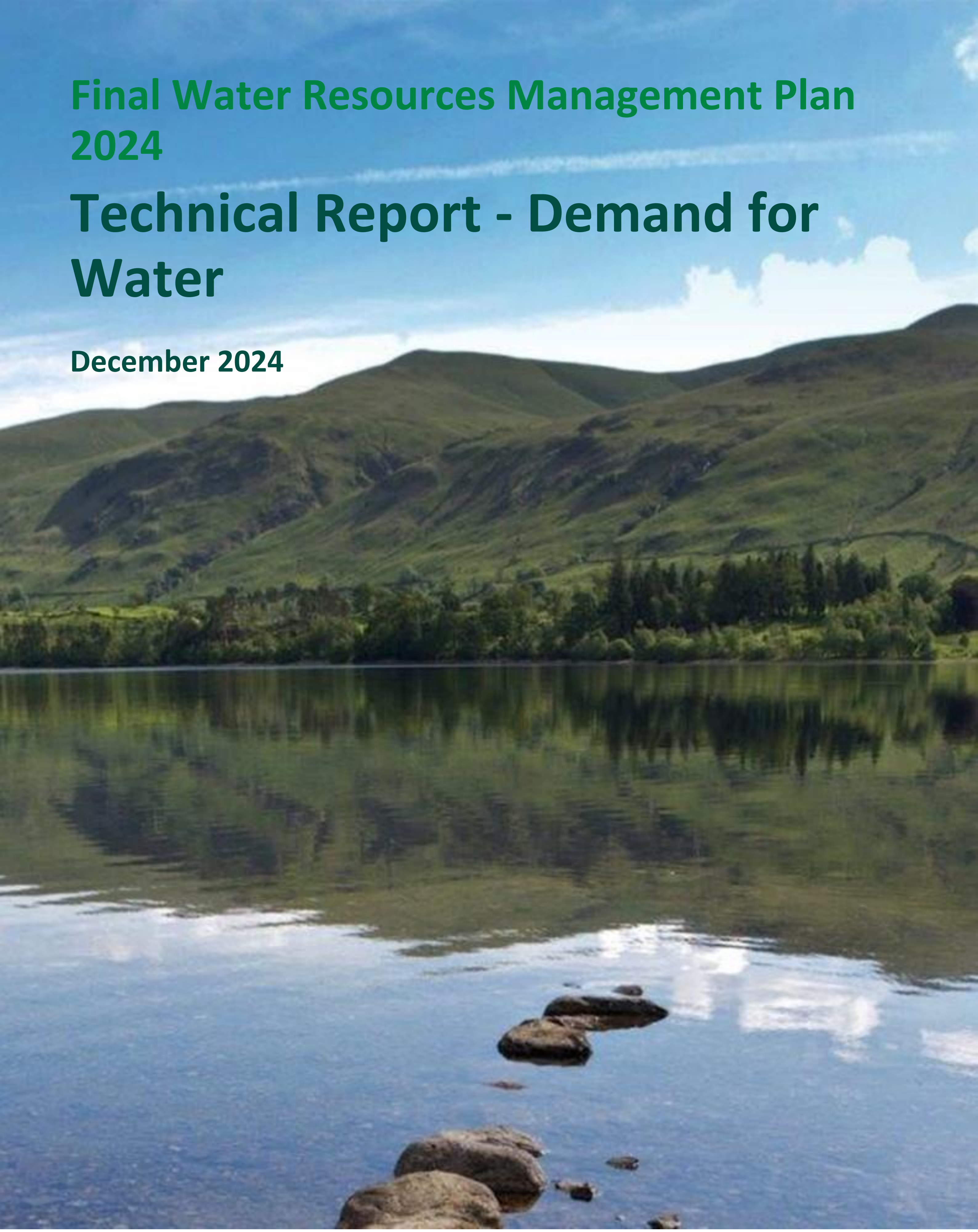
Final Water Resources Management Plan 2024

Technical Report - Demand for Water

December 2024



United Utilities

Water for the North West

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1. Introduction

United Utilities Water supplies water to a population of over seven million people across an area of approximately 13,800 km^2 in the North West of England. On average we meet a demand for water of approximately 1,830 million litres a day, and through our Water Resources Management Plan (WRMP) we must ensure that we will continue to meet future demand.

We have prepared our demand forecast using the latest available methods, and it has been informed by what customers, stakeholders and regulators have told us, including during our pre-consultation activities. This technical report outlines the key components of demand for water, and the data and methods which we have used to prepare a robust demand forecast for each of our water resource zones from 2025 through to 2100 to ensure that we can plan for the future. It also sets out our approach to managing future demand through a range of demand management actions, including metering, water efficiency promotion and leakage reduction activity.

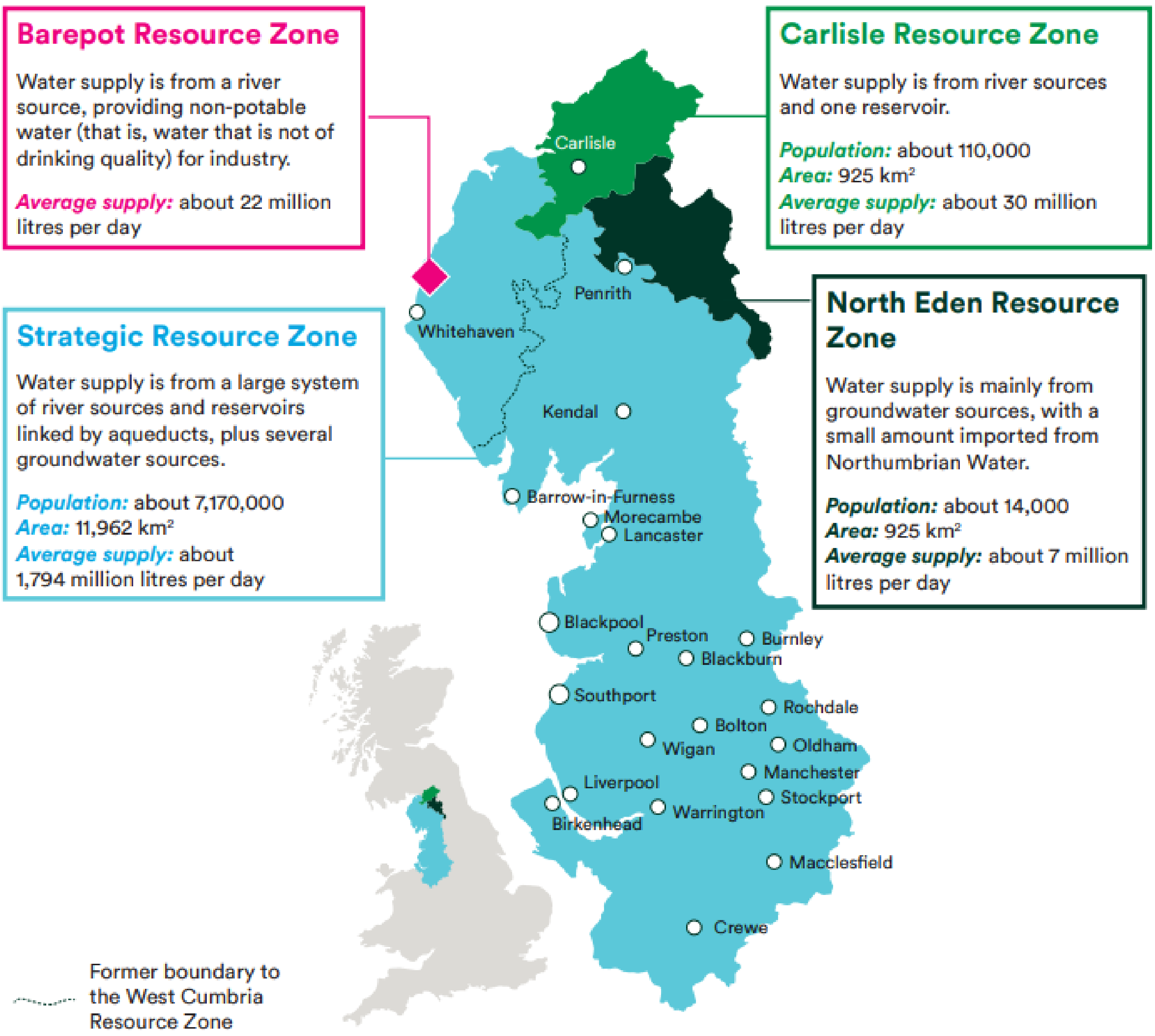
Our demand forecasting method aligns with regulatory guidance.

1.1 Water Resource Zones

Our supply area is divided into four separate water resource zones (RZs), with limited connectivity between them. One of these consists solely of a non-potable water supply to an industrial customer (Barepot RZ).

The characteristics and boundaries of our current water resource zones are shown in Figure 1.

Figure 1 Geographical locations of our Water Resource Zones



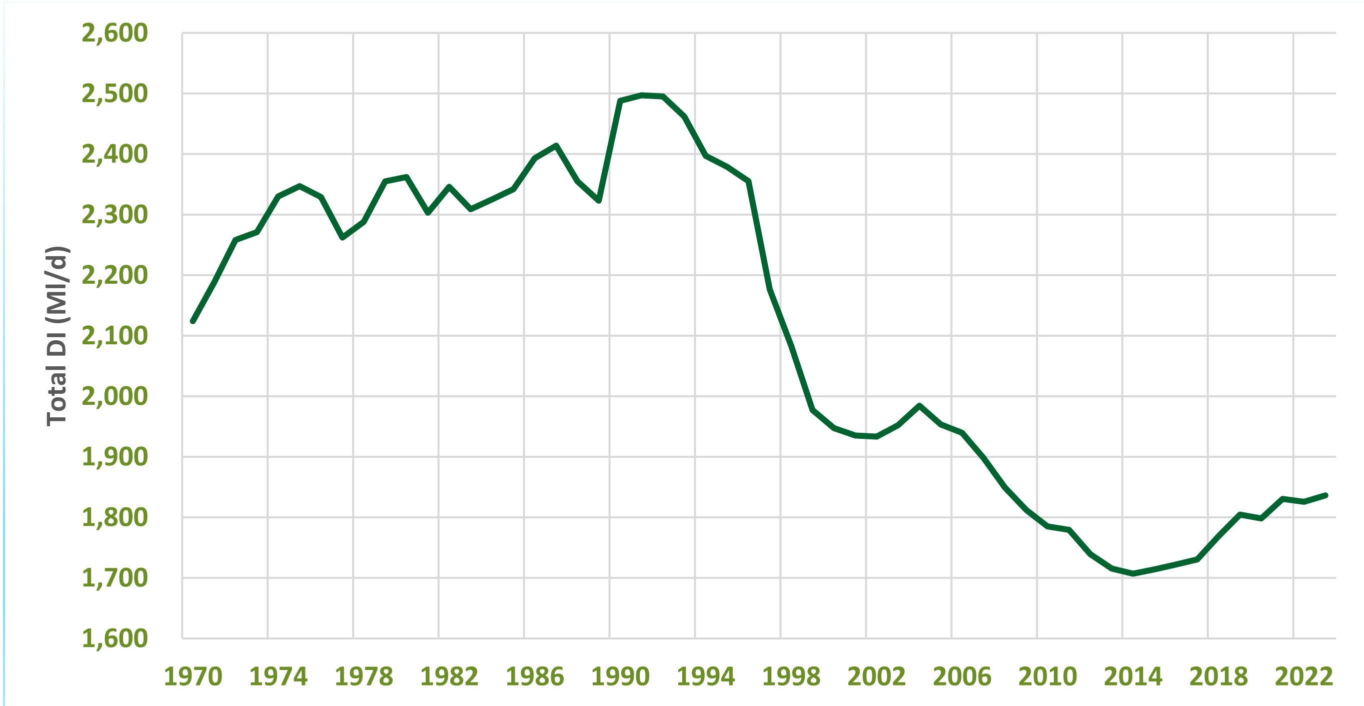
1.2 Observed demand

Figure 2 shows the trend in our annual average demand over the last 60 years. Since the early 1990s, demand has decreased significantly, despite an overall increase in population over this period. This is due to a number of factors, including:

- Increased metering of household properties to drive efficiency;
- Development of more water efficient appliances (e.g. dishwashers and washing machines);
- Building regulations ensuring more efficient use of water in new properties (e.g. smaller toilet cisterns);
- Water efficiency promotion undertaken by the company;
- Increased customer awareness of the need to use water efficiently;
- Leakage reduction activity undertaken by the company; and
- The decline of the non-service sector, which has been replaced by the lower use service sector in the North West.

In recent years we have seen a rise in demand. Demand for water does fluctuate on a yearly basis, in response to weather conditions and other factors (including the influence of the COVID-19 pandemic since 2020), however, we continue to monitor demand on a regular basis to assess whether this is the start of an upward trend. Changes in demand trends are a key reason for reviewing our company demand forecasts at regular intervals in line with our Water Resources Management Plan process, including annual reviews during the five-year periods between the publications of each updated plan.

Figure 2 Annual average demand (excluding non-potable supplies) – United Utilities Water region



Our base year from which we project forwards to produce our demand forecasts is FY20, i.e. 2019/20 (the period from 1 April 2019 to 31 March 2020). FY21 (2020/21) or FY22 (2021/22) has not been used because of the complexity around COVID-19 and questions around the medium to long term ramifications (e.g. are recent demand changes from COVID-19 now normal or short-lived?). However, as seen in Section 7.5, we have incorporated some adjustments to the balance of demand to account for the impacts of COVID-19 in our demand forecast based on the best available information. Furthermore, the calculation of dry year and normal year demand will be more significantly uncertain when considering the challenges of splitting out the impacts on demand from COVID-19 and warm weather. We will continue to monitor demand between FY20 and submission in FY23 and will review and agree with other companies within our regional planning group Water Resources West whether we need to change our base year. The total average observed demand during FY20 was 1,820 Ml/d (including non-potable supplies to Barepot Resource Zone).

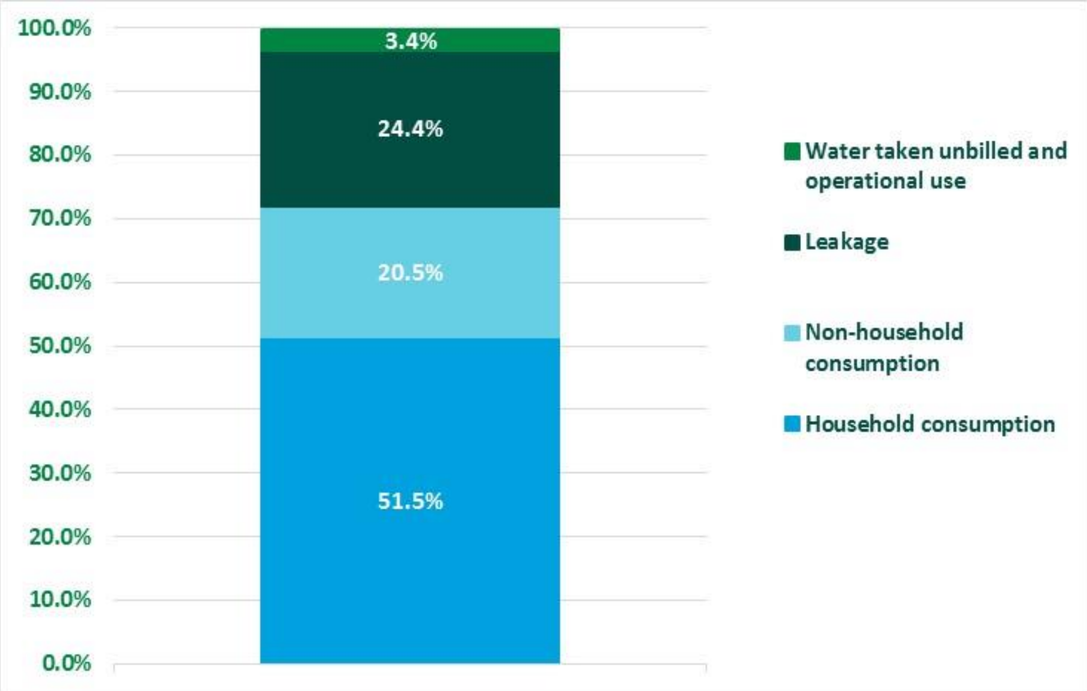
Demand is made up of a number of key components including household (domestic) customer consumption, non-household (commercial and industrial) customer consumption and leakage and minor components (Figure 3), and is reported in line with the UK Water Industry Research (UKWIR) 'Consistency of Reporting Performance Measures' report and the Ofwat report 'Leakage reporting guidance' (March 2020). Household and non-household water consumption can be further broken down by whether the supplies are metered (measured) or not (unmeasured). Table 1 shows the breakdown of demand by water resource zone (RZ) in 2019/20. For further information on how we report leakage, please see section 6.1.1.

Table 1 Key components of demand by water resource zone in our base year (2019/20)

Component (Ml/d)	Barepot RZ (non-potable)	Carlisle RZ	North Eden RZ	Strategic RZ	All (Region excluding Barepot)
Unmeasured household consumption	–	10.38	1.35	583.1	594.82
Measured household consumption	–	4.76	0.59	327.9	333.32
Unmeasured non-household consumption	–	0.28	0.07	11.30	11.63
Measured non-household consumption	21.50	7.02	1.04	349.9	357.95
Total leakage	–	5.50	3.71	430.4	439.6
Water taken unbilled	–	0.71	0.07	56.10	56.92
Operational use	–	0.06	0.01	3.90	3.96
Total demand	**21.50**	**28.71**	**6.84**	**1762.60**	**1798.2**

Note: numbers may not sum due to rounding.

Figure 3 Summary of key components of demand



1.3 Changes from draft to revised draft

Table 2 Changes made between draft and revised draft

Change	Reason	Update(s)	Relevant section(s)
Refreshed the AMP7 forecast of void properties and updated the longer term forecast	To take into account the latest data and strategy on voids	Updated technical report	3.2
Refined Covid-19 switch between non-household and household demand from 5% to 1.5%	Observed reduction in impacts from Covid-19 since draft plan submission	Updated split between NHH and HH consumption	7.5
Updated report to provide further detail on the methodologies, assumptions and limitations of population forecasting, individual micro-component approach, leakage and metering	Environment Agency request for more detail on the methodologies, assumptions and limitations of population forecasting, individual micro-component approach, leakage and metering	Updated technical report including new schematic on how household population forecast is developed	-Population forecasting (3) -Micro-component approach (4) - Leakage (6 and 10.1) - Metering (4 and 10.2.1)
Provided further detail on how void properties have been estimated for all properties	Environment Agency request for more detail on how measured, unmeasured, and void properties have been estimated for both household and non-household properties	Updated technical report	3.2
Provided further detail on the assessment of third party abstractors switching to public water supply including how a peak demand assessment is the appropriate method to use	Environment Agency request for more detail on our approach for assessment of third party abstractors switching to public water supply	Updated technical report	5.3

Change	Reason	Update(s)	Relevant section(s)
Provided further detail on 1 in 500 demand assessment and climate change has been considered as part of the non-household consumption forecast	Environment Agency request for more detail on 1 in 500 demand assessment, the uncertainty, and climate change approach with non-household demand	Updated technical report	7.3 and 7.6
Provided further detail on final planning demand including our leakage and consumption strategy	Further detail required from draft	Updated technical report	10.1 and 10.2

1.4 Changes from revised draft to final WRMP24

Table 3 Changes made between revised draft and final

Change	Reason	Update(s)	Relevant section(s)
Provided further detail on how we have aligned our baseline dry year annual average demand forecast with NAV WRMPs.	Alignment to NAV revised draft WRMPs.	Updated technical report and WRMP Tables 3a	3.5
Figure 11	Measured/unmeasured household consumption trends and projections – aligned to Final Plan Tables	Updated technical report	4.3
Table 20	1 in 500 versus DYAA household consumption per resource zone (Ml/d) update following alignment to NAV revised draft WRMPs.	Updated technical report	7.3
Figure 27 and Figure 28	Alignment to NAV revised draft WRMPs and Final Plan Tables	Updated technical report	10

2. Demand forecasting framework and guidelines

This section introduces the planning framework and regulatory guidelines which govern our approach to our demand forecasts. We review and update our forecasts every five years in line with the required timetable for updating our overall Water Resources Management Plan.

2.1 Regional planning

In the recently published National Framework for Water Resources (March 2020), Defra confirmed their requirement for Regional Water Resources Plans to be produced, to address the need for resilient and sustainable water supplies in a growing economy and changing climate. There are currently five regional groups across the UK, consisting of water companies, water industry regulators and stakeholders, working to address the requirement for regional plans.

United Utilities Water is a member of the Water Resources West regional group, along with Severn Trent Water, Dŵr Cymru Welsh Water, South Staffs Water and the Environment Agency and a number of associate members. Our 2024 Water Resource Management Plans are being developed in collaboration with Water Resources West, as the aim is for all individual company plans to align with the relevant regional plan. A key activity of the Water Resources West Group, therefore, is to align all plans using consistent tools and methods (where possible).

In order to drive consistency across the Water Resources West region, a demand forecasting methodology was agreed and applied to develop demand forecasts for all water companies in the group. Some aspects of our demand forecasts (namely the future projections of household and non-household consumption) have been prepared by consultants on behalf of all Water Resources West members, ensuring improved consistency in both company and regional forecasts compared to the 2019 Water Resources Management Plan. Furthermore, by contracting this work to industry experts, we are able to use the best available data and information.

2.2 Regulatory guidance

Our agreed demand forecasting methodology is compliant with the guidance set out by the Environment Agency in their Water Resources Planning Guideline (2021). The guidance has been developed through a range of UK Water Industry Research projects and other relevant studies. Key developments to the demand forecasting methodology since the publication of our 2019 Water Resources Management Plan (WRMP19) can be summarised as follows:

- Companies are encouraged to present an assessment of the demand that might be expected during a 1 in 500 year (0.2% annual risk of occurrence) drought event (though the guidance does not require this to be included in the baseline forecast);
- Companies are encouraged to consider the risk of a combination of pressures, such as the impact of the COVID-19 outbreak combined with a period of dry weather, possibly by considering this as a critical period scenario; and
- Leakage must be determined in accordance with the approach outlined in Ofwat's new guidance[1] published in March 2018.

2.3 Planning scenarios

The Environment Agency's Water Resources Planning Guideline states that Water Resources Management Plans should consider the supply-demand balance at times when a company's supplies are low and demand is high. The baseline scenario to be adopted for companies in England should be the dry year annual average scenario. However, the guideline also encourages companies to assess additional planning scenarios to consider the supply-demand balance at critical periods when peak demands put the supply system under strain. In response to

[1] https://www.ofwat.gov.uk/wp-content/uploads/2018/03/Reporting-guidance-leakage.pdf

periods of high peak demand experienced across our region in recent years, we have reviewed the planning scenarios that are appropriate to adopt for each of our water resource zones (further details can be found in our *Technical Report - Supply forecast*). As noted above, it also introduces the concept of planning for 1 in 500 year demand, though it remains optional at this stage.

The planning scenarios assessed in our 2024 Water Resources Management Plan (WRMP24) are shown in Table 4; these are consistent with the scenarios included in our previous plan. All RZs are assessed using a Dry Year Annual Average (DYAA) scenario, while the Carlisle Resource Zone is also assessed using a Dry Year Critical Period (DYCP) scenario. This additional scenario is required as Carlisle Resource Zone has a small number of sources and is reliant on direct river abstraction. Critical period planning scenarios are not required for the Strategic, North Eden and Barepot Resource Zones for the following reasons:

- **Strategic Resource Zone** – modelling assessment demonstrated the supply system is resilient to peak week demands;
- **North Eden Resource Zone** – there is sufficient spare production capacity and groundwater yield to meet temporary increases in demand; and
- **Barepot Resource Zone** – consists of a single river abstraction supplying a small number of industrial customers. No history of short-term increases in demand leading to stress on the raw water system.

Our demand forecasts have initially been prepared for the Dry Year Annual Average scenario, and a suitable uplift factor has then been applied to produce the Carlisle Resource Zone Dry Year Critical Period demand forecast. Further details are given in Section 7 of this report.

Table 4 Water resource zone planning scenarios for WRMP19 and WRMP24

	WRMP19		WRMP24	
Water Resource Zone	**Dry Year Annual Average (DYAA)**	**Dry Year Critical Period (DYCP)**	**Dry Year Annual Average (DYAA)**	**Dry Year Critical Period (DYCP)**
Strategic	✓	×	✓	×
Carlisle	✓	✓	✓	✓
North Eden	✓	×	✓	×
Barepot	✓	×	✓	×

The planning period for which demands will be forecast for our 2024 Water Resources Management Plan is from 2025 through to 2085. Our forecasts are projected from the base year 2019/20 and the forecasts include the period from 2020/21 up to 2024/25 (known as the pre-plan years).

