Water resources data and modelling technical report

Appendix of the National Framework for Water Resources 2025

August 2026

Version: 1.1

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Published by:

Environment Agency
Horizon House, Deanery Road,
Bristol BS1 5AH

www.gov.uk/environment-agency

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Contents

1 Introduction

The National Framework for Water Resources 2025 sets out the challenge for England's water resources over the next planning period. We have used the Environment Agency's national water resource supply demand model as well as data projections to quantitatively inform our understanding of our nation's future water needs for public water supply and non-public water supply.

The national water resources supply demand model was developed by the Environment Agency for the first National Framework published in 2020. We have automated and updated the model, allowing us to explore future public water supply scenarios around population, water efficiency, leakage, and scenarios of reductions in abstraction to improve the environment, as well as climate change scenarios, and non-household demand. The Environment Agency's national water resources supply demand model was primarily based on data from the water company 2024 water resource management plans (WRMP24). The focus was on the period 2030 to 2055. Section 2 of this document provides detailed information on the data sources, modelling approach, assumptions and limitations, scenarios and findings. It explores the significant drivers of future public water supply needs across a wide range of possible futures and options to resolve future issues around water availability including demand management including water efficiency measures, leakage reduction, drought measures as well as increased supply/transfers.

We explored water needs outside of public water supply, including an analysis of current and updated projections of future non-public water (non-water company) demand for Section 3.3 of the main report of the NFWR2025. Section 3 of this technical report provides the technical detail, including datasets and modelling approach taken as well as further breakdown of current and future estimated consumption within key non-public water supply sectors.

We have taken outputs from work undertaken as part of the Environmental Destination for water resources developed for the National Framework 2025 to assess water availability in the future. This study explores water availability under future scenarios of public water supply, non-public water supply and environmental needs to help steer where water has the potential to be available for sustainable growth. This is covered in Section 4.

2 Assessing current and future public water supply needs

The national water resources supply demand model was developed by the Environment Agency for the first National Framework published in 2020. We have used this model to quantify the range of future public water supply needs, what factors are driving them and explore how we could resolve future deficits through demand management.

The model is based on an aggregation of annual data at the water resource zone (WRZ) level from water company Water Resources Management Plan (WRMP) data tables. This aggregate approach to modelling balances water supply and water demand using the relevant data for discrete WRZs as per water company plans as well as other data sources, provided either separately by water companies or collated internally within the Environment Agency. Water company plan data (WRMP) utilised in this approach is often derived from external models including future population growth, climate change, water availability during different types of drought events. In WRMP24 tables, the water availability and demand values are annual single values that represent design conditions that would be expected if a drought occurred within that year. These are expressed through metrics such as the annual water available during a drought event (a 1 in 200 or 1 in 500 year event) and the annual water demand over the course of a dry year (dry year annual average). Dry year annual average demand is specifically defined where demand is at its highest before temporary use bans are imposed.

We have developed the model to explore the impact of different assumptions around population growth, per capita consumption, resilience to drought, as well as climate change and environmental improvements amongst others across 2025 to 2055. Our outputs explicitly explore the period between 2030 and 2055. This period is based on the assumption that water companies would have delivered the actions included in their first 5 years of their WRMP24 plans by 2030. The end date reflects the statutory minimum 25-year planning horizon as per the [Water Industry Act 1991.](#) The WRMP24 table data was extended out to 2100 where not already provided, however this did not include any new supply side options not already in WRMP24 preferred plans.

The model results are presented at a national and regional scale with the actual modelling undertaken at the WRZ level. This was to enable flexibility in the regional boundaries used. It also enabled a greater understanding of the deficits within a region which can often be hidden by surpluses in other WRZ within a region. Moving water within a region between WRZ in surplus and those in deficit would still require infrastructure development.

National figures include companies wholly or mainly in England. Water companies in Wales are not included in national figures, but Welsh water resource zones that fall in the Water Resources West region are included in maps and regional summaries. Any cross-border imports or exports involving Wales that impact water supply within England represented in water company water resource management plans are included.

The first stage of the modelling exercise was collating and extending the supply and demand WRMP24 data out to 2055. More details are provided in Section 2.1.1 and 2.2.2.

Water consumption is largely determined by how much each person uses (per capita consumption) and how many people are using it (population).

The population growth data is taken from water company forecasts developed for WRMP24. This provided three population scenarios (high, central and low) out to 2055 at WRZ scale that are used in the main report for the National Framework for Water Resources.

Public water consumption is primarily made up of household demand, and non-household demand and leakage. The Environment Act sets out a water demand target to reduce potable water supplied in England per head of population, by 20% from 2019-20 by 2038, with interim targets set out by the Environmental Improvement Plan 2023 of 9% by 2027 and 14% by 2032. To achieve this water demand target, reducing household demand, non-household demand and leakage is imperative.

Per capita consumption (PCC) for household water use, expressed in litres per head per day (l/h/d), is the major component of household demand. Nationally, the water industry in England is expected to reduce average PCC to 110 l/h/d by 2050, with interim targets of 122 l/h/d by 2038 set out in the Environmental Improvement Plan 2023. We selected a range of PCC scenarios to explore in the national water resources supply demand model as described in Section 2.1.4.

Most of public water consumption is driven by population and PCC for households. However, 20% of the water put into supply by water companies is considered non-household use. A 15% net reduction in non-household water use by 2050 and 9% by 2038 was set out in the Environmental Improvement Plan 2023. A range of non-household consumption scenarios were explored and are described in Section 2.1.5.

The water industry in England has committed to reduce leakage by 50% by 2050 as compared to the leakage volumes in 2017 to 2018. Interim targets have also been put in place through the Environmental Improvement Plan 2023 to reduce leakage by 37% by 2038. Details of the leakage targets used in the scenarios are provided in Section 2.1.6.

Climate change is affecting us now and this pressure will continue to grow in the future. As outlined in detail in the National Framework for Water Resources, we are facing less water overall, with warmer and wetter winters, and hotter and drier summers. Climate change will impact water available for abstraction (through naturally available resource and water quality), increase water demand and affect water needed for the environment. Section 2.1.8 describes the range of climate change scenarios we have explored in the national water resources supply demand model.

The Environmental Destination for water resources as outlined in the Environmental Destination technical report identifies where, and by how much, water abstraction needs to change to achieve and maintain a healthy water environment, both now and in the future.

It has developed three Environmental Destination planning scenarios that consider a range of environmental requirements which are used to understand current and future abstraction pressures. Section 2.1.9 describes how we have incorporated the three planning scenarios into the model to explore the impact on public water supply to meet the environment's water needs.

The last National Framework (2020) reflected government policy to increase the resilience of public water supplies. This step change in ambition in drought resilience is observed in the latest round of water resource management plans (WRMP24). By 2040, or earlier, water companies are planning to be resilient to a drought which has a 0.2% chance of occurring in any year (meaning a return period of 1 in 500 years). This level of resilience means that by 2040, the use of emergency drought options such as standpipes should not be needed unless there is a drought beyond this magnitude. We only explore the resilience as provided in WRMP24 (by 2040, this reflects the water available during a 1 in 500-year drought). Our approach is described in Section 2.1.7.

Water companies include in their WRMP24, options to use drought measures and the amount of water they could provide during use. This includes drought permits, media campaigns, temporary use bans (TUBs) and non-essential use bans (NEUBs). We explore the implications of these drought measures in Section 2.1.10, including removal of any damaging drought permits.

Within their WRMP24, water companies have selected preferred schemes to enable them to achieve a positive water balance between the water available and expected water demand. These schemes, including supply and transfers, and the water they provide are discussed in Section 2.1.11.

The model brings together these datasets to allow us to explore how these components impact the nation's public water supply needs through a scenario-based approach. We provide an overview of the model in Section 2.2. The modelling undertaken and published as part of the main report of the National Framework for Water Resources explored 4 future scenarios including a worst-case Do Nothing, a reasonable worst-case High water needs, a Central and a Low water needs scenario in 2055. These scenarios were compared to a baseline scenario (in 2025 or 2030) to understand additional water needs by 2055 relative to the current water situation. More detail on the scenarios modelled is provided in Section 2.3.1. Further scenarios were undertaken for the technical report to explore sensitivities and uncertainty in specific variables, as presented in Section 2.3.2. Our results and interpretation of the modelled scenarios are presented in Section 2.4.

2.1 Water resources datasets and scenarios

2.1.1 Extraction of data from WRMP24 tables

Where we use water resource management plan 2024 (WRMP24) planning tables data, the modelling extracts data from the latest data submission, reflecting a hybrid of revised draft and final data as outlined per **Table 2.1** below. All water companies provided

WRMP24 data out to at least 2050, with 6 companies providing data out to 2075, 2 to 2080, 5 to 2085 and 3 to 2100. The end dates for WRMP24 table data for each water company is presented in **Table 2.1**. Where data does not continue past 2050, it has been extrapolated as explained below in Section 2.1.2.

Table 2.1 WRMP24 datasets used in the modelling for the National Framework for Water Resources 2025 including end year of datasets.

Water company	WRMP24 version	End year
Affinity Water	Revised draft	2075
Anglian Water	Revised draft	2050
Bristol Water	Revised draft	2080
Cambridge Water	Revised draft	2100
Essex & Suffolk Water	Revised draft	2050
Hafren Dyfrdwy	Final	2085
Northumbrian Water	Final	2085
Portsmouth Water	Revised draft	2075
Severn Trent Water	Revised draft	2085
South East Water	Final	2075
South Staffordshire Water	Final	2100
South West Water	Revised draft	2050
Southern Water	Revised draft	2075
SES Water	Final	2075
Thames Water	Final	2075
United Utilities	Revised draft	2085

Water company	WRMP24 version	End year
Veolia Water	Revised draft	2050
Dŵr Cymru Welsh Water (DCWW)	Final	2100
Wessex Water	Final	2080
Yorkshire Water	Final	2085

The national analysis covered all water resource zones (WRZs) operated by water companies wholly or mainly in England, including Veolia Water.

For the main report, WRE totals contained Hartlepool region. We have corrected this for the report here, where Hartlepool is now included in WReN.

In our assessment, we include WRZs from Hafren Dyfrdwy and Dŵr Cymru Welsh Water that fall in the Water Resources West regional group but exclude them from the national-level figures. The WRZs included from Hafren Dyfrdwy are Llandinam and Llanwrin, Llanfyllin, Saltney and Wrexham. The WRZs included from Dŵr Cymru Welsh Water are Alwen /Dee, Hereford C.U. System, Pilleth, Ross-on-Wye, SE Wales C.U. System, Vowchurch and Whitbourne.

As Welsh companies do not follow the same statutory processes as those in England, we observe some differences within the datasets. However, several components remained consistent across both regions. We outline any differences in each relevant section below.

2.1.2 Extension of WRMP24 supply demand data

We extended all datasets to 2055 using a combination of linear regression, no-change assumptions, or climate change scaling factors. **Table 2.2** summarises the approach used to project each supply-demand component, indicating which methodology we use. Note that this does not include non-potable supplies, only supplies and options included as part of water resources WRMP24 supply demand balance.

Extending datasets to 2055 enables the analysis to capture the long-term impacts of population growth, climate change, and policy targets over a 30-year planning horizon (2030–2055) on a national scale.

Where linear regression was applied, we calculate the average annual change over the last 10 years of data and projected forward to estimate future values. Where we used no change assumptions, we carried forward the final year of available data for later years.

For assessing the impact of climate change on deployable output post 2050, we applied the scaling factors provided by Atkins in the report 'Regional Water Resources Planning: Climate Data Tools' to find future values. More information on the scaling factors is provided in Section 2.1.8.

Table 2.2 Approaches taken to extrapolate a range of WRMP24 planning table components for use in modelling

WRMP24 Table ID	Component	Extrapolation method after last year of data
2BL, 3BL, 4BL, 5BL	WRMP baseline transfer options (Raw water imported; Potable water imported; Raw water exported; Potable water exported)	Where data does not extend beyond 2049–50, the data for each WRZ is assumed to remain constant beyond that point
7.6BL, 8BL, 9BL	Other components of WAFU (Total other changes to DO; Raw water losses, treatment works losses and operational use; Total Outage Allowance)	Where data does not extend beyond 2049–50, the data for each WRZ is assumed to remain constant beyond that point
7.1BL (WRMP data)	Change in DO due to climate change	Used the scaling factors provided in the Atkins report 'Regional Water Resources Planning: Climate Data Tools' to scale the 2050 value to 2055 and then linearly interpolated between these values.
7.1BL (RCP 4.5, RCP 6.0, RCP 8.5)	Change in DO due to climate change	Used the scaling factors provided in the Atkins report 'Regional Water Resources Planning: Climate Data Tools' to scale the 2050 value to 2055 and then linearly interpolated between these values.
7.2BL and 7.3BL (WRMP)	Change in DO due to ED	Where data does not extend beyond 2049–50, the data for each WRZ is assumed to remain constant beyond that point

WRMP24 Table ID	Component	Extrapolation method after last year of data
7.2BL and 7.3BL (Current, Intermediate, Full ED datasets)	Change in DO due to ED	Only one value available to reflect the 2050s for the Current, Intermediate and Full ED datasets
21BL and 22BL	Water taken unbilled (WTU) and Distribution system operational use	Where data does not extend beyond 2049–50, the data for each WRZ is assumed to remain constant beyond that point
37BL	Measured non-household consumption (including ONS-18 principal (P) population and OxCam scenarios)	Where data does not extend beyond 2049–50, the data for each WRZ is extrapolated linearly based on the trend from the preceding 10 years
38BL	Unmeasured non-household population (including ONS-18 principal (P) population and OxCam scenarios)	Where data does not extend beyond 2049–50, the data for each WRZ is extrapolated linearly based on the trend from the preceding 10 years
39BL	Measured household population (including ONS-18 principal (P) population and OxCam scenarios)	Where data does not extend beyond 2049–50, the data for each WRZ is extrapolated linearly based on the trend from the preceding 10 years
40BL	Measured household consumption (including ONS-18 principal (P) population and OxCam scenarios)	Where data does not extend beyond 2049–50, the data for each WRZ is extrapolated linearly based on the trend from the preceding 10 years
48BL	Target Headroom	Where data does not extend beyond 2049–50, the data for each WRZ is assumed to remain constant beyond that point. National headroom remains relatively stable between 2040 and 2050, making this a reasonable assumption.

WRMP24 Table ID	Component	Extrapolation method after last year of data
2.1FP, 3.1FP, 4.1FP, 5.1FP	WRMP final plan transfer options (Raw water imported; Potable water imported; Raw water exported; Potable water exported)	Where data does not extend beyond 2049–50, the data for each WRZ is assumed to remain constant beyond that point
6.2FP and 6.3FP	WRMP supply options (DO benefit from increasing raw water abstractions, as well as the non- -related components of 6.3FP)	Where data does not extend beyond 2049–50, the data for each WRZ is assumed to remain constant beyond that point
Taken from Table 5 (equivalent to 6.3FP)	Drought Resilience (Table 5 was used as some water companies included increasing raw water abstractions as part of 6.3FP)	Most time series ended in 2038-39. These were not continued, unless specified in the planning tables.
Taken from Table 5 (equivalent to 7.01FP)	Supply side drought measures	Extended Wessex Water permit out to 2054-55 as assumed it would continue as only ended in 2049-50. Other permits finish earlier, and we did not make any changes to these.
Taken from Table 5 (equivalent to 7.02FP)	Demand side drought measures	If the data ended in 2050, it was extended to 2055, assuming the effects of TUBs and media campaigns remained unchanged.
12FP, 13FP, 23FP, 24FP	Non-household consumption	For the high, central and low scenarios it is assumed that there is no change after 2050

WRMP24 Table ID	Component	Extrapolation method after last year of data
20FP	Per Capita Consumption (PCC)	After 2049-50 there is no change to PCC. The reduction target is met by 2049-50, so it is assumed that once the target has been reduced, PCC will plateau.
29FP	Leakage	After 2049-50 there is no change to leakage. The reduction target is met by 2049-50, so it is assumed that once the target has been reduced, leakage will plateau.
Taken from Table 5 and Table 6	TUBs/ Media campaigns	Extended the benefits of TUBs and media campaigns out to 2055 with no change to the value

2.1.3 Population

The population forecasts used in our water resources modelling are those provided by water companies. As per water resources planning guidance, water companies use a range of data sources to inform population forecasts including, Local Authority Plan (LAP) based forecasts and Office of National Statistics (ONS) trend-based projections. Local authority forecasts are described as “housing-led”, where they provide a housing driven view on future population growth but are typically formulated for a 10-15 year period, shorter than the planning horizon (2025-2055) required by WRMP. For longer-term planning, population projections from the ONS 2018-based national population projection (NPP) including a principal, low and high growth rate outcome are often used. Growth rates under ONS scenarios are based on assumptions around future levels of fertility, mortality and international migration, which differ according to each variant of the central projection. Our assumptions intrinsic to each scenario are outlined in more detail below.

We base the central population scenario used in the National Framework on population forecasts in the preferred plan presented in WRMP24. Majority of water companies use local authority Local Plan forecasts in the early parts (10-15 years) of their preferred water resources management plan, with extension beyond the final year of available Local Plan data based on ONS trend-based forecasts, with the majority of companies using ONS 2018-based national population projection (NPP) together with principle or high growth outcomes relating to net migration. Majority of companies use the high growth outcome related to net migration (ONS-18-High).

For the Baseline, Do Nothing, and Central scenarios, we source the WRMP24 population profile from the planning tables, using the Baseline (BL) numbers. This includes Welsh water resource zones that fall within WRW. Total population is calculated by summing the measured and unmeasured components of both Non-Household (NHH) and Household (HH) populations. We use the BL figures instead of the Final Plan (FP) because the overall population remains consistent between the two, with only the distribution between measured and unmeasured components affected by metering assumptions. For the Baseline scenario, we use start year population figures, while for the Do Nothing and Central scenarios, we apply end year population figures.

The low population scenario used in the National Framework is based on the ONS-18 principal (P) population projection. This incorporates the mortality and fertility assumptions of the ONS 2018-based National Population Projections (NPP) principal scenario, along with its principal net international migration assumption. While this is not the lowest available forecast (e.g. ONS-18-L), we consider it to be a more realistic representation of a lower population trajectory. We used this dataset for all WRZs, including Welsh water resource zones that fall in WRW.

The high population 'OxCam' scenario used in the National Framework uses population forecast data provided by water companies within the OxCam growth corridor, which extends between Oxford, Milton Keynes, and Cambridge. These companies also supplied higher population estimates for areas outside the corridor, which we included in the analysis. For areas where no higher population or ‘OxCam’ data was available, we use standard data from the WRMP24 plans instead. **Table 2.3** outlines the companies in WRE and WRSE that provided OxCam data and what scenario they provided.

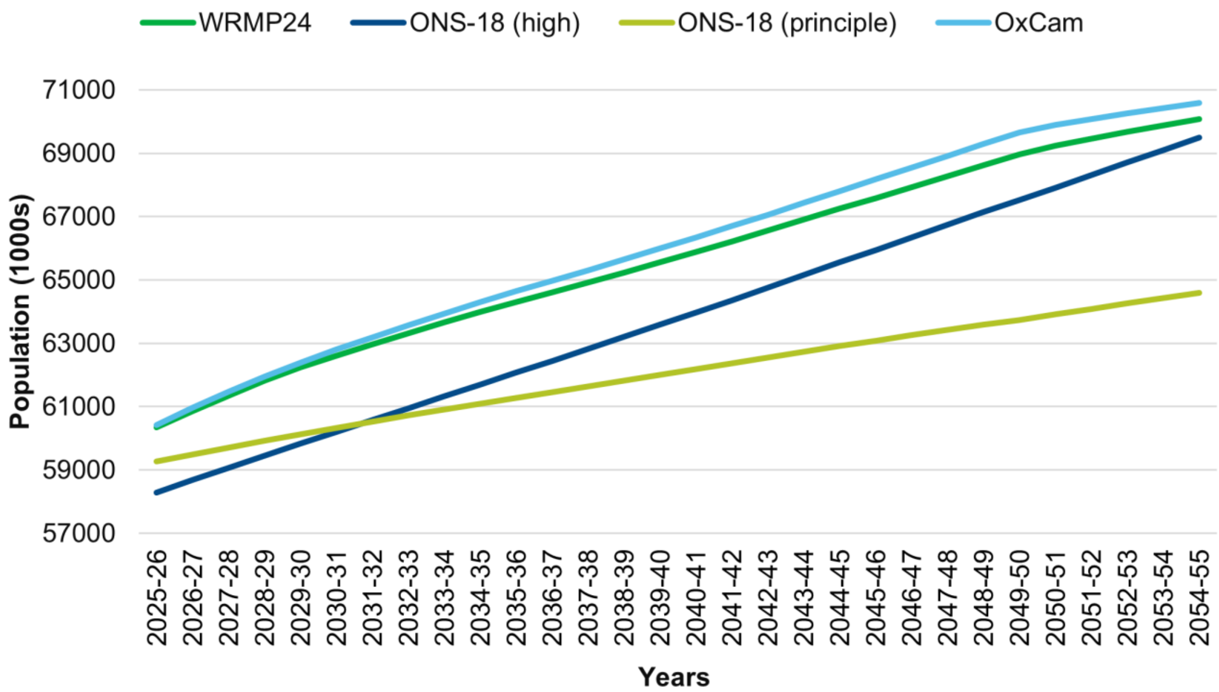
The OxCam 1a scenario assumes that 23,000 new homes are built each year, which is about 3,800 more than what is currently planned. These extra homes are spread across four areas: Cherwell (20%), Aylesbury Vale (20%), Central Bedfordshire (40%), and South Cambridgeshire (20%). From the year 2050 onwards, the amount of new housing follows official population growth forecasts from the Office for National Statistics, based on their 2018 projections.

