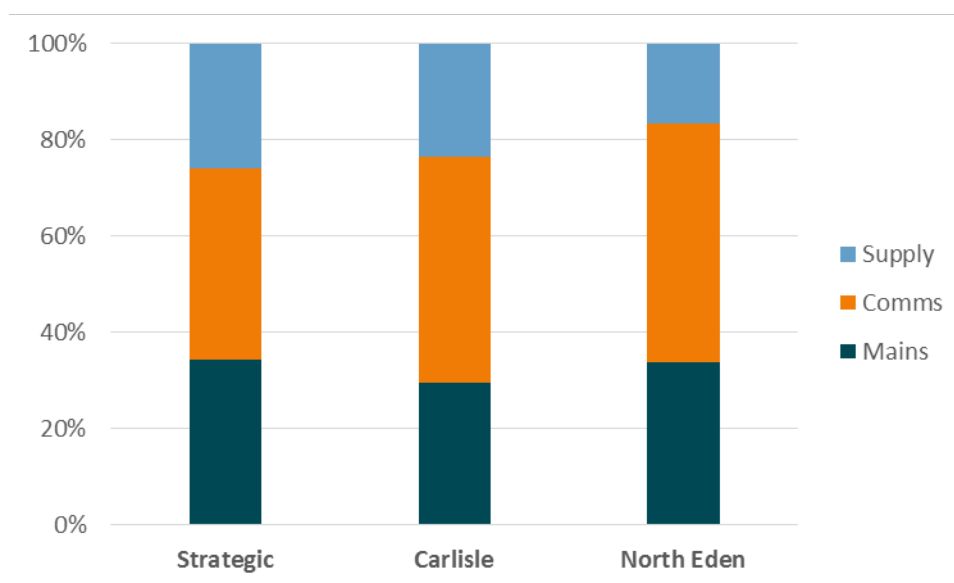


Figure 49 Burst frequency distribution

Marginal cost of water

The marginal cost of water (MCW) is used in the assessment of the ELL as this represents the cost that would be saved by reducing leakage, which essentially is the cost of water from the most expensive source. Volume related costs such as electricity, chemicals and sludge disposal are considered in assessing the marginal cost. Fixed costs such as resources, maintenance etc. are not included as they are not affected by the change in the leakage level.

Marginal costs of water have been provided by the Production Planning team, these included uplift for distribution pumping. The analysis was carried out for 3 years 2014-2016. Although there was no significant differences between analysed years, 2016 was selected as most accurate due to extensive improvements achieved through progress made in our production planning initiative. This is also the reason for the difference if compared to the MCW used in the PR14 ELL assessment.

Economic level of leakage

The Economic Level of Leakage (ELL) is the level of leakage above which any further leakage reduction activity would cost more than the value of water saved. The value of water saved is the marginal cost of water in the network (i.e. the marginal cost of water production) plus the marginal cost of distribution (i.e. pumping within the distribution network). In theory, water should be saved at the most expensive source first. It is also likely that network pumping will be localised and it will not be possible to make all the leakage savings within the pumped DMAs and so the marginal cost of distribution pumping is added at Water Resource Zone level.

Figure 50 shows the policy minimum derived from the analysis of the minimum historic levels of leakage that includes background leakage, trunk mains and service reservoir leakage, reported leakage and the fixed element of unreported leakage. The shape of active leakage control curve (detection cost), which asymptotes to the policy minimum, is a function of the natural rate of rise of leakage and the leakage detection survey rates and costs. Both, the level of the policy minimum and the shape of the detection cost curve are also impacted by the level of pressure management and mains rehabilitation selected by the model.

The Tripartite⁹⁰ report also requires that actual cost be adjusted to represent the steady state costs (i.e. costs of maintaining the current level of leakage in a year not impacted by external events e.g. severe weather, policy changes etc.). The average of FY14 and FY15 was used to calculate the current position.

⁹⁰ (WRc, 2002)

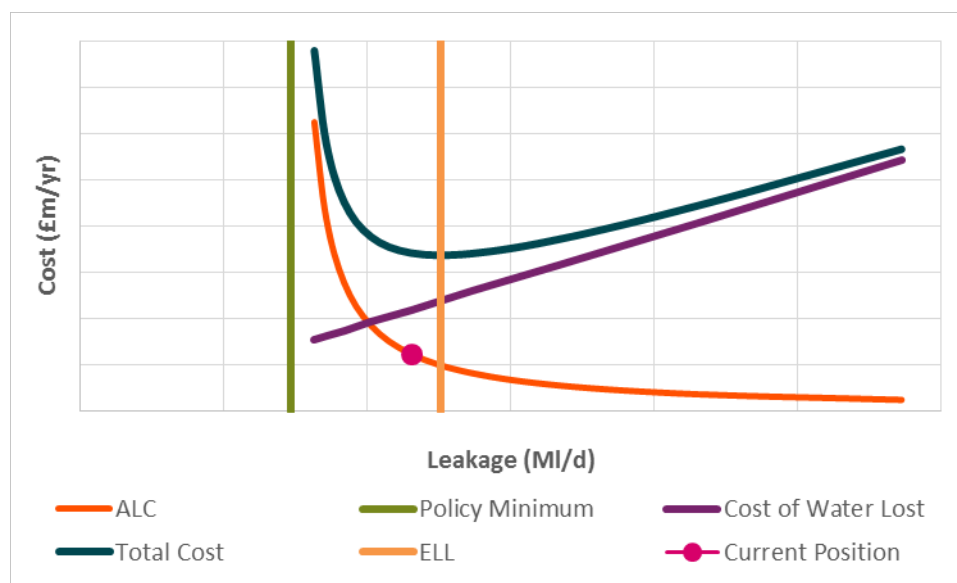


Figure 50 Illustration of the evaluation of ELL

The cost of water lost is shown on the graph as a straight line at the marginal cost of water described above. The upper curve is the total of the cost of leakage detection and the cost of water lost. The economic level of leakage is where this total cost is at minimum.

At this minimum the marginal cost of leakage control, pressure reduction and mains rehabilitation will be equal to the marginal cost of water.

Leakage repair costs are not included as the same number of leaks has to be repaired at any level of leakage and therefore the ELL is independent of the cost of repairs. However, additional transition costs are incurred in moving from one point on the curve to another. These can be estimated from the difference in leakage levels. A shift from one level of leakage to another will also incur and increase in the level of annual expenditure required to maintain that new, lower level of leakage (i.e. new steady state will be achieved).

The model was also used to develop leakage reduction packages for the three water resources zones as part of options identification. These are then considered alongside other supply-demand options as part of the options appraisal process, where appropriate.

Optimisation of ALC, pressure management and mains rehabilitation

The ELL model finds the minimum cost of operating a network by optimising active leakage control (ALC), pressure management and mains rehabilitation using a direct optimisation formulation. The leakage level at this minimum cost will be equal to the short-run ELL and the marginal cost-benefit of the selected leakage reduction schemes will be equal to the marginal cost of water. If the marginal cost of any of the leakage activities is higher than the marginal cost of water then this activity will not be considered economic and will not be selected by the model.

Sustainable economic level of leakage

The leakage cost relationship discussed above is based wholly on economics and determines short-run ELL for each water resource zone (i.e. ELL that refers to the current costs of leakage and current cost of water from existing supplies). The inclusion of social, environmental and carbon costs enables to assess short-run sustainable economic level of leakage.