We are also required to report demand forecasts for a normal year annual average (NYAA) scenario, although this scenario is not used for supply-demand balance analysis.

3. Population, property and occupancy

The Water Resources Planning Guideline states that population and property forecasts should be based as far as possible on local plans published by local councils or unitary authorities, while acknowledging that local authorities will be at different stages of producing their plans. The guideline states that water company property forecasts should not constrain growth, therefore our growth forecast is based on local authority plans. We have applied the same assumptions to all of our resource zones.

Our population and property forecasts have been prepared by Edge Analytics, a company with significant expertise in demographic modelling and forecasting. The forecasts are derived from Edge Analytics' VICUS[2] methodology, which has been used to configure and deliver housing and population growth evidence to the water industry's new regional planning framework. The data sources used are a combination of water industry data, Local Plan housing evidence (Consilium[3]), plus population and related demographic statistics. This includes data produced by the Office for National Statistics (ONS), the Greater London Authority (GLA) and the Welsh Government (WG). The population and property forecasts are prepared for a range of different assumptions (scenarios), which were built up from local authority level to both regional level and for the company's resource zones covering the planning period up to the year 2100.

Where local authority plans cross into neighbouring resource zones (e.g. Shropshire and Staffordshire Moorlands), property and population forecasts have been allocated based on the Royal Mail post code address file data. For example, 18% of the total property numbers of Staffordshire Moorlands local authority fall into our Strategic Resource Zone, therefore, a factor of 0.18 is applied to the forecast.

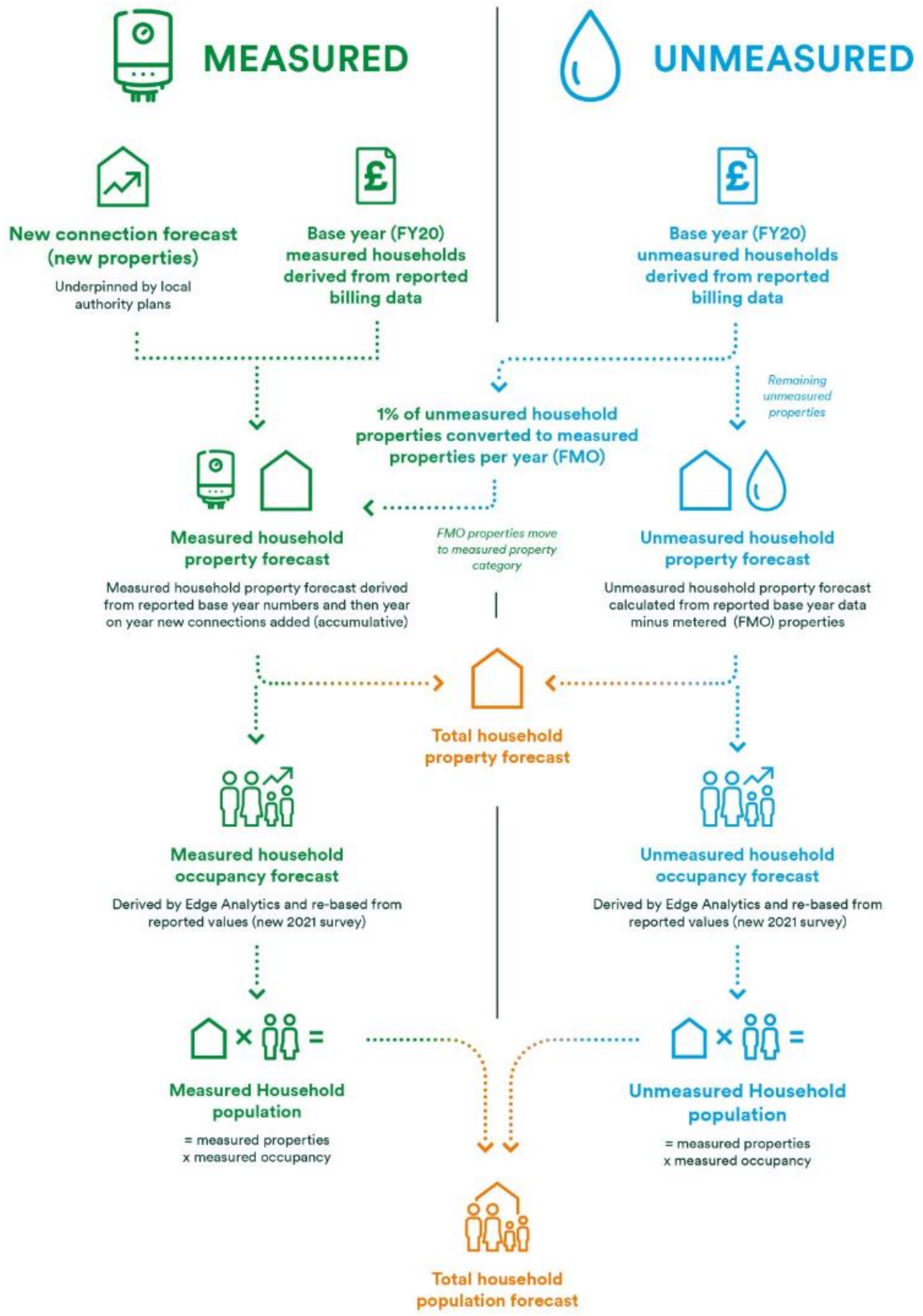
We are aware that local council housing plans are at different stages of development where many are still draft (at various stages), therefore we will periodically review (and discuss with local councils) any changes to published plans. If the changes are deemed to have a material change to our demand forecast, we will make the associated updates.

A summary of how household population is derived can be found below in Figure 4.

[2] VICUS is a suite of macro-micro forecasting models developed to support the specific objectives of the water industry planning process.

[3] Consilium is a database developed to be the definitive source of evidence on future housing growth plans for all Local Planning Areas (LPAs), and is updated through a continuous cycle of collaboration with local authorities.

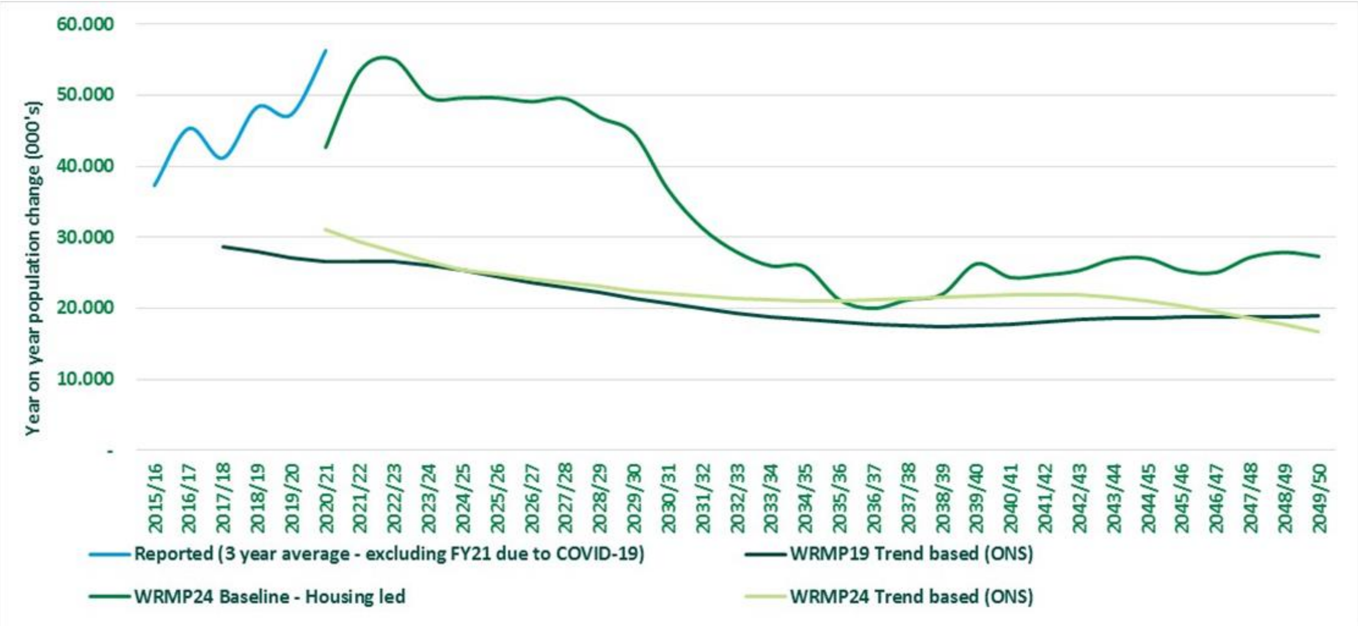
Figure 4 Derivation of household population from properties



The key assumption in using the housing (local authority) plan forecast for population is that there is a relationship between the homes that are built, and the population increase in our region. The starting point for a housing-led population forecast is a trend (ONS) projection, which is modified year-on-year to ensure reconciliation between population change and the capacity of the housing stock. The relationship between housing growth and population change is determined by the changing age-structure of the population, projected household representative rates (occupancy), a vacancy rate, plus the changing size of the population not-in-households. If the demographic trend does not match the capacity of the housing stock, then the trend is altered, through higher or lower migration. If the capacity of the housing stock exceeds the population growth trend, then additional growth through migration will result. Likewise, if the capacity of the housing stock does not meet the requirements of the population growth trend, then growth is reduced through migration to another region.
In summary, specific developments can lead to additional people being attracted into our region over and above natural population changes and international migration. In the Carlisle Resource Zone, a key development is the St Cuthbert's Garden Village-Carlisle South (which is included in our baseline forecast). Considering the substantial size of the development compared to the size of the zone, it is highly likely that additional people will move from outside the resource zone to occupy the new properties. In order not to constrain planned growth in line with the guidelines, we have assumed that new properties will be occupied leading to an increase in demand (assuming new build water standards and consumption trends).

Using the VICUS forecasting framework, Edge Analytics have produced population and property forecasts for 11 different scenarios covering both housing-led scenarios and trend-based projections. The key data and assumptions on which each of these scenarios is based are summarised in Table 5. This approach also forms the basis of our adaptive plan for demand.

Figure 5 Year on year population forecast since FY16: housing led vs trend-based forecast



Local Plan information on future housing growth is typically available for around a 10–15-year period. In each area the projected housing growth has been extended beyond the final year of available Local Plan data, based on long-term annual growth average up to 2050. In order to extend the population and property forecasts beyond 2050, growth scenarios for the period 2050–2100 have been aligned with the mortality and fertility assumptions of the ONS 2018-based national population projection (NPP), together with most likely, low or high growth outcomes relating to the following net migration assumptions:

- Most likely: Net international migration assumption of +190k p.a. for the UK in total;
- Low: Net international migration assumption of +90k p.a. for the UK in total; and
- High: Net international migration assumption of +290k p.a. for the UK in total.

We appreciate that there can be significant uncertainty in these forecasts, and we aim to capture the uncertainty ranges through target headroom assessment (*Technical Report – Allowing for uncertainty* for more details). The specific scenarios going into our baseline forecast (Housing-Plan trajectory) have been selected to ensure we don't constrain any planned growth; however, our choice also considers the recent historical performance of recent reported growth data where ONS trend-based forecast has consistently underestimated population growth over the last five years (Figure 5). As with all areas of demand, we will monitor the performance of these growth forecasts. If the forecast deviates significantly away from reported estimates, we will review and discuss whether we need to change our growth assumptions. This approach also forms the basis of our adaptive plan for demand.

The unmeasured non-household property forecast has been derived from the reported base year (2019-20) and projected forward excluding the PR19 forecast for non-household voids and deletions. For measured non-household properties, this is derived from the reported base year (2019-20), where the average number of non-household connections as a percentage of new household connections is calculated over the past 5 years (2015/16 to 2019/20 inclusive). This fixed percentage is then applied to forecast household connections over the planning period from our base year, to produce a forecast of non-household new connections (and associated non-household property forecast) for each year across the planning period. Unlike household properties (and consumption), the non-household properties (including population and voids) forecast does not influence the non-household consumption forecast.

Table 5 Scenario definitions for VICUS population and property forecasts, 2020-–2050

	ID	Scenario	Description
Trend Projections	1	ONS-14	ONS 2014-based sub-national population projection (SNPP), using a six-year history (2008–2014) to derive local fertility, mortality and internal migration assumptions, with a long-term UK net international migration assumption of +185k p.a.
	2	ONS-16	ONS 2016-based Principal sub-national population projection (SNPP), using a five-year history (2011–2016) to derive local fertility, mortality and internal migration assumptions, and a long-term UK net international migration assumption of +165k. In line with the ONS 2016-based national population projection (NPP), this round of projections includes a reduced UK fertility outlook compared to ONS-14 and a dampened rate of improvement in life expectancy compared to ONS-14.
	3	ONS-18	ONS 2018-based Principal sub-national population projection (SNPP), using a five-year history (2013–2018) to derive local fertility and mortality assumptions and a long-term UK net international migration assumption of +190k. Unlike earlier rounds of SNPP, the 2018-based Principal projection uses a two-year history (2016–2018) of internal migration assumptions, following recent changes to the methodology used for its estimation, which have only covered the latest two years. In line with the ONS 2018-based national population projection (NPP), this round of projections includes a reduced UK fertility outlook compared to ONS-16 and a dampened rate of improvement in life expectancy compared to ONS-16.
	4	ONS-18-High	ONS 2018-based High International Migration sub-national population projection (SNPP), incorporating a high long-term UK net international migration assumption of +290k p.a., with all other assumptions consistent with ONS-18.
	5	ONS-18-Low	ONS 2018-based Low International Migration sub-national population projection (SNPP), incorporating a low long-term UK net international migration assumption of +90k p.a., with all other assumptions consistent with ONS-18.
Housing-led	6	Completions-18Y	A Housing-led scenario, with population growth underpinned by a continuation of the rate of housing growth recorded in each local authority's 18-year completions history (2001–2019).
	7	Completions-5Y	A Housing-led scenario, with population growth underpinned by a continuation of the rate of housing growth recorded in each local authority's five-year completions history (2014–2019).

ID	Scenario	Description
8	Housing-Need	A Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's Local Housing Need (LHN) or Objectively Assessed Housing Need (OAHN). Following the final year of data, projected housing growth returns to the ONS-14 and ONS-16 long-term annual growth average by 2050.
9	Housing-Req	A Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's housing requirement. Following the final year of data, projected housing growth returns to the ONS-14 and ONS-16 long-term annual growth average by 2050.
10	**Housing-Plan – trajectory**	**A Housing-led scenario, with population growth underpinned by each local authority's Local Plan housing growth trajectory. Following the final year of data, projected housing growth returns to the ONS-14 and ONS-16 long-term annual growth average by 2050.**
11	Housing-Plan	A Housing-led scenario, consistent with the Housing-Plan scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter.

Figure 6 shows the long-term trend in regional population from 2006 to 2020, and the projected increase from 2020 to 2050 based on the housing plan-led scenario (Housing Plan Trajectory). Figure 7 highlights the range population forecasts using plan based and ONS based scenarios as set out in Table 5.

Figure 6 Long-term trend in United Utilities Water's total population, with housing-plan led forecast from 2021.

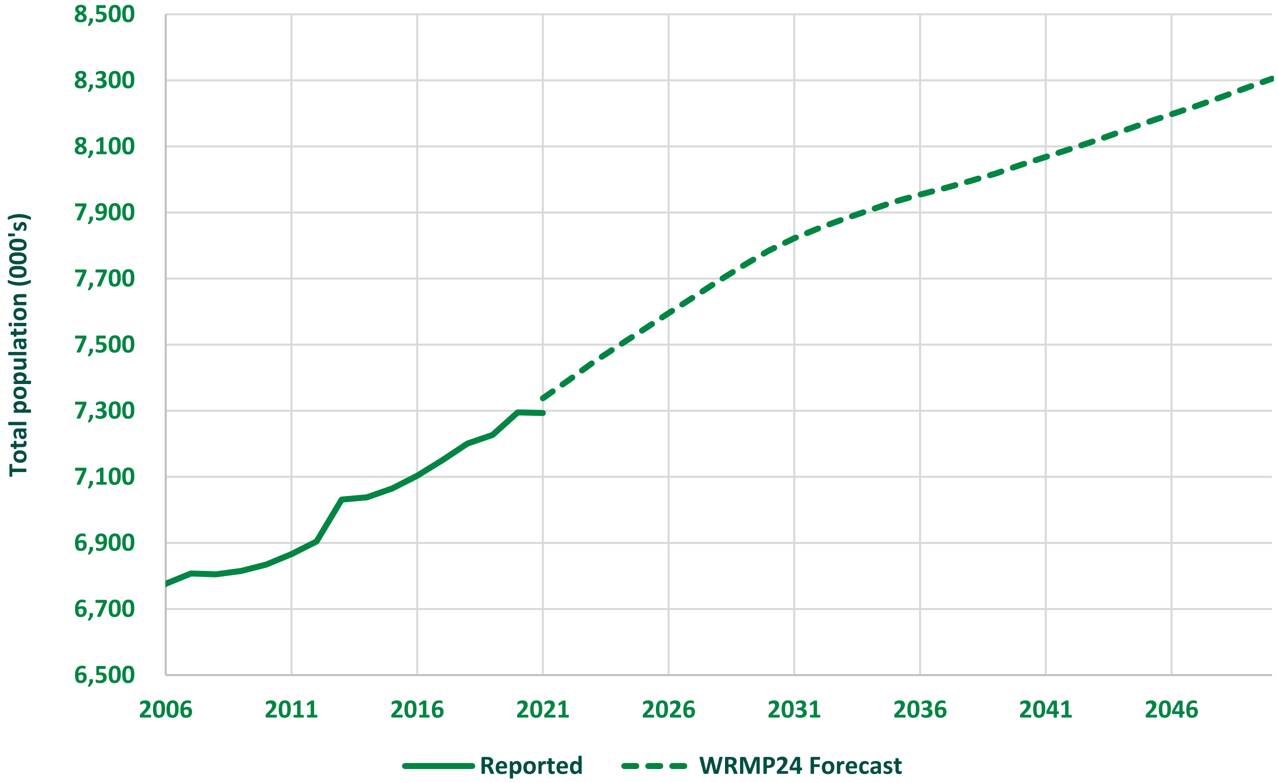
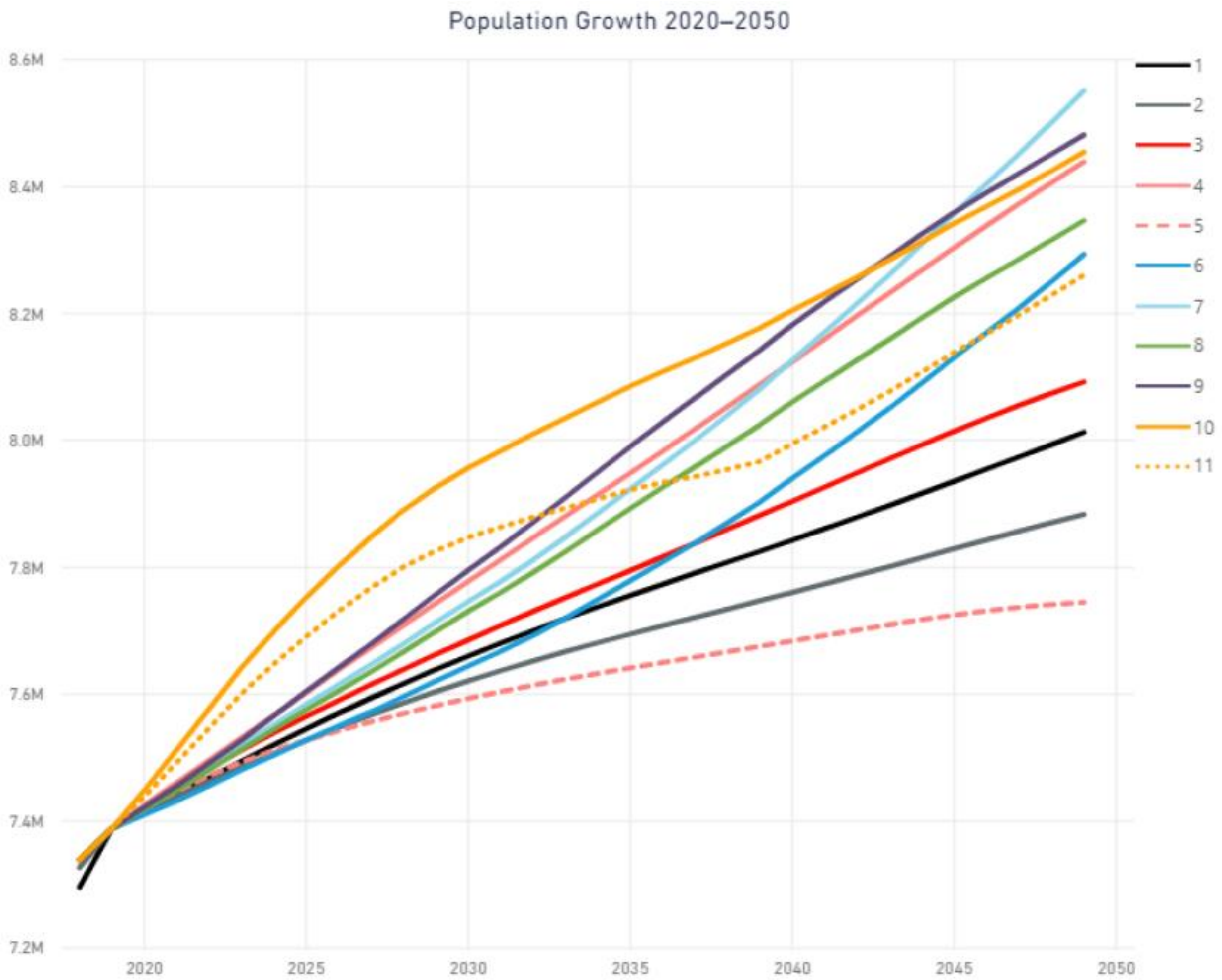


Figure 7 Population forecasts based on the various scenarios assessed



3.1 Occupancy and household size

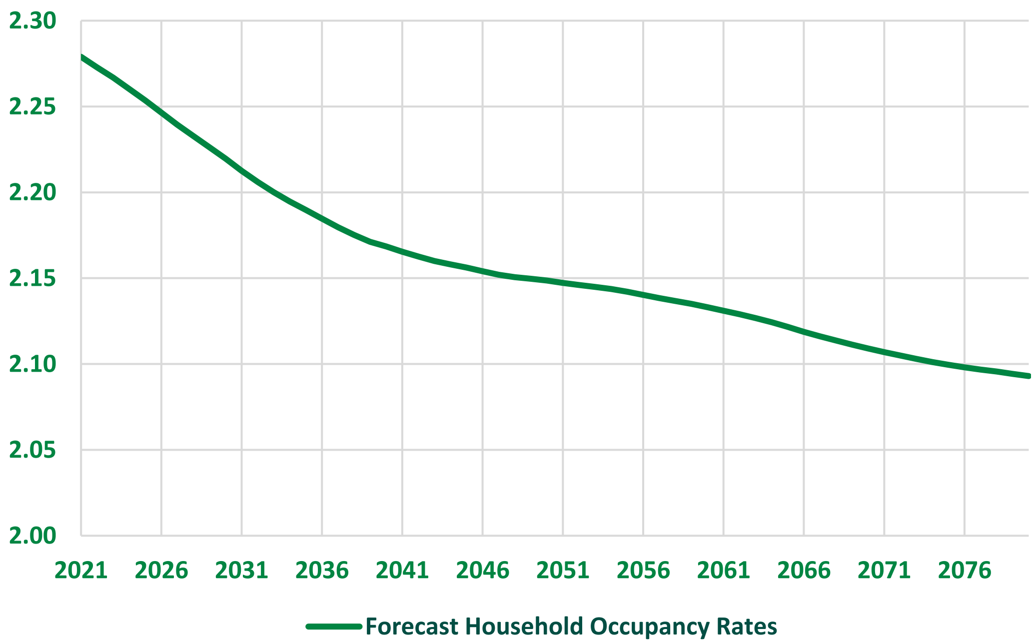
The outputs from Edge Analytics' work includes forecasts of household population and household property numbers in each of the company's water resource zones. From this data they have also derived forecasts of average household size or occupancy rates. The number of people in each household influences the overall water consumption in each property and also the average consumption per person, as the average per capita consumption (PCC) tends to be lower in larger households. In addition, the occupancy rate tends to be lower in measured properties compared to unmeasured properties, reflecting the greater incentive for smaller households with lower overall consumption to switch to a metered supply.