The OxCam 2b scenario assumes 30,000 new homes are built each year. About 11,200 of these are spread across seven key areas: Milton Keynes gets the largest share (30%), followed by Luton and Bedford (15% each), and then Oxford, Cambridge, Northampton, and Peterborough (10% each). It also assumes that by 2039, more young adults will be forming their own households and that this trend stays the same after that.

Table 2.3 OxCam population scenario data provided by each water company for modelling

Water Company	OxCam Scenario provided
Affinity Water	OxCam 1a
Anglian Water	OxCam 2b
Cambridge Water	OxCam 2b
SES Water	OxCam 1a
South East Water	OxCam 1a
Southern Water	OxCam 1a
Thames Water	OxCam 1a

The population scenarios utilised are outlined in **Figure 2.1**, showing the national total population forecast (household and non-household population) between 2025 and 2055. This figure excludes Welsh zones and Veolia Water.



Caption: Figure 2.1 is a line chart showing projected population growth from 2025-26 to 2054-55 under five scenarios: WRMP24, ONS-18 (high), ONS-18 (principle), and OxCam. Population increases across all scenarios over time. The OxCam scenario

shows the highest projected population in 2054-55 (~71 million), around six million more than ONS-18 (principal) scenario which has the lowest projection (~65 million).

There are inconsistencies between WRMP population forecasts and how water companies derive them. In the latter stages of the planning horizon, some WCOs for example Yorkshire Water, use different ONS trend-based projections – such as ONS-14 or ONS-16 long-term annual growth averages up to 2050 – while others, Northumbrian and Bristol water, apply the ONS-18 principal or high variants, and in some cases (e.g. Anglian), OxCam-specific forecasts are used.

The ONS-18 principal forecast – used for the National Framework "Low" scenario – is the only population projection applied consistently across all companies. Although it does not represent the absolute lowest population forecast (such as ONS-18-L), we consider it to be a more realistic lower-bound scenario.

A range of population growth forecasts exist for the OxCam region, and for the High scenario, water companies provided their highest available OxCam population projections. As a result, the OxCam scenarios (and the associated growth assumptions) are not applied consistently across companies, with some using OxCam 1a and others OxCam 2b as outlined in **Table 2.3**.

During the development of WRMP24, the UK faced the dual challenges of a global pandemic and its departure from the EU. These events created additional uncertainty, making it more difficult for water companies to anticipate future demographic trends.

Latest ONS-22 national population projections indicate a higher population growth for England when compared to the ONS-18 projections as used in WRMP24, estimating an extra 2.5 million people in England in the early 2040s when compared to ONS-18.

The scenarios explored here include WRMP24 assumptions on population growth. We are actively collaborating with the National Infrastructure and Service Transformation Authority (NISTA) and Ministry of Housing, Communities and Local Government (MHCLG) to use our national supply demand model in the government's national infrastructure spatial tool, now called the ALIGN tool, to explore additional growth scenarios that consider updated population forecasts (ONS-22) and updated housing (such as indicative local housing need and New Towns) and industrial growth scenarios.

2.1.4 Per capita consumption scenarios

Per capita consumption represents the volume of water we each use at home in a typical day. This water is used for activities such as bathing, showering, flushing toilets, washing dishes, drinking and preparing food.

Figure 2.2 shows the proportion of water used for a variety of purposes in a typical household.

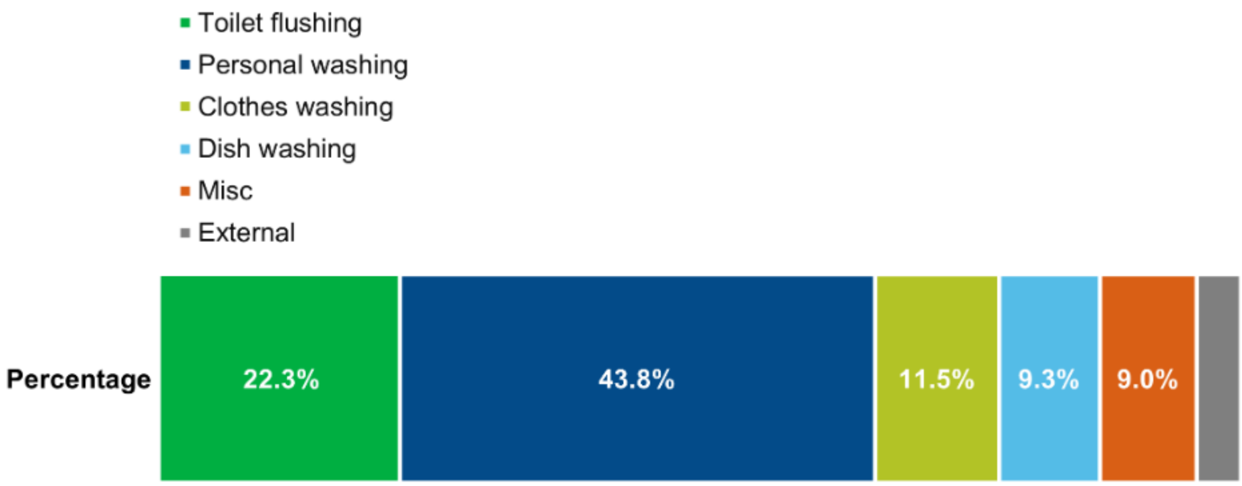


Figure 2.2 is a horizontal stacked bar chart showing the components that contribute to a typical household's water usage (per capita consumption): personal washing (44%), toilet flushing (22%), clothes washing (12%), dish washing (9%), miscellaneous (9%) and external (4%).

The modelling explores a range of potential future PCC scenarios including 120, 110 and 100 l/h/d by 2055 to understand the potential volume of water that could be saved under each and how this compares to the total potential pressures on water by 2055 nationally.

Following on from the first National Framework published in 2020, a national government target of 110 litres per head per day (l/h/d) by 2050 (at water company level) was introduced and agreed to across the water industry. Although the Welsh Government has not mandated a per capita consumption (PCC) target, both Hafren Dyfrdwy and Dŵr Cymru Welsh Water have adopted a target of 110 litres per head per day (l/h/d). This target forms the basis of the central per capita consumption (PCC) scenario (110 l/h/d by 2050) and we see this reflected in water resource management plans whereby at 2050, the national average PCC is 107 l/h/d.

We selected the high PCC scenario of 120 l/h/d by 2055 based on a range of factors including average current PCC (from annual review 137 l/h/d for outturn data (OT) and 140 l/h/d for outturn calculated as a dry year annual average (DYAA)), proposed water company demand management plans by 2050 (as per above) as well as a Water UK study published in 2019 exploring PCC savings associated with a range of demand side interventions including metering, water efficiency labelling and home audits. The high water needs scenario of 120 l/h/d falls within the uncertainty range of three scenarios explored in the 2019 Water UK report including 'Extended' that includes voluntary progressive metering by region, leaky loo find and fix and increased media campaigns and schools education, 'Enhanced-01', that includes water labelling (no minimum standards) and 'Enhanced-02' which includes voluntary progressive metering by region, innovative tariffs, targeted assisted audits, community wastewater recycling and increased media campaigns and schools education. The PCC of 120 l/h/d equates to the delivery of approximately 64% of demand targets.

The low PCC scenario of 100 l/h/d by 2055 was based on a range of factors. The PCC of 100 l/h/d is captured across three scenarios presented in the 2019 Water UK Report, including the ‘Enhanced-03’, ‘Enhanced-04’ and ‘Water Labelling Only’ scenario. These explore PCC savings related to demand side interventions including voluntary metering by region, water labelling with minimum standards; auto-switching to metering by region, innovative tariffs, targeted assisted audits, leaky loo find and fix, community wastewater recycling; and water labelling with minimum standards respectively. This scenario was also chosen to reflect the continued ambition the Environment Agency expects from water companies. Water companies have committed to a PCC of national average of 107 l/h/d by 2050/2055 in their WRMPs. We extrapolate data to 2055. The extrapolation here was based on the average annual decrease observed between 2040-41 and 2049-50, which was then applied to the following years to estimate the 2055 value.

For the baseline and Do Nothing scenarios, the start year PCC data at 2029-30 was taken from the WRMP24 planning tables. It was assumed that this PCC value remains unchanged throughout the modelling period.

We used the average PCC for each water company at the statutory target year 2049-50, as reported in the WRMP planning tables, to derive a scaling factor to align with target PCC values of 100, 110, and 120 l/h/d.

To calculate the PCC trajectory over time for each WRZ (including Welsh water resource zones that fall within WRW), our approach was as follows.

We assume that WRMP demand management options are delivered between 2025 and 2030. Therefore, the WRMP PCC profile is followed exactly during this period. From 2031 onward, we apply a scaling factor to each WRZ's profile. This factor preserved the individual profile shape of the WRZ but ensured that the water company-level average PCC met the reduction target by 2049-50.

Beyond 2049-50, we assume PCC values remain constant, reflecting the assumption that further reductions are not guaranteed without additional investment from water companies beyond the statutory target date. The time profile of the national PCC for WRMP24 and the three scenarios modelled can be seen in **Figure 2.3**. The range of PCC across the regions in 2055 for WRMP24 and the three scenarios modelled can be seen in **Figure 2.4**.

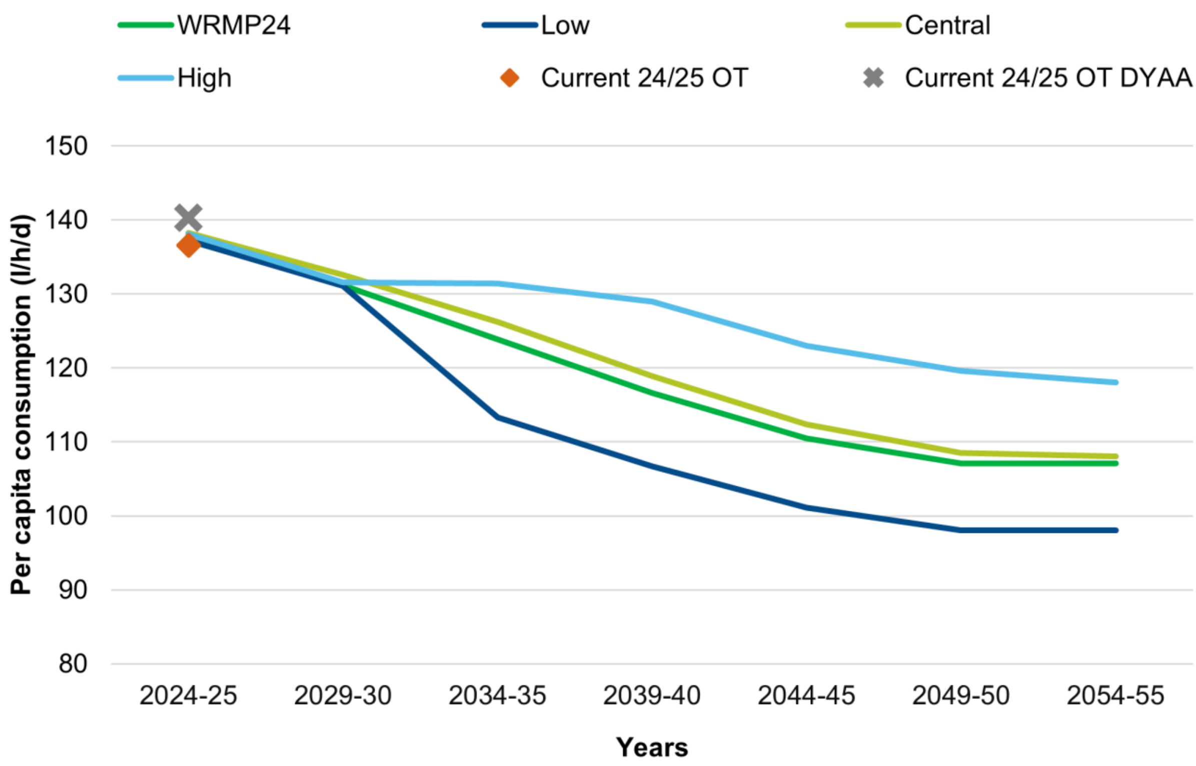


Figure 2.3: The change in national PCC in l/h/d from 2025 to 2055 for the range of PCC scenarios. Welsh regions are excluded from the national totals. We also include the annual review outturn data (OT) and the annual review outturn dry year annual average (OT DYAA) for 2024-25. For OT this is the observed data for the given year; for DYAA adjusted data, water companies were requested to consider the conditions in the reporting year and to adjust observed outturn data using assumptions in their WRMP24 plans to uplift/adjust outturn data to their dry year equivalent.

Figure 2.3 is a line chart showing how per capita consumption (PCC) is projected from 2025-26 to 2054-55 under four scenarios: WRMP24, Central, Low and High. PCC decreases across all scenarios over time from a starting 24-25 value of ~137 l/h/d to 107 l/h/d, 108 l/h/d, 98 l/h/d and 118 l/h/d by 2054-55 for WRMP24, Central, Low and High scenarios respectively. The Low scenario shows the biggest decrease by 2054-55, approximately twenty litres per head per day lower than the High scenario which has the highest projection. The current values from annual review data are also plotted (observed outturn and observed outturn adjusted to dry year annual average). The 24/25 observed outturn PCC (137 l/h/d) largely aligns with the 2024-25 PCC for all the scenarios. The observed outturn adjusted to dry year annual average is higher at ~140 l/h/d.

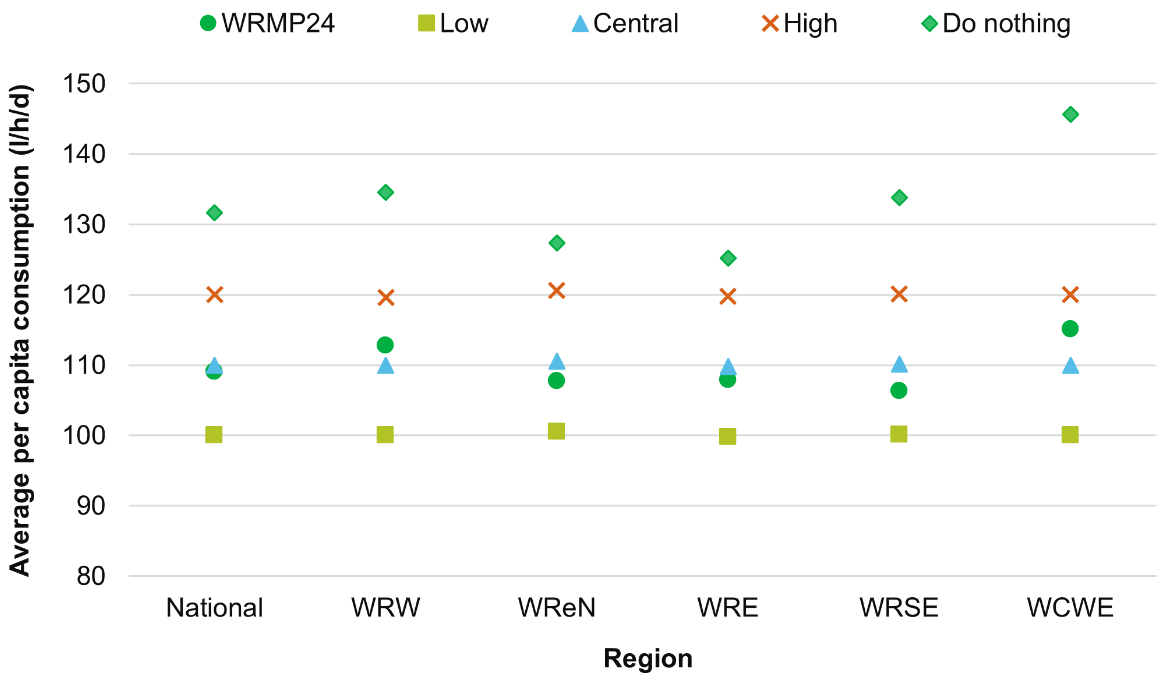


Figure 2.4 shows the regional PCC values in 2055 over the range of PCC scenarios: WRMP24, Do Nothing, Low, Central and High.

Figure 2.4 is a scatter chart showing how average per capita consumption ranges across water resources regional groups over five scenarios: WRMP24, Low, Central, High and Do Nothing. For low, central and high each region averages at 100 l/h/d, 110 l/h/d and 120 l/h/d respectively. WCWE average PCC is higher than average for Do Nothing and WRMP24. Do Nothing and WRMP24 are the only scenarios which differ across regions, with WRW and WCWE higher than the national average and WReN, WRE and WRSE lower.

Our figures assume that WRMP24 demand reduction interventions that are planned and funded for delivery in AMP8 will be fully delivered by 2030. Delays or failures in implementation would impact the projected demand profile. It is also assumed that there will be no further change in PCC beyond 2050. While this is unlikely to be accurate, the long-term impacts of demand measures are uncertain, making it difficult to predict how trends would continue.

We assume water companies meet the given PCC target by 2050, with the distribution of target ambition across WRZs aligned with existing WRMPs. However, from 2024-25 annual review data we observe a current average household PCC of 137 l/h/d (140l/h/d when assuming a dry year annual average), therefore the assumed future scenarios of 120, 110, or 100 l/h/d could be optimistic. We are actively collaborating with NISTA and WaterUK to use our model to explore worser case PCC scenarios that account for greater risks of under delivery of demand reductions.

We assume annual average per capita consumption expected in a dry year.

Our approach models the water saved under each PCC target scenario, we do not model the interventions required to meet PCC targets e.g. smart metering, water labelling, tariffs, audits, media campaigns etc. For PCC targets that exceed the statutory target of 110 l/h/d, we have not modelled the interventions required to meet this; only the water saved.

2.1.5 Non-household (NHH) demand scenarios

Public water consumption includes both household and non-household use, with non-household accounting for approximately 20% of total public supply. The main report explores a range of future scenarios for non-household water use, from a 9% to a 20% reduction by 2049-50. The Environmental Improvement Plan (EIP) sets national (England) targets of a 9% reduction from 2019-20 levels by 2038, and 15% by 2050. Water companies in England have currently committed to a 9% reduction by 2049-50 in their Water Resource Management Plans (WRMPs).

For the main report, we explore a 9, 15 and 20% reduction in non-household water use by 2049-50 to cover a range around the EIP target set. Whilst not included in the main National Framework for Water Resources report, we also explore two sensitivity scenarios of non-household water use including a scenario where non-household water use does not reduce from 2030 non-household consumption and a worst-case scenario where non-household water does not reduce from 2030 but increases as per WRMP24 baseline forecasts of non-household water consumption in 2055. These scenarios are important to sensitivity test for a range of reasons:

- Recent geo-political stability increases the change of the UK government building domestic capacity to reduce reliance on volatile international markets, particularly in energy, food production and strategic manufacturing – all heavy users of water.
- The impact of AI hyper scale data centres is still unknown. We cannot assume the current baseline indicating relatively low water usage by data centres can be projected into the future. More discussion on this in Section 2.4.6.
- Other supporting industry like blue and green hydrogen, carbon capture storage and battery factories to support NetZero and energy resilience are being considered and will require water whether provided through public water supply (water companies) or through direct private abstraction. More discussion on this in Section 3.3.5.
- 40% of private abstraction is by non-household sectors, many of which will also have a public water connection e.g. spray irrigation, horticulture, food and drink manufacturing, electricity production, paper and pulp and chemicals manufacturing. There is a risk that these sectors could move to non-household public water supply during times of drought or if abstraction limits are reduced overall. More information on current and future non-public water supply needs (private abstraction) is covered in Section 3.