Social, environmental and carbon impacts are examples of externalities that can impact cost-benefit of reducing leakage. The analysis of externalities was undertaken by AMEC Foster Wheeler in 2017 and was carried out in

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accordance with current best practice⁹¹. Full details of the assessment are contained in *Environmental and Social Costs of Draft Water Resources Management Plan 2019 Options: Final Report*.

Carbon content of water production was derived using Energy Consumption and Greenhouse Gas Accounting collated as part of annual data submission and used together with discounted cost of carbon to calculate the marginal carbon cost of water production.

The guidance divides externalities into two groups:

1. Leakage related externalities: these relate to the effects of changes in abstraction, treatment and distribution and are subdivided into environmental and carbon associated costs.
2. Leakage management externalities; these result directly from activities such as detection, repair and asset renewals and are subdivided into social and carbon associated costs.

Table 35 Costs of social and environmental externalities

Description	Cost
Marginal carbon cost of water (£/Ml)	£15.13
Social cost of repairs (£/repair)	£294.52
Carbon cost of repairs (£/repair)	£0.82
Carbon cost of surveys (£/survey)	£3.30

⁹¹ (Ofwat, 2008)

Appendix B: Water Balance

As explained in Section 4.2 the best practise is to estimate leakage using two nationally-agreed methods, the integrated flow approach ('top down') or the minimum night flow approach ('bottom up'). This appendix details all the water balance components and explains the reconciliation process between the 'top down' and 'bottom up' estimates of leakage.

Water balance components

Distribution input

Distribution input is the amount of potable water entering the distribution system and supplied to customers.

Household measured

Household measured demand is based on metered consumption records adjusted for accruals at the financial year end to include estimates of water used but not yet charged for.

Household unmeasured

The volume of water delivered to unmeasured households is calculated from the number of properties and the average per household consumption (PHC).

The average PHC is based on our control area monitors which cover a representative sample of 73 areas (known as 'cul-de-sacs') and contain over 2,800 properties across the region. The methodology follows the approach set out in the UKWIR report Best Practice for Unmeasured Per Capita Consumption Monitors⁹². The methodology was reviewed in 2015/16 by Crowder Consulting Ltd. and some minor improvements have been made. We have also carried out a full review of our monitor and identified 22 areas that have to be replaced due to their meter penetration being too high. This work is ongoing and we envisage to have it completed in 2018. We also have a well-established process of maintaining our monitor, this ensures all issues are identified early and promptly resolved to maximise the number of monitors reporting accurate data.

Non household measured

Non-household measured demand is based on metered consumption records adjusted for accruals at the financial year end to include estimates of water used but not yet charged for.

Non household unmeasured

The volume delivered to unmeasured non-household is calculated from the number of unmeasured households and an estimated per property consumption. Farm troughs are calculated separately in a similar manner and added to the total.

Unbilled legal

Water taken legally unbilled includes water used for the following purposes:

- Legal standpipe usage such as use for highway washing, weed control and sewer flushing;
- Building water;
- Firefighting and training;
- Supply pipe losses at void properties; and
- Supplies to company's own sites.

⁹² (UKWIR, 1999)

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Unbilled illegal

Water taken illegally unbilled includes illegal water connections, illegal standpipe and hydrant usage, and water taken by customers but unbilled due to lack of awareness that the water is not included in their bill. Quantities are derived from a combination of field surveys, estimates from existing data and our records of water use that is unbilled.

Operational use

Water taken for distribution operational use refers to water knowingly used by the company to meet its statutory obligations, particularly those relating to water quality. This includes:

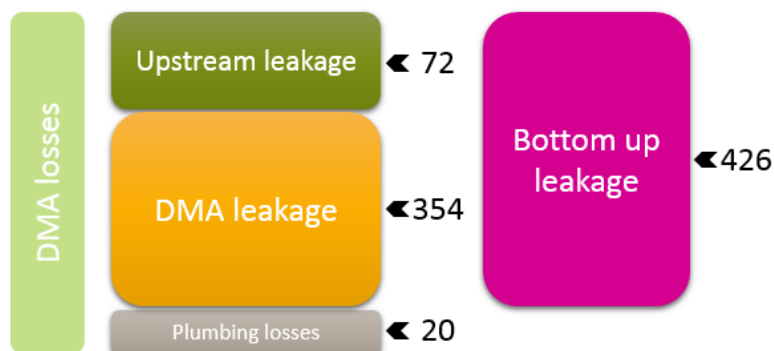
- Mains cleaning and flushing;
- Mains rehabilitation;
- Service reservoir cleaning;
- Commissioning works; and
- Discharges from water quality monitors downstream of production meters.

Upstream leakage (bottom up)

Upstream leakage occurs on the network between the distribution input meters and the district meter areas (DMAs) and includes both trunk mains and service reservoirs. In the water balance, actual flow data from distribution input meters, bulk meters and district meters is used to calculate upstream leakage. This process is recognised as tile balance approach and follows the recommendations of the UKWIR latest reporting guidance for leakage⁹³.

DMA leakage (bottom up)

DMA leakage is calculated from measured night flows taken directly from Netbase (a corporate system used to store and analyse flow and pressure data). The DMA leakage value is based on detailed analysis of minimum night flows (MNF) with appropriate adjustments for known, or estimated zonal pressures, and deductions for relevant allowances for measured and unmeasured demands.



FY17 submission, all values in MI/d

Figure 51 Bottom up leakage

Supply pipe leakage

Our supply pipe leakage was determined by Tynemarch in 2007 who also carried out a collaborative project for several other water companies to determine improved supply pipe leakage values for the 2007 Regulatory Reporting process (then known as June Return). Tynemarch used the national best practice methodology detailed in the

⁹³ (UKWIR, 2017)

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Towards Best Practice for the Assessment of Supply Pipe Leakage⁹⁴. We are currently in the process of tendering for a review of the estimates used in our water balance.

Plumbing losses

Plumbing losses within customer properties are estimated in accordance with the Managing Leakage⁹⁵ document and are deducted from DMA leakage in the total leakage calculation. We are currently in the process of tendering for a review of the estimates used in our water balance.

Reconciliation

Where the water balance components reconcile with measured distribution input to within the tolerances identified in the Ofwat Reporting Requirements and Definitions Manual⁹⁶ (5%), we undertake a reconciliation exercise. The reconciliation is carried out using maximum likelihood estimation (MLE) in accordance with the reporting guidance and the national methodology set out in the Demand Forecasting Methodology⁹⁷.

The statistical MLE method is applied to allocate the reconciliation gap across the individual components. The allocation of the gap to these components depends on the level of confidence in the estimate for each component. The confidence levels have been assessed by in-house in consultation with the Ofwat Reporter. Details of the different components that have been identified and their associated confidence grades can be found in the table below. Figure 52 below illustrates water balance reconciliation process.