A key component of any housing-led population and property forecast is the average 'occupancy' associated with the changing housing stock. The general 'aging' of the UK population results in a reduction in average occupancy, with the older population typically having smaller occupancy levels compared to the younger population. Since the financial crash of 2007/08, a counter-trend brought about by both financial constraints and a mismatch between demand and supply of new homes, has seen a reduction in the speed at which young adults are able to form new households, resulting in a dampening of the rate of occupancy reduction. These factors are considered in the housing-led analysis, however future occupancy surveys will help understand how long-term this counter-trend will be. Occupancy rates will be updated according to any new evidence of change.

In previous Water Resources Management Plans, we have based our assumptions about household occupancy rates on surveys of household size undertaken in 2003, 2007, 2011 and 2016. For this draft Water Resources Management Plan, we have adopted the reported occupancy rate (based on a recent survey in 2020/21) and applied the year on year forecast from Edge Analytics thereafter.

Figure 8 shows the forecast decline in average occupancy rates, reflecting a general trend towards smaller household sizes across our region.

Figure 8 Forecast trend in United Utilities Water's average occupancy rates from 2021



3.2 Void billing strategy

At any given time, a small proportion of properties within our region will be classified as 'void'; these are properties which are not currently on the company's billed database, because there is no owner or tenant registered as responsible for the payment of the water bill. This may be due to the property being currently unoccupied, however this is not always the case. In 2019/20, approximately 40% of void household properties (which is 7% of total household properties) were believed to be occupied and the company's strategy is to progressively bill as many of these households as possible in the near future. As a result, a significant number of occupied void properties are projected to be removed from the void pool and added to the measured or unmeasured household category. Adjustments to the projected water consumption for each of these categories have therefore been made, in order to account for the water use within these properties. Corresponding reductions have also been made to the Water Taken Unbilled component of the demand forecasts, which normally includes any illegal (unbilled) water use in void properties.

The adjustments to the components of the water balance to allow for the void billing strategy are outlined in sections 4.1 and 6.1.

For our revised draft plan, we have refreshed the AMP7 forecast of void properties in light of more recent data and have re-calculated the void billing adjustment calculation. We have also refined the longer-term forecast of void properties through the planning period to account for the change in void properties. This is reflected in the WRMP24 tables (34.6BL/FP) as an adjustment to reflect the movement of properties between unbilled and billed categories. This is due to a range of factors, for example, the void billing strategy but also property deletions (properties that become void before being demolished). The overall impact on demand is very small (less than 1 Ml/d) but does serve to increase water taken unbilled by approximately 8 Ml/d by 2050 (and decrease household consumption by the same amount).

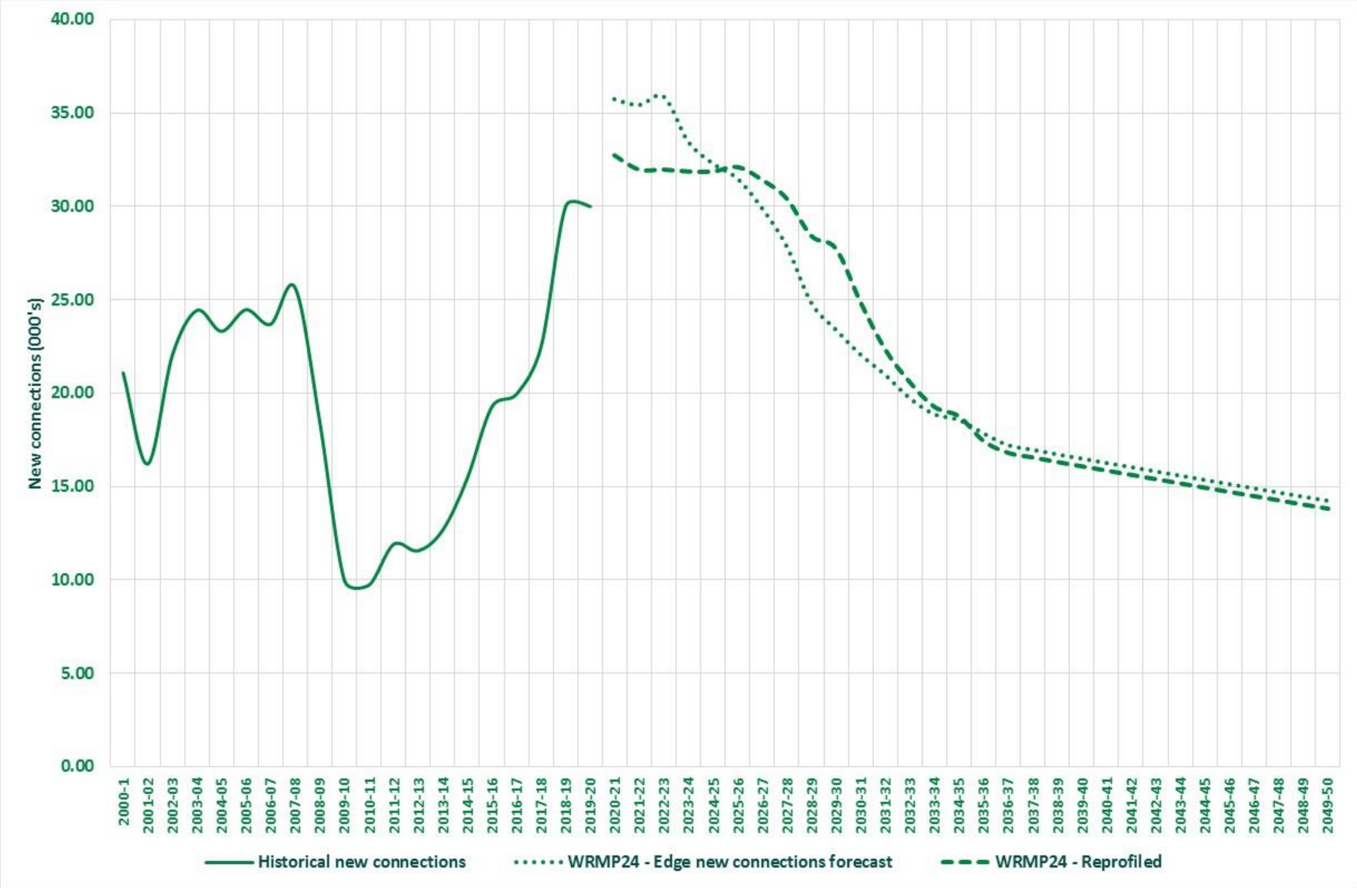
Once we have applied the AMP7 void billing strategy forecast, we have assumed the total number of void households are held at fixed percentages of total household numbers (measured and unmeasured). Net property management changes from 2025/26 onwards are then calculated from the assumed numbers of voids in each year, relative to the previous year, allowing for the small, assumed numbers of deletions.

The forecast of non-household voids in AMP7 were derived from PR19 and then held flat for both measured and un-measured non-household voids from 2025/26 for the rest of the planning period.

3.3 New connections

Our local authority plan-based (trajectory) property projections, prepared by Edge Analytics, are used to derive the annual forecast numbers of new household connections. Figure 9 shows that an upward trend in new connections since around 2011 was forecast to continue until 2021, and then the annual rate is forecast to remain steady before gradually declining over the remainder of the planning period. We chose the housing ‘trajectory’ forecast because it gives us a view of what councils intend to build in the short to medium term (5–20 years), which includes a significant demand for new properties. This presents a more ‘front-loaded’ view of property growth compared to the housing ‘need’ forecast. However, we have seen a recent increase in new connections over the last 3–4 years in line with the WRMP15 and WRMP19 forecasts, albeit slightly delayed. This may bring forward the investment timeline for certain options, however we want to ensure that we don’t constrain planned growth throughout the planning period, not just in the long term. There is uncertainty in whether this level of household new connections will be maintained into Asset Management Period 9 (AMP9), however discussion with industry suggests that it will.

Figure 9 Long-term trends in new household connections in United Utilities Water's region, with housing-plan led 'trajectory' forecast from 2020 (re-profiled from 2020–2030)



It has been recognised that forecasted growth in AMP7 (our 2020–25 investment period) is too high compared to 2019–20 reported values (32,000 compared to around 36,000 properties per year in total). This is largely because there was a delay (partly due to COVID-19) within the industry of the building of new homes, however the demand for new properties remains high (and is anticipated to remain high through AMP7, AMP8 and into AMP9). We sought recommendations from industry experts who suggested that the demand for new properties is likely to remain buoyant right through AMP8 (our 2025–30 investment period), for the following reasons:

- Reduction in land availability over the last five years, due to a combination of factors including uncertainty following the Brexit referendum, delays in the Greater Manchester Spatial Framework (GMSF), and significant growth in the industrial land market limiting availability of residential land and delays in decision-making due to the impact of the recent COVID-19 pandemic;
- Increased demand for the building of new properties, from traditional house builders, large regional developers and regional developer/contractors supplying the Registered Social Landlord (RSL) market - the RSL sector is increasing in importance and experiencing an increase in funding;
- Increasingly, major investment institutions are diversifying from property and city centre residential into the suburban housing market, contributing to an increase in the PRS (Private Rented Sector/Build to Rent) market;
- Significant demand increase from new entrants to the housing sector in the North West; and
- Both the RSL and the PRS markets are less susceptible to market downturns than their traditional 'for sale' competition and therefore may be more resilient to the potential effects of post-pandemic recession on the land market.

Industry experts also noted that local authority housing plan projections are typically front-loaded, reflecting a general need to accelerate the rate of new house building across local authorities in England. These projections often assume increased completion rates compared to historical rates; the scale of uplift is ambitious particularly in the context of recent impacts of the COVID-19 restrictions. In practice, therefore, the planned housing growth is more likely to be more evenly phased across the AMP7 (2020–25) and AMP8 (2025–30) plan periods, rather than being weighted towards the earlier AMP7 period.

We accounted for this feedback in the baseline forecast by re-profiling the housing plan 'trajectory' from Edge Analytics (for the Strategic Resource Zone only) to provide a more realistic view across both AMP7 and AMP8. This 'smoothing' of the new connection forecast effectively moves some anticipated property growth (for certain local authorities) in AMP7 into AMP8, ensuring that the total number of properties forecasted to be built remains the same by the end of AMP8 (Table 6). Ultimately, the new connection forecast underpins the total number of homes and therefore the household population forecast. Overall, the impact of re-profiling household properties and population through AMP7 into AMP8 has no impact to the overall growth forecast (and subsequently demand) by 2030 however slightly reduces the total number of properties (and population) at the end of AMP7. Considering the small numbers when re-profiling the growth forecast, the impact on option selection date is negligible.

For our revised draft plan we have reviewed the local authority plans to identify whether there have been any major changes, i.e. have the total numbers of properties planned to be built in the specific local authority plan recently changed? We found that there was very little difference in local authority's growth estimates, therefore we have not changed our household new connection forecast since our draft plan.

Table 6 Impact of re-profiling the housing plan 'trajectory' in AMP7 and AMP8*

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Region – housing trajectory (000s)	2'955	2'990	3'026	3'061	3'095	3'128	3'159	3'189	3'217	3'241	3'265
Region – housing trajectory (000s) – reprofiled	2'955	2'987	3'019	3'051	3'083	3'115	3'147	3'179	3'209	3'237	3'265
Difference in household dwellings (000s)	0.0	-3.0	-6.5	-10.5	-12.1	-12.6	-12.0	-10.5	-7.9	-4.4	0.0
% difference in household dwellings	0.0	-0.1	-0.2	-0.3	-0.4	-0.4	-0.4	-0.3	-0.2	-0.1	0.0

*This excludes the void billing strategy in AMP7 where unbilled properties are moved to billed (section 3.2)

3.4 Limitations of growth forecast

Our property and population growth forecasts adhere to the Water Resources Planning Guideline requirements, which state we must not constrain any planned growth when constructing our demand forecast. As with any forecasting approach, there are associated limitations.

3.4.1 Household property forecast

One of the main limitations of applying the local authority 'trajectory' forecast to the property forecast is historically, it has been shown to overestimate the number of new properties being built, especially in the short term. The trajectory forecast is effectively the number of properties built that the specific local council thinks can be delivered. This essentially front loads the forecast of new properties into the first two AMPs in the planning period. However, the overall total number of planned property builds is the same for the trajectory forecast and the policy 'need' forecast, therefore the main difference is the timing of when the properties are expected to be built. Observed property builds since 2019 show that the trajectory forecast remains the best predictor for future property builds in our region, as the build rate remains higher than the historic period since the mid-1990s.

3.4.2 Household population forecast

There are several limitations when deriving a household population forecast:

(1) Occupancy (base year – FY20): This is derived from survey of a selection of customers in 2021. Whilst the sample target and size was considered representative of metered and unmetered customers, there is uncertainty attached as a consequence of any sample based survey.

(2) Occupancy (forecast): This was derived from Edge Analytics which shows a small and gradual decline in average occupancy (i.e. 2.3 in base year to 2.15 by 2050). This reduction is a consequence of people moving out of higher occupancy homes into new builds. This is offset as a result of the 2008 credit crisis (and recent increase in interest rates) which has limited the movement of younger groups of people into new homes. The long term impact on occupancy rate is uncertain as a consequence of market forces.

(3) Housing-led population forecast: This is linked directly to the local authority trajectory forecast. A key assumption of a housing led population forecast is that, specific developments can lead to additional people being attracted into our region over and above natural population changes and international migration. This has the potential to over-estimate household population. However over the last 5 years. The housing-led population forecast has been shown to be a much better predictor than the policy based forecast (Figure 5).

3.5 New Appointments and Variations

Since we published our revised draft WRMP24, we received a request for further information from the Department for Environment, Food and Rural Affairs (Defra). Within this letter, we were requested to update our forecasts to align to those submitted by New Appointments and Variations (NAVs) in their revised draft WRMPs.

As stated in our response to Defra which was published on our website, we have aligned our baseline dry year annual average demand forecast with NAV plans. At the time of this analysis, there were four NAVs in total where UUW acts as the incumbent; ESP, ICOSA Water Services Ltd. (ICOSA), Independent Water Networks Ltd. (IWNL) and Leep Water Networks Ltd (Leep). We aligned our potable water exports to NAV forecasts by using their forecasts for final plan distribution input from their revised draft WRMP Table 18, which reflects their forecasted export requirements. We have therefore reduced our own demand forecast components accordingly in our Strategic and North Eden Water Resource Zones and adjusted our population and property forecasts. There has been no impact in Carlisle or Barepot resource zones. Our demand forecast for new connections is based on our methodology (section 3.3), which is different to those used by NAVs in their individual WRMPs. We have updated the WRMP24 tables with the changes to demand components, distribution input, contractual volumes, property and population.

The impact on our final plan demand forecast for the Strategic RZ in 2025/26 is a reduction of 4.08 Ml/d. In addition, there is a minor reduction in our demand forecast for the North Eden RZ in 2025/26 of 0.015 Ml/d. We have updated exports within the Technical Report – Supply forecast accordingly.

4. Household consumption

Household consumption is the volume of water supplied to all domestic customers, and accounts for just over half of all the water produced by our water treatment works. It includes both measured (metered) and unmeasured water consumption in household properties. Currently around 47% of households in the North West have a meter installed; this percentage is increasing over time as more customers opt to have a free meter installed, and all new household properties are automatically metered. We continue to support and encourage customers to be efficient with their water usage. Projections of likely future household consumption form a key part of our demand forecasts.

4.1 Forecasting method

Household consumption forecasts need to take into account factors such as population growth, climate change impacts, the effect of year-to-year weather variation, and peak demands which occur within years. Through WRW, we worked with Artesia to develop our household consumption forecasts.

Forecasts of measured and unmeasured household consumption for our water resource zones, and for the region as a whole, were provided by Artesia. The micro-component modelling approach was used by Artesia to derive these forecasts, and is summarised below.

The household consumption in each year is broken down by the following water activities (micro-components):

- Toilet flushing;
- Personal washing;
- Clothes washing;
- Dishwashing;
- Miscellaneous internal use; and
- External use (garden sprinklers and hosepipes etc.).

Micro-component modelling techniques are used to quantify the water used for specific activities (i.e. those listed above) by combining values for ownership (O), volume per use (V) and frequency of use (F). For example, per capita consumption (PCC) or per household consumption (PHC) can be modelled as:

$$PCC\ or\ PHC = \sum_i (O_i \times V_i \times F_i) + pcr$$

Where:

O is the proportion of household occupants or households using the appliance or activity for micro-component i,

V is the volume per use for i,

F is the frequency per use by household occupants or households for i,

pcr is per capita residual demand.

By applying this together with the population or property data, a water demand model can be formed. By forecasting changes in each of the variables (O, V, F or daily water use for each micro-component) over time, a water demand forecast can be created. Hence the micro-component forecast model requires estimates of changes in these variables, to reflect future changes in technology, policy, regulation, and behaviour.

Several national datasets have been used in building this model, to increase the understanding of historic and recent micro-component consumption. Historic micro-components are extracted from the WRc CP187 report (WRc, March 2005) and recent micro-components are extracted from an UKWIR study, (UKWIR, 2016).

This is micro-component data that has been collected by measuring the different micro-components used within the household (as opposed from survey questions and assumptions). This allows ownership (O), volume per use (V) and frequency of use (F), to be calculated for each micro-component. There were two main sources of data for this:

- 2015-16 data collected using the Siloette system
  - A sample of measured billed households, with associated occupancies and demographic information on the households, collated during an UKWIR Study (UKWIR, 2016). This contains 62 households from around England and Wales.
  - A sample of unmeasured billed households, which do not have associated demographics (collated from other anonymous Siloette studies carried out by Artesia Consulting, from England and Wales).
- 2002 – 2004 *O*, *V*, and *F* data collected using the Identiflow system (a sample of unmeasured billed households, (WRc, March 2005)).

Both the Siloette and Identiflow systems measure the flow into a property and compute the individual micro-components through pattern recognition (although the detailed methodology of the two systems is different). The UKWIR micro-component data for measured billed households were used for the modelling, because this dataset has a complete set of occupancy data for each household over the logging period. Table 7 and Table 8 provide more detail on the breakdown of micro-component volumes.

Micro-component calculation example: **Toilet Flush in a new build house with two occupants**

Ownership (O) = 1 (i.e. 100 % of all household properties have a toilet)

Volume per use (V) = 5.5 litres – New build

Uses per day = 6.143 + 3.7744 x ln (occupancy)[4]

Daily use (l/prop/day) = 1 x 7.58 litres (new build) x (6.143 + 3.7744 x ln (2)

= 5.5 x 8.76

= 52.6 litres per property per day

Table 7 Example Micro-component volumes dependent on meter status (toilet flushing)

Property type	Toilet Flush (mean litres/flush)
Unmeasured household	7.6
Existing measured	7.3
Optant	6.0
New build	5.5

Table 8 Breakdown of micro-component litres per property per day (FY20 DYAA)

Micro-component	Measured (l/prop/day)	Unmeasured (l/prop/day)
Toilet flushing	56.0	83.2
Personal washing	107.0	151.1
Clothes washing	31.6	44.0
Dishwashing	24.9	34.7

[4] In the case of toilet flushing, the number of flushes varies with occupancy. In this case, there a logarithmic relationship of frequency of use versus occupancy. A similar effect occurs under personal washing and clothes washing. For other micro-components like Dishwashing, External use and Miscellaneous internal use, daily use (l/prop/day) is simply 'Ownership x Volume per use x Frequency of use'.

Micro-component	Measured (l/prop/day)	Unmeasured (l/prop/day)
Miscellaneous internal use	28.8	48.5
External use	8.0	11.2
Total per household consumption	256.2	372.7

The final PHC or PCC household consumption values built up from the micro-component model are then multiplied by either the number of households (for PHC) or the number of people (for PCC) to obtain total household demand.

Relationships of the type outlined above are determined on the basis of population and property forecasts separated into categories, including unmeasured, existing measured, compulsory measured, optants and new properties, using the most recent available data on ownership, volume per use and frequency of use as appropriate for each micro-component. Rebasing of the data is undertaken to ensure consistency with the observed base year data (FY20). Future trends/assumptions are then incorporated into each linear model to reflect likely trends due to technology developments, policies and regulation, and behaviour change relating to each activity. These are based on several national datasets drawn from a number of recent studies, including a Water Research Centre CP187 report (WRc, March 2005) a UK Water Industry Research (UKWIR) study, (UKWIR, 2016) and Defra's Market Transformation Programme (MTP). We have also adjusted our forecasts of household consumption to take account of changing patterns of demand due to the effects of the COVID-19 pandemic (Section 7.5).

Whilst the micro-component method is the industry standard for forecasting household consumption, there are some limitations to this approach. The micro-component model uses national micro-component and occupancy data and is calibrated to the UUW operating area via the allocation of household to different metered groups. Whilst this approach is robust and is used effectively at a resource zone level, there will be limitations when applying the method locally. For WRMP29, we will look for opportunities to improve the method where possible. For example; collection of more data for the estimation of micro-components for new-build properties. This could be more important where this property type starts to become dominant against metered households in later parts of the planning period, given the rate of meter optants is low.

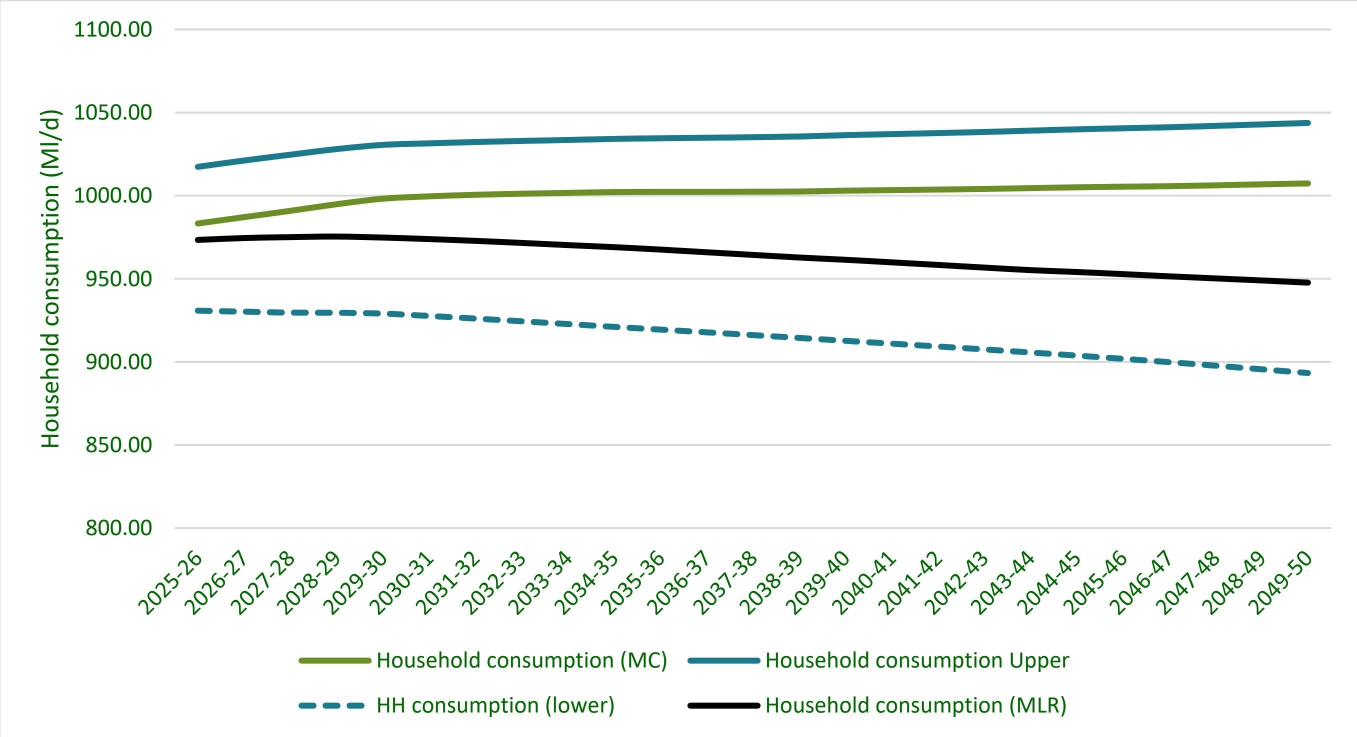
4.2 Forecasting methods review

In conjunction with Artesia, both micro-component (MC) and Multi Linear Regression (MLR) approaches were developed in order to derive the household consumption forecast – though in agreement with other water companies in WRW, we decided to retain the micro-component analysis approach (used in both WRMP15 and WRMP19) for our household consumption forecast in WRMP24.