For the baseline and Do Nothing scenarios, we use the start year NHH data from the planning tables. These scenarios assume that this NHH value remains unchanged throughout the modelling period and represents the NHH consumption at the end of the model run.

For low, central and high scenarios, we derive the national NHH consumption in 2049-50 from 2019-20 baseline data, applying reduction levels of 9%, 15%, or 20% depending on the scenario. This reduction is also applied to Welsh zones that fall in WRW for the purposes of consistency. In reality, targets do not apply to Welsh zones.

For the two non-household demand sensitivity scenarios of no change from 2030 and worst-case increase by 2055, we take NHH consumption from baseline WRMP24 data at 2030 and 2055 respectively.

We calculate non-household water consumption by subtracting measured and unmeasured underground supply pipe leakage from both the measured and unmeasured water delivered components, respectively.

To calculate the NHH trajectory for each WRZ, we assume that WRMP options are to be delivered between 2025 and 2030, and therefore the WRMP profile is followed exactly during this period. From 2031 onward, we adjust NHH consumption using a scaling factor that preserved the shape of the WRZs individual profiles but ensured the forecast would meet the national 2049-50 NHH reduction target.

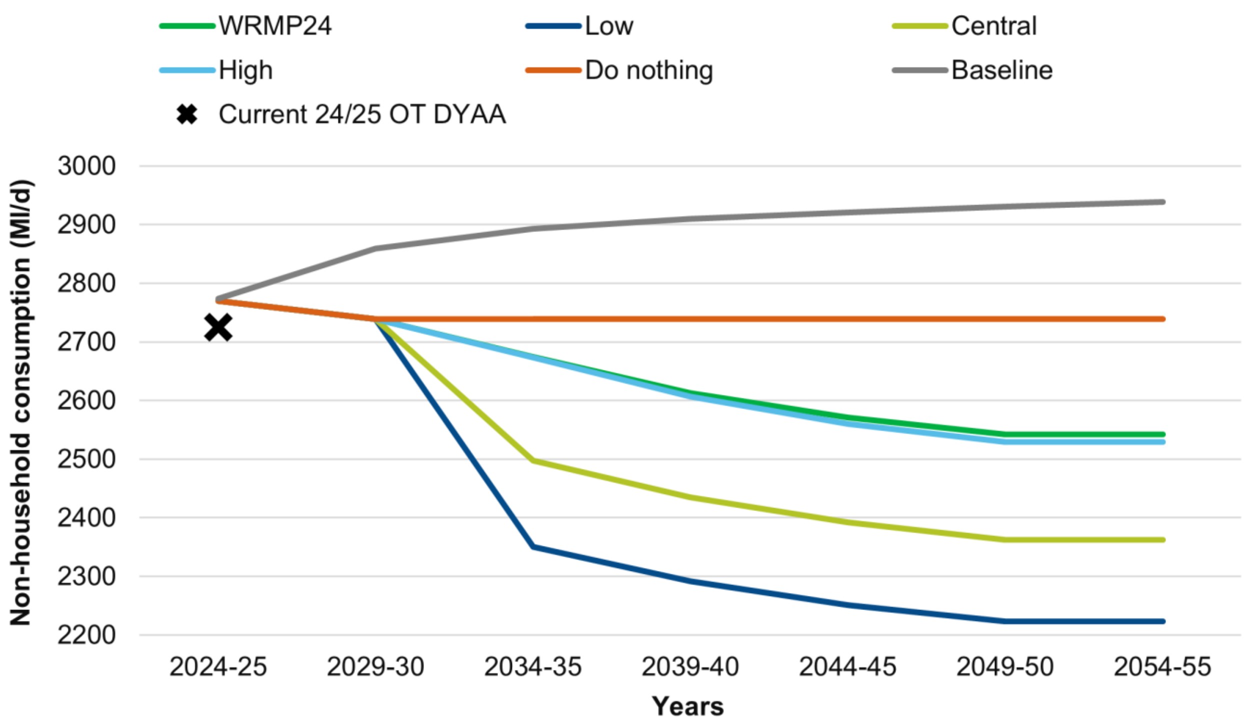


Figure 2.5: The non-household (NHH) water consumption from 2025 to 2055 under the WRMP, Low, Central, High, Do Nothing and Baseline scenarios. The black cross indicates the NHH water consumption taken from the 2024/25 Annual Review outturn data (normalised to dry year annual average).

Figure 2.5 is a line chart showing projected non-household (NHH) consumption from 2024-25 to 2054-55 under six scenarios: WRMP24, Low, Central, High, Do Nothing and Baseline. All scenarios start at 2770 Ml/d and then decrease except Baseline, which rises by 160 Ml/d from the start point over the period. The other scenarios decline in a similar way, until 2029-30, after which they diverge. Do Nothing stays constant from 2029-30 until 2054-55 while the other scenarios continue to fall at different rates. By 2054-55, the Low scenario shows the smallest projected NHH consumption. We plot the observed value from the annual review outturn data for 2024-25 (normalised to dry year annual average) as an individual point, this is 50 Ml/d less than the scenarios starting point.

Figure 2.5 shows the non-household water consumption profiles from 2025-2055 under each scenario. They assume that the NHH consumption remains constant beyond 2049-50 for the remainder of the modelling period. We present the 2024-25 annual review NHH consumption to highlight current NHH consumption. The annual review NHH consumption at 2024-25 is 2725 Ml/d, slightly lower than forecast by all the NHH scenarios.

For the end-member scenarios explored, we assume that NHH consumption is reduced by 2030 on a national scale, following the WRMP24 trajectory. Delays or failures in implementation of interventions to meet reduction targets would impact the projected demand profile. Our figures assumes static non-household consumption post-2050, this projection is unlikely to reflect reality, the long-term effects of reduction measures remain uncertain, limiting the ability to forecast future trends with confidence.

Water companies are expected to meet Environmental Improvement Plan (EIP) NHH statutory targets (9% reduction by 2038 and 15% reduction by 2050), with reductions distributed across WRZs in line with existing plans. However, given current water company commitments reflect only a 9% reduction by 2050, more ambitious scenarios of 20% and the EIP target itself (15% by 2050) could be optimistic.

We model the water saved under each non-household reduction scenario, our approach does not assess the interventions required to meet the reduction targets e.g. smart metering, water labelling, tariffs, audits, media campaigns etc.

We assume annual average non-household consumption expected in a dry year as per water company plans. This does not include potential seasonal peaks in non-household demand (e.g. due to summer heatwaves), which could have a significant impact on supply demand balance. We also do not explore non-potable sources of water that could be used to meet non-household demands.

Whilst our work uses water company WRMP24 data as the primary source of data for modelling presented in the National Framework, it is important to highlight that data from the Business Retail Market (BRM) will be an increasingly useful and reliable source of data to use. It uses a consistent and transparent data model where data can be provided monthly from 2017, covering approximately 90% of non-household customers, with volume accuracy set to significantly increase in AMP8 through smart metering. Whilst the data quality and segmentation have been an issue in the past, this has been improving and will continue to improve with the new market performance framework and BRM's strategic data programme that looks to improve industry segmentation. We use some of this data to explore current water consumption by data centres in Section 2.4.6.

2.1.6 Leakage scenarios

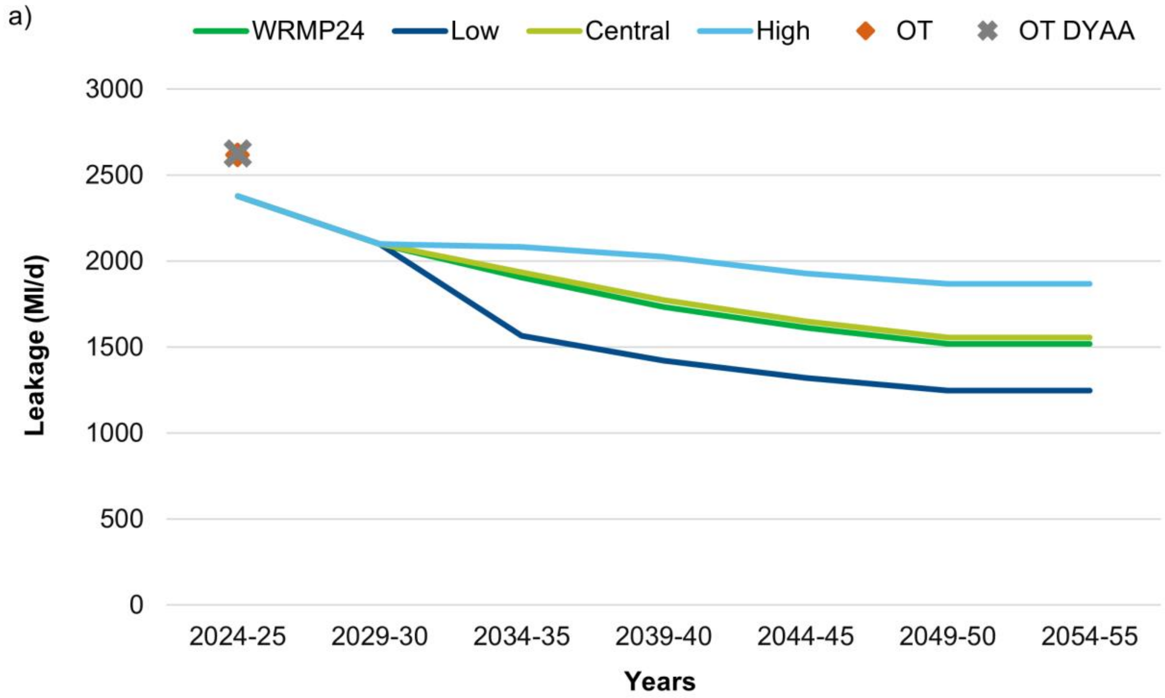
The water industry in England and Wales is committed to reducing leakage by 50% by 2050 as compared to leakage volumes in 2017-18 as part of the statutory targets set out in Environmental Improvement Plan (EIP). Hafren Dyfrdwy adopt a different base year for measuring leakage, using 2019-20 instead of 2017-18.

We have used three leakage scenarios to explore the uncertainty around delivery of this target. These include a 40, 50 and 60% reduction in leakage from a 2017-18 base year.

For the baseline and Do Nothing scenarios, we take the starting year leakage data from the planning tables. We assume that the leakage value remains unchanged throughout the modelling period and represents the leakage at the end of the model run.

For low, central and high scenarios of leakage, we derive leakage targets by the statutory end date (2049-50) from the 2017-18 base year data, using reduction levels of 40%, 50%, or 60% *per water company*. The exception to this is Hafren Dyfrdwy, which calculated its leakage target based on 2019-20 data, instead of 2017-18.

To calculate the leakage trajectory for each WRZ, we assume that WRMP options are delivered between 2025 and 2030, and therefore the WRMP profile is followed exactly during this period. From 2031 onward, we adjust leakage levels using a scaling factor that preserved the shape of the WRZs individual profile but ensured the forecast would meet the water company 2049-50 leakage reduction target. If this adjustment resulted in a value higher than the 2030 leakage level, we capped the value to prevent any increase, ensuring a consistent or declining leakage trajectory throughout the planning horizon. The modelled and WRMP leakage trajectories are shown in **Figure 2.6**.



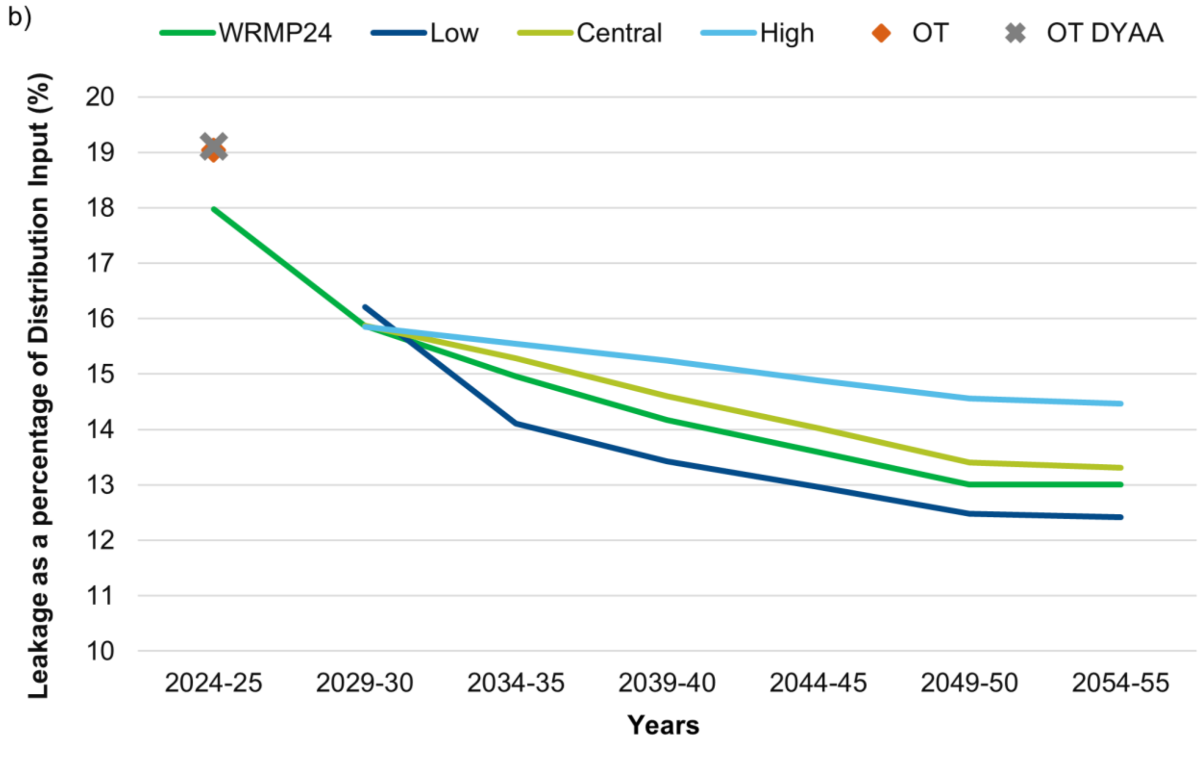


Figure 2.6a and 2.6b: The leakage profile from 2024/25 to 2054/55 under the WRMP, Low, Central and High scenarios represented as leakage in Ml/d in Figure 2.6a and as a percentage of distribution input in Figure 2.6b. The orange circle and grey triangle indicate the respective leakage metric as calculated from the 2024/25 Annual Review outturn data and 2024/25 Annual Review outturn data normalised to

dry year annual average respectively. In Figure 2.6b, the start point of Low is higher than the other scenarios (unlike in 2.6a where they align) this is because while the total leakage under all scenarios is the same at 2029-30, the distribution input is smaller, enough so for leakage to be a bigger percentage of the total DI in this scenario.

Figure 2.6a and **2.6b** are line charts showing leakage reduction profile from 2024-25 to 2054-55 under four scenarios: WRMP24, High, Low, Central, Do Nothing and Baseline. For 6a, all scenarios start at 2377 Ml/d and then decrease identically until 2029-30, after which they diverge. By 2054-55, the Low scenario shows the smallest projected leakage 622 Ml/d less than the highest scenario - High. The observed value from the annual review data for 2024-25 is plotted as a point 240 Ml/d higher than the scenarios starting point. **Figure 2.6b** follows a very similar trend with a general decrease over time. All scenarios sit within 10%-20% for the entire period starting at 18% in 2024-25 and decreasing to between 12-15% across scenarios by 2055.

We assume that leakage remains constant beyond 2049-50 for the remainder of the modelling period, as further reductions could not be guaranteed without additional investment from water companies beyond the statutory target date.

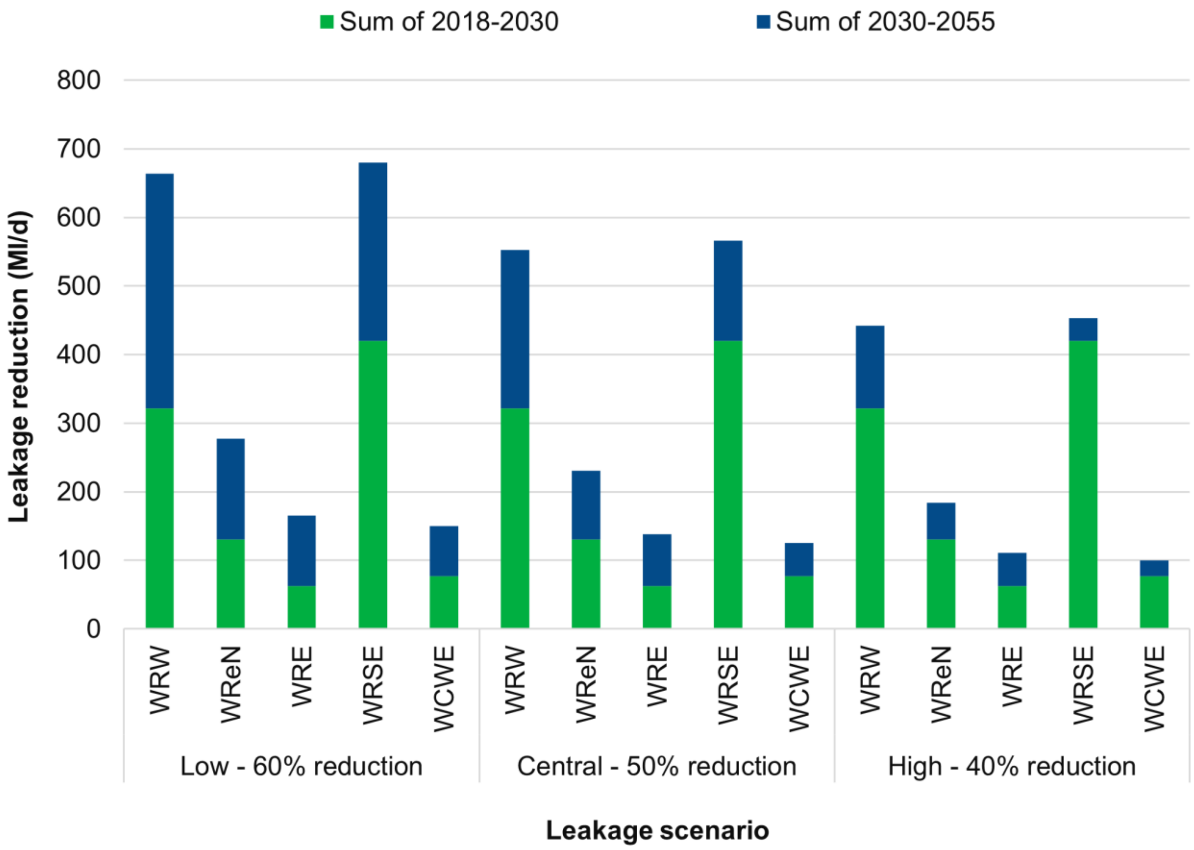


Figure 2.7: The leakage reduction (Ml/d) under the Low, Central and High reduction scenario split by region. The stacked bars show the proportion of leakage reduction implemented 2018-2030 (pre-2030) and 2030-2055 (post-2030).

Figure 2.7 shows the water saved in Ml/d due to leakage reduction under 40%, 50% and 60% reduction scenarios by region. It also shows the proportion of water saved in pre-2030 plans compared to post-2030 plans. The national amount water companies plan to save by 2030 is 1012 Ml/d. The proportion of leakage reductions pre-2030 varies across regions. In most regions, over half of the total reductions should be delivered by 2030 under the 40% and 50% modelled reduction scenarios. The only exception to this is in the WRE region which drops to fulfil just below half of 50% by 2030. The WRSE region shows close to a 40% reduction of all leakage by 2030. This trend varies when discussing a 60% reduction, where the only regions meeting at least half of the reductions by 2030 are WRSE and WCWE.

Our figures assume leakage reduces by 2030 in line with WRMPs. Delays or failures in implementation may affect the demand profile. Post-2050, we hold leakage static due to uncertainty around long-term impacts, limiting confidence in future projections, and further investment once targets have been met.

We model the water saved under each leakage reduction scenario; our approach does not explore the interventions required to meet the reduction targets e.g. leakage detection, fixing leaks, leakage network management, leakage prevention.

Across our scenarios, we assumed the distribution of the 2050 leakage target across WRZs aligned with existing WRMPs.

Our expectation is that water companies will fully deliver against their leakage reduction commitment by 2050. However, from 2024-25 annual review data we observe a current leakage reduction of 15.6% (15.9% when assuming a dry year annual average), the assumed future reduction targets of 40, 50 or 60% could be optimistic. We are actively collaborating with NISTA and WaterUK to use our model to explore worser case leakage scenarios that are trend based, instead of target focused.