Table 36 Water balance confidence grades

Confidence grade (%)	
Measured household	3%
Measured non-household	3%
Unmeasured household	5%
Unmeasured non-household	25%
Water Taken Unbilled-legal, excl. spl ⁹⁸	10%
Water Taken Unbilled-illegal, excl. spl	50%
Operational Use	25%
Upstream Leakage	25%
DMA Leakage	5%
Distribution input	1.02%

⁹⁴ (UKWIR, 2005)

⁹⁵ (UKWIR, 2011)

⁹⁶ (Ofwat, 2011)

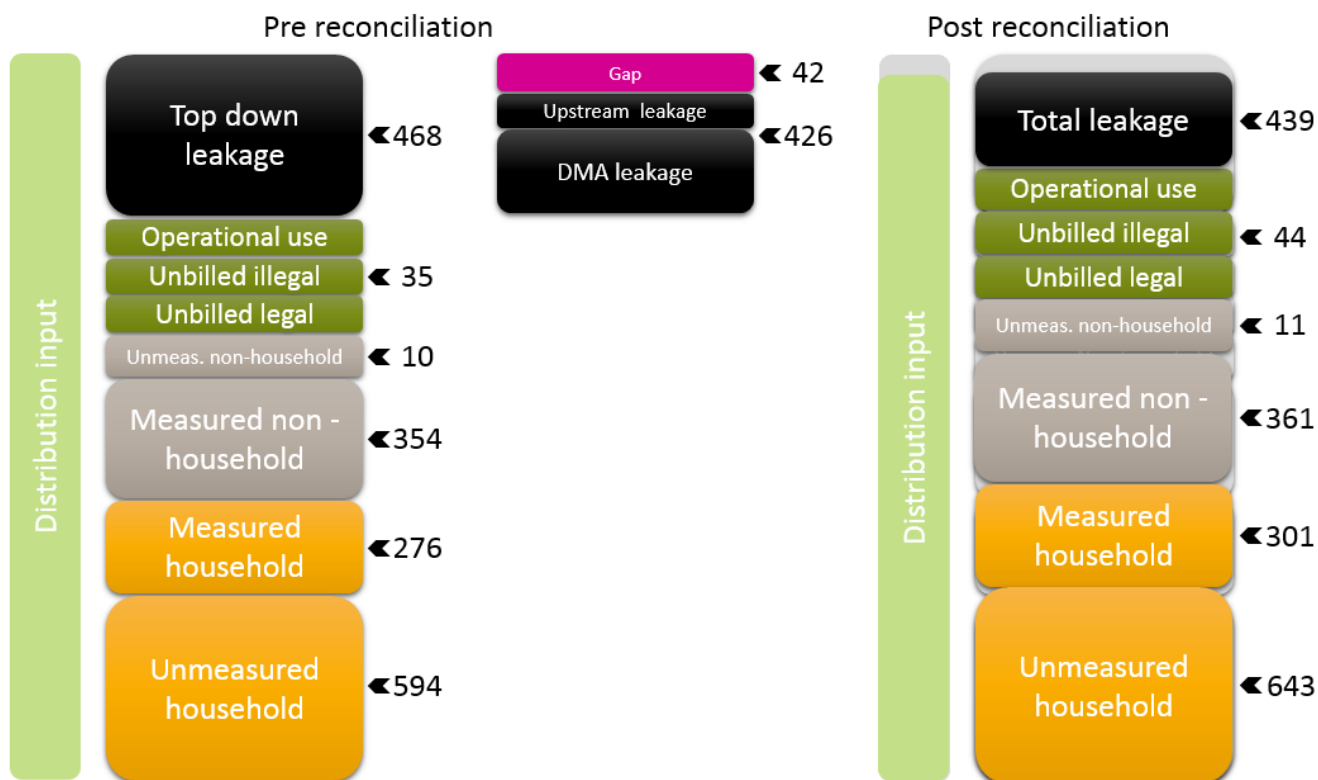
⁹⁷ (UKWIR/NRA, 1995)

⁹⁸ Excluding supply pipe losses

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Total leakage

The total leakage figure is derived through the water balance and for 2016/17 was 439 MI/d as set out in Figure 52, below.



FY17 submission, all values in MI/d

Figure 52 Water balance reconciliation

Appendix C: Leakage Convergence

Table from report submitted to Ofwat on 31st August 2017.

Component	Complaint (RAG)	Guidance requirement	Comment
Coverage	Green	At least 95% coverage of all properties served by a company within networks having continuous night flow monitoring through the year.	Over 99% of billed household and non-households are within designated network areas where night flow is continuously monitored and reported on a daily basis.
Availability	Yellow	At least 90% of all properties within continuous night flow monitoring networks shall be available for reporting night flow data through the year.	For FY17 our District Metered Areas operability was 85%.
Properties	Yellow		Overall status
	Red	Exclude properties that are defined as void from night use allowances unless a company can evidence any use or losses from illegal occupation.	Currently we do not have a void property flag in our leakage management software. The reason for this is that in our billing system properties are flagged as void when they cannot be billed, not necessary when they are empty. We are currently working on the best way to account for void properties in DMA leakage calculations.
Properties (continued)	Green	Map all properties to defined zones or DMAs using geo-location or similar methods available in the industry. Check the consistency of property numbers contained within DMAs or zones against its company's billing system to ensure there is no under- or over- counting. Valid differences shall be explained. Apply leakage allowance for properties not within DMAs or monitored zones consistent with other leakage estimates. Update property data at least annually.	Our network management software is updated with a property extract from the billing system on a monthly basis. Properties are assigned to their DMAs using geo-location (there is a common unique reference that links a property record from the billing system to property seed in GIS). As the billing system is the source of property data we are confident that there are no material differences. Network not covered by DMAs is split up to UMFs (unmeasured feeds). Leakage for these areas will be estimated within our leakage management software using zonal average leakage rate in l/prop/hr (calculated using only operable DMAs within the zone).
Night flow period and analysis	Yellow		Overall status
	Green	Night flow data frequency shall be at least every 15 minutes. The fixed period can be varied during the year for some or all DMAs or zones to address significant changes to night use patterns such as during Ramadan.	We calculate our night line using flow data logged at 15-minute intervals and fixed hour (average between 3:00 - 4:00). We do make adjustments to the night line used for the leakage calculation over the Ramadan period and a one of adjustment for seasonal variation in leakage at year-end.

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Component	Complaint (RAG)	Guidance requirement	Comment
Night flow period and analysis (continued)			
		Leakage shall be derived from a fixed period during the night of at least a one hour period although up to two hours may be used.	Our night use estimates for both household and non-household properties are derived using fixed hour (average between 3:00 - 4:00), which is consistent with the way we calculate minimum night flows.
		<p>Data infilling for a single DMA or zone shall not use more than six months of historic data before moving to area average.</p> <p>Data infilling taking the area average in which the DMA is located is valid if historic data is not available. When a DMA is restored to operability, for the purposes of annual average reporting, the subsequent leakage data should be used to update retrospectively the data infilling interpolating between pre- and post- data over at least one month. This is because a non-operable DMA is unlikely to be subject to detection processes and there is likely to be a natural rise in leakage over time. It is recognised that this may take time to achieve, as and when leakage software packages are updated. There is one exception where a DMA is inoperable at the end of a reporting year where alternative data infilling may be used.</p> <p>Where NHH properties are continuously monitored, the actual values of flow over the night flow period shall be used in place of estimates within the night flow analysis.</p>	<p>We do have some long term non-operable DMAs that fall outside the six month threshold.</p> <p>In the case where a DMA is non operable, its own historical leakage rate is used for four weeks before falling back to zone average leakage rate.</p> <p>Our leakage management software has no capability to in-fill non operable periods by interpolating between pre- and post- data. This will be picked up with the developer of the application in a workshop that is due to take place this autumn.</p> <p>Continuously logged non-household properties are accounted for in the calculation of minimum night flow.</p>
		<p>The night use allowance shall be adjusted regularly through summer months to allow for variable customer night use based on sample logging over the period or night use models.</p> <p>Weekly leakage estimates shall be used for annual reporting with no exclusions for summer months.</p>	<p>We do adjust the leakage calculation over the Ramadan period and also do a seasonality analysis at year-end. The seasonality analysis involves identifying periods of weather where both temperature and rain fall are very different from the long term averages. For these periods we identify DMAs where minimum night flow increased and decreased but no repair activity has taken place. We interpolate minimum night flows between pre- and post- data, calculate the difference between the actual and interpolated figures and use this to adjust DMA leakage.</p> <p>Our annual average leakage is based on a 52 week average with no exclusions.</p>
	Where average night use values are applied across all DMAs, it is appropriate to include negative leakage values when compiling values of annual average leakage.	We currently do not accept negative leakage and for DMAs where negative leakage occurs we manually invalidate it and force another, non-negative day to be selected and included in the weekly calculations. Although, there is a	