Multi linear regression is an alternative approach to the micro-component assessment and uses standard statistical processes to develop relationships between historic demand and the explanatory factors that influence demand (similar to non-household consumption forecast method). These include household occupancy, property type/size and some measure of socio-demographics. We used the outputs from the MLR method to help better understand the level of uncertainty in our approach.

We compared the forecasts of HH consumption using micro-component analysis versus multi-linear regression analysis, and whilst the latter falls within the uncertainty ranges, it is lower than the forecast from the micro-component analysis approach (Figure 10). Considering the outcome of the problem characterisation assessment (Carlisle and Strategic Resource Zones have increased in strategic need and complexity since WRMP19 – see *Main Report*), the micro-component analysis was deemed the better of the two approaches for WRMP24.

Figure 10 MC versus MLR forecasts of household consumption



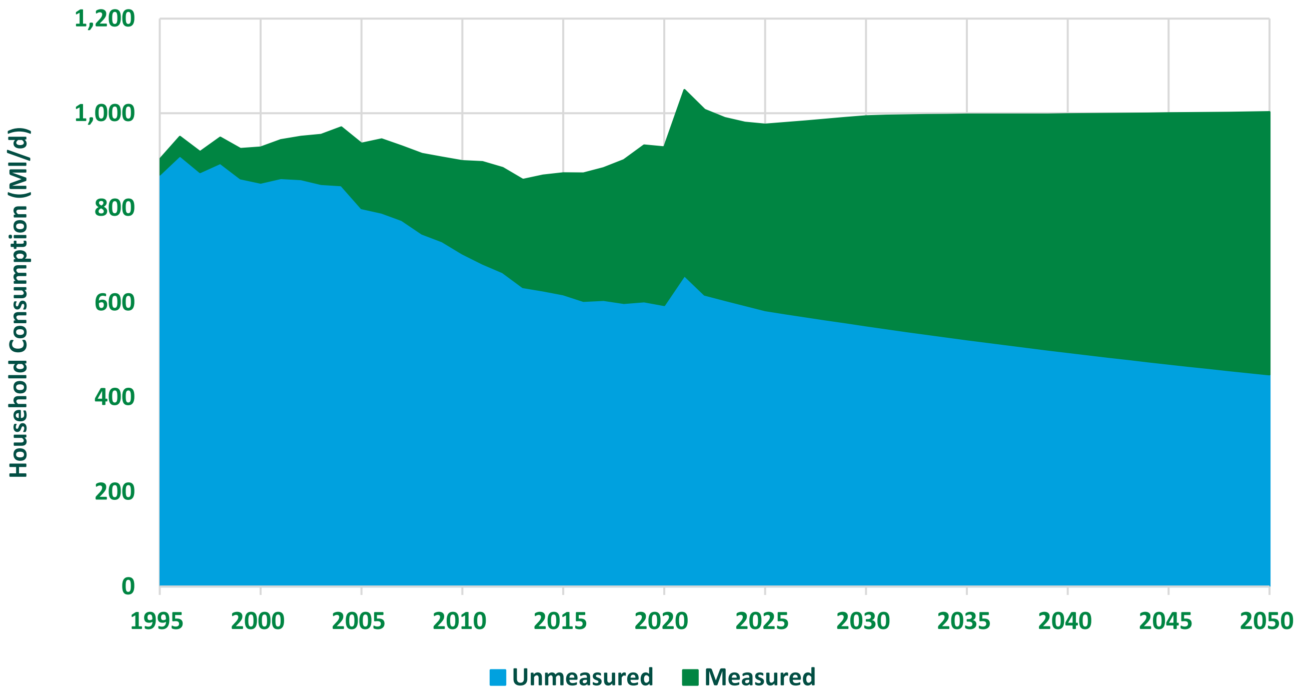
4.3 Customer metering and tariffs

We install meters in all new properties, and under our free meter option scheme we promote household customers to opt for a meter. The number of unmeasured non-households is relatively small following a programme to compulsorily meter unmeasured non-households several years ago (where practical to do so). Household customers, therefore, drive most of the annual growth in metering. Under current legislation, we are not permitted to implement compulsory metering as our region is not classified as a water-stressed area. However, our metering strategy based on our Lowest Bill Guarantee scheme, targeted at those customers most likely to benefit financially from a move to a meter, has been supplemented by a proactive enhanced metering programme to improve our delivery of meter installations. This includes metering customers on change of occupancy.

The number of customers opting for a free meter installation is generally expected to decline in the future; as the metering penetration increases, the number of unmetered customers who still stand to benefit most from a free meter reduces. Our baseline demand forecasts within this plan are based on an assumed proportion of unmeasured households (1%) opting to switch to a metered supply in each year without any encouragement from United Utilities Water. Our final plan builds on our enhanced metering programme and includes options that deliver a large smart (Advanced Metering Infrastructure or AMI) metering programme.

Figure 11 shows the historic trends in measured and unmeasured household consumption (to 2019/20) and the forecasts from 2020/21 to 2049/50, based on Artesia's 'Baseline scenario' forecasts with 1% meter optant switching per year and population growth based on Local Plan housing growth trajectory. Note that we are committed to our metering targets for 2020–25, which are included within our baseline forecast through our PCC target of 135 litres/head/day.

Figure 11 Measured/unmeasured household consumption trends and projections – United Utilities Water region



4.4 Scenarios and assumptions

During the development of our Water Resources Management Plan, we tested a range of different scenarios for our forecasts of household consumption, based on different assumptions regarding the housing and population growth, rate of meter switching and other factors. We selected the most likely forecast to adopt for our plan; this forecast is used in our analysis of the baseline supply-demand balance to assess the potential timing and magnitude of any future supply-demand options which may be required. As part of our draft submission, considering the impacts from Covid-19, household consumption was significantly elevated which led to a higher end of AMP7 PCC target of 138 litres/head/day by 2025. In light of more recent actual data, PCC has dropped since 2022 as a consequence of the reduction in impact from Covid-19, therefore we now expect to meet the PR19 target of 135 l/p/d. This has been reflected in our plan.

We recognise that there are a range of factors affecting future demand for water, and the changing patterns of demand due to the COVID-19 pandemic, economic and migration factors and climate change impacts mean that it has become more challenging to forecast future demand. While we aim to employ the best available data and methodologies to forecast future demand, there is inevitably uncertainty inherent within our forecasts. In order to account for this uncertainty, we also selected a 'lower' and 'upper' demand forecast to represent the possible range of forecasts. The lower and upper range of our demand forecasts are incorporated into our target headroom allowance (the margin between supply and demand to allow for uncertainty in the various components of the supply-demand balance). Further details are given in Section 8. The household consumption forecast assumptions are summarised in Table 9.

Table 9 Summary of household consumption forecast assumptions

Scenario	Housing/ Population Growth	Optant metering assumption[5]	Description
Scenario 15 ('Lower' forecast)	ONS-18-Low-L	1.5% of unmeasured	ONS 2018 trend-based scenario; low long-term UK net international assumption; annual metering uptake 1.5%; and low growth outcome 2050–2100.
Scenario 14 ('Most Likely' forecast)	Housing-Plan-P Re-profiled	1% of unmeasured	Housing-led scenario; population growth based on Local Plan housing growth trajectory with new connections re-profiled over AMP7 and AMP8; annual metering uptake 1%; high growth outcome 2050–2100; and uses Edge occupancy rates.
Scenario 11 ('Upper' forecast)	Housing-Plan-H	1% of unmeasured	Housing-led scenario; population growth based on Local Plan housing growth trajectory; annual metering uptake 1%; high growth outcome 2050-2100; and uses Edge occupancy rates.

[5] Percentage of remaining unmeasured customers opting for a meter each year.

5. Non-household consumption

Non-household consumption is the volume of water we supply to all our commercial and industrial customers. The majority of non-household customers are metered, and non-household demand accounts for just over twenty percent of the total volume of water produced by our water treatment works. Projections of non-household consumption are a key part of our demand forecasts and are linked to assumptions relating to economic growth and environmental protection policies, for example the extent to which tariffs and pricing structures influence the uptake of water efficiency measures within industry and business.

5.1 Non-household forecasting method

The baseline non-household (NHH) consumption/usage forecast uses an econometric, multiple linear regression (MLR) model, which has been produced for four cohorts of industrial sectors (agriculture, non-service industry excluding agriculture, service industry – population and economy driven). It uses factors that include population, gross value-added metrics, employment rates, population density and other factors where the modelling aims to find a linear relationship between historic observed consumption and these factors. This work was undertaken in collaboration with the other companies in Water Resources West.

Our forecasting approach, based on an econometric model of non-household consumption, relates changes in consumption to projected changes in industrial growth taking account of the ongoing efficiency trend in water usage. The model takes into account the changes in the non-household sector arising from market separation and uses Market Operator Services Ltd (MOSL) data. The baseline forecasts include existing water efficiency initiatives planned by both the wholesaler and retailer, but exclude any further interventions as these will be considered as part of the final planning forecasts through options.

Since the last set of non-household forecasts were completed for WRMP19, the non-household retail sector has undergone a transformation with the introduction of retail competition. In England, this allows all eligible (Ofwat's Eligibility guidance, 2020, for further information) business customers and public sector, charitable and not-for-profit organisations to choose their water supplier (retailer). Non-household customers in Wales who abstract greater than 50 megalitres per annum are able to choose a different supplier for water retail services. A significant impact from this is that metered non-household consumption data is now the responsibility of retailers, managed by the new MOSL. We have observed a change in data quality and consistency since the change in 2017, which has increased the uncertainty around the demand forecasts (which relies on a consistent set of time series data). We have addressed this by mapping sectors (i.e. the paper industry) to MOSL data prior to sending to Artesia, which has significantly reduced the uncertainty.

We plan to drive efficiency with non-household customers, and we will engage with retailers to help implement efficiency measures. It is important to add that driving efficiency in non-household demand is part of a road map where for WRMP24 there is a period of transition, and that the current barriers, enablers and frameworks for non-household efficiency are likely to be subject to change in the short, medium and long term as all groups work together to deliver greater water savings in this sector. Water efficiency in the non-household sector can be delivered through various options including business audits, site leakage reduction measures, device retrofits and behavioural engagement. Further information can be found in our *Technical Report – Options identification*, which focuses on efficiency in certain sectors.

Our assumptions regarding water efficiency for WRMP24 are treated separately to our actions in a drought. For example, there are further demand efficiencies assumed in a drought such as temporary use bans (hosepipe bans). Further information regarding the potential introduction of a drought order to ban non-essential use can be found in the Demand-side options technical report as part of our Drought Plan.

The methodology adopted for the preparation of non-household consumption forecasts is based on trend and regression econometric models and involves the following key steps:

- **Engagement with retailers:** through online or telephone questionnaires with key retailers in our region to obtain estimates of future demand (and effects of water efficiency) and how these might change under a range of future scenarios. This was also done in line with the 'supplementary guidance on retailer involvement in water resources planning';

- **Data collection**: review and audit of key data including billing extracts of non-household customers' water consumption, annual returns summarising non-household consumption by resource zone, population data and forecasts, Standard Industrial Classification (SIC) codes for each non-household customer and a range of economic forecasts/indicators (with those produced by Oxford Economics being the most useful);
- **Scenario development**: specify the time period and scope of a coherent and compatible set of scenarios, based on known economic drivers with uncertain outcomes (Brexit, HS2, Northern Powerhouse, COVID-19), and other factors such as tariff models, regulation, policy changes, behaviour change and the introduction of new water efficiency technology;
- **Modelling and forecasting**: review trends in the data, segment non-household consumption by sector using SIC code and build multiple linear regression (MLR) models between demand and econometric factors for each segment. The modelling methodology is based on the current EA water resources planning guidelines, the latest guidance from Ofwat on the definition of non-households following market separation, and current UK Water Industry Research (UKWIR) best practice guidance; and
- **Uncertainty analysis and climate change modelling**: once models have been built, tested and refined as required, further enhancements are made to incorporate the impacts of future climate change, based on an assessment of the weather influence on demand in specific non-household sectors. Uncertainty analysis is undertaken to determine the upper and lower range of uncertainty for each forecast, by resource zone and by non-household sector where possible.

5.1.1 Retailer engagement

In light of the retail-wholesale model of operation for non-household customers in England, WRW wanted to engage with retailers in the United Utilities Water (UUW), Severn Trent and Hafren Dyfrdwy company areas, in order to understand and incorporate their views of likely future water demand and water efficiency strategy.

UUW and Severn Trent Water joined together to create a new company – Water Plus – when the retail-wholesale model was created for non-households. This meant that by default, both companies' existing non-household customers became Water Plus customers following the market change in 2017. As a result, the vast majority of non-household customers in the Severn Trent and UUW areas are supplied by Water Plus. This is illustrated in Table 10, which shows the percentage of unique non-household 'Supply Point IDs' (SPIDS) by the top nine retailers in the UUW operating area.

Table 10 Percentage of SPIDS served by the top 9 retailers in the UU area

Retailer	Total SPIDs	% SPIDs in area
Waterplus	385,017	90.75%
Everflow	10,104	2.38%
Business Stream	6,934	1.63%
Wave	6,541	1.54%
Clear Business Water	4,309	1.02%
SES Business Water	2,461	0.58%
Castle	2,394	0.56%
Water 2 Business	1,935	0.46%
Pennon	917	0.2%

A survey (Table 11) was issued to the top retailers within our region and was followed up by tailored emails and phone calls with retailer contacts with the aim of arranging interviews. Four retailers were willing to be interviewed: Waterplus, Wave, SES Business Water and Water 2 Business.

Table 11 Questions asked to non-household retailers

#	Question
1	Overall, do you think your customers' water demand is likely to go up, down or remain the same in the next year, especially following the COVID-19 lockdown?
2	Overall, do you think your customers’ water demand is likely to go up, down or remain about the same in the next 5 years?
3	Overall, do you think your customers’ water demand is likely to go up, down or remain about the same in the next 25 years?
4	Overall, do you think your customers' water demand is likely to go up, down or remain the same following the end of the Brexit transition period (1st January 2021)
5	Overall, do you think your customers' water demand is likely to go up, down or remain the same as a result of the Northern Powerhouse initiative
6	Overall, do you think your customers' water demand is likely to go up, down or remain the same as a result of HS2 infrastructure investment
7	Has your organisation made a commitment to promote water efficiency to your customers?
8	Does your organisation have a water efficiency policy?
9	Has your organisation set targets for water efficiency?
10	Does your organisation provide a water efficiency audit service to customers?
11	Have you currently got any water efficiency devices/initiatives that you have implemented? Can you provide details please
12	Does your organisation promote water efficiency in your bills, website, elsewhere? Can you provide details please
13	Based on your responses to questions 10 and 11, do you provide these services to all your customers, or a subset of them? Can you provide details please
14	If you have answered no to either of questions 10 and 11, do you intend to offer any of these services in the future? Can you provide details please

With regards to views on future demand, feedback from Water Plus is particularly important, given its market dominance. They believed overall demand is likely to stay broadly the same over the same 5 to 25 year horizon. This feeling was mirrored by SES Business Water and Water 2 Business, however Wave felt demand may increase depending on the increased level of UK–based manufacturing that could result from the EU referendum.

Considering water efficiency, retailer responses were more varied than for future demand. For example, Water Plus has a water efficiency commitment, set targets and provide customer audits, depending on the category of customer. However, it was clear from the discussion with Water Plus that their high volume, low margin business model makes delivering water efficiency challenging. In contrast, Wave Utilities, who are more focused on public sector customers, provide more customer specific water efficiency support who see large retrofit projects as an ideal opportunity to install water efficient products.

5.2 Scenarios and assumptions

Forecasts of measured and unmeasured non-household consumption have been provided by Artesia for seven different scenarios. The seven initial scenarios are characterised in terms of two of the main drivers of future water availability/consumption – economic growth and environmental protection. The initial scenarios take account of specific drivers including COVID-19, Brexit, HS2 and Northern Powerhouse, and other drivers and response measures identified in Artesia's work on scenario development, along with feedback from retailers, collected via one-to-one surveys.

The non-household consumption forecast scenarios are summarised in Table 12 below. These scenarios provide a range of possible futures to test our plan for optimal balance between affordability and resilience.

Table 12 Summary of non-household consumption assumptions

Scenario	Title	Description
S0	Current landscape and ambition	Existing (summer 2020) non-household demand for water. Future demand continues along the same trajectory as in current plans. This is suppressed (lower than current WRMP19 forecast) because of the Coronavirus pandemic.
S1	High resilience	Economic growth is partly driven by strategic investment (e.g. HS2 and Northern Powerhouse) and is also facilitated by technological change and innovation. This is matched by high environmental standards aimed at addressing increased water scarcity, leading to a greater focus on water efficiency, reuse and collaborative working/circular economy.
S1a	High resilience (high popn.)	As S1 but with upper population forecast instead of central population forecast.
S2	Constrained growth	Economic growth is limited by the need to protect and enhance the environment, leading to legislative and regulatory policies that drive more efficient water use, and by the use of pricing and tariffs.
S3	Spare capacity	Economic growth is heavily impacted by the Coronavirus pandemic and Brexit, as well as by low levels of innovation and low population growth. Environmental protection is given a low priority and there is spare capacity in the provision of water services, with water efficiency and demand management measures deemed largely unnecessary.
S4	Economy First	Economic growth is promoted and encouraged through delivery of HS2 to the Midlands and via the Northern Powerhouse programme in the North West, resulting in higher than average growth in both the service and/or non-service sectors. Water companies need to identify new potable and non-potable sources to maintain the supply demand balance. Collaboration among water companies and between sectors is limited, with a greater focus on competition.
S4a	Economy First (high popn.)	As S4 but with upper population forecast instead of central (most likely) population forecast

Figure 12 and Figure 13 show the forecasts from 2025/26 to 2049/50, based on scenario S0. From a target headroom perspective, we have chosen S4a (Economy first) for the upper forecast and S2 (Constrained growth) for the lower forecast (Table 13). The final agreed scenarios are consistent with other water companies as part of Water Resources West.

Table 13 Uncertainty ranges in the non-household demand forecast

Element of non-household demand (uncertainty range for target headroom)	Scenario name	2025 (Ml/d)	2030 (Ml/d)	2050 (Ml/d)
Total non-household consumption (baseline forecast)	S0 – ‘Current landscape’	353.7	349.0	334.0
Total non-household consumption (upper forecast)	S4a – ‘Economy First’	371	373.9	377.1
Total non-household consumption (lower forecast)	S2 – ‘Constrained growth’	335.9	327.7	295.4
Uncertainty range		35.1	46.2	81.7

In order to account for COVID-19 effects on demand patterns, we assumed a switch of 5% of non-household to household consumption, which was included in the forecast from 2025 for our draft plan. The 5% switch was observed throughout FY21 and FY22, however, the impact from Covid-19 has reduced since. For our revised draft plan, we reduced the switch from 5% to 1.5%. The main impact from COVID-19 is included in the 2020–24 pre-plan years. We have applied a glide path trajectory (to 2025) of the switch between non-household and household consumption to ensure that there isn’t a significant drop in non-household consumption in 2025 after an increase through the period 2020–24.

Figure 12 Measured non-household consumption projections – United Utilities Water region

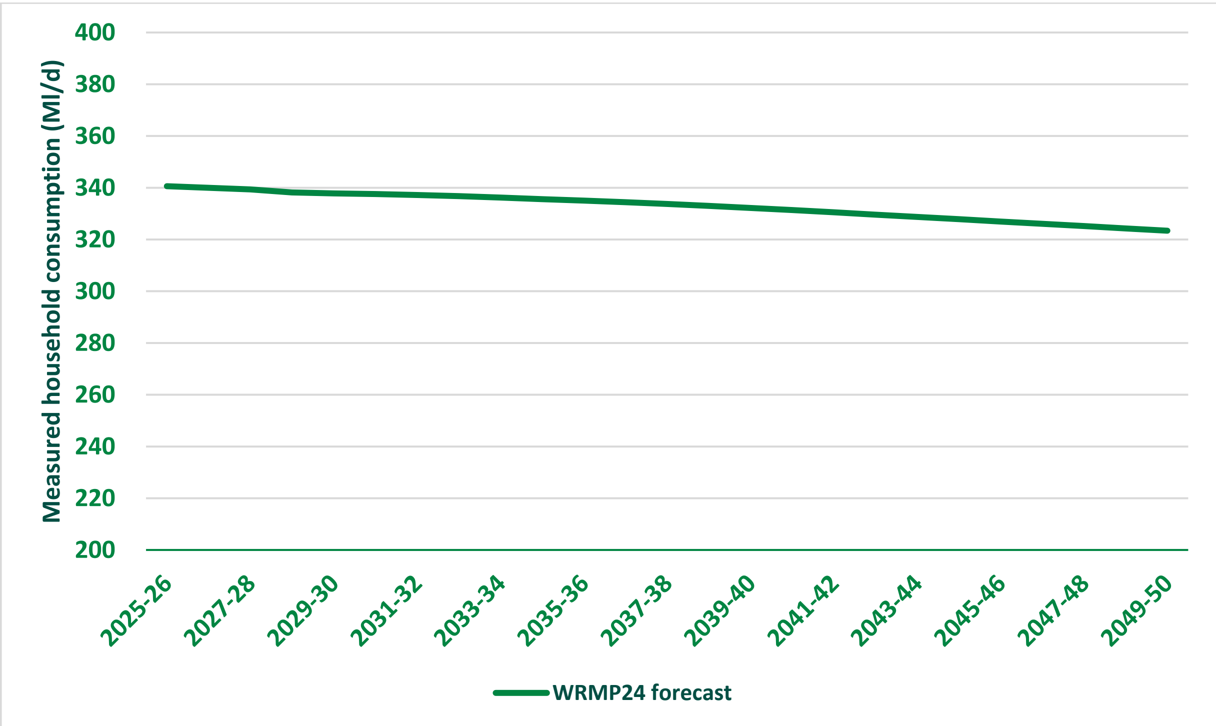
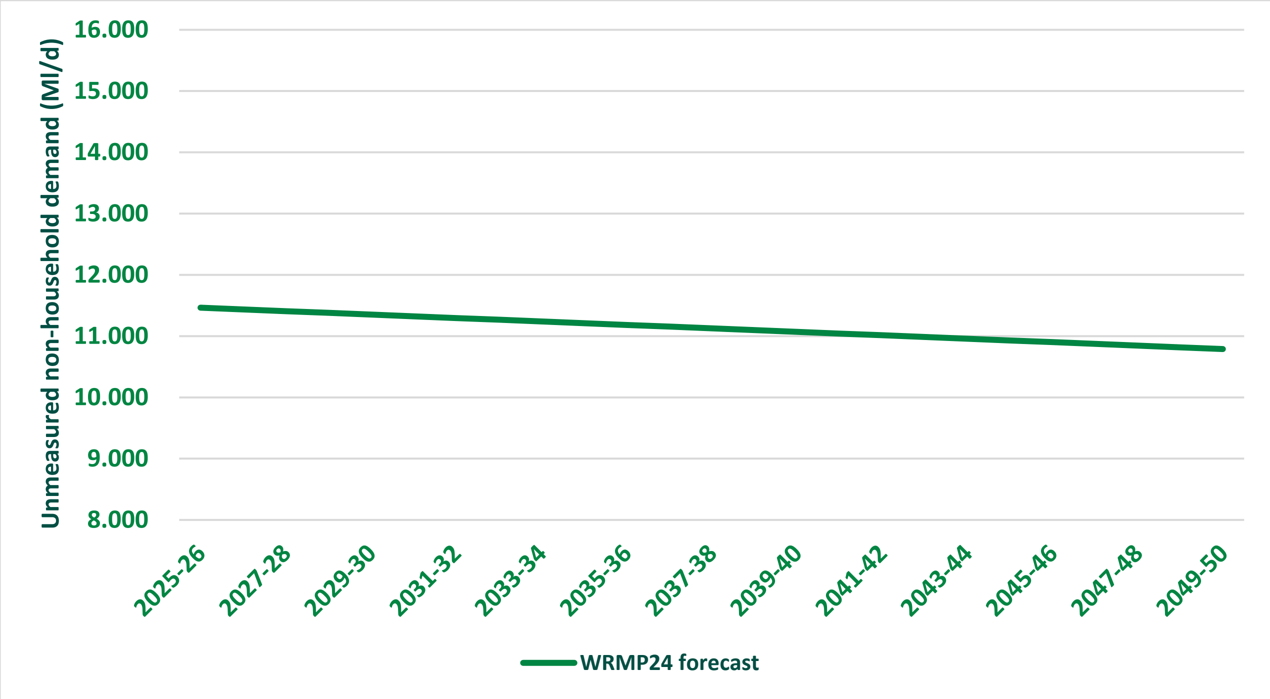


Figure 13 Unmeasured non-household consumption projections – United Utilities Water region



5.3 Switching of third party abstractors to public water supply

In conjunction with Water Resources West, an assessment has been made of the demand for water from new customers switching from third party supplies to public water supplies during a significant drought. We estimate that in practice the number of new customers of this type is very low because a new connection often takes time to arrange and can involve significant cost to lay pipes. Note that this assessment has been done using historical data, and the impact of climate change could increase the risk of non-potable sources switching to public supply. This may be especially so for abstractions from rivers, which have hands-off flow conditions attached. We will periodically assess any changes in trends to switching and we plan to undertake more a detailed assessment considering climate change in Asset Management Period 8 (AMP8) for WRMP29.