Our figures assume annual average leakage expected in a dry year as per water company plans.

2.1.7 Public water supply resilience scenarios

The water resources planning guideline sets a requirement for water companies to achieve resilience to a drought with an annual probability of 0.2% (1-in-500-year drought event) by 2039 at the latest. In the interim, a minimum resilience level of 1-in-200 years is expected, to allow time for planning and implementation.

All scenarios modelled here use WRMP24 resilience data aligned with reaching a 1-in-500-year standard by 2039. Due to inconsistencies in how resilience data is presented across the planning tables, we collated a dataset to isolate and standardise resilience figures for use in the model. For example, some WRZs included elements of climate change within their resilience data. To ensure clarity and consistency in the modelling, we separated this out and reassigned to climate change.

This analysis assumes that water companies comprehensively list all available resilience options in Table 5 of the water resource management planning tables.

2.1.8 Climate scenarios

Climate change has the potential to bring sudden and unpredictable impacts. Climate change is increasing the likelihood of hotter summers and combination hot and dry conditions like those experienced during 2018 and 2022. This needs to be incorporated into plans to increase the level of public water supply resilience to drought. Considerable work has taken place since 2020 to understand and achieve a level of resilience well beyond any drought event that companies have experienced historically through use of stochastic methods, climate change impact assessment and widespread use of hydrological and system simulation modelling.

The impact of climate change on the UK water industry including impacts on public water supplies is uncertain. It will depend on the trajectory of greenhouse gas emissions globally, how the climate will respond to those emissions and how individual water sources, surface water and groundwater, will be affected by that response. In particular:

- changes in rainfall patterns causing lower flows in rivers in summer that lead to regulatory conditions to reduce or prevent abstraction triggering more frequently and for longer
- changing the profile of water availability across the year in a way that reduces the amount that can be stored in reservoirs
- changes in patterns of groundwater recharge altering the amount of water in aquifers available for abstraction and the potential for rising sea levels to increase the risk that saltwater contaminates aquifers (known as saline intrusion)

These changing weather patterns and impacts to water sources are likely to require different ways of managing water.

The extent of climate change impacts on public water supplies may also be restricted by factors that are independent of climate change such as regulatory limits on the amount that can be taken over a given period, physical constraints on the amount of water that can be taken such as pump capacity and limitations of the distribution network and treated water storage that the site is supplying.

This uncertainty is highlighted by the allowance for climate change uncertainty (51 Ml/d) in water company WRMP24 plans at 2055. Sources of uncertainties include variations in results from different climate change models, the choice of greenhouse gas emission scenario (temperature projections between RCP 2.6 and 8.5 diverge significantly post 2050), impact of changing climate seasonal patterns (e.g. hotter and drier summers) and the period of impact (e.g. 2080 predictions show an accelerated impact).

Water company water resource management plan 2024 guidance included a tiered approach to assessing climate change impacts. For high vulnerability WRZs, the guidance suggested the use of a range of UKCP18 products and scenarios from the latest Met

Office model to consider the full range of uncertainty. For WRZ with medium or low vulnerability, UKCP18 products could either supplement WRMP19 results or not be used at all.

In WRMP24, the impact of climate change on water sources was based on UKCP18 data. UKCP18 climate projections suggest a greater chance of hotter, drier summers and warmer, wetter winters with more extreme weather and rising sea levels. This has the potential to lead to shorter sharper groundwater recharge season, increases in potential evaporation and drier soils and extended drought periods where wetter winters would not offset the impact of drier summers.

Water companies use a variety of approaches to incorporate climate change in their methods to estimate impacts. For example, some use change factors versus incorporating climate into their stochastic model fitting, some have only explored the median impacts of individual UKCP18 climate products, some have explored the full range of climate products, including those from different climate models and projections (UKCP18 and UKCP09 probabilistic projections across a range of representative concentration pathway (RCP) emissions scenarios and UKCP18 global climate model (GCM) and regional climate model (RCM) at RCP 8.5).

The flexibility in water resources management plan 2024 guidance in terms of approaches and datasets as well as the range of UKCP18 climate products available, means the climate change impact presented in preferred water company plans are not strictly comparable between water companies. In their preferred plan, approximately 60% of water companies have used the UKCP18 medium emissions scenario (representative concentration pathway (RCP 6.0) and the rest have used the UKCP18 high emissions scenario (RCP 8.5) as highlighted in **Figure 2.8**. Each pathway results in a different range of global mean temperature increases over the 21st century (**Table 2.4**), although note there is some overlap.

Table 2.4: The increase in global mean surface temperature averaged over 2081-2100 compared to the pre-industrial average (average between 1850-1900) for the UKCP18 RCP pathways used in the National Framework modelling (best estimate, 5-95% range).

UKCP18 Emissions Scenario (RCP)	Change in temperature (degrees C) by 2081-2100
Low (RCP 4.5)	2.4 (1.7-3.2)
Medium (RCP 6.0)	2.8 (2.0-3.7)
High (RCP 8.5)	4.3 (3.2-5.4)

Figure 2.8 indicates the approach used in each water company. For Welsh water resource zones, the impact of climate change has not been modelled.

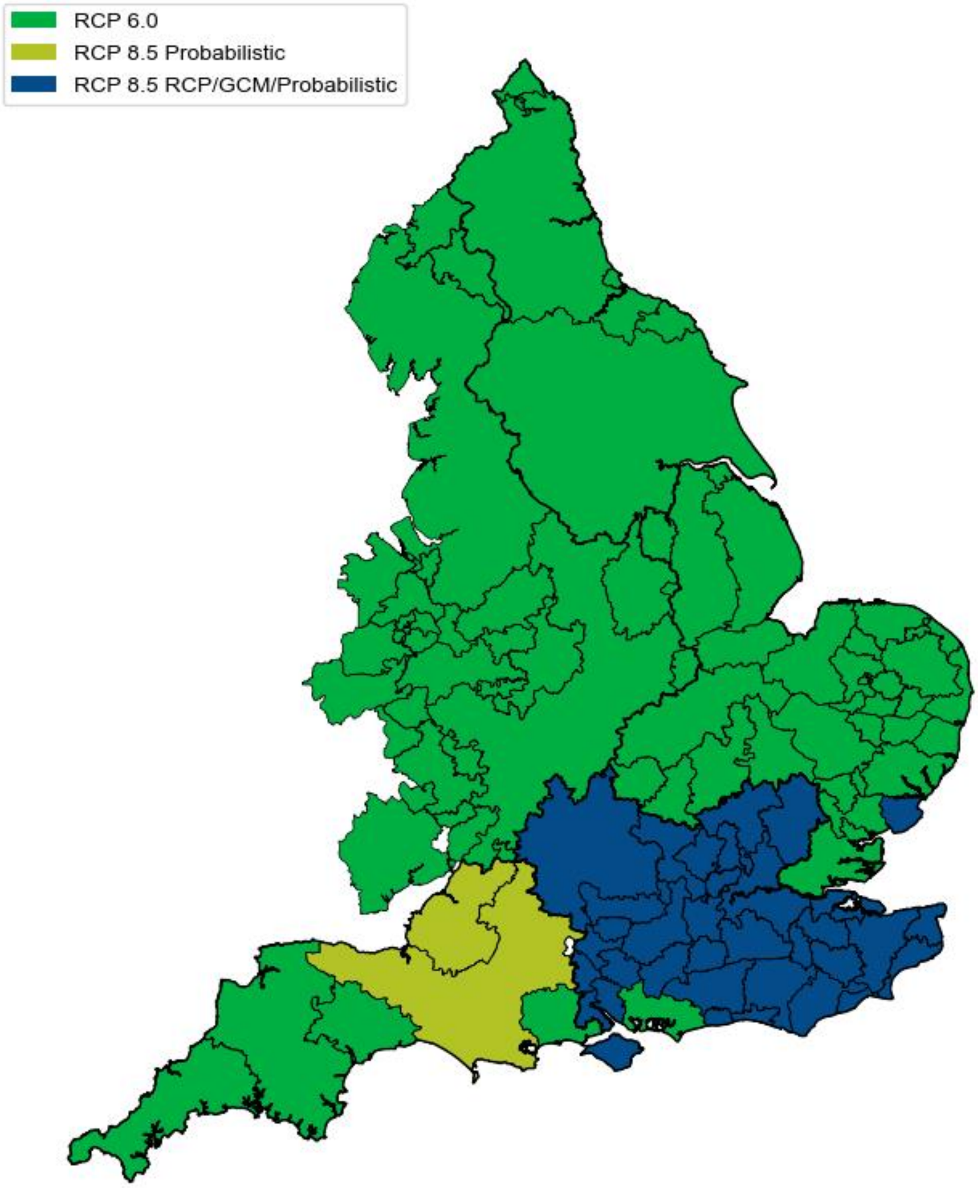
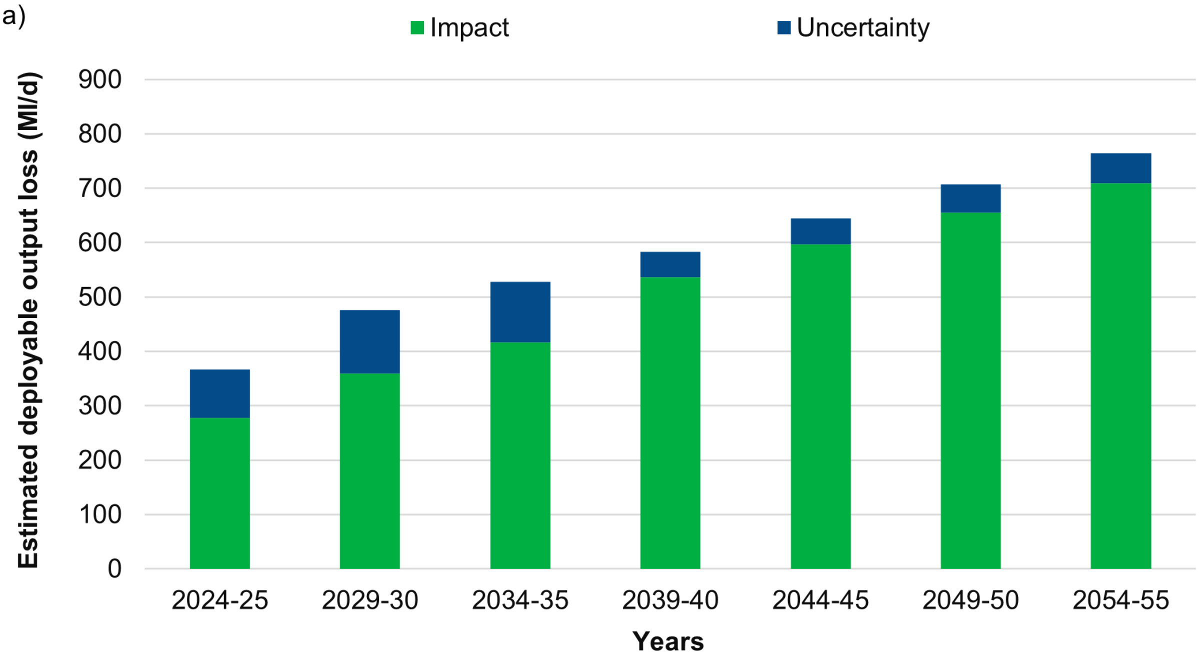


Figure 2.8 shows a map of England and outlines the climate change scenarios used in each water resource zone. RCP 6.0 was the most widely used – all of WReN, WRW, WRE and part of WCWE. RCP 8.5 RCP/GCM Probabilistic was used by all except one water resource zone of WRSE and one water resource zone in WRE. RCP 8.5 Probabilistic was only used by two water resource zones in WCWE.

Our assessment of climate impact on public water supply uses data provided in water company WRMP24 tables, data provided by water companies under other climate scenarios as well as internal analysis to provide a full dataset of potential future impacts of a range of climate change scenarios.

The water resource planning guidance for WRMP24 plans required water companies to quantify the impact of climate change on water availability that has occurred since the 1990s and incorporate this impact into the first five years of their plans. They were also required to include the uncertainty associated with climate change, either through preferred plans within headroom or through adaptive pathways.

a)



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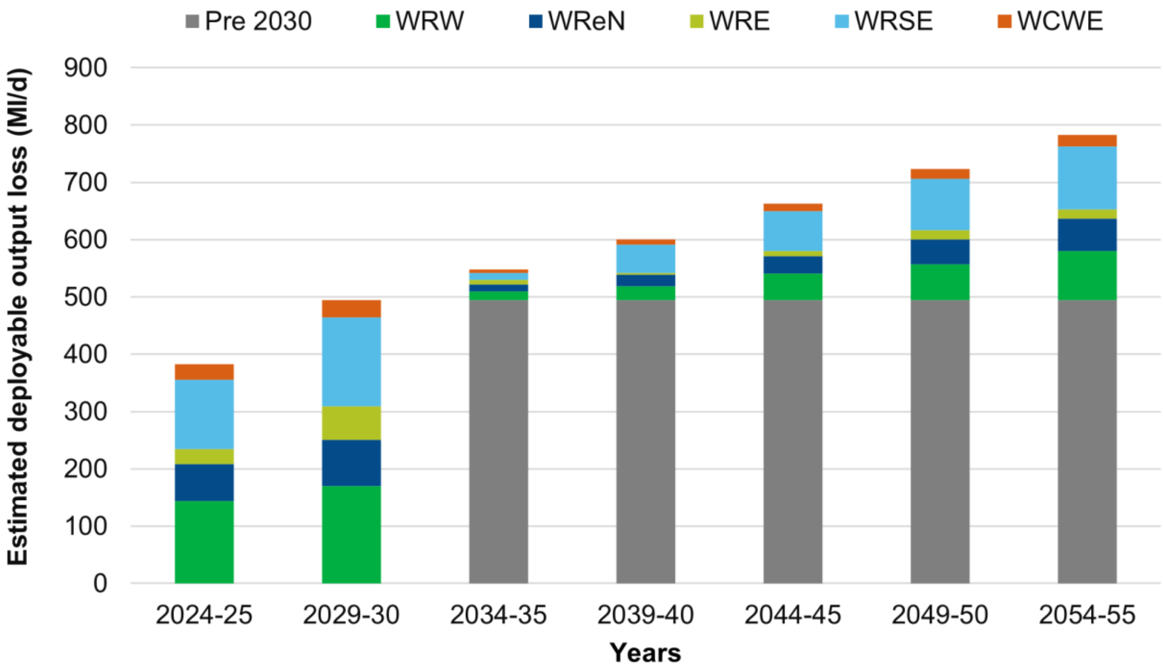


Figures 2.9a and 2.9b show WRMP24 preferred plan climate change impact on supply and uncertainty (climate component of target headroom) from 2024/25 to 2054/55. Figure 2.9a shows the split between impact and uncertainty through the years, whereas Figure 2.9b represents the total regional climate change demand,

with a grey bar to show how much climate change impact is accommodated before 2030.

Figure 2.9a is a stacked column chart showing how water companies expect climate change to affect deployable output, split into impact and uncertainty, from 2025-26 to 2054-55. The national climate change impact increases over time from ~280 Ml/d in 2024/25 to ~700 Ml/d by 2054/55. National uncertainty in climate change increases to a peak of 117 Ml/d from 2024/25 to 2034/35, then reduces to 48 Ml/d 2039/40 before increasing gradually to 55 Ml/d by 2054/55. **Figure 2.9b** is a stacked column chart showing how water companies expect climate change to affect deployable output, split into water resource regional groups, from 2025-26 to 2054/55, with a white bar to show where plans accommodate for climate change impact before 2030. Further detail is covered in the text below.

Climate change impacts have been considered in previous WRMPs resulting in investment already being put in place to support climate change adaptation. Between 2030 and 2055, around 5.3% of the existing water available in 2030 would be impacted by future climate change. Water companies will already be planning measures to meet this water need. The reported impacts of climate change are therefore smaller than they would have been without this investment. Over time the impact increases, however the uncertainty fluctuates. Uncertainty increases to a peak in 2030 at 117 Ml/d and then decreases to 48 Ml/d by 2040. It then gradually increases to a total of 55 Ml/d by 2055. By 2055, impact and uncertainty in climate change increase to a total of 709 Ml/d nationally. This fluctuation and range of uncertainty at the national level likely reflects the mix of approaches water companies and regional groups have taken to assess climate change uncertainty (whether through target headroom or adaptive planning that is not captured here).

Regionally, WRW and WRSE are impacted the most by climate change. With their supplies reduced by 193 Ml/d and 265 Ml/d respectively. Similarly to this, WRW (which includes some Welsh zones) includes the highest uncertainty around climate change, requiring 63 Ml/d by 2055 more than the English national total at 55 Ml/d. The higher uncertainty seen in WRW when compared to England is driven by ~15 Ml/d of uncertainty observed in Welsh zones. From the data, we observe that WRSE uncertainty around climate change drops to 0 Ml/d from 2040-2055; this is because uncertainty regarding climate change has been accounted for within their adaptive plan branches rather than the preferred plan.

The climate scenarios explored for the National Framework include a low (RCP 4.5), medium (RCP 6.0), high (RCP 8.5) and hybrid (WRMP24, 60% RCP 6.0, 40% RCP 8.5) climate emissions scenario.

To create a complete dataset for the high, medium and low emissions climate scenarios, we utilised the scaling method in the Atkins report ‘Regional Water Resources Planning: Climate Data Tools’ to estimate the impacts of different climate emissions scenarios using temperature-based scaling. This is useful when detailed modelling had not been undertaken by all water companies for all climate scenarios.

For all regions except WRSE, we took climate change impacts to deployable output data at 2080 from WRMP planning tables and scaled to RCM RCP8.5 and/or RCP 6.0 (depending on data available) and further scaled to RCP4.5 and applied over time, using the combined impact and timing scaling factors created by Atkins (Table 5-2, Atkins, 2021).

For WRSE (where they had modelled a full range of scenarios), we sourced the change in deployable output due to climate change under all scenarios directly from the WRMP tables, RCP8.5 from the preferred pathway, RCP6.0 from the Ofwat Core pathway, and RCP4.5 from alternative plan 2 pathway.

We present the deployable output (supply) loss associated with each climate scenario nationally and across regions in Section 2.4.3 where we explore the sensitivity around climate change, additional water required to account for it and impact to deficits if we do not.

The scaling methodology outlined by Atkins assumes that climate and hydrological impacts can be linearly scaled with temperature (across RCP scenarios), which potentially oversimplifies the complex interactions between climate variables and water resource systems. The Atkins report suggests that scaling factors could be applied to either rainfall, hydrological flows or deployable output. The methodology did not include water resources modelling to assess climate impacts and was not fully validated or tested. It is likely that the impacts of climate change will depend on catchment characteristics and water resources system characteristics. This introduces significant uncertainty into the results and limits confidence in the scaled outputs, where they only provide an estimate. Due to the methodology used to calculate climate change by water companies, the impact we are seeing to supply is likely to be an upper estimate, particularly around the west of the country.

Our work assumes climate change uncertainty (target headroom) to remain constant across all climate scenarios explored here where it is accounted for in the supply demand balance.

The impact of climate change explored here does not include the uncertainty of how climate change will impact water use and behaviour, where demand for water has been estimated to increase by 20% or more when temperatures exceed 26 degrees which requires accounting for through demand. The water resources planning guidance recommends an allowance for the impact of climate change on the demand of water, in most cases this is likely to be no more than 1% over the planning period and should not be more than 3%. We explore the impact of climate change on demand in sensitivity scenarios presented in Section 2.4.3.

2.1.9 Environmental needs scenarios

Sustainable abstraction is essential to ensure that river flows and groundwater levels support a thriving environment and protect biodiversity. It is also vital to ensuring a secure, clean supply of water for all users. There are a significant number of locations where abstractions are currently unsustainable. A changing climate is likely to bring greater variability in rainfall and higher temperatures which could led to different environmental water needs in the future to protect the environment. Moving to sustainable abstraction will provide greater resilience to changes in climate and drought pressures.

The Environment Agency continues to identify where and by how much, current and future water abstraction needs to change to meet environmental requirements through the Environmental Destination (ED) for water resources for England. We address this in detail in the National Framework for Water Resources 2025 main report and the National Framework for Water Resources Environmental Destination technical report.

The National Framework for Water Resources 2025 has developed three Environmental Destination planning scenarios to explore potential long-term abstraction reductions in England. These scenarios are termed as current, intermediate and full. We provide a summary of these, including environmental targets/objectives under each in the Environmental Destination technical report.