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Component	Complaint (RAG)	Guidance requirement	Comment
Night flow period and analysis (continued)		The reasons for any prolonged periods of negative leakage need to be investigated and explained.	setting in our leakage management software that enables us to accept negative leakage our current processes make it impossible to apply this retrospectively. We have introduced a new process and now our leakage analysts will ensure that any invalidation of negative leakage is flagged with appropriate comments. This will enable the invalidation process to be reverted in the shadow database and an "accept negative leakage" setting correctly applied. We will be able to fully account for negative leakage in FY18 shadow reporting.
Household night use			Overall status
		The values of household night use night flow shall be used with values of night flow and non-household night use for the same time period and on the same statistical basis to derive an estimate of leakage representative for the DMA or zone.	HHNU is derived using fixed hour consistent with minimum night flow analysis.
		<p>It shall use its own data or shared data with proximate companies. National default values are not valid.</p> <p>It shall demonstrate that its survey is representative of the company as a whole; disaggregation of the sample by demographic factors, property type or similar represents good practice.</p> <p>It shall demonstrate that the sample size is sufficient to capture continuous and intermittent night use with reasonable confidence.</p> <p>The application of IHMs, SAMS or a combination of both. It is unlikely that the IHM on its own will be of sufficient size to capture a valid sample of intermittent use.</p> <p>HHNU shall be derived daily with regular, adjustment of values on a weekly or monthly frequency to reflect</p>	We use Small Area Monitor (SAM) to derive both night use and per household consumption. The monitor uses ACORN to stratify properties into six groups. The stratification is representative of the region in terms of proportion of each property type. The night use allowances are updated and statistical significance checked on a monthly basis.

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Component	Complaint (RAG)	Guidance requirement	Comment
Household night use (continued)		actual seasonal use. This may need to be done retrospectively.	
		Plumbing losses shall be included and based on the company's own data.	<p>We are using managing leakage estimate of plumbing losses.</p> <p>We are in a process of tendering for a review of plumbing losses and supply pipe losses.</p>
		Continual monitoring and maintenance of IHM and SAMs monitors	<p>We have a well-established process of actively monitoring and maintaining our SAM. This is to ensure that all issues are fixed promptly and a high number of areas is available and included in the analysis each month. We have reviewed our monitor last year and identified 22 monitors with too high meter penetration. These are currently in the process of being replaced.</p> <p>We have commissioned a trial to assess the use of fast logging technology on sample of our SAM. We will use results from the trial to decide whether we will roll this technology out to all our SAMs. Trial will be completed in FY18 and if successful will be rolled out in 2018/19 for inclusion in shadow reporting.</p>
Non-household night use			Overall status
		The values of NHHNU night flow shall be used with values of night flow and HHNU for the same time period and on the same statistical basis to derive an estimate of leakage representative for the DMA or zone	NHHNU is derived using fixed hour consistent with minimum night flow analysis.
		<p>It shall use its own data or shared data with proximate companies. National default values are not valid.</p> <p>Application of the 1999 UKWIR methodology with the appropriate time window as used for the night flow and the published outcome of further methodology development.</p> <p>It shall demonstrate that the stratification of non-households to a number of groups and consumption bands is representative of the varying characteristics of commercial and industrial properties.</p> <p>It shall demonstrate that the sample size is sufficient to capture night use by stratification with reasonable confidence.</p> <p>Development of a reliable and representative average billed volume (ABV) model based on data logging of the representative sample sufficient to capture demand variations with further seasonal logging where relevant. Continuously logged properties are unlikely to form part of the sample as these generally have greater consumption than the stratified samples.</p>	<p>Our non-household night use model has recently been updated by an external consultant and the final report states that: <i>The model is now considered to be statistically stable and robust for reporting purposes, with an estimated error range in the order of +/- 10%. This is not expected to change significantly if additional samples were added, so additional sampling is not recommended at the current time.</i></p> <p>We have commenced a project to identify our compliance against the requirements for continuously logging industrial customers. For each identified site we will look at the performance of the DMA the site is located in to understand whether there is any impact on the DMAs night line and additional logging is required.</p>

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Component	Complaint (RAG)	Guidance requirement	Comment
Non-household night use (continued)		Direct linkage of the ABV model to a company's billing system or replacement database of billed volumes. Update the average billed volumes at least annually.	
		The target threshold for continuous monitoring is where average demand of an individual non-household is greater than 24 to 48 m ³ /day (or night flow >1000 to 2000 l/hr) or 25% of a DMA night flow. A company should define its criteria, reflecting the impact of night use on the ability of a DMA to produce consistent and valid leakage estimates.	We have commissioned a piece of work to understand whether additional logging will be required.
Hour to day conversion			Overall status
		The hour-to-day factor shall be derived separately for each DMA or zone using pressure logging within each DMA. The factors shall be updated at least annually or where there are any significant changes to pressure regimes. As an alternative, hydraulic models can be used provided they have been updated to reflect the latest network reconfiguration and any pressure changes, and provided it is dis-aggregated in sufficient detail at sub-zone level.	We have DMA specific HDFs and these are routinely updated. A review is done each month for all discrete pressure areas (DPAs) where difference between static HDF (used for leakage calculations) and dynamic HDF (calculated in Netbase Summary Data application) is more than 5%. HDF is also updated following any change to the DMAs pressure regime. 98.2% of all properties are located within DPAs with permanent pressure logging. We are currently going through the process of temporary logging and updating default HDF values used in the remaining DPAs. We believe our process is very robust and the areas that are estimated are generally small and would only require an update of HDF following any changes to the pressure regime and annual updates would not bring any material change. Guidance should be updated to reflect that the update frequency should take account of area size and materiality of the change.
		An N1 value of 1.0 to 1.2 in the leakage – pressure power law relationship ⁷ unless a company is able to demonstrate a higher or lower value would be more appropriate using its own data.	We currently use a default N1 factor of 1.25, this is not in line with the new guidance. We will look into updating N1 estimate and are currently assessing the best way to go forward. We are currently assessing the best way to update N1 factor we used in the HDF assessments.
Annual distribution leakage		The average weekly data shall be derived from valid daily values of leakage using data points which are representative of the week. Where valid data is not available from three or more data points then the weekly data should be backfilled using the methods described in Section 5.4 – night flow analysis.	Currently we use a minimum of the week to represent the weekly leakage value. Changing the way weekly average is calculated is a simple change of setting in our leakage management software.
Annual distribution leakage (continued)		The annual value of leakage expressed as MI/d shall be derived from an average of the 52 week data.	
Trunk main leakage		Company-specific data shall be used to assess the value of trunk main leakage.	Our industry leading approach in calculating and managing trunk main losses fulfils the