In order to calculate the anticipated switching volume, we have taken the number of new connections made during periods of historical droughts and dry summers (adjusted to remove new non-household developments).

Candidate industrial sectors for switching such as aquaculture, spray irrigation, chemical, canals, power and amenity are assumed unlikely to switch because of the large volumes, cost involved and potential 'waste of water' grounds (e.g. golf courses and spray irrigation, which in turn are unlikely to be supplied by us). Furthermore, we would not supply an activity which would be subject to a temporary use ban during a drought. Therefore, we have focused our assessment on the agricultural industry.

On this basis, we found that in 2018 there were 18 new connections, of which 17 of these connections in summer 2018 were for trough supply connections, with one connection for a small garden centre. To calculate maximum trough usage, we can compare against anticipated volume requirements for a large dairy farm based upon the typical water requirement assessment. For example, a large dairy farm with a 400-cow herd requires 2,800 litres per half an hour (67'000 litres/67m^3 per day or 0.067 Ml/d per farm), which equates to 1.2 Ml/d additional demand (as a worst-case scenario). Many of these connections are unlikely to be permanent as a potable supply is generally much more expensive than a private supply. This potential additional demand is captured through seasonal demand profiles in our Hydro-Logic® Aquator modelling as part of our supply forecast assessment, where these profiles are based on actual weekly demand data from 2018. Within Aquator, demand profiles are included in the baseline modelling. These enable us to stress test the system and assess the system response impact on deployable output as a consequence of temporary higher demands. As these volumes for switching are estimated to be small, and period of use short and likely temporary, we have not included it in our baseline demand forecast (annual average demand).

With regards to considering the failure of private water supplies and calling on us as a supplier of last resort, for this assessment of private water supply, the Drinking Water Inspectorate (DWI) sets out a working definition:

'… for the purpose of this guidance, a private water supply that is insufficient is one that fails to provide enough water for the purposes of human consumption, as defined in regulation 3 of The Private Water Supplies (England) Regulations 2016. This includes all domestic purposes as defined in section 218 of the Act (drinking, washing, cooking, central heating and sanitary purposes). Sanitary purposes include washing, bathing, showering, laundry and toilet flushing.'

On this basis, our assessment encompasses household supplies such as single dwelling boreholes, and commercial properties where the private water supply provides water for domestic uses such as factory canteens and toilets, hotels and outdoor centres. DWI guidance goes further and states:

'As a guideline, if a public water supply fails, public water companies are required to plan to supply their customers with alternative supplies of at least 10 litres per person per day for the first 24 hours, and for a prolonged event, 20 litres per person per day.'

Taking average consumption of 135 l/h/d and the private water supply estimate for our region (based on returns data from the Drinking Water Inspectorate) of 1.42 Ml/d, applying the nominal demand from above at 20 litres/per/day would be around 0.21 Ml/d to be delivered via bottles, tanker and bowser. This volume is based on a worst-case scenario, which assumes all private water supplies failing at the same time in a drought, which in reality is unlikely to be the case.

Further to this, we have guidance in place, 'Framework for provision of alternative supplies for Private Water Supplies,' 2017, which has evolved since the first iteration in 2012. This has been communicated with local authorities through public health liaison routes. Our policy can be found in our drought plan found here.

In November 2021, the Environment Agency published guidance on preventing deterioration to the environment. The guidance specifically sets out how they propose to cap abstraction licences for both potable and non-public water supply (Non-PWS) sources that are currently at risk of causing deterioration to the environment. We envisage that a proportion of non-PWS abstractors whose licences are capped in line with the new guidance may request to join the potable supply network. We have reviewed catchments in the North West and where waterbodies are either at moderate or high risk of deterioration, associated licences in the specific waterbody are likely to be capped at recent actual demand. There is approximately 0.46 Ml/d of non-PWS licence volume in these waterbodies, therefore we can conclude that the potential impact of switching to the potable supply network due to licence capping of non-PWS licences is low.

6. Leakage and minor components

6.1 Background

In addition to consumption by household and non-household customers, leakage and minor components also contribute to the overall demand for water from our supply system. Leakage management plays a key part of our plan to reduce demand, which contributes to sustaining the overall supply-demand balance in our region. Leakage reduction can be achieved incrementally and is one of the most flexible options in the WRMP as it can be scaled over time.

Across the industry and for the purpose of the WRMP, leakage is defined as the loss of treated 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 or customer side leakage). Raw water losses upstream of water treatment works are considered separately as part of the supply forecast. The key components of leakage, as shown in Table 14, are as follows:

- **Upstream leakage**: leakage from trunk mains and service reservoirs;
- **DMA (District Metered Area) leakage**: leakage from distribution pipes and connections to properties (communication pipes); and
- **Customer side leakage**: leakage from customer supply pipes, also known as supply pipe leakage

Table 14 Components of regional leakage in 2019/20

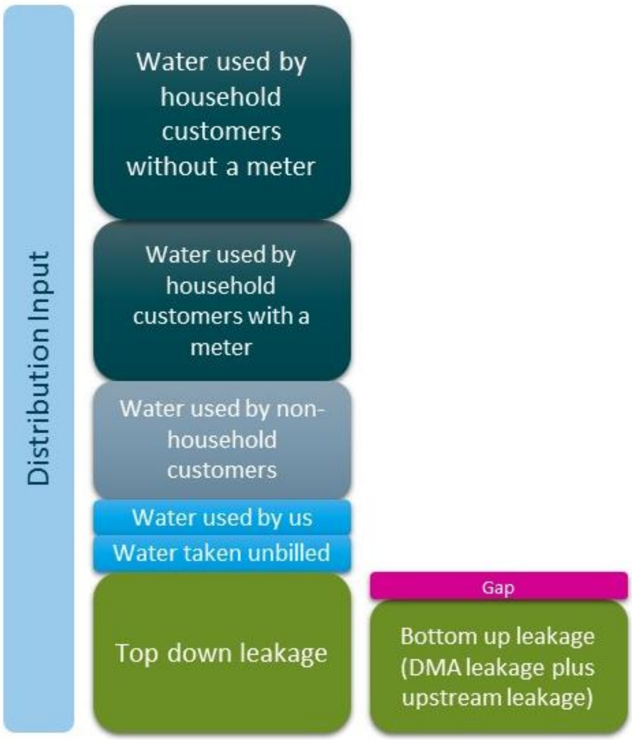
Component	Region (% of total leakage)
Customer side leakage	12
Upstream leakage	11
DMA leakage	**77**

6.2 Reporting leakage

When it comes to measuring ‘distribution input, this is the amount of water entering the distribution system at the point of treated water production. This is known as the top down (integrated flow) method. We account for the water consumed/used legally and illegally via direct measurement (e.g. customer meters) and estimates (e.g. studies). Distribution input minus the accounted for water equals “top down leakage”.

When measuring leakage directly, we apply a bottom up (minimum night flow) method. This is done by measuring the flows through the meters of around 2’800 district metered areas (DMAs) between the hours of 3am and 4am (known as “minimum night flow”). We account for legitimate night use via household night use estimates from our small area (cul-de-sac) monitors and non-household night use estimates from a non-household night use model. Minimum night flow minus legitimate night use and plumbing losses gives “DMA leakage”. We add leakage upstream of the DMAs (estimated using a balance of distribution input meter, bulk supply meter and DMA meter flows) to DMA leakage to get “bottom up leakage”. A conceptual diagram of the reconciliation approach to leakage (and other components of demand) can be found in Figure 14*.*

Figure 14 Reconciliation approach of leakage and other components of distribution input



When reporting demand, we reconcile the difference between top down and bottom up figures of leakage by very slightly adjusting all the components to account for the “gap”.

When applying the reconciliation approach, ‘Maximum Likelihood Estimation (MLE) is used. This is a statistical method used to redistribute the discrepancy between the top down and bottom up leakage amongst the water balance components. The proportion of the discrepancy attributed to each individual component depends on its scale/size and confidence level (Table 15). Following Ofwat guidance, MLE can only be applied if the discrepancy between top down and bottom up leakage is less than 5% of distribution input. Reviews of our confidence levels have been carried out in 2009 and more recently in 2019.

Table 15 95% confidence level of various components of reported demand data

95% confidence level	
Component	**2019**
Measured household	3%
Measured non-household	5%
Unmeasured household	10%
Unmeasured non-household	25%
Water Taken Unbilled-legal, excl supply pipe leakage	10%
Water Taken Unbilled-illegal, excl supply pipe leakage	50%
Operational Use	25%
Upstream Leakage	10%
DMA Leakage	5%
Distribution input	**1.02%**

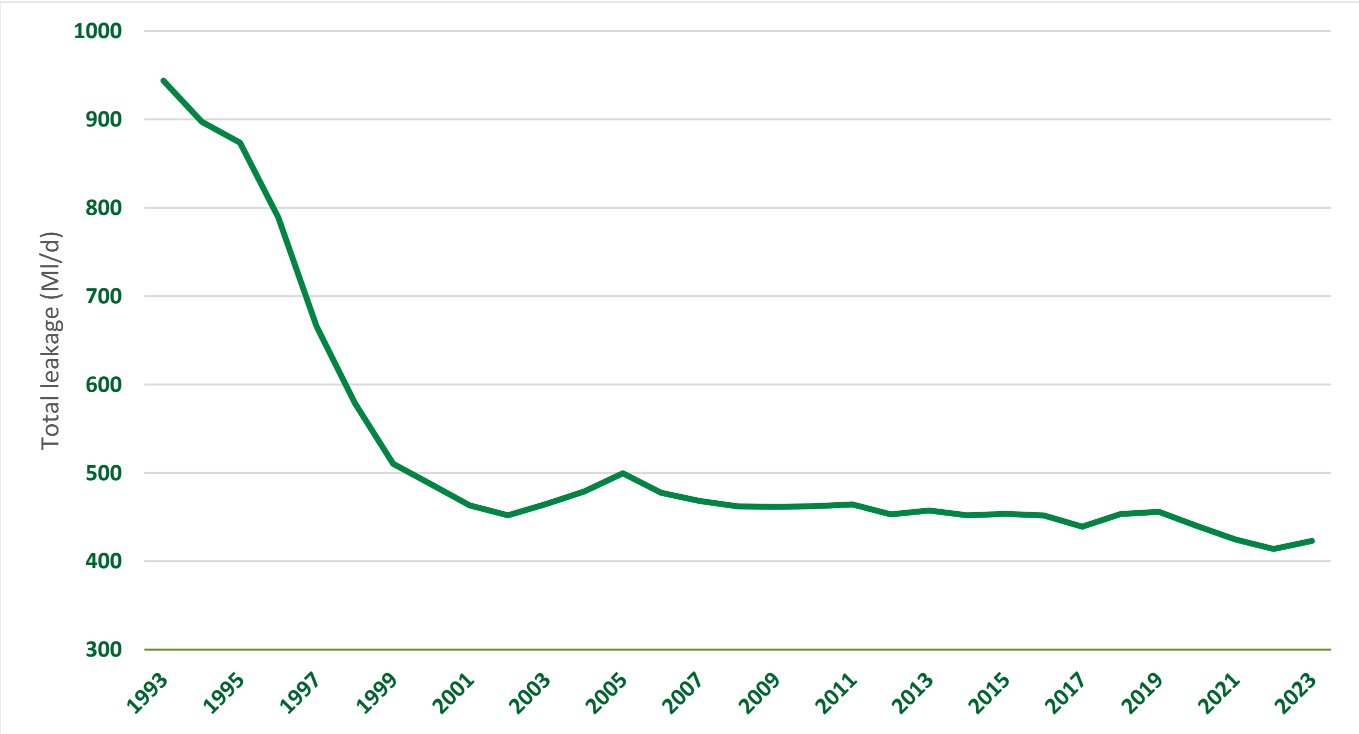
In 2018, Ofwat produced guidance for the consistent reporting of both leakage and per capita consumption (PCC) across the industry. Since then, we have implemented a leakage convergence programme to ensure that our operational data and systems comply with the guidelines, and we have 'shadow reported' both leakage and PCC using the new calculation methods. Our shadow reporting to date has indicated that the new definition will result in only a minor change in the total reported leakage, of around 1% or less. From 2020/21 onwards, our annual performance against our leakage targets is being reported in accordance with the Ofwat definitions.

6.3 Historic performance

Since the 1990s, leakage management activities have played a key role in reducing leakage and therefore demand across our region. Through our focus on leakage management, we halved reported leakage during an 18-year period, from 944 Ml/d in 1993 to 463 Ml/d in 2001, and we have continued to achieve a reduction since then, reporting a level of leakage of 440 Ml/d in 2019/20. Our progress in regional leakage reduction is shown in Figure 15.

Our regulatory targets for annual leakage are determined by the WRMP and Ofwat's Price Review processes. Leakage performance can vary from year to year, for example in response to external factors such as the weather. In recent years we have experienced several severe winters, notably in 2009/10, 2010/11 and 2017/18, which has affected our leakage performance through freeze-thaw events, which can increase the rate of burst pipes. This led to small increases in total leakage during those years, however, the overall trend in leakage is still downwards and by 2022/23 we had achieved our regulatory leakage targets for 17 consecutive years.

Figure 15 Regional reported total leakage performance from 1993 to 2023



6.4 Leakage forecast

Our WRMP24 forecast for reducing leakage is aligned to our WRMP19 forecast. Our target for the five-year period from 2020–25, aligned with our regulatory target set by Ofwat in their final determination of our 2019 Business

Plan, is to reduce total regional leakage by 15%. Our baseline leakage forecast therefore includes the benefits of leakage reduction schemes funded in our PR19 business plan period (2020–25), as shown in Table 16.

Table 16 Resource benefit of funded schemes across the 2020-25 (PR19) business plan period

		Cumulative benefit (demand reduction), Ml/d					
Scheme type	**Scheme reference**	**2020/ 21**	**2021/ 22**	**2022/ 23**	**2023/ 24**	**2024/ 25**	**2025/ 26**
Active leakage management	WR500a	1.36	1.61	3.63	7.17	9.50	10.00
Active leakage management	WR500b	1.36	1.61	3.63	7.17	10.00	10.00
Active leakage management	WR500c	1.09	1.29	2.90	5.74	8.00	8.00
Active leakage management	WR500f	0.68	0.80	1.81	3.58	4.99	4.99
Active leakage management	WR500g	0.66	0.78	1.75	3.46	4.82	4.82
Active leakage management	WR500h	1.36	1.61	3.63	7.18	10.00	10.00
Active leakage management	WR500i	1.38	1.64	3.68	7.28	10.15	10.15
Active leakage management	WR500j	1.35	1.60	3.61	7.14	9.95	9.95

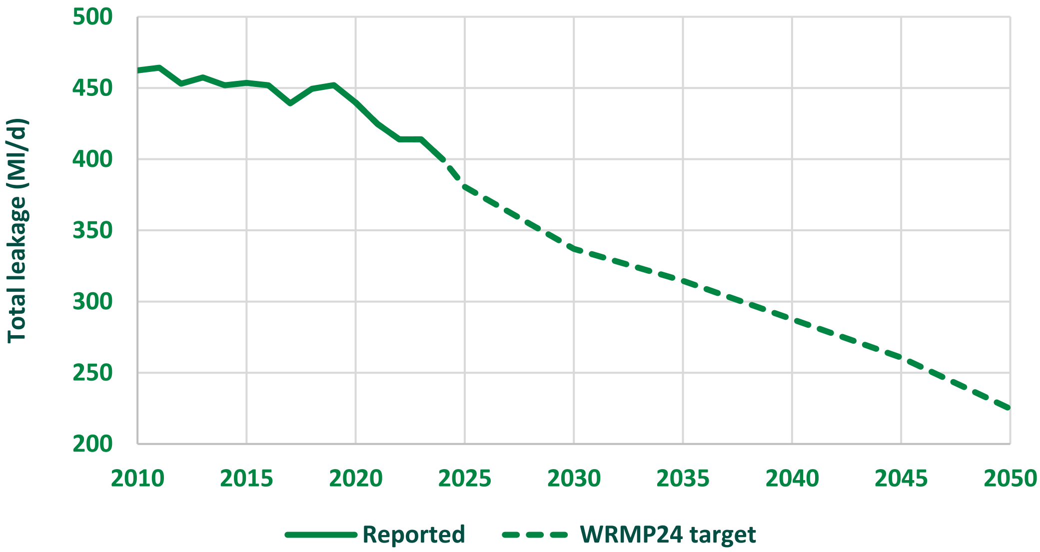
In our baseline forecast, leakage is kept static from 2025 and includes our AMP7 leakage reduction target of 15% (Figure 16). We have increased our ambitions for the current Water Resources Management Plan in line with the 'Water resources planning guideline - Supplementary Guidance: Leakage', as well as the National Framework for Water Resources (driven by recommendations made by the National Infrastructure Commission), to halve rates of leakage by the year 2050. Our target, therefore, is to reduce our total leakage by 50% from the 2017/18 reported value, to 224 Ml/d by 2049/50. This will form part of our final planning demand forecast and details of how we will reduce leakage through options are provided in our *Technical Report – Deciding on future options*.

Table 17 Final planning leakage forecasts from 2025 to 2050

Leakage Forecast	2024/25	2029/30	2034/35	2039/40	2044/45	2049/50
Total leakage (Ml/d)	380.6	330.7	296.8	261.8	237.5	224.0
% reduction from baseline (2017/18)	15%	25%	30%	36%	42%	50%

The profile of leakage reductions, compared to reported leakage trends up to and including our base year of 2019/20, is shown in Figure 16.

Figure 16 Regional final planning leakage forecast from 2020 to 2050



6.5 Minor components

The minor components of the water balance are shown in Table 18.

Table 18 Minor components of the water balance

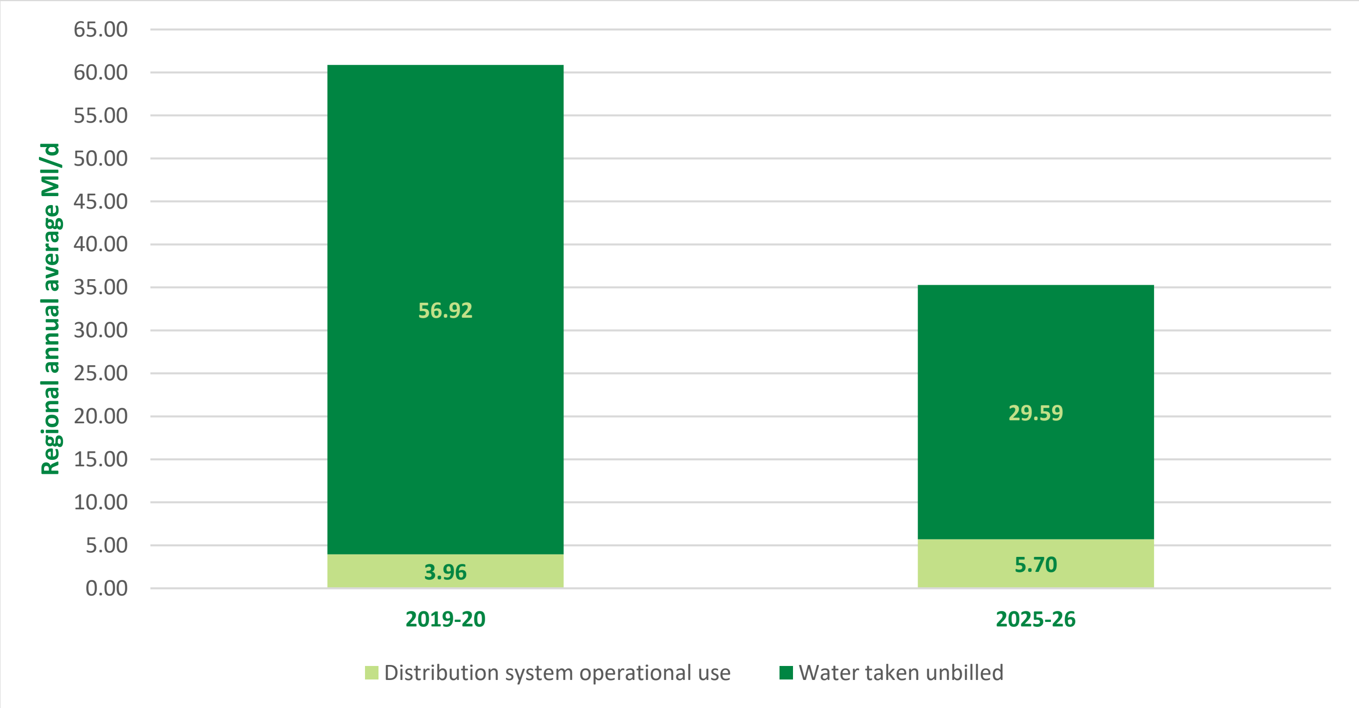
Component	Definition (from our Regulatory Reporting Methodology)
Distribution system operational use	Water knowingly used by a company to meet its statutory obligations, particularly those relating to water quality. This includes, among other things, service reservoir cleaning, mains flushing/air scouring, 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. From year to year the figures 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.

Our forecasts of minor components of demand reflect a reduction in the water taken illegally unbilled in the early years of our planning horizon, aligned with our void billing strategy focused on achieving significant reductions in the number of occupied unbilled properties during the period 2020–25 (Section 3.2). Figure 17 shows the effect of this programme on minor components, comparing the observed base year data from 2019/20 with the first year of forecasts, 2025/26.

The volume taken for distribution system operational use and legal unbilled purposes (firefighting and similar uses) varies from year to year. For our forecasts of minor components, we have taken a five-year average from the period 2016–20 and assumed that this value remains fixed over the planning horizon, other than the adjustment for our void billing strategy as outlined above. However, we have also incorporated the maximum and minimum values over the same period into our lower and upper demand forecasts, to represent the potential variability of these minor components. These contribute to the variability in our overall demand forecasts, represented by the lower and upper range forecasts, which are incorporated into our target headroom allowance (Section 8).

For our revised draft plan, we refreshed the AMP7 forecast of void properties (as more data became available), re-calculated the void billing adjustment calculation, and updated the longer-term forecast of void properties through the planning period. These changes are included in our WRMP tables (34.6BL/FP) and include an adjustment to the movement of properties between unbilled and billed categories. There is only a small change to the split between water taken unbilled and household consumption and a very minor impact to overall demand by 2050. These updates have been made to take into account our latest void billing strategy to make improvements since completing our draft plan.

Figure 17 Regional minor components – baseline and forecast



7. Demand uplifts

In order to assess all resource zones for the normal year annual average (NYAA) and dry year annual average (DYAA) planning scenarios (Section 2.3), forecasts of both normal year and dry year demand are required. Demand projections are initially prepared from a base year, and then a dry year uplift factor is applied to the household consumption component of demand to represent the increase in demand that would be expected in a year in which a significant period of hot, dry weather is experienced. Similarly, an adjustment factor is applied to the base year demand projections to prepare demand forecasts for a 'normal' year: a year in which demand is neither increased due to dry weather, nor decreased due to relatively cooler and/or wetter weather conditions. This work was done in accordance with the UK Water Industry Research (UKWIR) report (2016) – WRMP19 Methods – Household Consumption Forecasting.

In previous Water Resources Management Plan updates (2015 and 2019) we have worked with the Met Office to develop models which relate water demand to weather parameters. The demand for water attributed to these weather parameters is termed 'weather-dependent usage' (WDU). The Met Office Demand-WIM (Weather Intelligence Model) enables us to determine the magnitude of weather-dependent usage and therefore to understand the relationship between 'dry' and 'normal' years in our observed demand data. This relationship is used to determine the appropriate normal year and dry year uplift factors to apply to our base year demand, to produce forecasts for the required planning scenarios. The current method to calculate weather-related demand (and associated dry year uplift) is considered industry-leading and has been adopted by neighbouring water companies. We will continuously review our approach and, where there are new and updated methodologies, will consider (in conjunction with Water Resources West) the benefit to implementation for our demand forecast.

The Demand-WIM has been calibrated to a number of key weather parameters using around ten years of data on the demand for water:

- 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.

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 the dry year uplift factor is applied to this component only.