We have modelled the impact of four different scenarios of environmental needs on public water supplies in the National Framework. These include the three Environmental Destination planning scenarios at 2050 (Current, Intermediate and Full) as well as the Environmental Destination outlined by water companies in their WRMP24. WRMP24 reflects previous Environmental Destination scenarios outlined in National Framework for Water Resources 2020 and developed through the WRMP24 planning round. WRMP24 scenario definitions are not always consistent across water companies and regional groups but reflect a preferred environmental destination scenario for each region based on 2024 regional and water resource management plans. Wales does not adopt the Environmental Destination used in England, therefore scenarios, licence reductions and deployable output loss presented here do not include water resource zones in Wales.

The Ml/d impact to public water supply (deployable output) will differ from the estimated reduction of abstraction (licence reductions) for a few reasons including:

- hands off flow (HOF) conditions on surface water abstractions reduce the availability of water for abstraction during droughts
- storage (e.g. reservoirs) can limit the effect of licence reductions
- groundwater sources can be operated at different rates seasonally within the annual licence

The environmental needs datasets (deployable output change associated with changing abstraction) used in the national water resource supply demand model either take information from WRMP24 planning tables or have been generated based on potential abstraction licence reductions under each of the Environmental Destination planning scenarios at 2050. For the purposes of our modelling, we have taken one of the two simulated climate projections in the Environmental Destination work – the wetter range climate scenario in the 2050s (RCM04), for more information on this, please refer to the Environmental Destination technical report. We based this on observing the highest licence reductions nationally under this climate projection (to provide a maximum impact as RCM04 demonstrated 100 Ml/d higher reductions than RCM11), despite it reflecting the 'wetter' range.

We have taken the best available and most appropriate licence reductions for water company WRMP24 (to reflect their BAU+ or Enhanced scenario) and mapped them to WRMP24 water company deployable output reductions to restore sustainable abstraction (7.2BL) and for Environmental Destination (7.3BL) at 2050 as provided in planning tables. This mapping exercise defines a relationship between WRMP24 licence reduction and deployable output reduction for each water company and we used it to create a basic scaling factor. We took licence reductions for WRMP24 BAU+ or Enhanced scenarios from either work undertaken for the National Framework Water Resources 2020 (Enhanced scenario) or from data provided by water companies (BAU+/Enhanced). To have assurance that the licence reductions utilised were appropriate and to validate the scaling factors that we created, we benchmarked the approach to the National Framework Current 2050 planning scenario. This scenario is semi-equivalent to BAU+ scenario which was largely used for WRMP24. We calculated that the assumed licence reductions used for WRMP24 to be within 2% of the 2050 Current ED planning scenario licence reductions nationally. When we applied the scaling factors, the estimated deployable output reduction under 2050 Current ED planning scenario was also within 2% of WRMP24 deployable output reduction at 2050 nationally.

To estimate a deployable output change (usually a loss) for Current, Intermediate and Full at 2050, we take the licence reductions observed at 2050 under each scenario aggregated to water company scale and apply the equivalent water company scaling factor created in the previous step. The estimated 2050 deployable output loss for each water company under each scenario was distributed across each water resource zone based on WRMP24 distribution of Environmental Destination deployable output loss. Water resource zone 2050 deployable output loss under each scenario was distributed across the planning period (2025 to 2049) through linear interpolation, using 2025 WRMP24 7.2 and 7.3BL as the base year. Post 2049-50, our figures assume no changes to Environmental Destination. We substitute these datasets of Current, Intermediate and Full in place of WRMP24 7.2 and 7.3 BL datasets in the model.

For the baseline scenario, we applied DO loss related to WINEP using the 2030 start year value. In the Do Nothing scenario as presented in the publication of the National Framework for Water Resources 2025, we used the end year value for DO loss from WINEP (2055), along with additional DO loss from reductions required for WRMP24 Environmental Destination by 2055. The Do Nothing scenario as presented in the main publication does not reflect the latest National Framework ED planning scenarios.

For the high, central and low needs scenarios in the publication of the National Framework for Water Resources 2025, we use the DO loss under Full, Intermediate and Current Environmental Destination planning scenarios respectively. We outline the licence reductions and associated DO loss nationally and regionally used in the main publication of the National Framework in **Table 2.5**.

Table 2.5: The licence reductions (Ml/) and estimated deployable output loss (Ml/d) for each scenario regionally and nationally as used in the modelling in the main publication of the National Framework for Water Resources 2025. Licence reductions for Current, Intermediate and Full ED planning scenarios were based on recent actual, not fully licensed.

	WReN	WRE	WRW	WRSE	WCWE	National Total
Licence reduction for WRMP (Ml/d)	41	522	611	1905	165	3245
Associated DO loss for WRMP (Ml/d)	112	507	597	1405	193	2813
Licence reduction for Current (Ml/d)	339	538	476	1462	165	2981
Associated DO loss for Current (Ml/d)	118	539	596	1449	163	2865
Licence reduction for Intermediate (Ml/d)	369	629	499	1672	191	3360
Associated DO loss for Intermediate (Ml/d)	127	638	627	1660	185	3236
Licence reduction for Full (Ml/d)	376	648	499	1701	192	3416
Associated DO loss for Full (Ml/d)	129	658	627	1695	186	3295

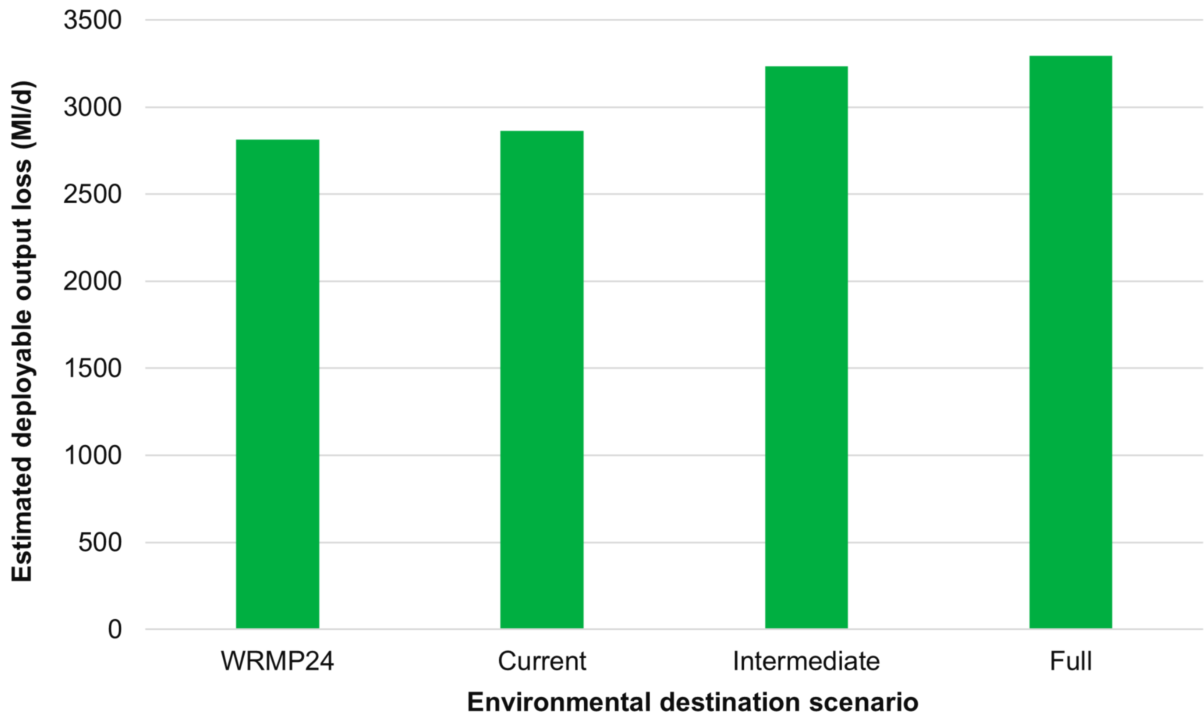


Figure 2.10 is a column chart showing the estimated national environmental needs impact on public water supply (deployable output loss) under WRMP24 and each Environmental Destination Planning Scenario used in the main report. Sustainability changes as part of the Water Industry National Environment Programme (WINEP) are included in each scenario, these are plans which have already been approved and funded and accounts for 468 Ml/d in every scenario. The national total set out in WRMP24 plans is 2813 Ml/d; this is 482 Ml/d less than the 'Full' ED planning scenario at 3295 Ml/d, representing the future range in environmental needs impact on supply across the scenarios.

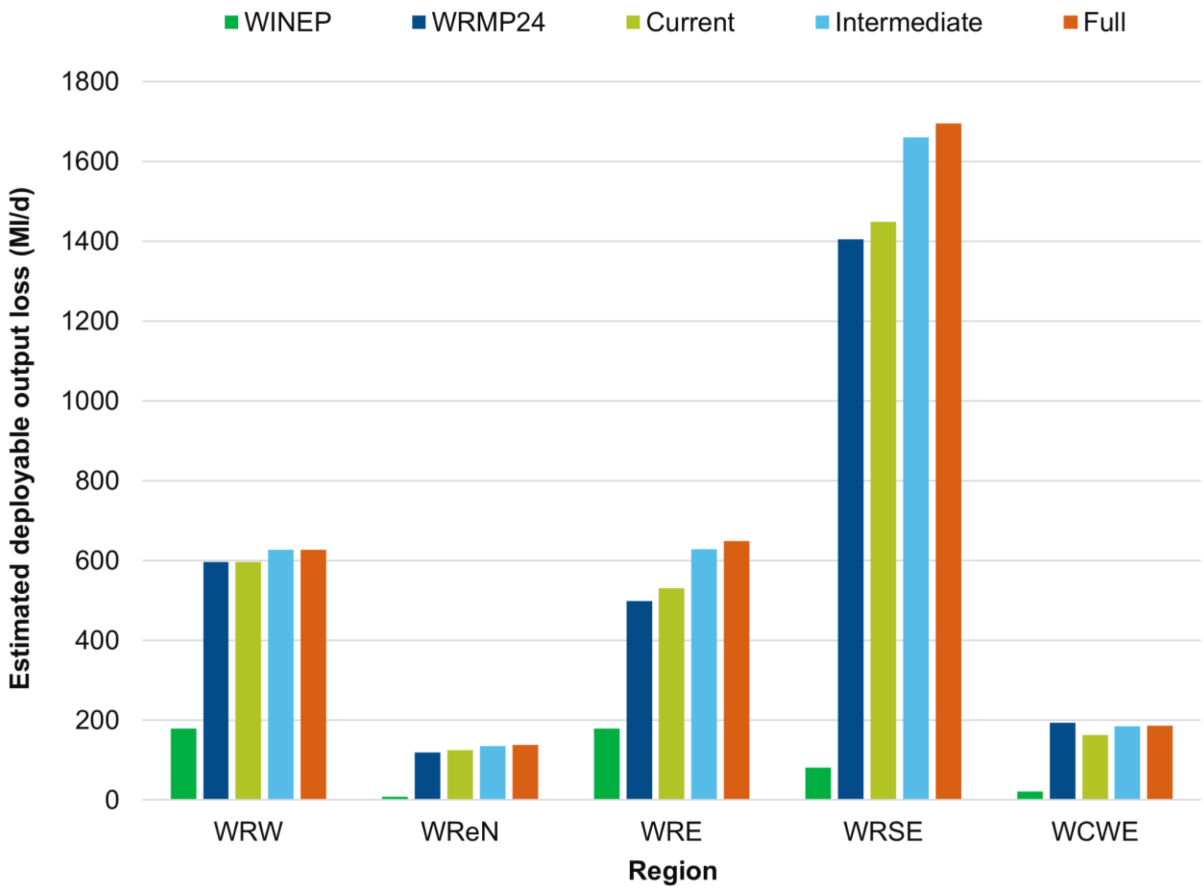


Figure 2.11 shows the estimated environmental needs impact on supply (loss of deployable output due to environmental needs) across regions due to the range of sustainability targets set out in the different scenarios at 2050. We include WINEP as a bar to see each regions contribution to the programme; WINEP totals are also included in each of the scenarios – WRMP24, Current, Intermediate and Full. Water Industry National Environment Programme (WINEP) includes the sustainable abstraction reductions that have already been approved, funded and are expected to be delivered between now and 2030. WINEP reductions are included in each scenario. Environmental Destination scenarios are the modelled full range of potential needs.

Figure 2.11 is a clustered column chart showing the impact on regional deployable output due to environmental needs across five programmes: WINEP, WRMP24, Current, Intermediate and Full. Across most regions, the estimated loss of deployable output increases as the environmental needs increase – listed above in order from smallest to largest environmental need. With totals in WReN and WCWE considerably lower than WRW, WRE, WRSE - WRSE the largest of them all. The only region where we do not see this increase on impact is WCWE, where WRMP24 has the biggest impact on deployable output.

The region estimated to have the highest environmental needs impact on supply is WRSE. Observing the total loss to deployable output under the full scenario, WRSE loses 1695

Ml/d. This is close to four times of the total of WRE or WRW - the next highest regions. We can also see the regional split of WINEP, showing these plans mostly impact WRE and WRW. The national total for WINEP in 2050 is 468 Ml/d.

After the publication of the NFWR main report in June 2025, there have been improvements to the Phase 1 licence reduction datasets for the Current, Intermediate and Full ED planning scenarios. For the NFWR main report, licence reductions were relative to recent actual. For sensitivity scenarios explored in this technical report, we use the improved Phase 1 reduction datasets under fully licensed for Current, Intermediate and Full. To be in line with this new dataset, we updated our scaling factors based on WRMP24 fully licensed reductions instead of recent actual; this improves our validation, where we see only a 1.5% difference between assumed WRMP24 fully licensed reductions and Improved Phase 1 fully licensed reductions for the 2050 Current ED planning scenarios. We outline this updated dataset in **Table 2.6** and compare it to previous datasets in **Figure 2.12**.

Table 2.6: The final phase 1 improved fully licensed reductions (Ml/d) and estimated deployable output loss (Ml/d) for each scenario regionally and nationally.

	WReN	WRE	WRW	WRSE	WCWE	National Total
Licence reduction for WRMP (Ml/d)	35	392	743	1909	165	3245
Associated DO loss for WRMP (Ml/d)	112	449	597	1428	194	2829
Licence reduction for Current (Ml/d)	495	542	894	1649	381	3962
Associated DO loss for Current (Ml/d)	108	697	708	1181	199	2892
Licence reduction for Intermediate (Ml/d)	561	664	919	1924	420	4488
Associated DO loss for Intermediate (Ml/d)	123	847	728	1395	218	3312

	WReN	WRE	WRW	WRSE	WCWE	National Total
Licence reduction for Full (Ml/d)	573	698	919	1998	332	4519
Associated DO loss for Full (Ml/d)	126	893	728	1456	149	3351

Figure 2.12 demonstrates the estimated national environmental needs impact on supply (deployable output loss in Ml/d) at 2050 for each scenario using the various licence reduction datasets including the original Phase 1 as used in the main report of NFWR2025, the improved Phase 1 using recent actual reductions and the improved Phase 1 using fully licensed reductions. Under the Full ED planning scenario in 2050, the NF2 main report indicated a 3295 Ml/d deployable output loss nationally, when taking the improved licence reduction datasets, this increases to 3351 Ml/d.

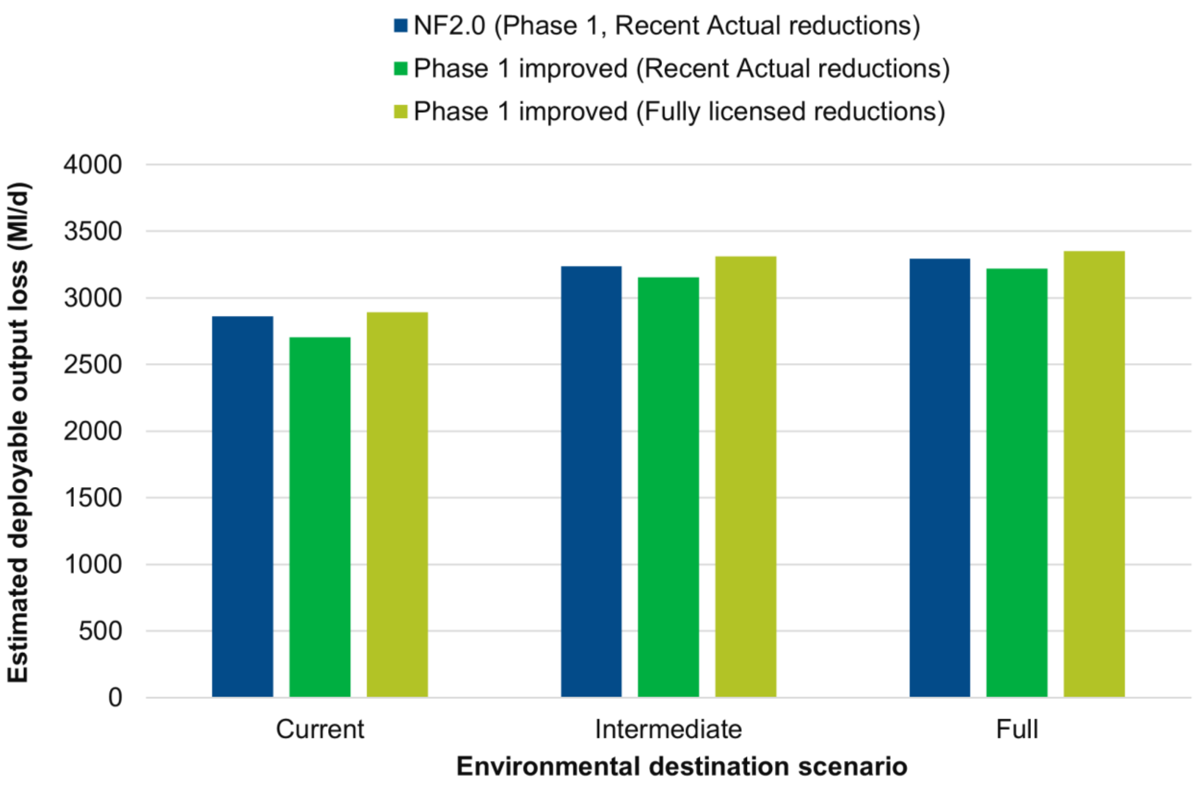


Figure 2.12 is a clustered column chart showing the impact on deployable output across the Current, Intermediate and Full scenarios for the different licence reduction datasets: NF2.0 (Phase 1, Recent Actual reductions, as used in the main report), Phase 1 improved (Recent Actual reductions) and Phase 1 improved (Fully licensed reductions). Across each scenario, Phase 1 improved (Recent Actual reductions) provides the smallest estimated

loss of DO (2702 Ml/d to 3218 Ml/d from Current to Full), then NF2.0 (Phase 1, Recent Actual reductions) and then Phase 1 improved (Fully licensed reductions) provides the highest loss of DO (2892 Ml/d to 3351 Ml/d from Current to Full).

There have been significant assumptions made to estimate the deployable output loss under the National Framework ED planning scenarios, resulting in significant uncertainty associated with these figures. These figures should be taken as rough estimates only and we advise that water companies either run individual public water supply licence reductions under the range of ED planning scenarios through their water resource system simulation models or undertake further analysis on the individual licence reductions and current deployable output to determine a more accurate deployable output loss. The assumptions in this work include the following:

- Licence reductions under WRMP24 Environmental Destination scenarios have been assumed from either National Framework 2020 work for BAU or Enhanced or through provision of water companies. Licence reductions under WRMP24 ED scenarios were gradually improved over the WRMP24 planning round, with water companies taking National Framework licence reductions and carrying out further work to revise them. As a result, licence reduction datasets used could be outdated and inappropriate to relate to WRMP24 ED DO loss.
- Licence reductions presented in Current, Intermediate and Full ED planning scenarios are assumed to include licence reductions that have already been agreed through WINEP, reflecting both 7.2 and 7.3 BL as per WRMP24.
- That the relationship between WRMP24 ED licence reductions (under BAU+ or Enhanced) and DO loss is consistent under other Environmental Destination scenarios. This is unlikely to be true due to the differences in individual licence reductions across the scenarios, the complexities of individual licence reductions and how impacts play out within a catchment.
- That the distribution of WRMP24 ED licence reductions/deployable output loss across water resource zone scale and over time is consistent under other Environmental Destination scenarios. This is unlikely to be true given differences in licences that are reduced between WRMP24 and the latest ED planning scenarios.
- Taken the National Framework 2025 Environmental Destination estimated licence reductions as the only way to meet all environmental requirements as per each ED planning scenario. These potential reductions should be considered as a starting point only, where further, detailed modelling is advised. All assumptions made to estimate potential licence reductions that are detailed in the Environmental Destination technical report are carried forward in this work here.
- The wetter range of climate projection (RCM04) as representative of future climate, despite it being equally as likely as all other RCM climate projections. This demonstrated the highest licence reductions nationally but reflects only one scenario.