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Component	Complaint (RAG)	Guidance requirement	Comment
		<p>A proactive leakage monitoring approach shall be applied where trunk main losses form a significant element (>5%) of total leakage or the MLE water balance gap is greater than +/-2%. This approach shall be a combination of field inspections, analytical techniques, and flow balance methods. A company should have sufficient meters installed to allow flow balances to be calculated over 95% by volume of the trunk main network. The selection of methodology and level of leakage monitoring activities shall reflect the proportion of estimated losses in relation to total leakage and the characteristics of the network. Companies with trunk main losses greater than 5% of total leakage shall review and refresh estimates annually.</p>	<p>requirements of the guidance. We use tile balances and actual meter data to derive upstream losses for the entire Region. All the analysis and validation is carried out on a weekly basis by our upstream losses team.</p>
Service reservoir leakage		<p>Company-specific data shall be used to assess the value of service reservoir losses. Reservoirs with known high leakage, structural deficiencies or are at risk of water quality failures shall be investigated on an individual basis. Drop tests are an appropriate approach and normally carried out every five or ten years in parallel with ongoing routine reservoir inspection programmes. Drop tests shall be carried out for at least 12 hours depending on the size of the reservoir. All valves should be checked to ensure they are closed tight; and The extent of losses through reservoirs overflows should be investigated. Where reservoirs are shown to be at risk of overflowing, appropriate monitoring arrangements shall be put in place to control and minimise overflow events.</p>	<p>Please see comment for Trunk Main losses above. We use tile balance, therefore service reservoir losses are already included in our estimate of upstream losses. Valve checks and reservoir drop tests are part of the inspection criteria for service reservoirs. We have an ongoing service reservoir cleaning programme. We will ensure that these activities are logged against in Service Reservoir inspection.</p>
Distribution input			Overall status
		<p>Distribution input to the system shall be metered with at least daily readings at all defined locations. Meters shall be an appropriate size for the flow to be measured and located at appropriate inputs to the network confirmed by record plans. Any treatment works take-off downstream of a meter shall be excluded from the DI calculations; Data validity checks shall be carried out at least monthly. Any missing data shall be infilled using both pre- and post- data for the location over at least one month, extrapolated from pump hours or use of upstream or downstream meters.</p>	<p>All our DI meters are logged or on telemetry, sized appropriately for the flow and our DI figure accounts only for water delivered into the distribution network. We calculate and validate distribution input on a weekly basis and this enables us to quickly act in case there are any meter failures.</p>
		<p>The data transfer systems from meter output to central database shall be checked and validated on a risk-based frequency from one up to two years; Flow checks shall be carried out on DI meters consistent with the principles of the document 'EA Abstraction Good Metering Guide'9 and in particular the</p>	<p>Distribution input meters are also used in tile analysis to derive upstream losses. This enables us to pick up and investigate any significant meter inaccuracies.</p>

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Component	Complaint (RAG)	Guidance requirement	Comment
		frequency of flow checking defined in Table 6.2 of the EA guide.	A supply meter validation programme is being created and a steering group is being set up that will ensure this programme is being delivered and meters are verified in accordance with the EA guidelines.
Water delivered measured		<p>Metered data as derived from a company's own billing system or from CMOS for non-households. An estimate of supply pipe losses shall be included for internally metered properties consistent with the company's current assumption of supply pipe losses. Inclusion of any leakage allowance can be included where a rebate has been applied to a customer's bill. Meter under-registration shall be applied consistent with a company's own estimates. A company shall assume a meter under-registration not exceeding an average 3% unless it can evidence a higher value. Meter replacement consistent with a company's replacement programme.</p>	<p>Metered data is derived from Alto (our billing system) for households and CMOS for non-households.</p> <p>We have not recently made any changes to the estimates of supply pipe losses. These are applied following current best practise. We are currently in the process of tendering for a review of supply pipe losses and plumbing losses estimates.</p> <p>For FY17 we have reported MUR of 1.67%, it is below the 3% threshold stated in the guidance.</p> <p>We have completed a series of meter verification tests for PR19 and will update our MUR model with results of these tests.</p>
Water delivered unmeasured			Overall status
		The PCC surveys shall follow the principles set out in the UKWIR Report 'Best Practice for unmeasured per-capita consumption monitors 199910 and the more recent report Future Estimation of Unmeasured Household Consumption, UKWIR 201711	We follow the best practice in our assessment of unmeasured household consumption. We have commissioned a trial to assess the use of fast logging technology on sample of our SAM. We will use results from the trial to decide whether we will roll this technology out to all our SAMs. The trial will be completed in FY18 and if successful will be rolled out in 2018/19 for inclusion in shadow reporting.
		<p>An estimate of PCC shall be derived from a company's own individual household monitor or small area surveys.</p> <p>It shall demonstrate that its survey is representative of the company as a whole; disaggregation of the sample by demographic factors, property type or similar factors represents good practice. Valid data from the survey shall be from at least 80% of monitors as an annual average measure. A company may develop and use an alternative survey as defined in the 2017 UKWIR Report.</p> <p>A SAM shall also comprise a representative sample of customer' characteristics. The sample size shall be sufficient to provide a statistically representative sample after allowing for outages.</p> <p>Quantify the uncertainty allocated to unmeasured household consumption and provide evidence to justify the uncertainty value used;</p>	We use Small Area Monitor (SAM) to derive both night use and per household consumption. The monitor uses ACORN to stratify properties into six groups. The stratification is representative of the region in terms of proportion of each property type. Per household consumption (PHC) allowances are updated and statistical significance checked on a monthly basis.
		Where the proportion of metered properties in an area exceeds 50% of total properties then further data validity tests shall be applied.	We have reviewed our monitor last year and identified 22 monitors with too high meter penetration. These are currently in a process of being replaced and once commissioned our

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Component	Complaint (RAG)	Guidance requirement	Comment
Water delivered unmeasured (continued)			<p>compliance with the guidelines will improve significantly.</p> <p>For any other monitors where meter penetrations exceeds the 50% stated in the guidance appropriate comments are made to justify inclusion of this monitor in the overall assessment.</p>
		<p>Continual monitoring and maintenance of IHMs and SAM monitors;</p> <p>Meters shall be selected to provide sufficient granularity to detect low continuous flows indicative of plumbing losses or leakage short duration flow variations. The value of meter under registration should be less than the company's average meter stock.</p>	<p>We have a well-established process of actively monitoring and maintaining our SAMs. This is to ensure that all issues are fixed promptly and high number of areas is available and included in the analysis each month.</p> <p>We update the estimate of MUR on an annual basis and it is consistent with the value used in the annual return.</p>
		<p>Estimate of plumbing losses shall be based on the company's own data.</p>	<p>We are in a process of tendering for a review of plumbing losses and supply pipe losses.</p>
		<p>Unmeasured non-household consumption:</p> <p>Where this reported volume is less than 2% of total non-household demand, data from a per property consumption study shall be refreshed every five years; Where reported volumes are greater than 2% of non-household demand, data from a property study shall be refreshed every two years.</p>	<p>We have completed a compulsory metering programme of all non-domestic properties. Currently approx. 9% of all our billed non-households are unmeasured. These properties remained unmeasured as it was either not possible to fit a meter (due to connectivity) or the cost of the work required to enable meter installation was too high. We have attempted to update our current allowances but due to the issues mentioned above we have been unsuccessful.</p> <p>Unmeasured non-household consumption currently accounts for just below 3% of total non-household demand.</p>
			Overall status