The Demand-WIM was fully reviewed and recalibrated for our 2019 Water Resources Management Plan, and for the current plan the model output was extended to cover the last 59 years of demand data up to and including our base year, 2019/20. This allowed us to analyse the effects on demand of a period of hot, dry weather experienced during the summer of 2018. Using the Met Office model, the weather-dependent usage during 2018/19 was calculated to be 80 Ml/d, the highest experienced in our region over the 59 years of data as indicated in Figure 18. This compared to modelled WDU of 49 Ml/d for 2019/20, which was ranked only 41 in the 59 years of data. The 95th percentile value of WDU was estimated to be 71 Ml/d, although this is only based on the 59-year data set available (it equates approximately to the 1989 modelled value). The median or 50th percentile of WDU was estimated to be 55 Ml/d and is equivalent to the 1980 modelled value.

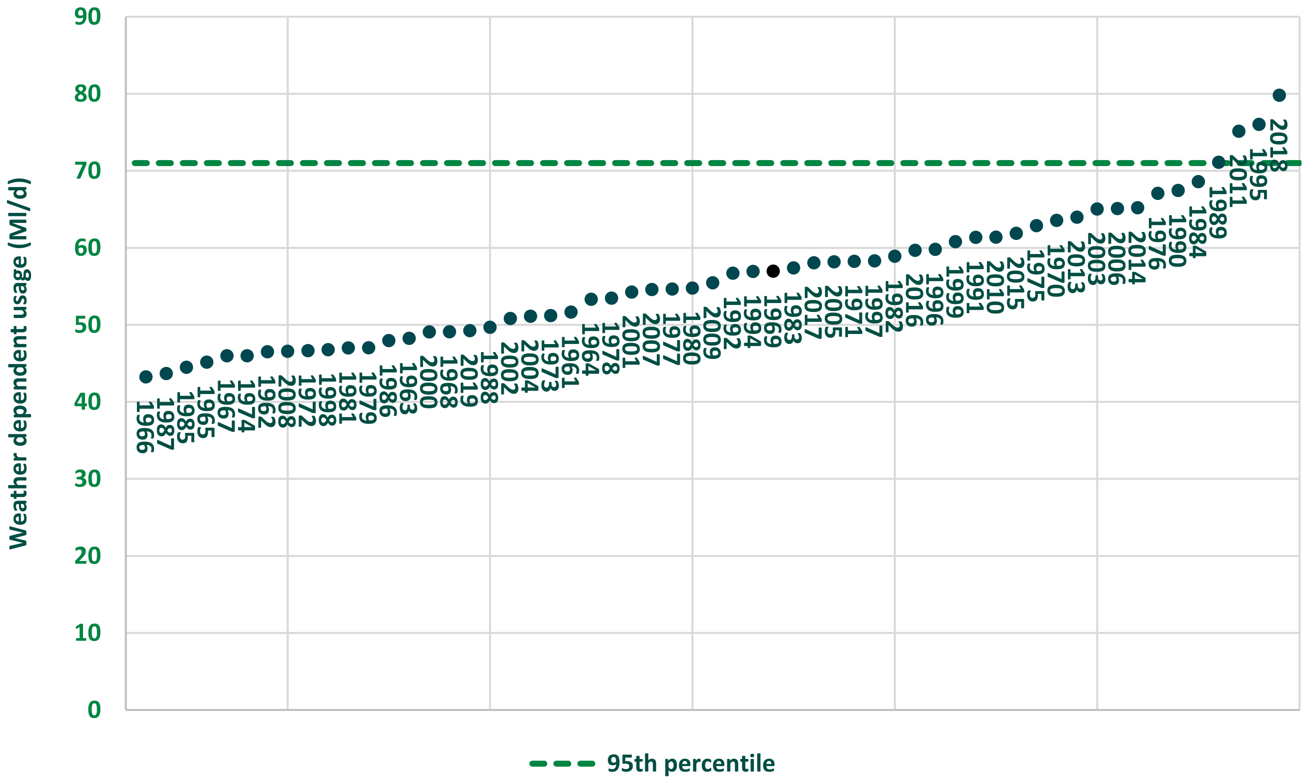
A summary of the key weather-dependent usage values from the latest Met Office model is provided in Table 19.

Table 19 Summary of Met Office modelled weather-dependent usage

Year/percentile	Weather-dependent usage (Ml/d)	Rank (out of 59 years)	Uplift factor to apply to 2019/20
2018/19	80	1	3%
2019/20	49	41	–
50th percentile (median)	55	30	1%
95th percentile	71	–	2%
99.8th percentile	79	–	3%

For this plan, we have applied a 2% uplift (from our base year 2019/20) to our household consumption forecast to create a ‘dry year’ annual average demand forecast, and a 1% uplift to create a ‘normal year’ annual average demand forecast.

Figure 18 Ranked modelled weather-dependent usage based on observed demand data showing 95th percentile value



7.1 Normal year uplift

An uplift factor is applied, to adjust the household consumption for the base year (and subsequent household consumption forecast) to be equivalent to a ‘normal year’. In order to determine the equivalent normal year demand, the weather-dependent usage of our base year, 2019/20, is adjusted to the median (50th percentile) value as observed in 1980. This equates to a small upwards adjustment of 1% as shown in Table 19 (9.9 to 10.3 Ml/d between 2025 and 2050). This 1% normal year uplift factor is applied to the base year projections of household consumption, for each Water Resource Zone, across the planning period to 2099/00. Within the individual micro-components of household water use (Section 4.1), the increased water use due to the normal year uplift is assumed to occur solely in the external use component (garden hosepipes and sprinklers etc.), as this is where the majority of the variation in household water use due to weather-related factors is expected to be observed.

The uplifted household consumption forecasts are combined with the forecasts of non-household consumption, leakage and other minor components of demand, to produce the dry year annual average demand forecasts for each Water Resource Zone and for the region as a whole.

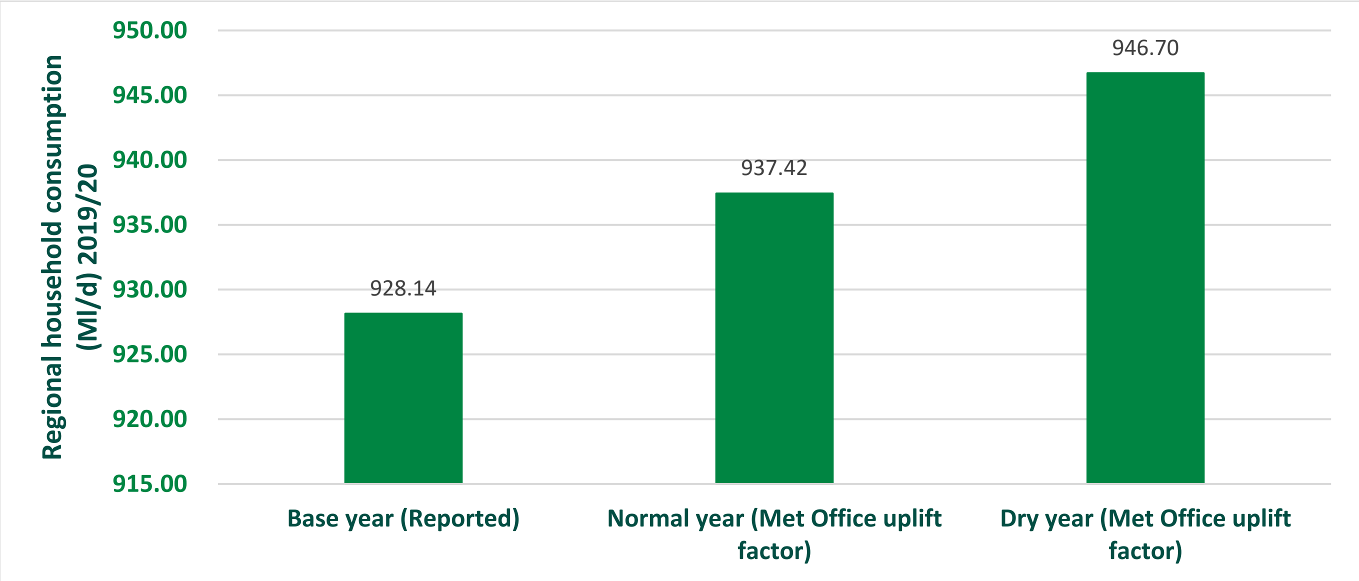
7.2 Dry year uplift

An uplift factor is applied, to adjust the household consumption for the base year (and subsequent household consumption forecast) to be equivalent to a 'dry year'. The dry year uplift factor, based on adjusting the 2019/20 weather-dependent usage to use the 95th percentile value, is calculated as 2% (19.5 to 21 Ml/d between 2025 and 2050). Using the 2018/19 WDU (or the 99.8th percentile, which is close to the 2018/19 value) to calculate the dry year uplift factor would result in an uplift of 3%. However, for planning purposes we have selected the 95th percentile value of WDU in order to calculate the dry year uplift factor, to align with the planning requirement to assess dry year unrestricted demand.

As for the normal year uplift, the 2% dry year uplift factor is applied to the base year projections of household consumption (external use component only).

The effects of the normal year and dry year uplifts on household consumption across the region are illustrated below in Figure 19.

Figure 19 Regional household consumption (Ml/d) 2019/20



7.3 1 in 500-year uplift

Our supply forecasts are calculated to account for a 1 in 500 (0.2% annual risk of occurrence) drought. Our weather-demand modelling to date uses approximately 60 years of historic demand data in order to calculate the equivalent dry weather demand. In order to calculate an equivalent 1 in 500-year annual average demand, the same historic dataset needs to be extrapolated.

Therefore, we commissioned (through WRW) the Met Office to undertake a statistical technique known as 'Extreme Value Analysis' (Bayesian technique) to determine the weather-dependent usage for a 1 in 500 return period event. This technique allows us to increase the 60 years of data into over 700 data points by applying accumulated rolling 12 monthly demand to weather related demand. For example, 1 data point is the sum of demand from January – December, February to January and so on. Using this technique, a value of 82 Ml/d has been estimated as the weather dependent usage for a 1 in 500 return period, which gives an uplift factor of 3.5% (on household consumption) using the same approach as adopted for the dry year annual average uplift (section 7.2). This is in comparison with a 2% uplift for the equivalent dry year demand. Table 20 shows the difference in household consumption when applying 1 in 500 and DYAA uplifts.

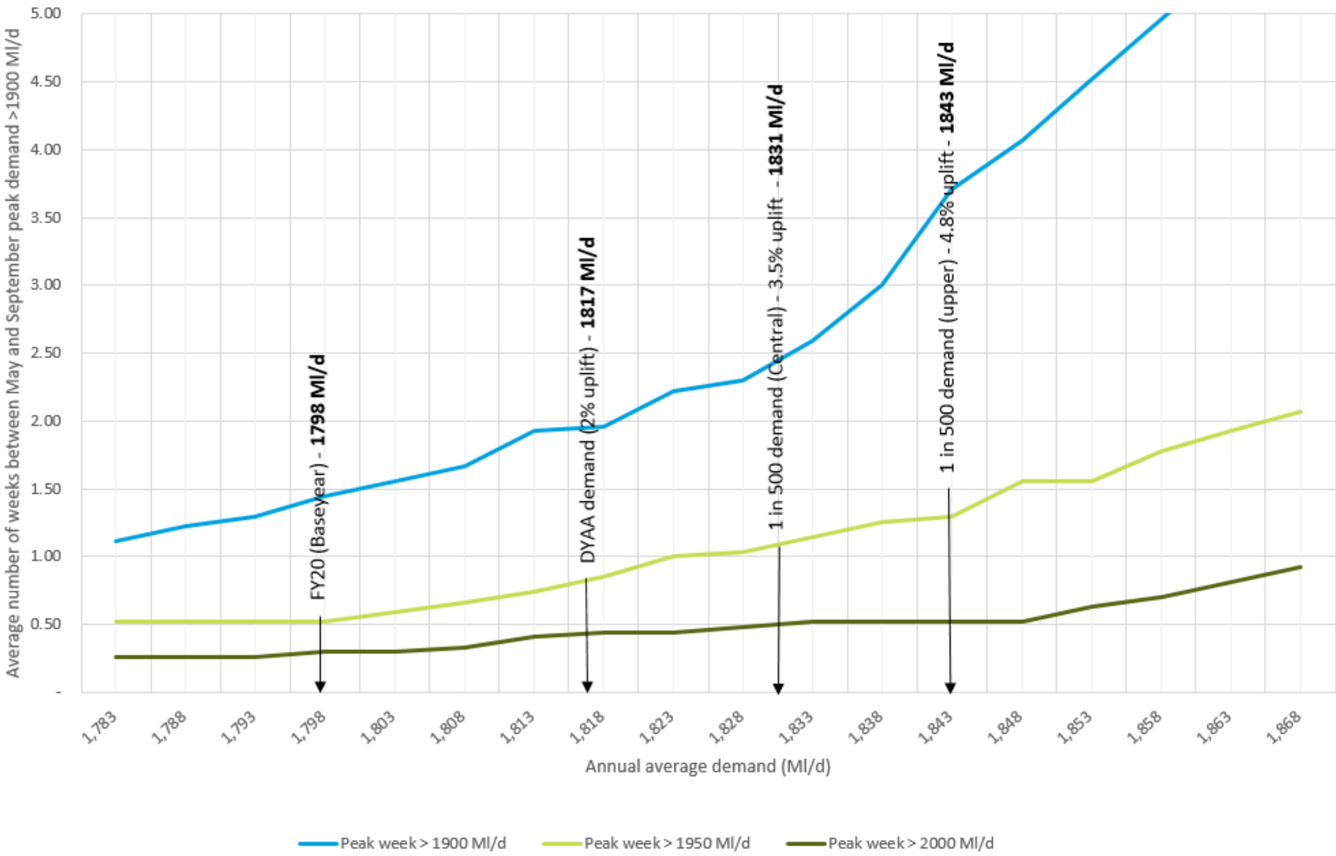
Table 20 1 in 500 versus DYAA household consumption per resource zone (Ml/d)

	Uplift	2025	2030	2035	2040	2045	2050
Carlisle	Dry year	16.12	16.68	17.24	17.62	17.80	17.72
	1 in 500	16.36	16.93	17.50	17.89	18.06	17.99
North Eden	Dry year	2.02	2.01	2.00	1.99	1.97	1.95
	1 in 500	2.05	2.04	2.03	2.02	2.0	1.98
Strategic	Dry year	957.89	974.87	977.99	978.35	980.27	982.74
	1 in 500	972.26	989.49	992.66	993.02	994.98	997.48

Through the work the Met Office undertook, an additional +/- 3% uncertainty range was applied to estimate upper and lower weather-dependent usage for the 1 in 500-year scenario (over and above the existing DYAA uplift uncertainties), to ensure an appropriate range of uncertainty for target headroom analysis (section 8).

Whilst there is a modest increase in weather related demand when comparing 1 in 500 demand with dry year demand, it's important to consider it in the context of the impact on peak week demand. Annual average demand is 1.5% higher for 1 in 500 demand verses a dry year, however the prevalence of peak week demand between May and September increases by nearly 25% when considering weekly demand of over 1900 Ml/d. For example, considering our dry year demand (1,817 Ml/d), the average number of weeks average 'weekly' demand has exceeded 1900 Ml/d is around 1.9 days per year. Applying the 1 in 500 year uplift from the EVA method to base year demand (1831 Ml/d) increases the occurrence rate to 2.4 days per year, even though the overall additional uplift is 1.5% higher than for a dry year (Figure 20).

Figure 20 Impact of 1 in 500 demand uplift on peak week demand occurrences



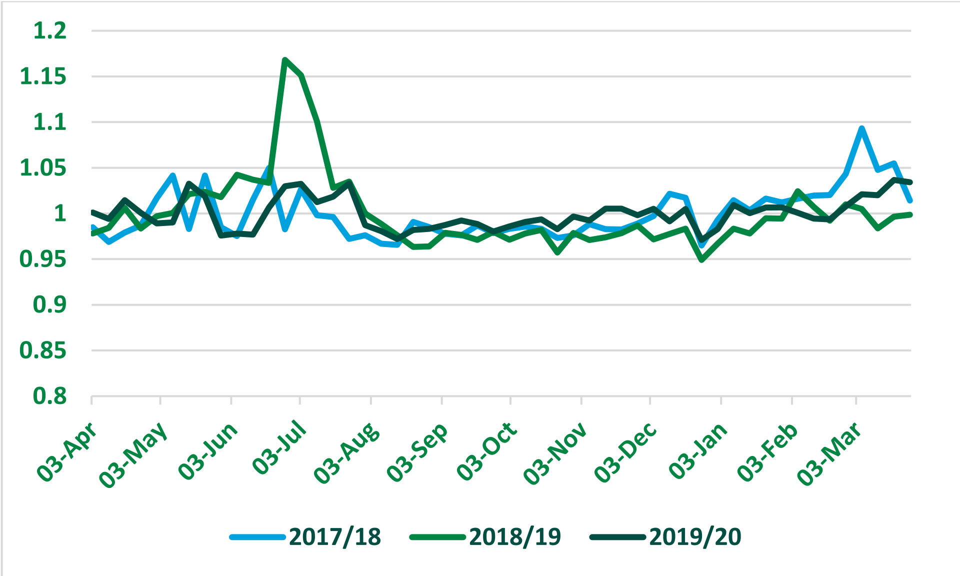
Currently, 1 in 500 demand is applied from 2020 has been tested as an alternative scenario to our baseline demand forecast. The results of the Met Office analysis for WRMP24 are complete however as the work is in its infancy and uncertainty is very high, we did not apply this to our baseline demand forecast. Further work will be required for WRMP29 which will enable us to explore other methods and refine the expected 1 in 500 year demand and reduce the uncertainty in the current EVA method. This includes the potential to utilise a stochastic temperature record (aligned to our supply forecast weather generator), which in turn can be linked to annual extreme weather-related demand. In conjunction with WRW, we are anticipating using 1 in 500 'stochastic' demand in our baseline supply-demand balance in the 2029 Water Resources Management Plan, assuming this is stipulated in the water resources planning guidelines.

Considering the WPG guidance, we have not included any additional 1 in 500 uplift to demand in either the WRMP24 baseline of adaptive plans as the equivalent 1 in 500 with demand reduction measures in place is lower than the dry year demand.

7.4 Critical period uplift

The dry year uplift factor is applied to normal or base year annual average demand, to produce a value for dry year annual average demand. Within each year, demand also varies seasonally, monthly, weekly and daily, depending on weather patterns and other factors. Figure 21 shows the ratio of average weekly demand to annual average demand (both expressed as Ml/d) over the years 2017/18, 2018/19 and 2019/20.

Figure 21 Weekly seasonal demand factors – United Utilities Water region



In a dry year, the peak week factor (highest ratio of average weekly to annual average demand) is typically higher than in a normal year. The 2018/19 demand profile exhibits a large peak (maximum demand factor of 1.17) in the summer of 2018; this reflects a significant increase in demand in response to a prolonged spell of warm, dry weather. Large peak week factors can also be due to freeze-thaw events causing short-term increases in leakage, which can have a significant impact on overall demand, as seen in the winter months of 2017/18 (around February/March 2018).

Large peak demand events within a year may be due to a variety of factors:

- Increase in household consumption in response to periods of warm, dry weather (for example, increased garden watering, social use (hot tubs) and increased showering and other personal water use);
- Increase in non-household consumption due to increased watering of sports pitches, non-residential parks and gardens etc.; and
- Some temporary increases in leakage may be experienced, either as a result of freeze-thaw events or possibly due to instability in ground conditions during particularly prolonged spells of hot, dry weather.

Following a prolonged period of hot, dry weather and high demand experienced in many parts of the UK during the summer of 2018, a collaborative study was undertaken by Artesia on behalf of the Environment Agency and several UK water companies. The aim was to investigate the impact of 2018's extreme summer weather on distribution input, household and non-household consumption and leakage, including a review of how peak factors are assessed and used in demand planning.

Some of the key findings of Artesia's study relating to peak demands can be summarised as follows:

- Both the magnitude and the duration of demand peaks was notable in 2018;
- Metering reduces both internal and external consumption and suppresses the effect of weather on peak demand; and
- Household night use increased during the hot dry spell of 2018 (potentially influencing the seasonal night use adjustments in our leakage calculations).

We have undertaken analysis to determine the peak week factors using weekly distribution input data from recent years including the hot dry period of summer 2018. Our analysis has indicated that seasonal peaks in demand can be seen to some extent in all components of demand, and that the highest peak week to annual average ratios are observed when applied to total distribution input (demand including both household and non-household consumption as well as leakage and minor components).

Based on the analysis undertaken to date, the recommended peak uplift factor for use in WRMP24 demand forecasting and supply-demand balance analysis is 1.20 (Carlisle Resource Zone). The peak factors are based on observed demand patterns in the year 2018/19. This factor is applied to the dry year annual average demand forecasts for Carlisle Resource Zone, in order to derive a Dry Year Critical Period (peak week) demand forecast across the planning period to 2099/2100. Recent analysis of data found that 2018 remains the highest peak week-demand in the period between 2018 and end of 2022 (when applying the new critical period uplift method), therefore no update was required. Note that we have not adopted a Dry Year Critical period for the Strategic, North Eden or Barepot Water Resource Zones, as outlined in Section 2.3.

7.5 Influence of the COVID-19 pandemic

The global COVID-19 pandemic has significantly impacted society from early 2020 onwards, and there are likely to be continuing effects for the foreseeable future. Changes in working patterns due to government restrictions had significant impacts on water consumption during 2020/21; in particular we saw a large shift in demand from non-household consumption to household consumption due to large numbers of people either working from home or furloughed from their normal occupations due to temporary business closures, as directed by the government. The high numbers of people spending the majority of their time at home led to significant increases in household consumption, exacerbated by an extended period of warm, dry weather during the first few months of the first lockdown period in the spring of 2020. These increases outweighed the corresponding reductions in non-household consumption, and so the net impact was an increase in the overall demand for water.

The impacts of the pandemic and associated government restrictions have lessened over time, with restrictions being eased as the benefits of the vaccination programme take effect in controlling the spread of the virus. However, it is likely that there will be some longer-term changes in ways of working and we therefore expect to see continued changes in customer consumption in future. A group of 13 water companies in England and Wales, along with the Environment Agency, therefore commissioned a collaborative study to understand how the pandemic has impacted household and commercial water consumption, and predict how the changes will evolve over the short, medium and long term. This study was undertaken by Artesia Consulting[6], using data and information provided by water companies and also from a three-month social science research project with the University of Manchester, which gathered evidence of changes in household water use (around the country) and the social, behavioural and technical factors influencing them during the pandemic.
During the study, Artesia also established links with others who are investigating the effects of the pandemic on water use, including Frontier Economics who are leading a project on behalf of Ofwat and Water UK to investigate the broader impacts of COVID-19 on water companies.

Findings of the report included the following:

- COVID-19 has led to significant increases in household consumption (of around 9% on average), even after weather effects are separated out;
- There has also been an effect on non-household consumption which is highly variable depending on the sector: on average there has been a 25% reduction in daily consumption, but some sectors have experienced reductions of up to 70% during the most restrictive phases of the pandemic;
- However, the overall impact has been an increase in demand for water, of 2.6% on average across the water resource zones included in the study;
- Impacts vary substantially across regions, and it would not be straightforward to apply an adjustment to remove the effects of COVID-19 from our reported per capita consumption (PCC) values; and
- The impacts on PCC are continuing and will need to be investigated for some time to come.