2.1.10 Drought measures

There are 4 levels of response to a drought for water companies wholly or mainly in England. Water company drought plans set out how it will manage a drought between levels 1-3, emergency drought plans cover level 4. Level 1 responses generally include increased communications with customers (media campaigns) and reducing outage. Level 2 responses generally include temporary use bans (TUBs), formerly known as hosepipe bans, and drought permits and drought orders with minor environmental impacts. Level 3 actions generally include non-essential water use bans (NEUBs) for businesses and drought permits and drought orders that carry higher environmental risk. Level 4 restrictions include standpipes and rota cuts. Level 4 is seen as a last resort as these measures would have major impacts on customers. These measures are also likely to be impractical, particularly when needed on a large scale in response to a drought, or in densely populated areas.

Demand actions, including media campaigns and temporary use bans (TUBs), historically referred to as hosepipe bans, are an established way for water companies to reduce demand in times of drought. DEFRA, Natural Resources Wales and the Environment Agency require water companies to implement TUBs before drought permits and orders (including non-essential use bans (NEUBs)) are granted, particularly between 1 April and 1 October. This requirement can be relaxed during winter periods when TUBs can have a lesser impact.

We collated a dataset to capture media campaign and TUBs options from the WRMP24 planning tables. The data were primarily sourced from Table 5 of the planning tables to allow for a full time series of data. To provide a consistent picture across all companies (and not only include savings in the preferred plan), for certain companies, we took the relevant information from Table 6 where not included in Table 5 (preferred plan). We assume demand savings provided by water companies at WRZ scale to be an estimate upon implementation during a drought.

Demand savings estimated upon implementation of media campaigns and TUBs were identified in water company WRMP24 plans at water resource zone scale. Analysis of this data highlights an average of ~7% demand savings of total consumption when temporary use bans are in place. This is in line with an UKWIR report published in 2007 that estimated summer reductions on the order of 5 to 9.5% for a full hosepipe ban based on analysis of demand in the 2006 drought (UKWIR, Report ref 07/WR/02/3, 2007). A more recent UKWIR report published in 2023 that reviewed the impact of TUBs during the 2022 drought, highlighted lower demand savings on the order of 2.7 to 4.1% reduction in distribution input across the six water companies who implemented TUBs. It is important to note that every drought will be different, and consequently the response to each drought by water companies and associated demand savings will also differ.

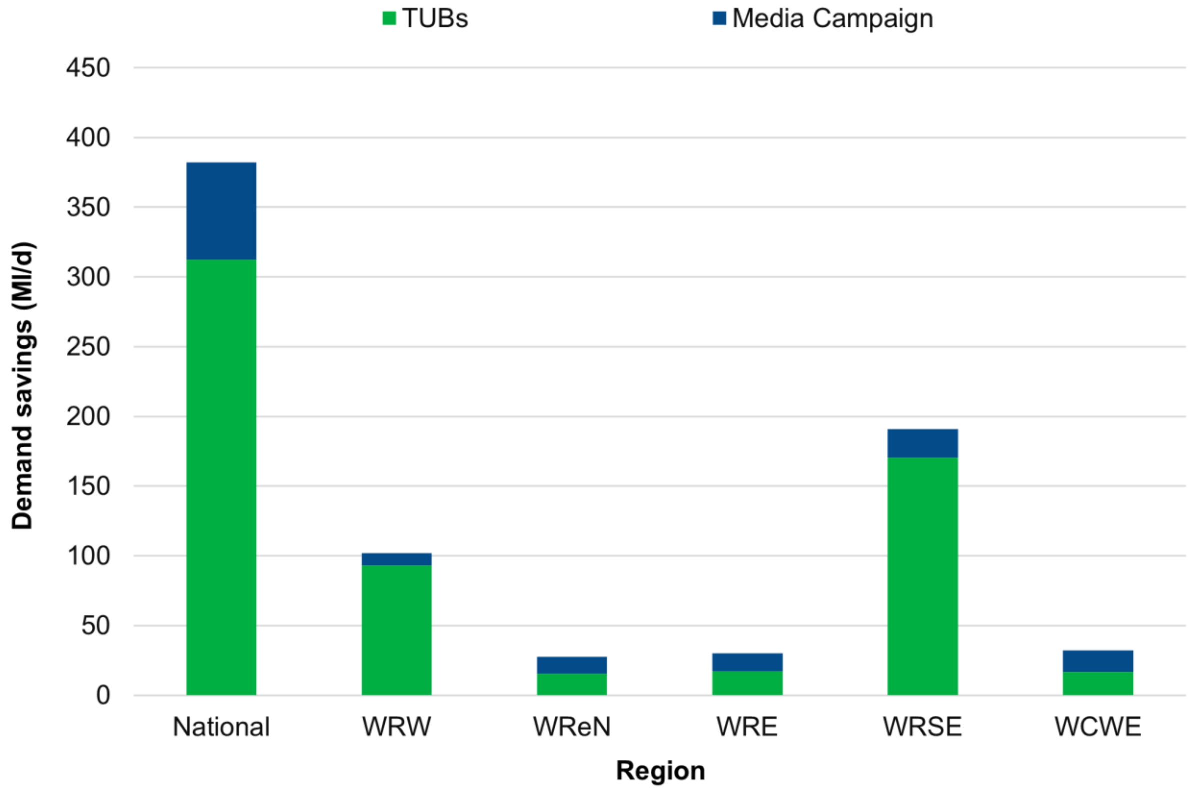


Figure 2.13 is a stacked column chart showing the demand savings (Ml/d) nationally and across regions from introducing media campaigns and TUBs during a drought under WRMP24. Nationally, a total of 382 Ml/d is saved, 312 Ml/d of this supplied from TUBs. Regionally, we see the same pattern where TUBs provide majority of the savings. We can see WRSE benefits the most from these drought measures being enforced – more than half of the national benefit at 191 Ml/d. This ranges down to WRE and WReN who benefit the least (~30 Ml/d from combined media campaigns and TUBs)

The national water resources supply demand model has assumed that during a 1:500 drought event that media campaigns and TUBs (and their associated demand savings) would be in place (not including baseline and Do Nothing scenarios). For each water resource zone, we calculated the percentage of demand savings provided by media campaigns and TUBs and applied to modelled total consumption to calculate the equivalent volume reduction across a range of consumption scenarios.

Our figures assumed that the impact of media campaigns and TUBs would remain proportionally consistent across different levels of water consumption. However, this assumption may not hold in all cases – particularly where new demand arises from newly built properties, which could respond differently compared to existing buildings. In this specific case, demand savings are likely to be an upper estimate.

We excluded non-essential use bans (NEUBs) and their associated demand savings from end-member modelling scenarios as they are rarely implemented. However, we have explored them here as a sensitivity scenario for this technical report. To do this, we compiled the data for NEUBs using the percentage demand savings provided by companies in their WRMP24 tables (Table 6). We applied the given percentages to their estimated WRMP24 Distribution input (DI) at 2050 as well as to total DI under other scenarios as discussed in Section 2.4.8.

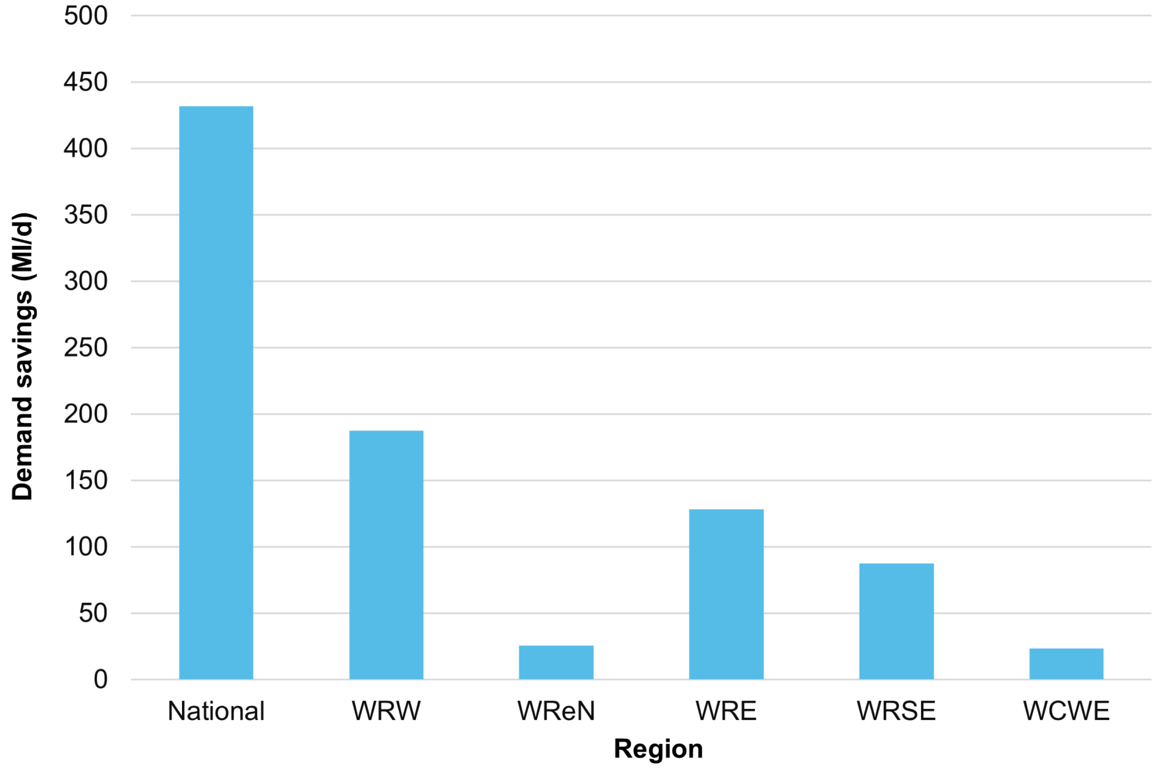


Figure 2.14 is a column chart that shows the national and regional demand savings when NEUBs are implemented.

Nationally, NEUBs could save 420 Ml/d under a WRMP24 scenario if all were implemented during a drought. This equates to 3.69% demand savings of WRMP demand in 2050. This is considerably lower than expected (~18.5% as per an UKWIR report published in 2007 (UKWIR, Report ref 07/WR/02/3, 2007). The most water saved by NEUBs is seen in WRW, saving 176 Ml/d, but the largest savings as a percentage of total demand is found in WRSE; this is because WRW is a larger region so has a larger demand. WReN and WCWE receive the lowest benefit from NEUBs – around 25 Ml/d.

Table 2.7 shows the percentage demand savings gained when implementing NEUBs across the country. It's calculated taking percentage demand savings from Table 6 and applying to 2050 final plan distribution input.

	Percentage demand savings (%)
National	3.69 %
WRW	5.00 %
WReN	1.50 %
WRE	7.67 %
WRSE	2.17 %
WCWE	2.27 %

NEUBs are implemented cumulatively after lower-level drought actions. If we combine this data with the TUBs and Media campaigns used for the model, we observe a 814 Ml/d national saving under WRMP24, equivalent to 8.33% demand saving.

National savings presented here assume that all water companies would implement either media campaigns, TUBS or NEUBs at the same time. This is unlikely, whereby drought will impact different geographical areas at different times, in different ways.

Supply actions, including drought permits and drought orders can also be utilised by water companies in a drought, if granted by the Environment Agency for drought permits or Defra for drought orders. As per water company water resources planning guidance 2024, water companies should plan to use drought permits and orders less frequently in future, particularly in sensitive areas.

We explore three scenarios of utilisation of drought permits and orders including: i) not utilised ii) all utilised and iii) only non-environmentally damaging permits are utilised.

Water companies provide a list of their drought permits and orders and the water available from them in WRMP24 planning tables (Table 5) which we use here. If a drought permit extended to the year 2049–50, we assumed that the associated benefits would continue through to 2055. However, if a permit stopped being utilised before 2049–50, in Table 5, we assumed that the benefits would not persist beyond its final year of use.

The identification of environmentally damaging permits relied on discussions with Environment Agency representatives. While informed, this process may involve subjective judgement and could vary between regions.

2.1.11 Water company preferred supply and transfer options

We calculated the increase in supply and transfers for each WRZ between 2025/2030 and 2055 using water company WRMP24 components as outlined in **Table 2.8**. The values were then checked against the preferred supply options outlined in WRMP24. In some cases, water companies included resilience measures within component 6.3FP; we excluded these to isolate the total contribution from new supply and transfer options only.

We explored two supply and transfer option utilisation scenarios including:

1. all supply and transfer options in the preferred WRMP24 plan are implemented between 2025 and 2030 only (no new supply and transfer options were included beyond 2030) and;
2. all supply and transfer options in the preferred WRMP24 plan are implemented between 2025 to 2055.

We assumed baseline transfer arrangements (imports and exports) continued through to the end year of the model run.

Table 2.8 lists the component identifiers from the WRMP24 plan that are used to calculate the increase in supply and transfers for each WRZ.

WRMP24 Table ID	Component
6.2FP	DO benefit from increase raw water abstractions
6.3FP	Other options to increase deployable output
2.1FP	Raw water imports
3.1FP	Potable water imports
4.1FP	Raw water exports
5.1FP	Potable water exports

Figure 2.15 illustrates the composition of the preferred new supply options in WRMP24 between 2025 and 2055. This excludes transfers, drought permits and orders, and resilience options.

Supply-side options included all those classified under the following types:

- Aquifer recharge/ aquifer storage recovery
- Water treatment works capacity increase; Water treatment works loss recovery

- New groundwater; new reservoir; new surface water; new water treatment works; new / enhanced pumping station
- Water reuse; rainwater harvesting
- Desalination
- Surface water enhancement; Groundwater enhancement; Reservoir enlargement
- Conjunctive use

Between 2025 and 2055, WRSE see the largest increase in new supply options, totalling approximately 900 Ml/d. WRE also experience a significant increase of around 430 Ml/d, followed by WRW with approximately 140 Ml/d. In contrast, WReN and WCWE see only minimal development of new sources.

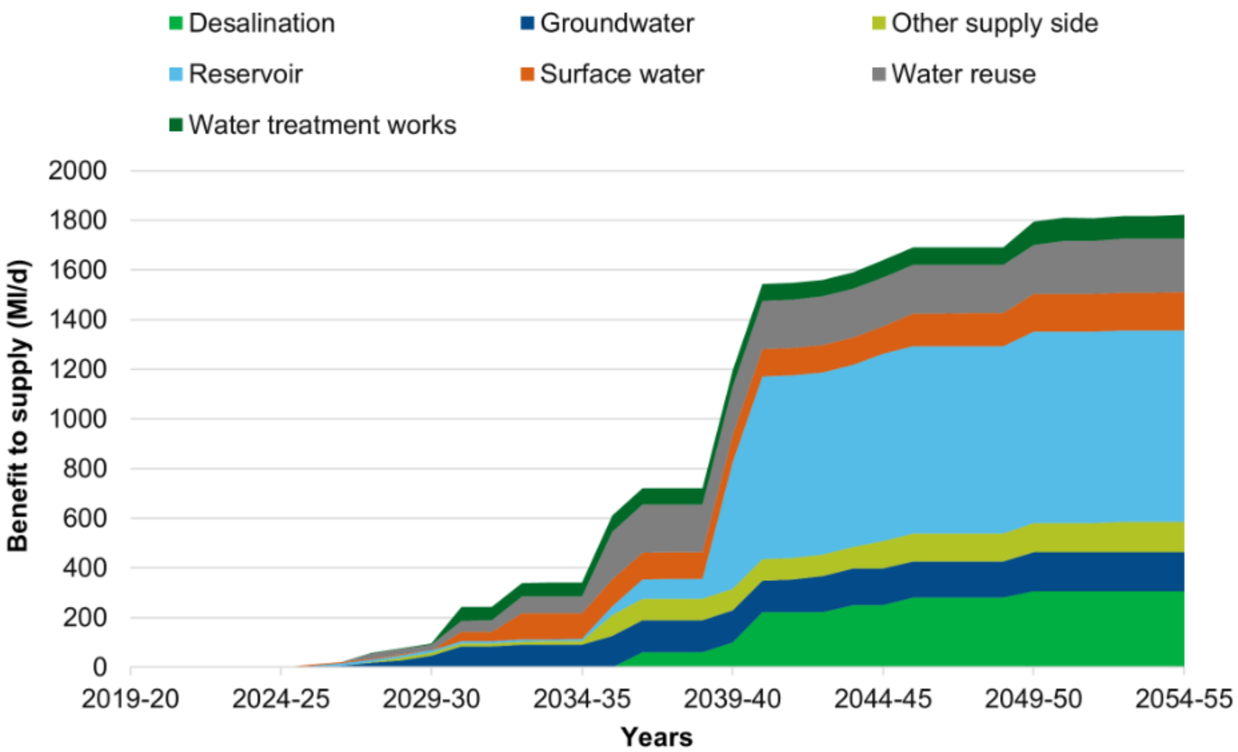


Figure 2.15: The water in Ml/d provided by the supply-side options presented in WRMP24 from 2019-20 to 2054-55 in Ml/d presented as a stacked area chart. The total volume of water has been broken down into the contribution from each type of supply option.

Figure 2.15 illustrates the water provided in Ml/d from different supply-side options from 2019-20 to 2054-55, options as follows: Desalination, Groundwater, Other supply side, Reservoir, Surface water, Water reuse and Water treatment works. These are listed in the order they appear on the chart. Water provided from options begins after 2024-25 and the amount increases to 1822 Ml/d by 2054-55; the largest provider of water is reservoirs – 770 Ml/d. All the other options provide less than 250 Ml/d, with the smallest benefit seen by water treatment works.

The options referenced were taken from Table 5 in WRMP planning tables. We assume that benefits from supply options extend through to 2055.

We assumed that under all three end member scenarios - each reflecting different combinations of population growth, climate change, environmental need, and demand and leakage reduction – that the same set of supply and transfer options would be implemented, regardless of whether the scenario resulted in an overall water surplus or deficit.

Water companies can develop additional supply options for their water resource management plans. These include reservoirs, water transfers, desalination, water reuse, river abstraction and groundwater abstraction. Infrastructure options play an important role given the uncertainty that surrounds ambitious planned reductions in leakage and per capita consumption.

Since the 2020 National Framework for Water Resources, the Regulators' Alliance for Progressing Infrastructure Development (RAPID) has been established to help scrutinise, assess and enable the development of strategic resource option (SRO) schemes which are likely to be needed to address the nation's future water needs.

To do this, RAPID:

- aims to improve interconnectivity and tests for alternative options
- supports regional water resources planning
- supports funding decisions by Ofwat through a gated assessment process
- facilitates the development of nationally significant supply schemes
- identifies and pursues regulatory and commercial enablers of delivery

Read more about the RAPID gated process.

Information on the current list of Strategic Resource Options (SROs) being considered and their associated timelines can also be found on the RAPID website. The main options being considered include those presented in **Figure 24** of the main report of the 2025 National Framework. Together, the strategic schemes could provide 1156 Ml/d by 2055.

The National Framework aims to not only assess future water needs but also to understand how the nation can meet those future water needs. In the 2020 publication of the National Framework for Water Resources and through following work commissioned by RAPID in 2021, and published in 2024, we worked with the University of Manchester to explore and identity the potential options available to address future water deficits in England. This was achieved through the creation of a national scale water resource supply-demand model for options comparison. The model enables identification of potentially cost-efficient combinations of water supply options and water transfers nationally. It provides a top-down national view of how water companies could work together to cost effectively meet estimated future annual water demands, which could then be explored further with more local knowledge and granularity.

For the 2025 National Framework, we have brought this national model in house and built upon it, exploring the potential options available to meet the latest range of future water deficits in England, particularly in the face of significant environmental needs, population growth and climate change. It aims to highlight nationally cost-effective portfolios (combinations of supply and transfer options), how these compare to water company water resource management plans (WRMPs) in terms of option-type selection, volume (Ml/d) and financial cost as well as identifying the potential benefits of new water transfers that do not yet exist. It also explores the potential benefit and cost of a more connected water network or 'grid'. A summary of this work will be accessible through the National Framework for Water Resources 2025 Modelling Dashboard.

2.2 Modelling approaches

The approach used in the Environment Agency's national water resources supply-demand balance model is outlined below. We developed an aggregate python-based model, building on the national water resources supply-demand spreadsheet model used in National Framework 2020. This updated version, consolidates all WRMP24 planning table data into a single data frame for each table, enabling efficient analysis across water companies.