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Component	Complaint (RAG)	Guidance requirement	Comment
Company own use		All sewage treatment sites and other key assets using greater than 10 m ³ /d (0.01 MI/d) shall be metered.	<p>We are currently working on a review of logging requirements for any of our own sites.</p> <p>We believe it is important to log sites that have significant impact on DMA flows and therefore leakage estimate.</p> <p>The impact on DMA leakage assessment and therefore leakage targeting and reporting should be the driver for additional logging requirement and not consumption threshold.</p>
Company own use (continued)		An estimate of total company own use shall be included in the water balance, based on a clear methodology and actual data;	Our methodology of calculating operational use has remained unchanged for a number of years and it is audited for consistency and robustness each year through a rigid audit and internal sign off process.
Company own use (continued)		Where an estimate of distribution operational use is greater than 0.6% of distribution input then this value needs to be clearly stated and justified. There should be no change to current assumptions unless clearly evidenced.	Operational use quoted for FY17 is below the 0.6% of DI threshold stated in the guidance.
Other own water use		<p>Other use components should be based on a company's own data.</p> <p>Where an estimate of water delivered unbilled (legally and illegally) is greater than 1.8% of distribution input then this value needs to be clearly stated and justified.</p> <p>Estimates should be updated when there is a material increase or decrease to volumes.</p>	<p>Operational use quoted for FY17 was 2.1% of DI.</p> <p>Our methodology of calculating operational use has remained unchanged for a number of years and it is audited for consistency and robustness each year through a rigid audit and internal sign off process.</p>
Water balance and MLE		<p>Apply the MLE methodology and identify any water balance gap.</p> <p>Disclose and explain the reasons for any water balance gap exceeding 3% of distribution input.</p> <p>Any water balance gap in excess of the +5% gap, expressed as MI/d, shall be added to the leakage component.</p> <p>Revisit all material components of the water balance where the water balance gap is >5% or < -5%.</p>	Confidence limits used in the MLE analysis are consistent with the guidance. FY17 water balance gap was 2.4%, so below the 3% threshold quoted by the guidance.

Appendix D: Impact of metering on water consumption

Several studies have evaluated the effect of metering on water consumption and found that metered customers use less water than unmetered customers. Results from key studies can be summarised as follows:

- The National Metering Trials (*Water Metering Trials Final Report*, The National Metering Trials Working Group, 1993) covered 60,000 households in 12 trial areas across the country. It was primarily aimed at assessing the practicalities of metering on a large scale. Data on the effect of metering on water demand were assessed: there was a wide range in the results, with the average reduction in water use recorded as 11% (excluding the Isle of Wight which was a different type of trial);
- The subsequent UKWIR study (*The effect of metering on peak and average demand*, UKWIR, 1994) investigated the demand effects in more detail and observed a reduction in peak demands of about 30% in hot, dry summers and about 15% in cooler, wetter summers;
- National Economic Research Associates (NERA) *A Framework Methodology for Estimating the Impact of Household Metering on Consumption* for UKWIR (2003). The report includes a detailed literature review which concludes: “We found the UK empirical literature on metering impact effects ... usually suggests 10% to 15% savings in average demand follow from (compulsory) metering ... Peak demand savings of differences were only very seldom suggested to be above 30%.”;
- As part of this work NERA carried out a detailed statistical study of the water consumption at over 1300 houses across England prior to and after opting to be billed as metered. The data was derived primarily from houses which had been part of household water consumption monitors and had subsequently taken up a meter option. The study found that meter optants tend to have significantly lower water consumption (before opting) than other billed unmeasured houses, and that water consumption reduced by an average of 9.6% after metering;
- NERA also carried out a similar detailed statistical analysis of water consumption before and after opting at 242 houses which had been part of our Household Consumption Monitor. The study (NERA, 2003) concluded that the average post-switching consumption is 91.7% of the pre-switching consumption for the same houses. This average demand reduction of 8.3% compares closely with the average value of 9.6% which NERA obtained for the country as a whole;
- Subsequently NERA carried out further analysis for UKWIR (2004). The report found that the demand reductions are sustained (and may increase) through time. There was no evidence of a “bounce-back” effect on demand even 3 years after opting;
- The UKWIR (2004) study found that the effect of metering on water consumption is greatest in summer months, with the largest average monthly reduction of 16.4% occurring in August; and
- A comprehensive review of studies on the effect of metering on water demand has been undertaken by Professor Herrington for UKWIR (2005). It concluded that the average demand reductions are typically in the 10% to 15% range for compulsory metering, and 9% to 21% for optional metering.

The work done by NERA in 2003 for UKWIR and United Utilities represents the most robust assessment in the UK to date as it is based on the most comprehensive data sets available and thorough detailed statistical analysis.

Appendix E: References and data sources

Guidance, methodologies and publications

Year	Report name	Author
1996	Climate change and the demand for water	Professor Herrington for Department of the Environment (now part of Defra)
2001	A scenario approach to water demand forecasting	Environment Agency
2002	Best Practice Principles in the Economic Level of Leakage Calculation	Tripartite Group
2002	Leakage Target Setting for Water Companies in England and Wales, known as the "Tripartite Report"	Ofwat, Tripartite Group
2003	The Impact of Household Metering on Consumption: Empirical Analysis (A Final Report for United Utilities Water)	National Economic Research Associates (NERA)
2003	CCDeW: Climate Change and Demand for Water	Downing et al
2005	Increasing the Value of Domestic Water use Data for Demand Management (Final Report P6832)	WRc plc
2006	Assessing the Cost of Compliance with the Code for Sustainable Homes (Final Report UC7231)	WRc plc
2007	International comparison of water and sewerage service	Ofwat
2007	Quinquartite Report	Ofwat
2007	Providing Best Practise Guidance on the Inclusion of Externalities in the ELL Calculation	Ofwat
2008	Water and energy consumptions of dishwashers and washing machines: An analysis of efficiencies to determine the possible need and options for a water efficiency label for wet white goods	Waterwise
2008	Water Use in New Dwellings (Final Report P7694)	WRc plc
2011	Market Transformation Programme (MTP) BNWAT01 WCs: market projections and product details	Defra
2011	Market Transformation Programme (MTP) BNWAT02 Showers: market projections and product details	Defra
2011	Market Transformation Programme (MTP) BNWAT03 Baths: market projections and product details	Defra
2011	Market Transformation Programme (MTP) BNWAT04 Taps: market projections and product details	Defra
2011	Market Transformation Programme (MTP) BNWAT08: Modelling projections of water using products	Defra
2011	Market Transformation Programme (MTP) BNWAT22: Domestic water consumption in domestic and non-domestic properties	Defra
2011	Market Transformation Programme (MTP) BNW DW01: Dishwashers Government Standards Evidence Base 2009: Key Inputs	Defra
2011	Market Transformation Programme (MTP) BNW01: Combined Laundry: Government Standards Evidence Base 2009: Key Inputs	Defra
2012	Review of the calculation of sustainable economic level of leakage and its integration with water resource management planning	Defra, Environment Agency
2015	Sustainable Economic Level of Leakage (SELL) Prioritisation of the 2012 report recommendations	Environment Agency
2015	Good Practices on Leakage Management	EU Reference Document
2016	Water resources long term planning framework (2015-2065)	Water UK
2017	Water Resources Planning Guideline	Environment Agency
2017	Planning for the future: a review of our understanding of household consumption (Final Report AR1170)	Artesia Consulting for Water UK: Water resources long term planning framework