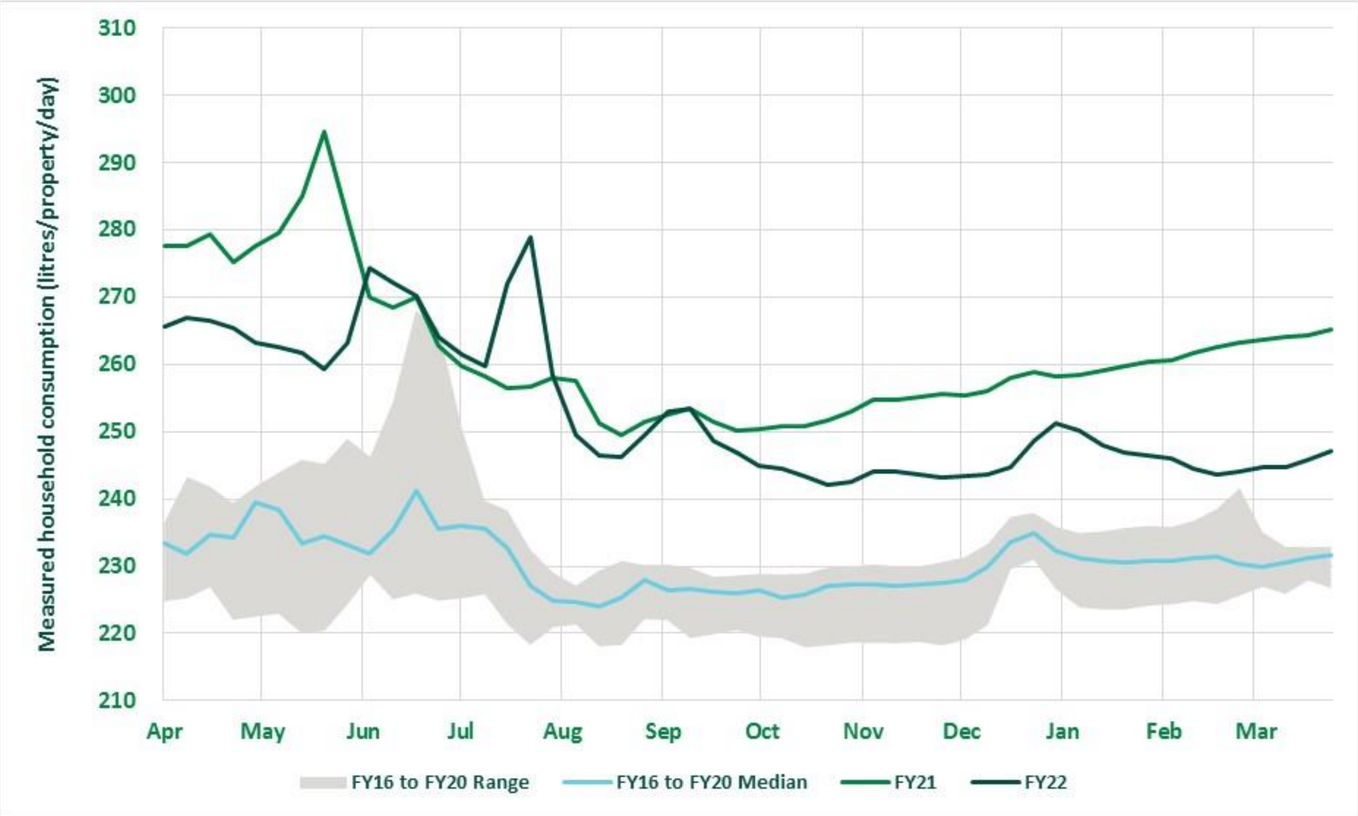
In order to reflect the influence of the COVID-19 pandemic on future patterns of working, affecting the balance between household and non-household water consumption, we have applied an adjustment to our forecasts by shifting an estimated proportion of demand from the non-household (5%) to the household component. This has subsequently been refined from 5 to 1.5% in light of more recent household and non-household consumption

[6] The impact of COVID-19 on water consumption – April 2021 report (Artesia Consulting, 2021).

data. This results in net zero increase in average annual demand. However, when the dry year uplift is applied, this leads to an overall small increase in the total dry year demand forecast, as the dry year uplift factor is applied to household consumption but not to non-household consumption (Section 7.2). This switch has been applied from FY21 and does not affect our base year consumption values (FY20). Whilst the impact on overall demand is very minor, it has resulted in a reduction in PCC. As a consequence, we reverted back to the original PCC target from PR19 of 135 l/p/d by the end of AMP7 for our revised draft and final plan (for our draft plan PCC was 138l/p/d in 2025).

While evidence for demand change from COVID-19 in the short term is clear, there is significant uncertainty of what may happen in the future. There is still uncertainty around the long-term impact of people working from home and whether changes in customers' behaviour remains. For example, we might expect water efficiency to decrease when someone is working from home versus in the office (e.g. overall increase in toilet flushing). If working from home, or hybrid working, is considered the new norm, this is something we still need to consider in our demand forecasts over and above the non-household to household switch. To account for the potential of household demand remaining high due to working from home patterns, we have created an elevated household demand forecast reflecting alternative projections of per capita consumption. This is applied as a scenario in our adaptive plan, because it is too early to know what the long-term impacts of COVID-19 will be.

Figure 22 Changes in household demand due to COVID-19



7.6 Climate change impacts

At WRMP14/15 and 19, we included the findings from the Impact of Climate Change on Water Demand UK Water Industry Research (UKWIR) project (2013) to determine the climate change uplift to apply to household consumption usage. Five case studies were analysed to derive relationships between water use and variations in weather. These relationships were then used with UKCP09 climate projections to derive estimates of the impact of climate change on household water demand for each UK River Basin District. The UKWIR project on climate change (2013) is still the principal source of climate change demand uplift information and we have used this to inform climate change impact on demand for WRMP24. For WRMP29, we will explore opportunities to update climate change impacts on demand using UKCP18 figures.

For WRMP24, we have applied the UKCP09 50th percentile climate change factors for household relationship (North West England river basin) in line with WRMP19 to our projections of household consumption (all scenarios). This additional uplift to demand is applied to the external use component of household consumption and the overall impact on demand is small, ranging from 1.7 Ml/d in 2025/26 (0.2% of household consumption) to 8.4 Ml/d in 2049/50 (0.8% of household consumption) for the region as a whole. This is in line with the approach applied in our 2019 Water Resources Management Plan. Climate change impacts on non-household demand are treated separately with further details in the non-household forecasting method (section 5.1). We will review this to identify whether this methodology is the most appropriate and include further updates if deemed necessary.

The impact of climate change on non-household demand has been treated differently to household demand. A relationship was derived between historical temperature and rainfall with different sectors of non-household demand, and then the non-household demand forecast was scaled according to the anticipated change in future temperature and rainfall. The overall impact on demand is negligible, ranging from 0.0001 Ml/d in 2025/26 (0.06% of NHH consumption) to 0.0008 Ml/d in 2049/50 (0.26% of NHH consumption).

The development of climate change impact on NHH demand is in its infancy and for WRMP24, we applied the same climate change assumptions across all NHH scenarios used in target headroom. We will be looking to develop this further in WRMP29 alongside WRW.

8. Demand forecast uncertainty

We recognise that there is uncertainty inherent within our future demand forecasts, and we have assessed a wide range of scenarios, in particular relating to varying assumptions around population and property growth, patterns of household water use and economic recovery following the global COVID-19 pandemic. Uncertainty in the components of our supply-demand balance is captured with an allowance or margin between supply and demand, termed target headroom, which is described in our *Technical Report – Allowing for uncertainty*. However, we have included below a brief summary of the key uncertainty assumptions relating to our demand forecasts. Demand uncertainty also features in our adaptive plan.

8.1 Demand growth uncertainty

The uncertainty surrounding future demand forecasts is captured within the range between the upper and lower forecast, with the adopted (baseline) forecast scenario being the 'most likely'. The differences between the upper and most likely forecasts, and between the most likely and the lower forecasts, form the parameters of triangular distributions which are input to the Monte Carlo simulation model used to combine multiple uncertainty factors into the target headroom allowance.

The upper forecast, selected from the range of both household and non-household consumption scenarios provided by Artesia, is based on the scenarios with the assumptions that will tend to produce an overall forecast at the high end of the range e.g. high (housing plan-based) population/property growth, high economic growth, relatively lower assumed rate of meter optants, etc. Similarly, the lower forecast is based on scenarios which incorporate assumptions leading to a relatively low-end forecast, e.g. suppressed economic growth, lower (trend-based) population/property growth and a higher annual rate of meter optants.

Table 9 and Table 13 summarise the household and non-household consumption scenarios adopted for the baseline scenario and the upper and lower forecasts.

Uncertainty ranges relating to the dry year uplift factor (-2% to +4%) and the minor components (-38% to +37%) are also incorporated into the overall lower and upper forecasts. The percentage uplift for the minor components (upper range) is based on the percentage difference between the maximum and average value of the minor components over the five-year period from 2015/16 to 2019/20 inclusive. Similarly, the percentage downshift for the minor components (lower range) is based on the percentage difference between the minimum and average value of these components over the same five-year period.

Figure 23, Figure 24 and Figure 25 show the lower, central (most likely) and upper demand forecasts for each water resource zone, indicating the ranges of uncertainty around the central forecasts, which are incorporated into the demand forecast uncertainty component of the target headroom assessment.

Figure 23 Lower, most likely and upper range dry year annual average forecasts (Carlisle Resource Zone)

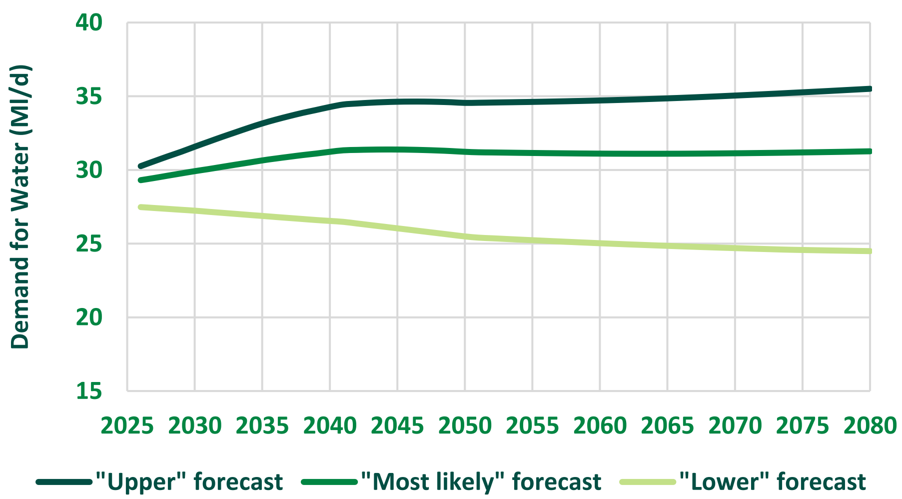


Figure 24 Lower, most likely and upper range dry year annual average forecasts (North Eden Resource Zone)

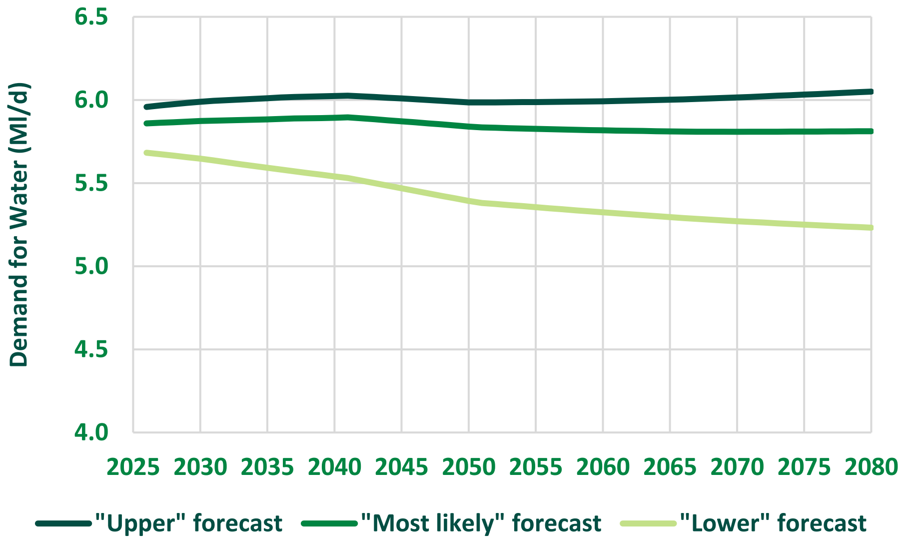
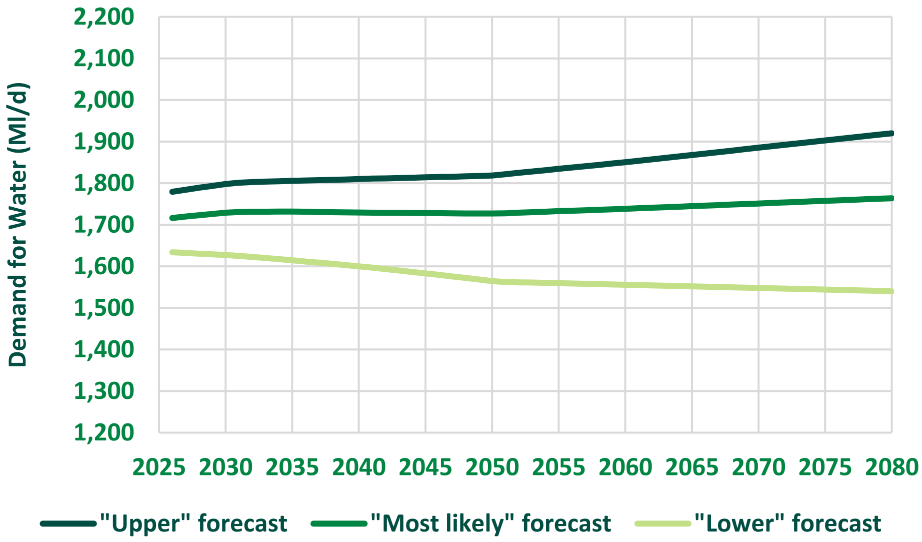


Figure 25 Lower, most likely and upper range dry year annual average forecasts (Strategic Water Resource Zone)

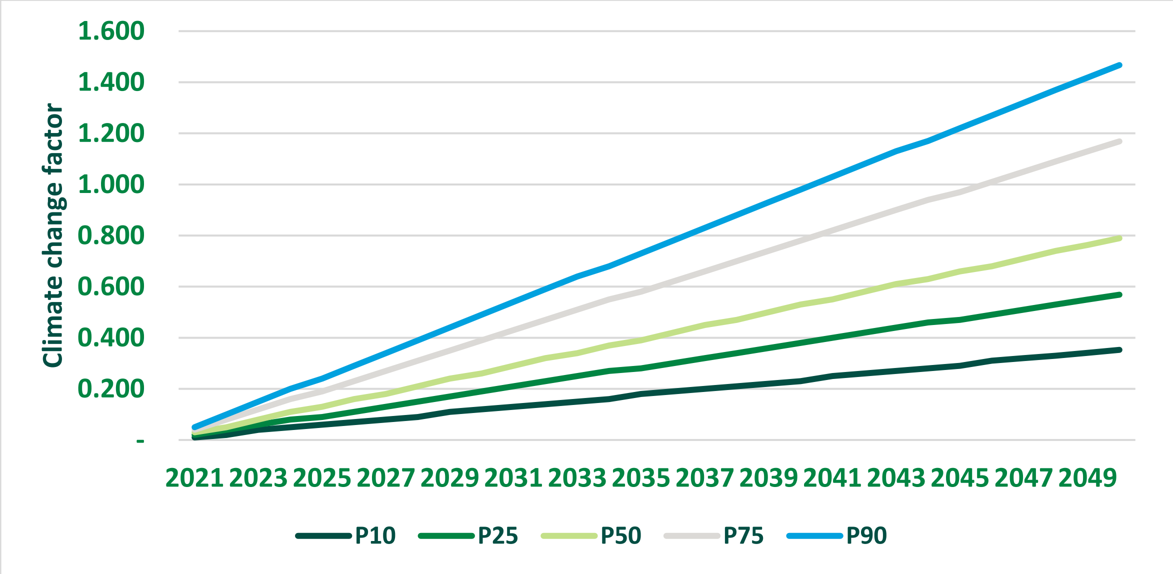


8.2 Climate change uncertainty

In line with the Severn Trent/Water Resources West agreed approach, climate change impacts on demand have been applied to the external use component of household consumption only. The external use components for both the 'no climate change' and 'with climate change' scenarios were separated out from the forecasts to quantify the increase in consumption due to climate change impacts.

We have applied the UKCP09 50th percentile climate change factors from the Severn Trent household relationship (North West England river basin) to all scenarios. Effectively these are the same percentage uplifts as used previously in WRMP19 but shifted along to start from the new base year of 2019/20. In order to determine the potential range of impacts of climate change on demand, for the uncertainty assessment within the target headroom component, the 10th and 90th percentile factors (Figure 26) from the Severn Trent household relationship have been applied to the external use component of household consumption. This produces upper and lower bounds for the range of the climate impacts on demand, with the mid-range or 'most likely' impacts adopted within the forecasts being the 50th percentile factors already applied within the baseline forecasts (Section 7.6). The upper and lower bounds are then used to define triangular probability distributions for the uncertain impacts of climate change on demand, which form inputs to the Monte Carlo simulation used to combine a range of uncertainty factors into the zonal and company target headroom allowances.

Figure 26 Climate change factor for external use demand



9. Overall baseline dry year demand forecast

Our baseline demand forecast is based on projections of household and non-household consumption and assumes that we will implement our planned leakage reductions and meet our PCC targets for the period covered by our Business Plan, 2020–2025. An assumed rate of meter optants is incorporated in the baseline forecasts and all new properties are assumed to be metered, which means that our company average PCC will show a declining trend when incorporating our AMP7 PCC targets. When including both the planned reduction in leakage and PCC reduction targets, this leads to our baseline demand forecast indicating a reduction from 2020 to 2025. However, no further leakage reductions or metering/water efficiency interventions are assumed in the baseline forecast; these demand management activities are assessed as options and the final selected set of demand-side options are included in our final planning forecast.

9.1 Baseline dry year annual average demand forecast

Table 21 presents a summary of the dry year annual average demand forecasts from the start of the planning period 2025/26 and at five-yearly intervals to 2049/50.

Table 21 Summary of baseline dry year annual average demand forecasts by resource zone

Resource Zone	2025/26	2030/31	2035/36	2040/41	2045/46	2049/50
Strategic	1711.8	1724.7	1,725.1	1723.0	1721.6	1,721.1
Carlisle	29.3	30.1	30.8	31.3	31.4	31.2
North Eden	5.8	5.9	5.9	5.9	5.9	5.8
Barepot	26.9	26.9	26.9	26.9	26.9	26.9

9.2 Baseline dry year critical period demand forecast

Table 22 presents a summary of the dry year critical period demand forecasts, from the start of the planning period 2025/26 and at five-yearly intervals to 2049/50.

Table 22 Summary of baseline dry year critical period demand forecasts for Carlisle Resource Zone

Resource Zone	2025/26	2030/31	2035/36	2040/41	2045/46	2049/50
Carlisle	35.1	36.0	36.9	37.5	37.6	37.4

10. Overall final planning demand forecast

Our final planning demand forecast has been prepared following a full appraisal of both supply-side and demand side water resource options, taking into account baseline projected supply-demand balance in each water resource zone, as well as customer preferences, legislation, government aspirations and economic and environmental factors.

As described in our *Main Report*, as part of a suite of demand targets, we are planning to achieve a 50% reduction in leakage (based on 2017/18 reported values) and reduce per capita consumption (PCC) to 110 litres per person per day by 2050, in line with government policy. These activities play a key role in reducing overall demand across our company, ensuring a sustainable supply of water across the North West. Our proposed demand management plan therefore reflects this ambition.

Our glidepaths for leakage and PCC have been developed with the following considerations:

- Our Asset Management Period 7 (AMP7) plans and targets;
- The targets in 2050;
- Our previous options, plans and commitment at WRMP19 and PR19;
- The impact on bills that these targets could have on customers;
- Customer preferences;
- A stretching but achievable delivery plan;
- Reliability of delivery; and
- Rapidly changing technology.

Further information regarding specific demand options and the decision making process that identifies what demand options are selected as part of our final plan can be found in our *Technical Report – Options identification and Technical Report - Deciding on future options.*

Table 23 Demand reduction targets in 2050 for PCC and leakage in each WRZ[7]

Water Resource Zone	2050 PCC reduction (Ml/d)	2050 PCC reduction (%)	2050 Non-household reduction (Ml/d)	2050 Non-household reduction (%)	2050 leakage reduction (Ml/d)	2050 leakage reduction (%)
Strategic	141.2	23%	20.3	15.5%	153.7	50%
Carlisle	2.5	15%	0.53	4.5%	2.6	50%
North Eden	0.2	1%	0.02	4.7%	0.3	16%
Company average/total	143.9	23%	20.8	15%	156.6	50%

Due to the population differences between zones (Carlisle Resource Zone and North Eden Resource Zone make up less than 2% of the total population in the region), most of the demand reduction will be as a result of demand management programmes in the Strategic Resource Zone where the changes are most cost effective to enact. We have therefore created a plan which will reduce PCC in all of our zones to various extents, reducing the regional average PCC to 110 l/p/d.

The profiles at which we are expecting to meet our targets are displayed in Figure 27 and Figure 28. Further information can be found in section 6.1 in our *Technical report – Deciding on future options*.

[7] WRMP24 planned reductions from AMP8 are in Ml/d. Percentage reductions are from FY18

Figure 27 PCC reduction glide path for the for the region

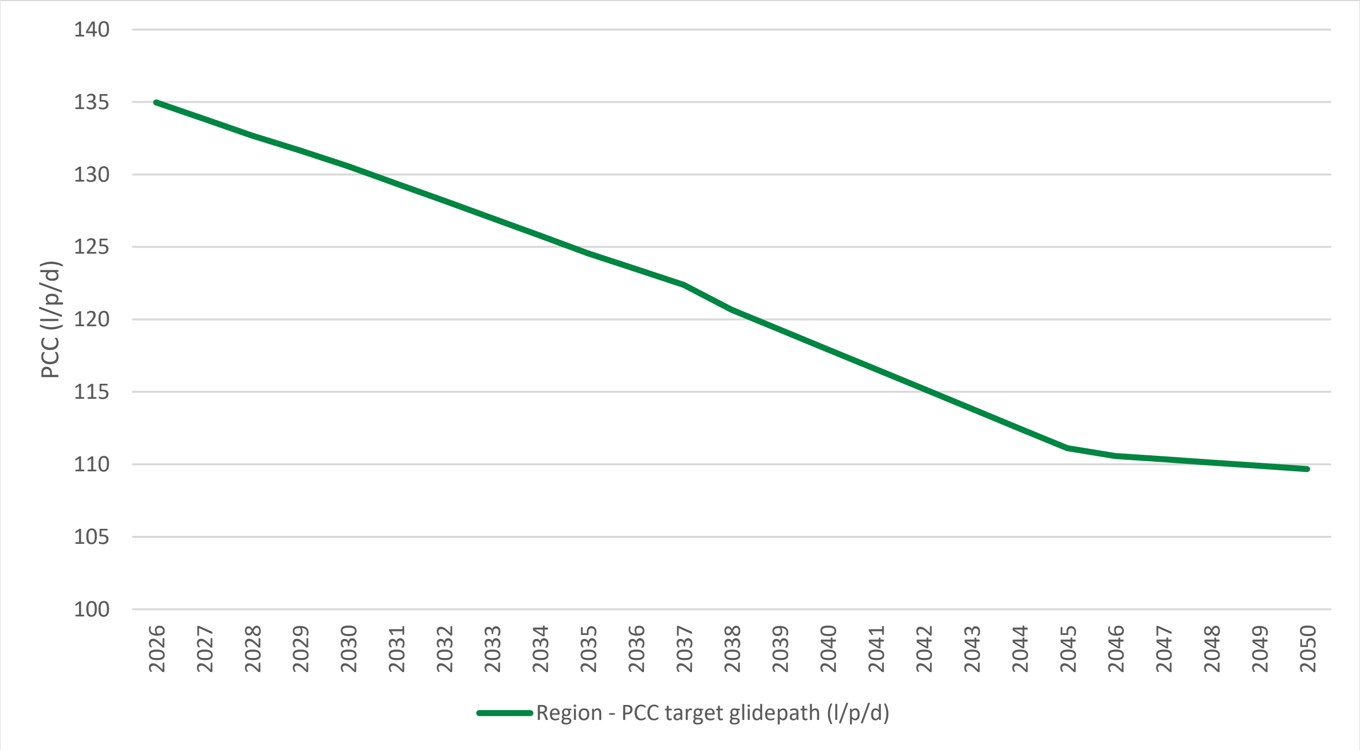
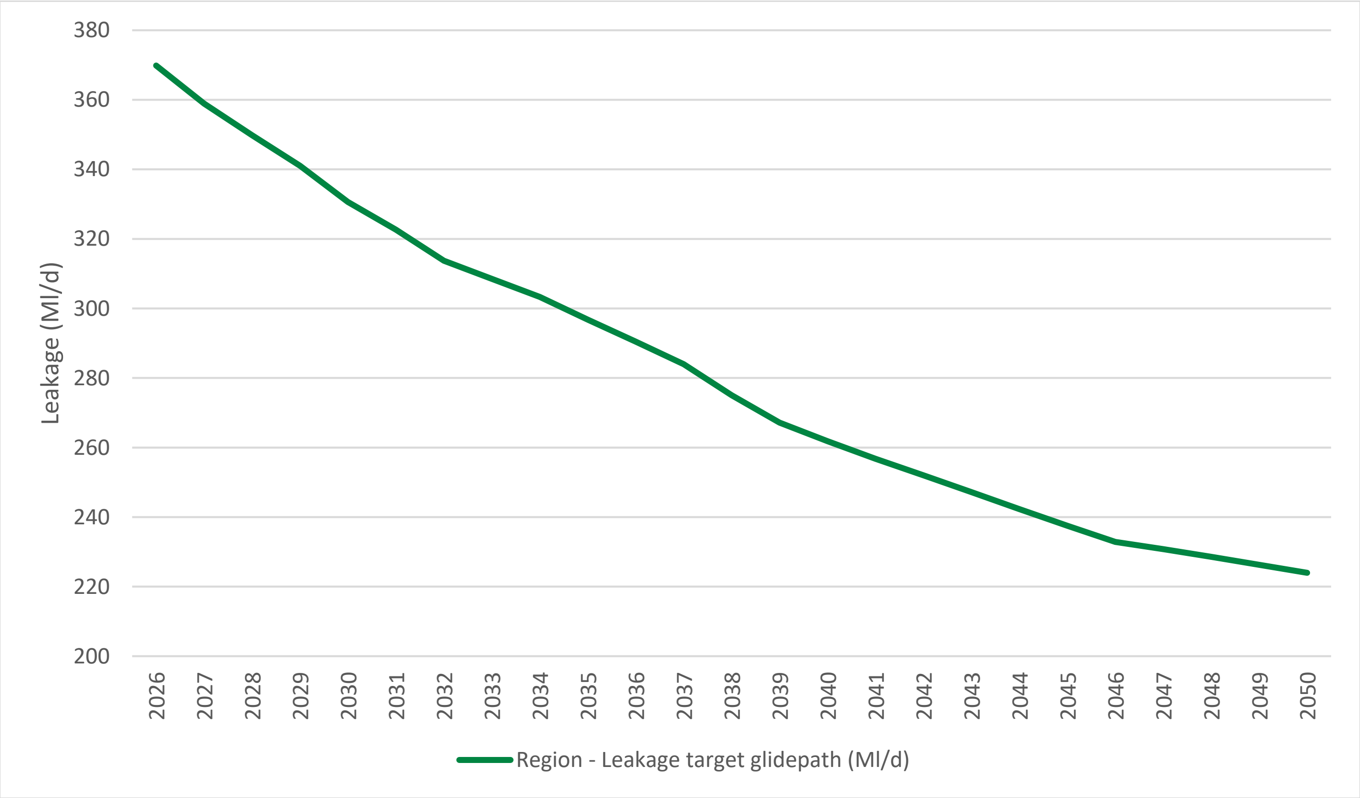


Figure 28 Leakage reduction glide path for the region



We have developed an integrated approach to our demand management strategy that seeks to enable smart metering, reduce 'all losses' (catchment to customer) and drive water efficiency. We are building this strategy on a foundation of data-driven insights provided via options that deliver a large smart (Advanced Metering Infrastructure or AMI) metering programme and targeted enhanced operation of our water system as part of our systems thinking approach.