The model operates at WRZ scale with annual timesteps, providing output data on water availability and demand for each WRZ under defined scenarios. These scenarios, described in more detail in Section 2.3, form the basis for assessing future resource pressures and planning needs.

The scenarios are defined in a configuration file (.yaml) that sets model parameters. These parameters determine which dataset to use or how WRMP data should be adjusted to produce different trajectories. For example, for population, different CSV files are read depending on whether we select WRMP, ONS-18, or OxCam populations, whereas for leakage, trajectories are adjusted based on the percentage reduction chosen. We describe the collation of data for each parameter in the previous section.

We collated and compared the outputs from each model run to assess the impact of different scenarios. For most results presented here, we compared the results from the end year of the modelling period (2055) against the 2030 base year to evaluate the scale of change, under the assumption that all planned options between 2025 and 2030 are delivered.

Our outputs are presented in the National Framework for Water Resources 2025 Modelling Dashboard, allowing users to explore and download the scenarios and datasets.

2.2.1 Calibration

To ensure that the National Framework model was functioning as expected, we run a scenario based on WRMP24 data as a calibration. This calibration run is repeated upon any changes or bug fixes to the model, to make sure that the results of the model aligned with the supply demand balance provided in the WRMP24 planning tables.

2.2.2 Modelling assumptions, caveats and limitations

Our modelling process makes several assumptions. We detail assumptions specific to individual parameters or datasets in Section 2.1. We outline more general modelling assumptions, which introduced caveats and limitations to the results, below.

Collating the WRZ data from the WRMP24 tables has highlighted inconsistencies in how WRMP24 table data has been reported. We put significant effort into making the data as consistent as possible but differences in approaches by water companies around how the data was calculated and derived from supporting models still exists. In addition, as mentioned in Section 2.1.1, where there is referral to WRMP24, the model has used a hybrid of revised draft and final plan WRMP24 data.

The use of an "aggregated" model that reports an annual average value for water availability under a specific type of drought event provides a single estimate of what the future supply/demand balance might look like during a theoretical design drought event at a given point in the future. This approach will not give the same level of understanding of the uncertainties around water availability and demand that would be obtained from a system simulation model using a nationally consistent library of drought events.

The model assumes Dry Year Annual Average (DYAA) conditions. In WRMP24, water availability and demand are presented as single annual values that reflect design conditions expected during a drought year. These are expressed through metrics such as the annual water available during a drought event and the annual water demand during a dry year.

We calculate the supply demand balance (surplus/ deficit) using the WRMP24 Target Headroom (46FP and 47FP) across all scenarios. This is a limitation, as it assumes a fixed headroom regardless of changes in the underlying SDB.

The model takes an objective-based approach, applying fixed targets for reductions in PCC, leakage, and non-household demand, as defined in each scenario. These reductions follow the WRMP24 final plan trajectories at the WRZ level. However, we do not use demand management options to calculate how these reductions are achieved. This is a limitation, we assume targets are met without modelling the feasibility, timing, or effectiveness of specific interventions.

The work carried out using this model aims to make the best use of data from water company WRMP24 submissions to illustrate future challenges for public water supply across England.

2.3 National Framework 2025 Modelling Scenarios

As outlined in the main report of the National Framework for Water Resources Section 2.2, the National Framework takes a scenario-based approach to model the impact of public water supply pressures and quantify how different pressures drive the deficit. There are many components (pressures) that drive future water need and each of these pressures has its own uncertainty. Any one combination of components (pressures) makes up a potential future of public water supply need or ‘scenario’ as presented here.

Water resources modelling has looked at pressures on public water supplies across a range of future demand and climate scenarios and environmental needs. It allows us to assess the range of uncertainty in different pressures and enables us to understand the potential range of deficits we may face.

The National Framework has looked at a range of future water needs to 2055. Water resources modelling scenarios are for public water supply only (they do not include direct abstraction for other sectors e.g. non-public water supply). We express water availability (supply) and demand in annual terms during a drought or dry year.

2.3.1 End-member scenarios

The water resources modelling presented for the main report of the National Framework explores four scenarios. We designed the scenarios to explore endmembers (the potential range) of our nation’s future water needs to 2055. The compound scenarios aim to capture the envelope of need, from the worst case to lowest water need (best case for deficits).

We developed the scenarios through a series of technical workshops and we have been informed by a range of National Framework stakeholders, including regulators, regional groups and water companies. We outline these scenarios in the text below, with details outlined in **Table 2.9**.

Do Nothing

This is the worst-case scenario that assumes no action is taken after 2030. It assumes actions from 2025-2030 as outlined in water company WRMP24s are fully delivered, but no demand management and resource development occur after 2030. As such, per capita consumption (PCC), leakage and non-household demand remain the same as 2030. Population is based on WRMP24 forecasts for 2055. There are no demand or supply side drought actions included (such as temporary use bans (TUBs) or drought permits). Public water supply reductions to meet climate and environmental needs are as per WRMP24 at 2050/55.

High water needs

This scenario aims to reflect the reasonable worst case for public water supply needs. It assumes the highest reduction in licensed abstraction for public water supply to meet full environmental requirements and assumes reasonable worst case climate change impacts.

It includes the highest population growth forecasts. It assumes demand management only achieves 60% of the planned savings. This scenario includes drought demand savings associated with media campaigns and TUBs as a proportion of WRMP24 and only non-damaging supply side drought actions.

Central water needs

This scenario includes meeting national targets such as 15% non-household demand reduction, 50% leakage reduction and 110 litres per head per day (l/h/d) PCC by 2050. It uses WRMP population growth forecasts. It assumes the estimated reduction in public water supplies to meet both the environmental needs under an intermediate pathway between current and full requirements and climate change impacts associated with 2 to 3.7°C of warming. It includes drought permits and orders as per WRMP24 and drought demand savings associated with media campaigns and TUBs as a proportion of WRMP24.

Low water needs

This scenario aims to reflect the best case for water needs or deficits. It shows the lower end of the possible range. It includes future demand ambition and lower climate change impacts. It reflects public water supply reductions under the current regulatory and statutory environmental requirements. It assumes lower population forecasts, 60% leakage reduction, 20% non-household demand reduction and PCC of 100 l/h/d. It includes drought permits and orders as per WRMP24 and drought demand savings associated with media campaigns and TUBs as a proportion of WRMP24.

Table 2.9 National Framework for Water Resources 2025 end-member scenarios

NF 2.0 Modelling End-member scenarios	Baseline 2025/2030	Do Nothing 2050-2055	High Water Need	Central Water Need	Low Water Need
Year	2025/2030	2055	2055	2055	2055
Resilience*	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24
Population Growth	WRMP24	WRMP24	OxCam High	WRMP24	ONS-18-P
Climate Change (°C warming by 2100)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	RCP 8.5 (3.2-5.4)	RCP 6.0 (2-3.7)	RCP 4.5 (1.7-3.2)
Environmental Destination Planning Scenario (Semi-equivalent ~WRMP24 scenario)	WINEP	WRMP24 (NF2.0 Intermediate)	NF2.0 Full (~Enhanced)	NF2.0 Intermediate (~Enhanced)	NF2.0 Current (~BAU+)
New supply sources	None	None	WRMP24	WRMP24	WRMP24
Household PCC by 2050	As in 2025/2030	As in 2025/2030	120 l/h/d	WRMP24 (~110 l/h/d)	100 l/h/d
Non-Household reduction by 2050 (from 2019-20)	As in 2025/2030	As in 2025/2030	WRMP24 (~9.0%)	15%	20%

NF 2.0 Modelling End-member scenarios	Baseline 2025/2030	Do Nothing 2050-2055	High Water Need	Central Water Need	Low Water Need
Leakage reduction by 2050 (from 2017-18)	As in 2025/2030	As in 2025/2030	40%	WRMP24 (50%)	60%
Demand-side drought measures (Media campaigns and temporary use bans)	None	None	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24
Supply-side drought measures (Drought permits/orders)	None	None	Only non-damaging permits/orders in WRMP24	WRMP24	WRMP24

*Resilience reflects WRMP24 which is largely 1:200 from now until 2039 and 1:500 from 2039 onwards.

2.3.2 Sensitivity scenarios and exploring uncertainty in pressures on public water supply and options available to meet them

The water resources modelling presented for the technical report of the National Framework explores a range of sensitivity scenarios. We designed the scenarios to explore individual pressures, how they impact the size of the future national public water supply deficit and their uncertainty. We outline the scenarios in **Table 2.10** with results reported on in Section 2.4.

Table 2.10 National Framework for Water Resources 2025 sensitivity scenarios modelled for the technical report

NF 2.0 PWS Modelling Sensitivity Scenarios	WRMP24 Standard	Environmental needs – Full using Improved Phase 1 FL	Worst case non-household	Climate change impact on demand	PCC – 120 l/h/d	Population - OxCam	Climate – RCP 8.5	Leakage 40%	Turn off Media campaigns & TUBs	NEUBS	Turn off Drought permits	1:200 Resilience	Updated Reasonable worst case
Year	2055	2055	2055	2055	2055	2055	2055	2055	2055	2055	2055	2055	2055
Resilience	WRMP24 -Current (1:200), 1:500 from 2039	WRMP24 - Current (1:200), 1:500 from 2039	WRMP24 - Current (1:200), 1:500 from 2039	WRMP24 -Current (1:200), 1:500 from 2039	WRMP24 -Current (1:200), 1:500 from 2039	WRMP24 - Current (1:200), 1:500 from 2039	WRMP24 -Current (1:200), 1:500 from 2039	WRMP24 -Current (1:200), 1:500 from 2039	WRMP24 - Current (1:200), 1:500 from 2039	WRMP24 -Current (1:200), 1:500 from 2039	WRMP24 -Current (1:200), 1:500 from 2039	1:200	WRMP24 - Current (1:200), 1:500 from 2039
Population Growth	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	OxCam	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	OxCam
Climate Change (°C warming by 2100)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	RCP 8.5	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	WRMP24 (RCP 6.0/8.5)	RCP 8.5
Environmental Destination Planning Scenario (Semi-equivalent ~WRMP24 scenario)	WRMP24	NF2.0 Full (~Enhanced)	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	NF2.0 Full (~Enhanced)
New supply sources	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24
Household PCC by 2050	WRMP24 (~110 l/h/d)	WRMP24 (~110 l/h/d)	WRMP24 (~110 l/h/d)	WRMP24 + 3% PCC	120 l/h/d	120 l/h/d	120 l/h/d	120 l/h/d	120 l/h/d	120 l/h/d	120 l/h/d	120 l/h/d	120 l/h/d
Non-Household reduction by 2050 (from 2019-20)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 Baseline (2055)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 (~9.0%)	WRMP24 Baseline (2055)

NF 2.0 PWS Modelling Sensitivity Scenarios	WRMP24 Standard	Environmental needs – Full using Improved Phase 1 FL	Worst case non-household	Climate change impact on demand	PCC – 120 l/h/d	Population - OxCam	Climate – RCP 8.5	Leakage 40%	Turn off Media campaigns & TUBs	NEUBS	Turn off Drought permits	1:200 Resilience	Updated Reasonable worst case
Leakage reduction by 2050 (from 2017-18)	WRMP24 (50%)	WRMP24 (50%)	WRMP24 (50%)	WRMP24 (50%)	WRMP24 (50%)	WRMP24 (50%)	WRMP24 (50%)	40%	WRMP24 (50%)	WRMP24 (50%)	WRMP24 (50%)	WRMP24 (50%)	40%
Demand-side drought measures (Media campaigns and temporary use bans)	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24	None	% Savings from WRMP24 + % Saving for NEUBS	% Savings from WRMP24	% Savings from WRMP24	% Savings from WRMP24
Supply-side drought measures (Drought permits/orders)	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	WRMP24	None	WRMP24	WRMP24

2.4 Understanding the uncertainty on future pressures driving public water supply and options available to meet it

We discuss the national pressures on public water supply in Section 2 and 3 of the National Framework for Water Resources 2025 main report. Water company water resource zone pressures on public water supply are highlighted in maps in **Figure 11** of Section 3 of the National Framework for Water Resources 2025, with a full discussion of pressures at a water resource regional group scale in Appendix B of the National Framework for Water Resources 2025. All datasets can be accessed through the National Framework for Water Resources 2025 Modelling Dashboard.

As highlighted in Appendix B of the NFWR 2025, there is uncertainty in each of our future pressures. The water resources modelling aimed to overcome this by exploring a range of future water needs scenarios where we explore compound uncertainty in those pressures as outlined in the main report. To explore uncertainty in individual pressures on public water supply and the options available to meet them, we have run sensitivity scenarios as outlined in Section 2.3.2 and outline the results below.

The pressures we explore here include environmental needs, climate change, population, per capita consumption, non-household demand and resilience.

The options available for meeting public water supply needs explored here include household water efficiency (PCC), non-household water efficiency, leakage reduction, drought measures (supply and demand) and increasing supplies and transferring water.

2.4.1 Environmental needs

As discussed in Section 2.1.9, the Environment Agency continues to identify where and by how much current and future water abstraction needs to change to meet environmental requirements through the Environmental Destination for water resources. This applies to England only. As part of the National Framework 2025, three Environmental Destination planning scenarios were developed, and we have explored the impact of this range of environmental needs on public water supply and compared to current WRMPs as well as comparing to the original impact to public water supply presented in the main report (prior to improvements in the datasets as outlined in Section 2.1.9).

This range may not capture the full range of uncertainty associated with environmental needs impact to supply; this is because the licence reductions associated with each planning scenario reflect only one possible solution to the problem and the deployable output loss under each planning scenario is a rough estimate based on significant assumptions (as highlighted in Section 2.1.9). The uncertainty we discuss here is uncertainty associated with impact to public water supply and does not reflect the uncertainty related to environmental flow recovery itself.

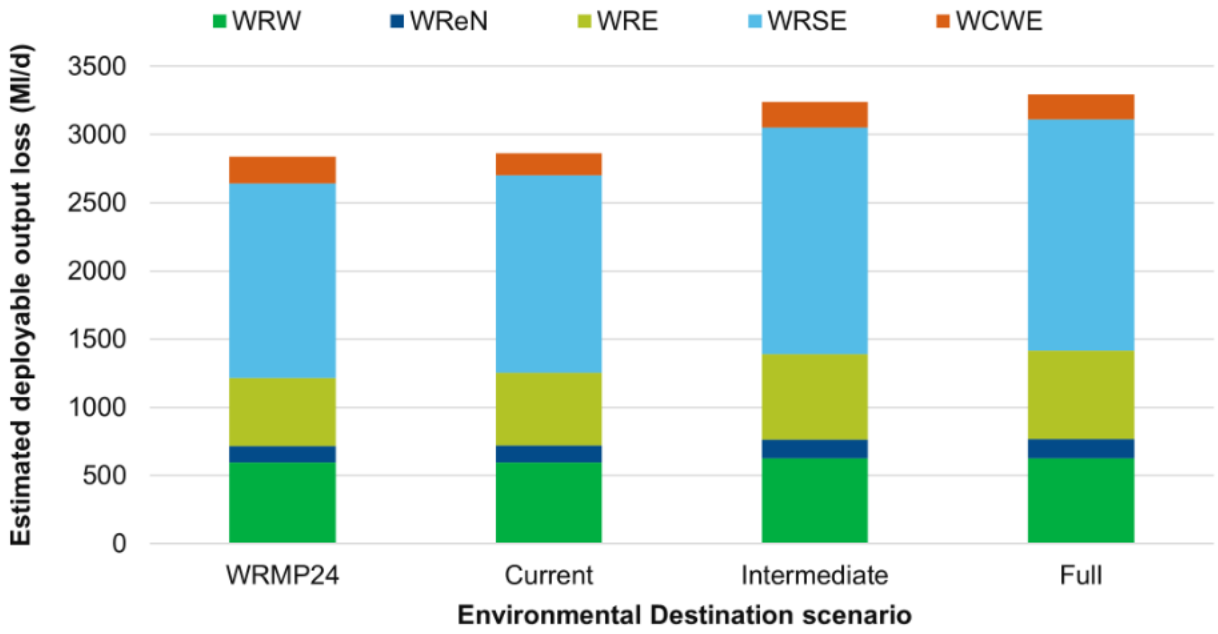


Figure 2.16 is a stacked column chart showing the environmental needs impact on public water supply (deployable output (DO) loss) in 2055 under WRMP24, Current, Intermediate and Full Environment Destination scenarios. The stacked bars show the distribution of DO change by region.

Figure 2.16 shows the environmental needs impact on public water supply (deployable output (DO) loss) at 2055 under the WRMP, Current, Intermediate and Full Environmental Destination scenarios. The Environment DO is 2837 Ml/d, 2865 Ml/d, 3237 Ml/d and 3296 Ml/d for the WRMP, Current, Intermediate and Full ED scenarios respectively. In all scenarios, WRSE has the largest estimated loss in DO (~1400 to ~1700 Ml/d)), followed by WRE, WRW with WCWE and WReN showing the lowest estimated loss (~100 to 200 Ml/d). The Full ED planning scenario causes the largest estimated loss in DO of 459 Ml/d by 2055 over the WRMP scenario as it takes the current environmental regulations and several additional environmental protection measures into account over the period.

2.4.2 Population change

Water consumption is largely determined by how much each person uses (per capita consumption) and how many people are using it (population). We have explored a range of population forecasts in our modelling as outlined in Section 2.1.3 and how household water consumption changes nationally and regionally under these forecasts and when compared to WRMP24 under the same 2055 per capita consumption.

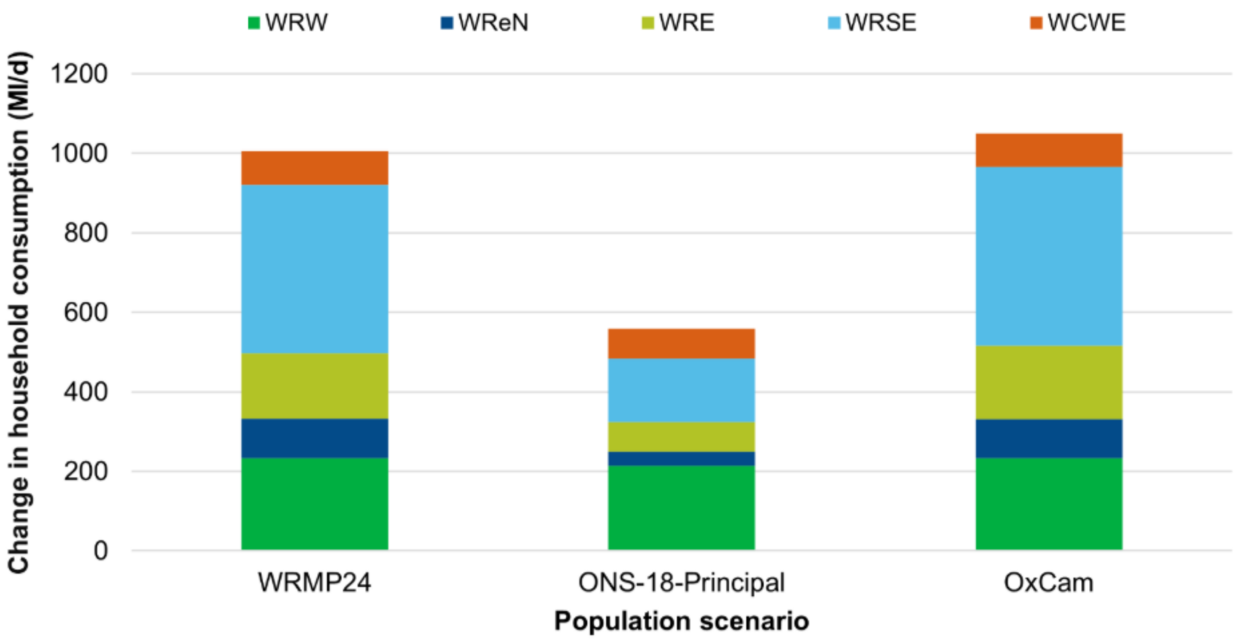


Figure 2.17 is a stacked column chart showing the change in household consumption in Ml/d between 2030 and 2055 for the WRMP24, ONS-18-Principal and 'OxCam' population scenarios, assuming baseline PCC (WRMP24 2030). The stacked segments show the distribution of water consumption by region.

The change in household consumption for each population scenario between 2030 and 2055 is shown in **Figure 2.17;** all regions see an increase in household consumption. The national household consumption at 2055 using the baseline PCC and WRMP24, ONS-18-Principal and OxCam population scenarios are: 8994 Ml/d, 8269 Ml/d and 9059 Ml/d respectively. The ONS-18-principal projection shows a 727 Ml/d lower national consumption than WRMP24; OxCam scenario estimates national household consumption to be 66 Ml/d higher than WRMP24's projection. The largest increase under each scenario is observed in WRSE and WRW, the smallest is observed in WReN. WRSE's impact on population is caused by an increase in population in the zones around Oxford and Cambridge.