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Key UK Water Industry Research (UKWIR) reports

Year	Manual/report name	Manual/report reference	Key components/elements that are informed/impacted
1995	Demand Forecasting Methodology	95/WR/01/1	A common methodology for UK water suppliers and their regulators to forecast water demands
1997	Forecasting Water Demand Components - Best Practice Manual	97/WR/07/1	Informed the approach for non-household consumption forecasting (see Section 3.3)
1999	Best Practice for Unmeasured Per Capita Consumption Monitor	99/WM/08/25	
2002	The Economics of Balancing Supply and Demand	02/WR/27/4	
2003	A Framework Methodology for Estimating the Impact of Household Metering on Consumption	03/WR/01/4	Informing meter optant forecasting, although we have worked with Artesia Consulting to develop an updated model (see Section 2.2.6)
2005	Towards Best Practice for the Assessment of Supply Pipe Leakage	05/WM/08/32	
2005	Natural Rate of Rise in Leakage	05/WM/08/33	
2006	Peak Water Demand Forecasting Methodology	06/WR/01/7	Deriving “peak” type demand uplifts (see Section 7.3)
2009	Assessment of the Significance to Water Resource Management Plans of the UK Climate Projections 2009	09/CL/04/11	Informed the “Impact of Climate Change on Water Demand” UKWIR project
2011	Managing Leakage	10/WM/08/42	
2012	Customer Behaviour and Water Use - A good practice manual and roadmap for household consumption forecasting	12/CU/02/11	Informed the “Household Consumption Forecasting” UKWIR project
2013	Impact of Climate Change on Water Demand	13/CL/04/12	Deriving climate change demand uplifts (see Section 7.2)
2014	Understanding Customer Behaviour for Water Demand Forecasting	14/WR/01/14	Informed the “Integration of Behavioural Change into Demand Forecasting and Water Efficiency Practices” UKWIR project
2015	WRMP19 Methods – Population, Household Property and Occupancy Forecasting	15/WR/02/8	Deriving population, household property and occupancy forecasts (see Section 2.1)
2015	WRMP19 Methods – Household Consumption Forecasting, previously Demand Forecasting Methods	15/WR/02/9	A key change for WRMP19 and informed the choice of approach for household consumption forecasting (see Section 2.4.1)
2015	Economics of Supply Pipe Leakage	15/WM/08/56	
2016	Integration of Behavioural Change into Demand Forecasting and Water Efficiency Practices	16/WR/01/15	Informed our customer behaviour, occupancy and ownership survey (see Section 2.1.3 and 2.4.3)
2016	WRMP 2019 Methods – Decision Making Process: Guidance	16/WR/02/10	Informed the thinking for our WRMP19 problem characterisation and approach selection, documented in our <i>Draft WRMP19 Technical Report - Options appraisal</i>
2016	WRMP 2019 Methods – Risk Based Planning	16/WR/02/11	Informed the thinking for our WRMP19 problem characterisation and approach selection, documented in our <i>Draft WRMP19 Technical Report - Options appraisal</i>
2017	Consistency of Reporting Performance Measures - Leakage	17/RG/04/5	

Web sources

- <http://www.leakssuite.com/concepts/uarl-and-ili>
- <http://www.unwater.org/downloads/Water facts and trends.pdf>

Appendix F: Key demand related terminology and definitions

Term	Acronym (if applicable)	Meaning
Distribution input	DI	The total water put into supply, assessed from the water production flow meters at each of our water treatment works, and adjusted where appropriate to account for any potable water bulk supply imports and exports. The water production meters have been installed and are maintained in accordance with our asset standards for flow meters.
Measured		Household and non-household customers that have a meter that measures their consumption.
Total leakage		The total losses from a company's distribution system and customer supply pipes.
Netbase		Our corporate system to allow monitoring and management of leakage levels in each DMA.
District Meter Area	DMA	An area (of up to 3000 properties) where the supply to it is continuously monitored.
Demand Monitoring Zone (also known as Distribution Monitoring Zone)	DMZ	An area that is used to monitor losses and customer demand. They are largely historic, being loosely based on council boundaries, but all supply inputs and outputs are metered. DMZ size varies widely. They are now mainly used to monitor long-term trends.
Automated Meter Reading (also known as Automatic Meter Reading)	AMR	The technology of automatically collecting consumption data from water meters.
Per capita consumption	PCC	The average amount of water used by a person each day, generally presented as litres per person per day
Per household consumption	PHC	The average amount of water used in a household property each day, generally presented as litres per property per day
Water balance		Best practice is to estimate leakage and, therefore, demand for water, using two nationally agreed methods, the integrated flow approach (or "top down") or the minimum night flow approach (or "bottom up"). The difference in estimated demand for water between the "top down" and "bottom up" approaches is applied back to the components of demand using maximum likelihood estimation (MLE), based on the relative component uncertainty.

Appendix G: Local Authority Districts and Unitary Authorities

At the time of writing, our region comprises of just over 50 Local Authority Districts and Unitary Authorities (LADUA) and three National Park Authorities (NAP).

LADUA or NAP	Approximate % in our region	Local plan status as at June 2017	Local plan period as at June 2017
Allerdale	100.0%	Adopted	2011/2029
Barrow-in-Furness	100.0%	Draft	2012/2031
Blackburn with Darwen UA	100.0%	Adopted	2011/2026
Blackpool UA	100.0%	Adopted	2012/2027
Bolton ⁹⁹	100.0%	Consultation	2015/2035
Burnley	100.0%	Draft	2012/2032
Bury ⁹⁹	100.0%	Consultation	2015/2035
Calderdale	0.1%	Emerging	2015/2032
Carlisle	100.0%	Adopted	2013/2030
Cheshire East UA	100.0%	Examination	2010/2030
Cheshire West & Chester UA	72.3%	Adopted	2010/2030
Chorley	100.0%	Adopted	2010/2026
Copeland	100.0%	Adopted	2013/2028
Craven	28.0%	Consultation	2012/2032
Eden	99.9%	Examination	2014/2032
Flintshire UA	0.1%	Consultation	2015/2030
Fylde	100.0%	Examination	2011/2032
Halton UA	100.0%	Adopted	2010/2028
High Peak	68.3%	Adopted	2011/2031
Hyndburn	100.0%	Emerging	
Knowsley	100.0%	Adopted	2010/2028
Lake District	100.0%	Adopted	2010/2025
Lancaster	100.0%	Consultation	2011/2031
Liverpool	100.0%	Draft	2013/2033
Manchester ⁹⁹	100.0%	Consultation	2015/2035
Newcastle-under-Lyme	30.3%	Emerging	2013/2033
Northumberland UA	0.1%	Draft	2011/2031
Oldham ⁹⁹	100.0%	Consultation	2015/2035
Peak District		Adopted	2011/2026
Pendle	92.8%	Adopted	2011/2030
Preston	100.0%	Adopted	2003/2026
Ribble Valley	100.0%	Adopted	2008/2028
Rochdale ⁹⁹	100.0%	Consultation	2015/2035
Rossendale	100.0%	Adopted	2011/2026
Salford ⁹⁹	100.0%	Consultation	2015/2035
Sefton	100.0%	In examination	2012/2030
Shropshire UA	3.1%	Consultation	2016/2036
South Lakeland	99.9%	Emerging	
South Ribble	100.0%	Adopted	2010/2026
St Helens	100.0%	Consultation	2018/2033
Staffordshire Moorlands	17.7%	Emerging	
Stockport ⁹⁹	100.0%	Consultation	2015/2035
Tameside ⁹⁹	100.0%	Consultation	2015/2035
Trafford ⁹⁹	100.0%	Consultation	2015/2035
Warrington UA	100.0%	Adopted	2012/2027
West Lancashire	100.0%	Adopted	2012/2027
Wigan ⁹⁹	100.0%	Consultation	2015/2035
Wirral	100.0%	In preparation	2003/2028
Wrexham UA	0.1%	Draft	2013/2028
Wyre	100.0%	Emerging	2011/2031
Yorkshire Dales		Submission	2015/2030

⁹⁹ Part of the Greater Manchester Spatial Framework, which is a joint plan for Greater Manchester that will provide the land for jobs and new homes across the city region.