In developing the list of unconstrained demand options, various external and internal factors[8] were considered as summarised below:

- The National Framework for Water Resources[9], which clearly sets out the expectation that water companies will reduce demand by reducing per capita consumption (PCC) to 110 litres of water per person per day (l/p/d) by 2050, by driving down water use across all sectors, and to halve leakage rates by 2050[10];
- It is unlikely that there will be a change in compulsory metering policy for water company areas not determined to be in areas of serious water stress;
- It is unlikely that a change in policy regarding supply pipe adoption will occur within the next ten years;
- Although there is growing pressure within the industry and from groups such as Waterwise for improvements in building regulations, water labelling and implementation of rainwater harvesting or grey water (particularly for new builds) to reduce household water demand, it may be another ten or more years before a significant change occurs;
- Technology is continually developing, particularly with regard to smart metering and leakage detection, but concerns around cost, tangible benefits, system integration, operation and maintenance, training, as well as scalability, often mean the roll out of new products is delayed;
- There has been limited innovation in the repair and prevention areas of leakage reduction, although this is now developing;
- Recent years have seen the growth of digital innovation (machine learning and artificial intelligence (AI), digital twins, etc.) and although this is currently focused on leakage detection, it is limited by a lack of sensors on the network and therefore is still in development; and
- How will COVID-19 change future household demand patterns and will expectations around PCC change? Could this blend lead to a change in central government policies around compulsory metering, water labelling and water efficient new builds to include rain harvesting or grey water systems?

An overview of our approach to our demand management strategy is provided below; further details on the specific demand options for each of our resource zones can be found in our *Technical Report – Options identification* and our *Technical report – Deciding on future options.*

10.1 Leakage reduction strategy

Since the 1990s, leakage management activities have played a key role in reducing leakage and therefore the overall demand across our region. In our previous plan, we set out our strategy to achieve further leakage reductions of 190 Ml/d over the 25-year planning horizon, a reduction of over 40% below the baseline position, with 67 Ml/d reductions (15%) taking place from 2020–2025.

In the National Framework for Water Resources (2020) the government set out ambitious targets for the industry to reduce water consumption to 110 litres of water per person per day and halve rates of leakage by 2050. Therefore, this strategic choice is effectively, a regulatory expectation.

Our leakage reduction strategy considers the need to enable efficiency in the longer term; smart metering will enable more efficient leakage reduction, as we'll know whether we are targeting leaks on the distribution-side or customer-side. Network sensors work well in the short term, but require replacement approximately every 5 years, which is a factor that needs to be taken into consideration.

[8] External factors include legislation and policy set by government and regulators, current trends in the industry and technology and innovation. Internal factors include existing company commitments, processes and mechanisms, integration of technology and innovation and data availability.

[9] https://www.gov.uk/government/publications/meeting-our-future-water-needs-a-national-framework-for-water-resources

[10] We have set out a number of ambitious short-term and long-term targets for leakage and PCC: to reduce leakage by 15% (c. 67 Ml/d) by 2025 and an additional 35% (c. 157 Ml/d) by 2050, whereas targets for PCC have been set at 135 l/p/d by 2025 and 110 l/p/d by 2050.

Our strategy is to transition from “find and fix” or “locate and mend” to an increased awareness (through network monitoring), which will support the prediction and prevention of leaks (through mains renewal, pressure management and optimisation etc.). A balanced programme of longer-term interventions (such as targeted mains renewal) and shorter term interventions (such as active leakage control and network sensors) is required to deliver sustainable reductions in leakage. The leakage detectors/network sensors will be prioritised by targeting areas with relatively high leakage and/or low water resources in terms of drought resilience. Whilst our water mains renewal rate since 2015-16 has been lower than other companies, we have still achieved service improvements via network monitoring (e.g. network sensors) and optimisation (e.g. large-scale pressure management, with remote capability), as well as investments in asset resilience (e.g. our service reservoir programme). However, to drive leakage reductions that can be sustained in the longer term, a balanced strategy that includes mains renewal is required.

Customers can continue to report leaks via "Report a Problem" (RAP) at our company website[11]. The timescales involved have been reported in our PR24 table CW19 (UUW19)[12], which include the company level average run time of mains repairs that are customer reported, which is 4.2 days (2022/23 and 2023/24).

Our approach to leakage reduction increases focus in the PALM (Prevent, Aware, Locate and Mend) model on ‘Prevent’ and ‘Aware’, as we optimise a predictive and preventative leakage strategy (Table 24).

Table 24 PALM approach/categories, with example interventions/options

PALM category	Description	Example interventions/options	Pertinent to UUW
Prevent/ prevention	Ability to stop leaks from occurring or, at least, reduce the size of leaks	Pressure management and/or optimisation, including active pressure and/or remote control (flow modulation) Mains rehabilitation/renewal/replacement, including mains lining Calm networks, including tackling pressure surges or “pressure transients”	In AMP5, we carried out a company-wide desktop modelling exercise and identified a number of existing pressure management valve (PMV) optimisation schemes and over 1,000 new potential pressure management schemes. A number of schemes were delivered in AMP6 or identified to be delivered in AMP7, including the installation of PMV flow modulation/remote control units on over 700 existing PMVs. Our mains rehabilitation/renewal /replacement rate is a key area of focus, as we seek to address the deterioration in water network asset health.
Aware/ awareness	Ability to identify a leak as it occurs	Additional district metered areas (DMAs) and/or DMA optimisation (changing the configuration, metering arrangement and/or size). Optimisation of the areas upstream of DMAs (covering larger service reservoirs, trunk mains etc.). Smart networks (we term this “Dynamic Network Management”), smart meters and network sensors (e.g. acoustic/noise, flow, pressure, strain etc.).	A key area of innovation and investment over AMP6 and AMP7. We invested in approx. 70,000 acoustic sensors that cover approx. 20% of our water network. We combined this with advanced analytics of the sensor sound files to remove “false positives” and ensure we are identifying leaks (pressure management valves and lampposts can sound like leaks).

[11] United Utilities - report a problem

[12] Our proposed plan documentation | United Utilities

PALM category	Description	Example interventions/options	Pertinent to UUW
Locate	Ability to find/pinpoint the exact location of the leak	Activity to expedite (or, at least, robustly prioritise) the pinpointing of leaks using: • Aerial surveys (drones, plans, satellites etc.) – although, depending on accuracy, these can be considered under "Aware" as well. • Automatic acoustic/noise correlation • Optical fibres • Step testing • Surface sounding	Once we are made aware of a potential leak, our highly skilled Leakage Technicians carry out investigations to determine if the issue is related to a leak (or, for example, illegal use) and, if a leak is identified, mark the precise location of the leak for repair. We acknowledge that it can take years to develop the skills required and, therefore, we have sought to ensure that we are "fit for the future" with our Leakage Apprenticeship programme and in-house training suite.
Mend	Action to fix/repair the leak	Activity to expedite (or, at least, robustly prioritise) the repair of: • Mains, including trunk mains • Mains fittings • Communication pipes • Supply pipes (assets within the property boundary and owned by the property owner) • Reduce disruption via "no dig" and "in pipe" repair techniques	Following leak location, UUW promotes work to our network partners to repair leaks on the various assets. We work with our network partners to prioritise leak repairs, based on customer impact and size of leak, as well as how we can implement innovative techniques (e.g. "live repairs") to reduce repair times generally.

With a strong focus on the need to **Prevent** leakage, we are promoting options which:

- Ensure that our networks are effectively optimised and managed via 'calm networks'[13], live valve status and remote control;
- Apply intelligent maintenance to water network assets; and
- Stop deterioration in water network asset health, ensuring that we've already applied appropriate operational mitigation and that any new network is leak-free.

This approach is reflected in our asset rehabilitation, replacement and dynamic network management (DNM) options. DNM involves installing monitoring technology to enable us to proactively pinpoint and prevent leaks or reduce leak run times.

Our approach to ensuring that we are **Aware** of leaks so that we can efficiently repair them, is to:

- Prioritise targeted enhanced monitoring; and
- Use the latest data analytics and prediction techniques to shift the balance from customer reported leaks to proactively found leaks.

To **Locate** leaks, we will work with our suppliers to develop and implement automatic correlation for pinpointing leaks to reduce leak runtimes. Finally, our demand-side options will enable us to **Mend** leaks, by implementing a robust repair prioritisation, using customer impact and size of leak, and reducing disruption by continuing to seek out and implement 'no dig' and 'in pipe' repair techniques, as well as utilising temporary repairs for leak mitigation.

[13] 'Calm networks' aim to minimise the risk of inducing surge pressures and flow as a result of the way hydrants, valves and pumps are operated. This is primarily achieved through effective training of operatives, including United Utilities Water employees and third parties who interact with the water network (e.g. fire service and large industrial users).

We are also conducting trials of innovative technologies which can help to reduce leakage, as part of our Innovation Lab programme. This has included a trial of an app that manages and monitors valve operations and reduces transient pressure waves on a potable water network. The intuitive tool enables the following:

- Valve operations to be carried out in-line with our calm network procedures, ensuring we minimise the water quality and transient pressure risk, particularly in the first and last 10-20% of the valve operation; and
- Update live valve information and provide additional data such as photos/notes to assist in ensuring the correct valves are operated. This will also assist with calculating and targeting leakage.

10.2 Consumption reduction strategy

Our strategy has five key 'pillars' and seeks to reduce demand for water. The key pillars are:

- Boosting meter penetration;
- Consumption led interventions;
- Driving behavioural change;
- Addressing business usage; and
- Effective incentives for developers.

We have set out within this section below more detail on specific elements of our consumption strategy including metering and water efficiency.

10.2.1 Metering strategy

We have developed a metering strategy which underpins our demand management plan in all of our resource zones. The strategy has a twin track benefit which enables us to not only help identify and reduce leaks (as mentioned in our leakage strategy), but can encourage water efficiency and help reduce PCC.

Meter penetration within our company supply area is currently around 47% for households (excluding vacant/void properties) and 45% (including vacant/void properties) and 91% for non-households. This is lower than for many other UK water companies, however unlike many companies in the east and south of England we are not located in an 'area of serious water stress', meaning that we are legally unable to implement compulsory metering. With a current meter penetration of less than 50% for our enhanced metering programme, our roll out strategy will initially prioritise urban areas with low meter penetration, high leakage, high change of occupancy rates and a large number of void properties. The introduction of smart metering will help us achieve our strategic objectives on PCC and leakage, which help ensure future water resilience. Further information on how household customers are being influenced to have a meter installed can be found in UUW61R Water (Supply Demand) Enhancement Case - Chapter 6 supplementary document, section 3.1.10, pg.7.

Key considerations in developing an initial list of metering options for screening include potential delivery mechanisms and ability to increase meter penetration levels, what meter types to install (dumb, automated meter reading or AMR with advice, or smart metering), impacts on costs, programme and meter coverage and how the overall metering strategy may impact our ability to deliver water efficiency and leakage targets. The smart metering roll-out will also provide data and insight on leakage performance (awareness and location) within District Meter Areas, contributing to our leakage reduction options as outlined in Section 10.1.

In areas where meter penetration is high, the use of tariffs may provide a potential tool for managing demand in households. The two main types of tariff identified for consideration are 'rising block tariffs', comprising additional charges for volumes above a threshold or multiple thresholds and 'seasonal tariffs', comprising increased charges during specific periods. However, customer feedback has consistently indicated that tariffs are unpopular and in all cases there is a need for the tariff to be: fair, easy to quantify, not overly complex, considerate of occupancy/household size and not lead to 'water debt'.

When looking at potential benefits achieved through metering programmes, the key benefit is the improvement made to the water balance based on the ratio of measured/metered demand against unmeasured/unmetered demand. This in turn will help to improve assumptions around PCC, customer-side leakage and leakage on the distribution network. For further information refer to our *WRMP24 Technical Report – Options identification section 3.5.2.*

With regards to non-households, we received feedback on our non-household metering strategy during our draft plan consultation. Since our draft plan, we have carried out further studies with third parties on the benefits of smart meters to improve our understanding and in our revised draft plan have set out plans to implement smart meters to around 170,000 metered non-household properties by 2030. This represents 90% of total non-household properties.

Addressing the issues associated with Long Unread Meters (LUMS) and Long Long Unread Meters (LLUMS) will be a result of the benefits of our smart metering programme, in that LUMS and LLUMS will be reduced over time.

Our approach during the most recent AMPs has been to replace broken meters only, with no proactive replacement programme that would target meters older than 15 years. Replacing older non-household meters with smart enabled equivalents could deliver 2.5% in demand reduction, as well as benefits from reduced leakage. The pace of technological development was considered in the scenarios in line with guidance published by Ofwat. The Ofwat faster technology scenario assumes full smart meter penetration by 2035 and implementation of a smart water supply by 2035. The Ofwat slower technology scenario assumes full smart meter penetration by 2045 and implementation of smart water supply by 2040.

The issues associated with Long Unread Meters (LUMs) will be addressed through a combination of approaches; as a result of the benefits of our smart metering programme (NHH LUMs meters will all be exchanged to AMI), improving our internal meter reading processes and increasing working hours to improve the access rate to customer properties. Largely, LUMs are a result of no access to the property meter, resulting in an estimated water bill for the customer.

In addition, during AMP7, we have focused on increasing passive read capability (AMR meter reading) as a step change from basic meters and AMR walk by. The company has installed AMR meters since 2010, having made the decision to move from installing basic meters, which require eyeball reading. AMR meters helped facilitate the development of a customer portal supported by more frequent reads (fortnightly), allowing customers to monitor their own consumption. Our AMR solution came with the capability of a drive by solution enabled by installing remote readers in bin lorries allowing the fortnightly collection of data in sync with the refuse collection cycle. We are continuing to extend passive AMR network by establishing passive meter reading contracts with council agreement. We will continue to convert AMR walk by meter reads to passive meters through securing more passive contracts (recently signed up Knowsley Council & Cumberland Council) and maintaining our existing passive receivers.

As we move into AMP8, our meter reading capability will be further enhanced through the introduction of AMI (smart) meters. In total 921,891 meters are planned to be fitted in AMP8, of which 54 per cent of these (501,000) will be new meters for existing household (HH) customers and 420,000 household (HH) and non-household (NHH) will be meter replacements.

There are currently 3,254 LLUMs, comprising of 2,177 vacant properties (where the meter can't be read) and 1,077 occupied properties. As part of a separate company project, all properties will be visited by field staff to return a read where possible by March 2025. In the event where no meter read is available, the issue will be identified and a report will be returned with actions (e.g. Missing/Damaged Meter). Where a property is identified as vacant with an internal meter, there is a process in place to flag as a 'true vacant'. When the retailer changes the occupancy status to 'occupied', a second visit is then arranged to gain access and identify why the meter remains unread.

10.2.2 Water efficiency strategy

Our water efficiency options were developed in collaboration with the industry through Water UK and the Waterwise strategic communications programme. We engaged with customers and stakeholders, including non-household customers via retailers, and specifically targeted the education and tourism sectors where we believe significant savings can be made. Many of our options utilise data-driven insights to target our activities, for example water efficiency audits. Options to reduce consumption focus on:

- Customer communications (community and direct messaging);
- Smart metering;
- Water efficiency home audits; and
- Water efficiency audits for non-households (likely to focus on education and health).

We already have a number of programmes promoting free or subsidised water efficiency devices that customers can order from our website, or which can be fitted during home audit visits. Existing programmes delivered by water companies have provided benefits in reducing demand, however the benefits of particular devices are variable and not easily quantifiable. The demand savings realised depend on a range of factors including:

- Customer behaviour;
- Existing plumbing arrangements;
- Existing connection pressures;
- The particular suite of devices installed;
- Whether devices are self-fitted or fitted by water companies as part of audit visits; and
- Whether measured benefits are also due to finding and resolving supply pipe leakage or internal plumbing losses as part of the audits.

Further information on how water efficiency measures will be delivered can be found in UUW61R Water (Supply Demand) Enhancement Case - Chapter 6 supplementary document, section 5.3.15 (pg.14).[14]Based on our commitments to reduce demand for water, to support water resources resilience and reduce our impact on the environment, we are requesting that all local authorities in our supply area adopt the optional minimum building standard of 110 litres per person per day (lppd) in all new builds. We already incentivise water efficiency in new builds, by offering a 90% reduction in water charges to developers building water efficient homes which include measures to reduce water use to 100 lppd. This scheme was launched in 2018 and initially targeted a standard of 110 lppd, but due to the success of the scheme and to encourage further improvements in water efficiency, we reduced the threshold to 100 lppd in 2020. To date, more than 86,000 plots have been registered with many of these already built, creating savings of £25 million for developers. A similar reduction on wastewater charges is available for properties featuring sustainable drainage, and both schemes are still available to developers building homes in the North West.

Other approaches to reducing household demand include water labelling schemes, rainwater harvesting and greywater recycling schemes.

Our strategy for deciding the best approach for applying water efficiency measures is done regionally (including Carlisle and North Eden resource zones) using a Catchment to Customer model from which area-specific town action plans are developed. This would include area wide/area specific communications (i.e. local radio, social media and partnership with local water advocates). Also, customers are then prioritised based on whether they would benefit most from a meter, high users or sensitivity to dry weather. Specifically, for unmeasured customers or high users, we will engage with them through direct messaging about installing a meter or directing them to our website (including Get Water Fit) for hints and tips to save water. For example, there are six focus areas (DMZs) for FY24 where a town action plan will be developed and Carlisle is one of them. Along with other DMZs in the region via our catchment to customer model, North Eden will be monitored and will be included in the town action plan when appropriate, however any customer identified to benefit from a meter or high consumer/leak will be engaged with as part of the direct communication programme.

With regards to non-household water efficiency, as per the draft plan, we are still planning to deliver thousands of non-household water efficiency visits to save almost 10 Ml/d by 2030. These visits will identify and where

[14] UUW61R Water (Supply Demand) Enhancement Case (unitedutilities.com)

possible fix leaking toilets, taps, urinals and showers, and where appropriate fit water-saving devices to address both leakage and wastage. We will work with retailers to structure a scheme which ensures businesses across our region have access to water efficiency visits free of charge. The scheme will encourage retailers to engage with their customers directly, however if take-up of the scheme by certain retailers or particular areas or sectors is limited then we will deliver the visits ourselves.

We are also looking to expand some of our household water efficiency initiatives to non-household customers. We will work with retailers to ensure the most effective delivery of communication materials

10.2.2.1 Water labelling

In order to help achieve our PCC target of 110 l/p/d by 2050, along with all water companies, we are reliant on government intervention with regards to water labelling.

On 1st July 2021, the Department for Environment, Food and Rural Affairs (Defra) published a statement15 announcing the intention to make regulations to introduce a mandatory water efficiency label to inform consumers and encourage the purchase of more water efficient products for both domestic and business use. Since the Draft WRMP publication, the WRPG was also updated to direct water companies to include the benefits of water labelling from 2025.

Water labels allow customers to make informed choices about the water efficiency of the water-using products they buy. A mandatory water labelling scheme linked to minimum fittings standards has been in place in Australia since 2005, and such schemes have been deemed by Waterwise to be the single most cost-effective intervention that government could make to help reduce personal water use16. Labels set with minimum standards ensures that manufacturers develop more efficient products, and legislation would phase out lower rated products over time.

In the statement, Defra also announced the intention to write to local authorities, encouraging them to adopt the optional minimum building standard of 110 litres per person per day in all new builds where there is a clear local need, such as in water-stressed areas.

We are assuming that water labelling is introduced in 2025-2026 and that the benefits to reducing demand are in line with the Artesia study, Pathways to long-term PCC reduction (in this case, water labelling is estimated to provide 68 Ml/d worth of demand reduction by 2050, which equates to around 10 l/p/d)

10.3 Final dry year annual average demand forecast

Table 25 presents a summary of the final planning dry year annual average demand forecasts, for the first year of forecasts 2025/26 and at five-yearly intervals to 2049/50. These forecasts include the impact of leakage reductions (50% reduction), water efficiency (PCC of 110 litres/person/day) and metering options and other demand management options (beyond those measures already included in the baseline forecasts).

Table 25 Summary of final planning dry year annual average demand forecasts by resource zone

Resource Zone	2025/26	2030/31	2035/36	2040/41	2045/46	2049/50
Strategic	1694.0	1614.4	1548.9	1473.1	1414.0	1406.5
Carlisle	28.6	27.3	27.6	27.1	26.1	25.6
North Eden	5.7	5.5	5.5	5.4	5.4	5.3
Barepot	N/A	N/A	N/A	N/A	N/A	N/A

[15] Reducing demand for water, George Eustice, July 2021.

[16] Why we need a Mandatory Water Label, Waterwise, 2019.

10.4 Final dry year critical period demand forecast

Table 26 presents a summary of the final planning dry year critical period demand forecasts, for the first year of forecasts 2025/26 and at five-yearly intervals to 2049/50. These forecasts include the impact of leakage reductions, water efficiency and metering options and other demand management options (beyond those measures already included in the baseline forecasts).

Table 26 Summary of final planning dry year critical period demand forecasts by resource zone

Resource Zone	2025/26	2030/31	2035/36	2040/41	2045/46	2049/50
Carlisle	34.4	33.3	33.7	33.3	32.3	31.8

11. Non-potable demand

Artesia provided forecasts of non-household demand by industry sector and by water resource zone for three different scenarios corresponding to the lower, central (most likely) and upper demand forecast. These were applied as percentage increases over the planning period to base year data for the company's non-potable supplies, including Barepot, which is a separate resource zone. The River Dee non-potable supplies (and other bulk supplies) do not form part of the Strategic Resource Zone demand forecast but are simulated within the Hydro-Logic® Aquator model for the zone.

Appendix A References

Meeting our future water needs: a national framework for water resources (Environment Agency, March 2020).

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