Appendix H: Population, number of properties and occupancy by property type

The tables below show the change in population, property and occupancy rate by type of customer and by resource zone¹⁰⁰.

Strategic Resource Zone	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Population (000's)							
Unmeasured	3,977	3,491	3,065	2,683	2,348	2,057	1,853
Measured (Optant)	1,142	1,474	1,831	2,178	2,510	2,825	3,063
Measured (Built Pre 2010)	925	922	901	879	860	844	833
Measured (Built Post 2010)	168	540	863	1,119	1,360	1,584	1,747
Demand Management	7	7	8	8	8	8	8
Non-Households	761	867	883	865	820	757	694
Total Population	6,980	7,302	7,551	7,732	7,906	8,075	8,199
Properties (000's)							
Unmeasured	1,725	1,499	1,327	1,172	1,033	911	824
Measured (Optant)	640	807	975	1,127	1,262	1,381	1,464
Measured (Built Pre 2010)	391	386	380	374	369	364	361
Measured (Built Post 2010)	71	226	364	476	583	683	756
Demand Management	4	4	4	4	4	4	4
Non-Households	163	165	169	171	174	176	177
Total Properties	2,994	3,087	3,219	3,324	3,426	3,519	3,586
Occupancy Rates							
Unmeasured	2.3	2.3	2.3	2.3	2.3	2.3	2.2
Measured (Optant)	1.8	1.8	1.9	1.9	2.0	2.0	2.1
Measured (Built Pre 2010)	2.4	2.4	2.4	2.4	2.3	2.3	2.3
Measured (Built Post 2010)	2.4	2.4	2.4	2.4	2.3	2.3	2.3
Demand Management	1.8	1.8	1.9	1.9	2.0	2.0	2.1
Non-Households (Measured)	4.7	5.2	5.2	5.1	4.7	4.3	3.9

¹⁰⁰ Note: Values may not sum exactly due to rounding

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Carlisle Resource Zone	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Population (000's)							
Unmeasured	66	62	59	55	52	49	46
Measured (Optant)	11	14	17	20	23	27	29
Measured (Built Pre 2010)	18	18	18	17	17	17	16
Measured (Built Post 2010)	5	12	19	26	30	33	34
Demand Management	-	-	-	-	-	-	-
Non-Households	10	11	11	10	9	8	8
Total Population	109	117	123	128	131	133	134
Properties (000's)							
Unmeasured	31	28	27	26	24	23	22
Measured (Optant)	6	7	9	10	11	13	14
Measured (Built Pre 2010)	8	8	8	8	8	7	7
Measured (Built Post 2010)	2	5	8	11	13	15	15
Demand Management	-	-	-	-	-	-	-
Non-Households	5	5	5	5	5	5	5
Total Properties	51	54	57	59	61	63	63
Occupancy Rates							
Unmeasured	2.2	2.2	2.2	2.2	2.1	2.1	2.1
Measured (Optant)	1.8	1.9	1.9	2.0	2.1	2.1	2.1
Measured (Built Pre 2010)	2.3	2.3	2.3	2.3	2.3	2.2	2.2
Measured (Built Post 2010)	2.3	2.3	2.3	2.3	2.3	2.2	2.2
Demand Management	1.8	1.9	1.9	2.0	2.1	2.1	2.1
Non-Households (Measured)	2.1	2.4	2.3	2.1	1.9	1.7	1.6

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North Eden Resource Zone	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Population (000's)							
Unmeasured	7.2	6.9	6.6	6.4	6.2	6.0	5.8
Measured (Optant)	1.1	1.3	1.5	1.8	2.0	2.3	2.5
Measured (Built Pre 2010)	2.7	2.7	2.7	2.6	2.6	2.5	2.5
Measured (Built Post 2010)	0.7	1.5	2.2	2.8	3.3	3.6	3.7
Demand Management	-	-	-	-	-	-	-
Non-Households	2.1	2.2	2.2	2.1	2.0	1.9	1.8
Total Population	13.7	14.6	15.2	15.7	16.0	16.2	16.3
Properties (000's)							
Unmeasured	3.4	3.1	3.0	2.9	2.8	2.8	2.7
Measured (Optant)	0.6	0.7	0.8	0.9	1.0	1.1	1.1
Measured (Built Pre 2010)	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Measured (Built Post 2010)	0.3	0.7	1.0	1.2	1.4	1.6	1.6
Demand Management	-	-	-	-	-	-	-
Non-Households	1.0	1.0	1.0	1.0	0.9	0.9	0.9
Total Properties	6.4	6.6	6.9	7.1	7.3	7.4	7.5
Occupancy Rates							
Unmeasured	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Measured (Optant)	1.8	1.9	1.9	2.0	2.1	2.1	2.2
Measured (Built Pre 2010)	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Measured (Built Post 2010)	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Demand Management	1.8	1.9	1.9	2.0	2.1	2.1	2.2
Non-Households (Measured)	2.3	2.5	2.4	2.3	2.3	2.2	2.1

Appendix I: Measured non-household consumption¹⁰¹ by Standard Industrial Classification categories

Sector	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Agriculture, horticulture, forestry & fishing	24	21	18	15	13	11	10
Extraction of minerals and energy producing materials	0	0	0	0	0	0	0
Food and drink (manufacture)	40	39	40	41	41	41	41
Textile, fur and leather (manufacture)	1	1	1	1	0	0	0
Other manufacturing	4	3	2	2	1	1	1
Paper (manufacture)	7	6	5	5	4	4	4
Fuel refining	3	4	5	6	8	10	12
Chemicals, rubbers, plastics and man-made materials (manufacture)	36	32	30	27	24	22	20
Non-metallic minerals (manufacture)	4	4	4	4	3	3	3
Basic metals, fabricated metal products and machinery (manufacture)	5	4	4	4	3	3	3
Transportation and manufacture of transport equipment	13	13	13	13	13	13	14
Electricity, gas and water supplies	8	8	8	8	8	8	8
Construction	1	1	1	1	1	1	1
Wholesale and retail	19	19	18	17	16	16	15
Hotels, bars and restaurants	41	43	44	45	46	46	47
Other services	75	75	76	78	79	81	82
Education and health	41	38	35	32	29	27	25
Unallocated	13	13	13	13	13	13	13
Total	337	323	317	311	305	301	298

¹⁰¹ It's worth noting that these figures do not account for meter under-registration, as well as other reconciliations as part of the Water Balance process.