The OxCam scenario in this report shows a significantly larger population in 2055 than all ONS-18 forecasts so it represents the upper bound of the modelled total consumption. The ONS-18- Principal population scenario is considered to be the most realistic forecast from ONS-2018 but we take it as the lower bound of the modelled total consumption. Therefore, the values of the upper and lower bounds of the total household consumption are 9333 Ml/d and 8540 Ml/d respectively. These bounds yield a range of 793 Ml/d and this represents the uncertainty in our prediction due to the uncertainties present in the population scenarios.

Latest ONS-22 national population projections indicate a higher population growth for England when compared to the ONS-18 projections as used in this report, estimating an extra 2.5 million people in England in the early 2040s when compared to ONS-18. This is currently being explored, alongside updated housing growth scenarios as part of our collaboration with NISTA and MHCLG.

2.4.3 Climate change

Our analysis of water industry data, including our extrapolation for other UKCP18 representative concentration pathway (RCP) emissions scenarios, suggests that the impact of climate change on national water supply could range from 162 Ml/d to 773 Ml/d between 2030 and 2055.

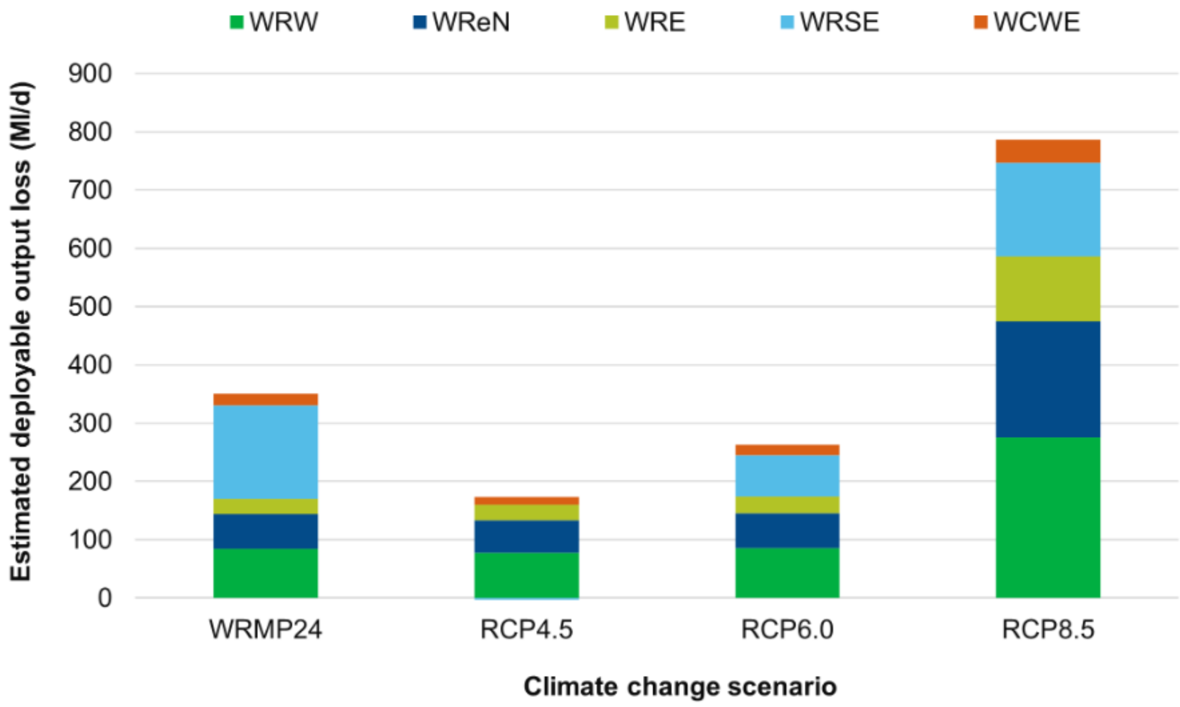


Figure 2.18 is a stacked column chart showing the change in deployable output (DO) in Ml/d between 2030 and 2055 due to climate change under the different climate scenarios; WRMP24, RCP 4.5, RCP 6.0 and RCP 8.5. The stacked segments show the distribution of climate impact (DO loss) by region.

Figure 2.18 shows the change in deployable output (DO) at 2055 under several climate scenarios. The national DO loss for each scenario are as follows: 528 Ml/d (RCP4.5), 576 Ml/d (RCP6.0), 1145 Ml/d (RCP 8.5) and 709 Ml/d (WRMP) - with baseline removed these totals become 162 Ml/d (RCP4.5), 256 Ml/d (RCP6.0), 773 Ml/d (RCP8.5) and 358 Ml/d (WRMP). It is estimated that the most extreme climate scenario (RCP8.5) causes an additional reduction in DO of 436 Ml/d compared to the WRMP climate scenario provided by water companies. In all scenarios, WRW is region most affected by the climate and shows the largest change in DO. In RCP 4.5, the total in WRSE in 2055 is lower than baseline implying the DO loss due to climate change would be less in 2055 under RCP4.5 than it is currently.

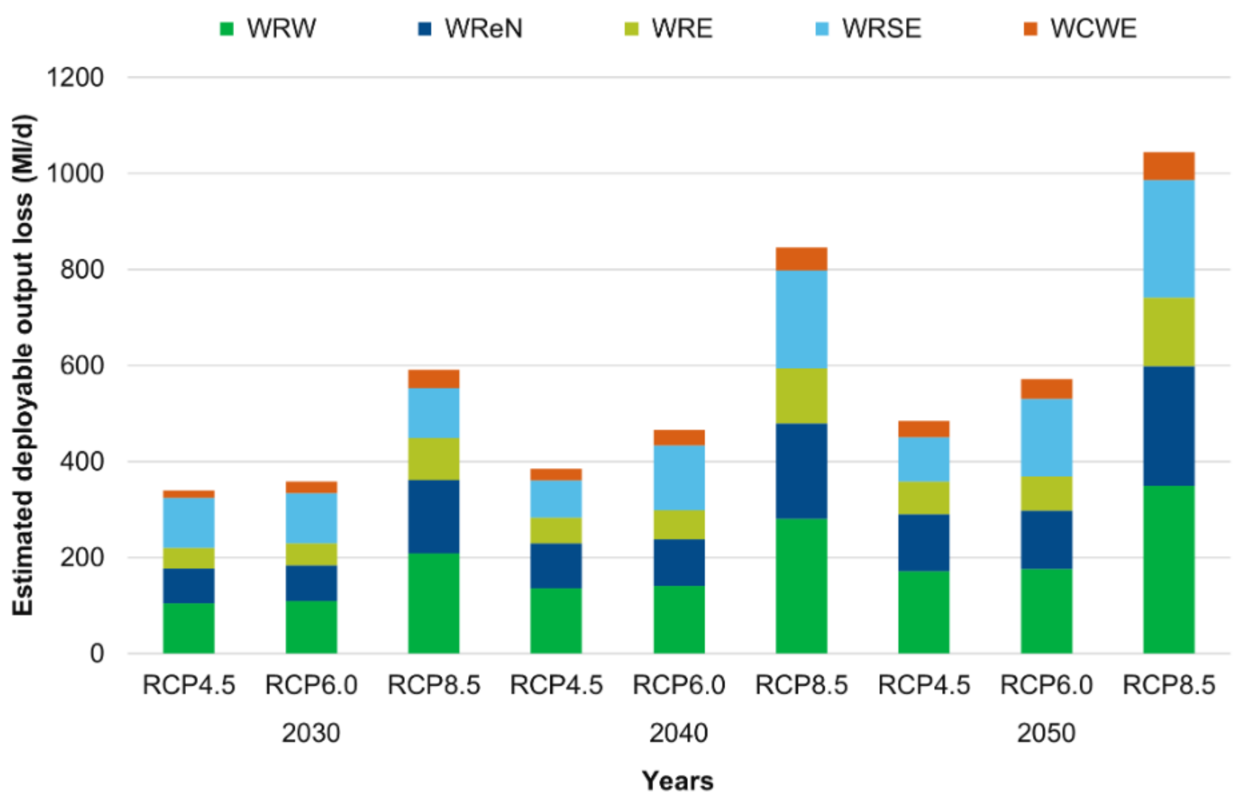


Figure 2.19: Impact of climate change on deployable output loss in Ml/d over time for high (RCP 8.5), central (RCP 6.0) and low (RCP 4.5) climate scenarios.

Figure 2.19 is a stacked column chart showing the climate change impact on deployable output in Ml/d across low (RCP 4.5), central (RCP 6.0) and high (RCP 8.5) climate scenarios in 2030, 2040 and 2050, split by region. The impact climate change has on DO loss increases from low (RCP 4.5) to high (RCP 8.5) climate scenarios as well as across the years from ~340 to 600 Ml/d in 2030 to ~480 to 1040 Ml/d by 2050. The stacked segments show the distribution of DO by region, with WRW the most affected region and WCWE the least.

To explore climate change impact on demand, we have run a sensitivity scenario where we increase PCC by 3% relative to WRMP24, this accounts for an additional water need nationally of 182 Ml/d by 2055.

2.4.4 Drought resilience

The last National Framework reflected government policy to increase the resilience of public water supplies. People need to have a secure supply of water, clean and healthy rivers and a secure sustainable energy supply.

The latest round of water resource management plans has led to a step-change in ambition for drought resilience. By 2040, or earlier, water companies in England are planning to be resilient to a drought which has a 0.2% chance of occurring in any year (meaning a return period of 1 in 500 years). Whilst not a Welsh Government requirement, DCWW and HD are planning to meet this target as well. This level of resilience means that by 2040 the use of emergency drought options such as standpipes will not be needed unless there is a severe drought beyond this magnitude. Improving drought resilience is crucial to safeguard the environment from unnecessary drought measures during a severe drought and ensuring that businesses and communities are not adversely affected by additional costs and disruption.

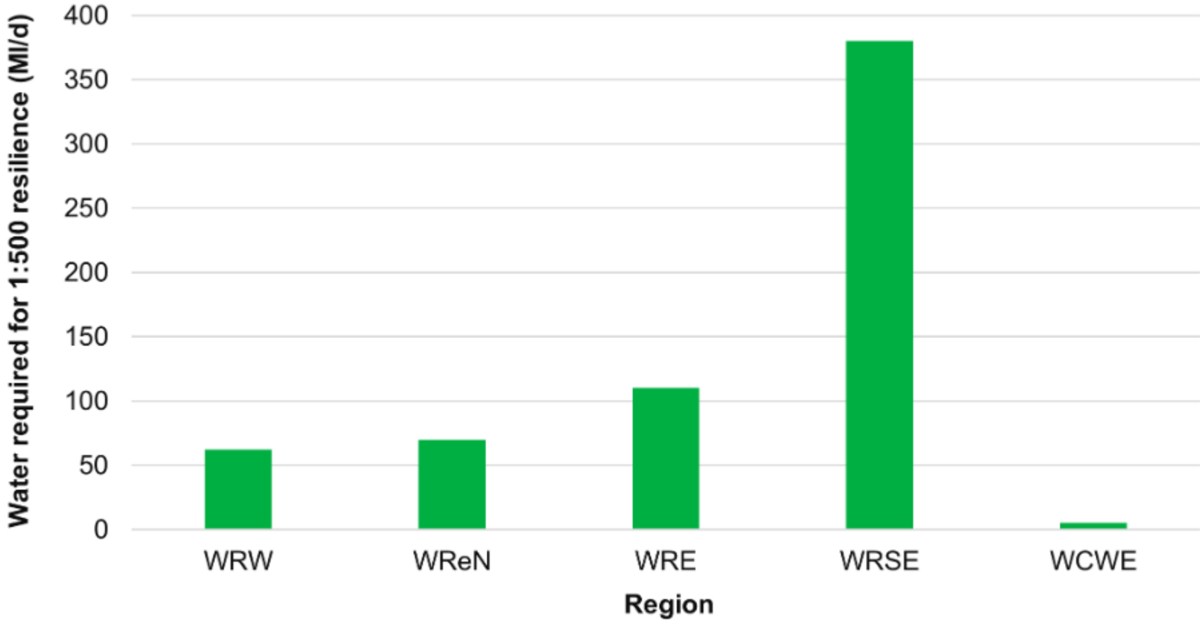


Figure 2.20: Additional water required (Ml/d) in each regional group to reach a drought resilience of a 1-in-500 year event from a 1-in-200 year event.

Figure 2.20 presents the water required in each region to enhance drought resilience from the 2030 level (1 in 200) to a 1-in-500-year event. Nationally, this requires 627 Ml/d by 2055. Regionally, WRSE requires the majority of this, at 377 Ml/d and corresponds to 55% of the national water required for a 1:500 resilience. WCWE has the smallest contribution to the national total of 5 Ml/d.

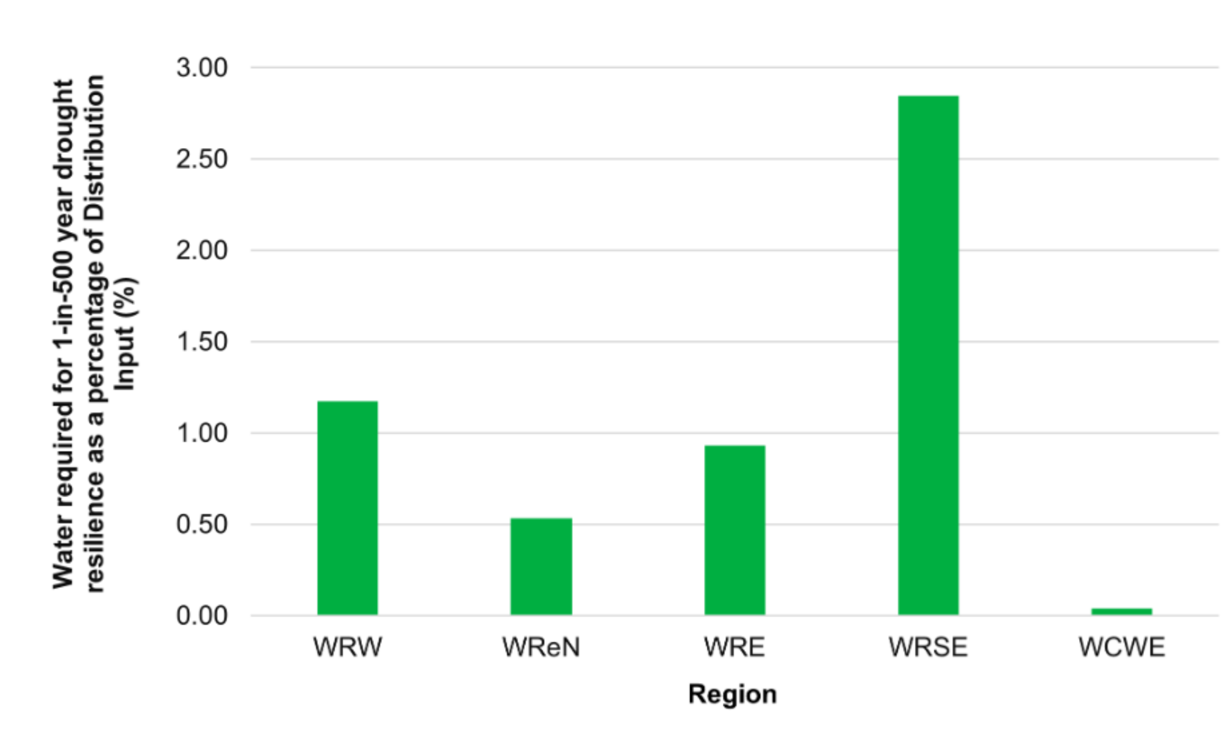


Figure 2.21: Additional water required for each regional group to reach a 1-in-500 drought resilience from a 1-in-200-year resilience expressed as a percentage of demand (distribution input (DI)) in 2055.

Figure 2.21 shows an estimate of the water volume required in each region to increase drought resilience from a 1:200-year event to a 1:500-year event as a percentage of the regional dry year public water demand (distribution input) in 2055. WRSE has the largest percentage of 2.85%, followed by WRW with 1.2%, WRE with 0.9%, WReN with 0.5% and WCWR with 0.04%. All regions are consistent with the absolute water required in Ml/d presented in **Figure 2.20**.

2.4.5 Household water efficiency (per capita consumption)

Per capita consumption is currently 137 litres per person in England on average. If each person reduced the amount of water they use, it would go a long way to meeting future water needs. Water can be saved in the home by using water wisely, reducing waste and improving technology.

The modelling explores a range of potential future PCC scenarios. The scenarios are Low, Central, High and Do Nothing with a PCC value of 100 l/h/d, 110 l/h/d and 120 l/h/d and 138 l/h/d respectively, by 2055 to understand the potential volume of water that could be saved under each nationally and regionally.

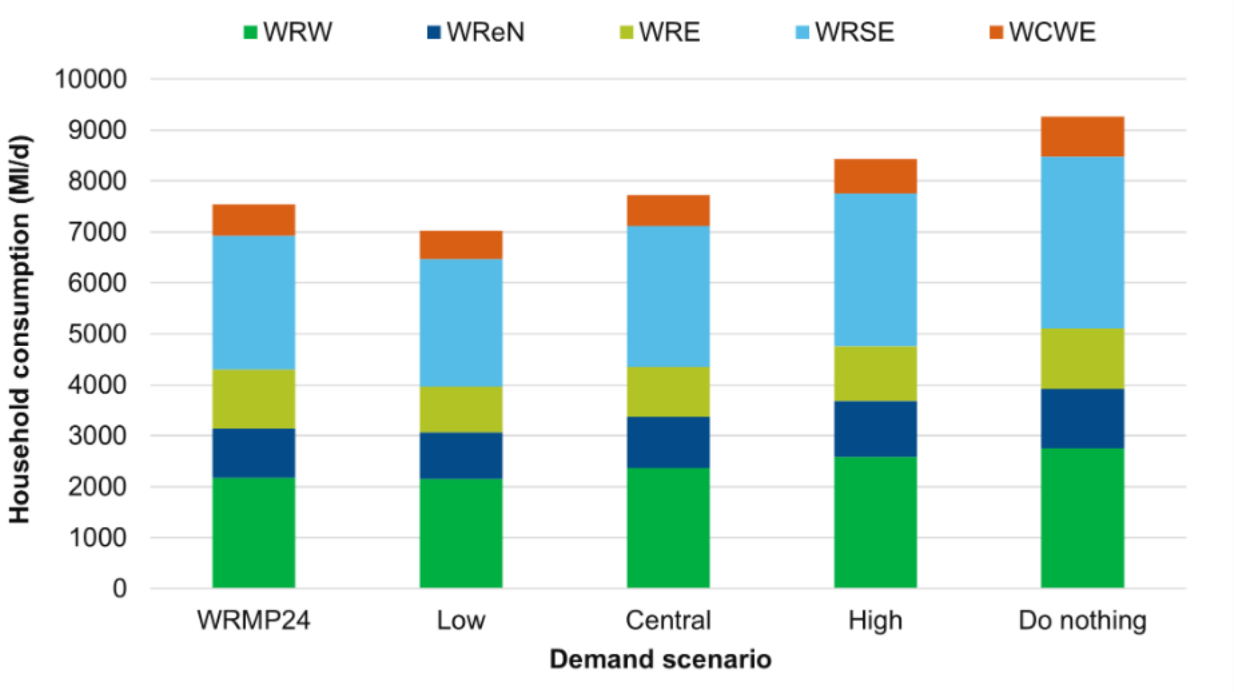


Figure 2.22: A stacked column chart showing the household consumption at 2055 under the WRMP, Low (100 l/h/d), Central (110 l/h/d), High (120 l/h/d) and Do Nothing per capita consumption scenarios, broken down by region. The WRMP24 population forecast was used for each scenario.

Figure 2.22 shows the household consumption at 2055 under each PCC demand scenario, assuming WRMP24 population. The Do Nothing scenario results in the largest household consumption at 2055 of 9267 Ml/d and the Low scenario results in the lowest household consumption at 2055 of 7023 Ml/d. The WRMP and Central scenarios yield similar household consumption values which are consistent with the PCC profiles described in Section 2.1.4. In all PCC scenarios, WRSE has the largest household consumption at 2055 ranging from 2500 Ml/d to 3380 Ml/d compared to WCWE with the smallest household consumption ranging from ~550 Ml/d to ~800 Ml/d.

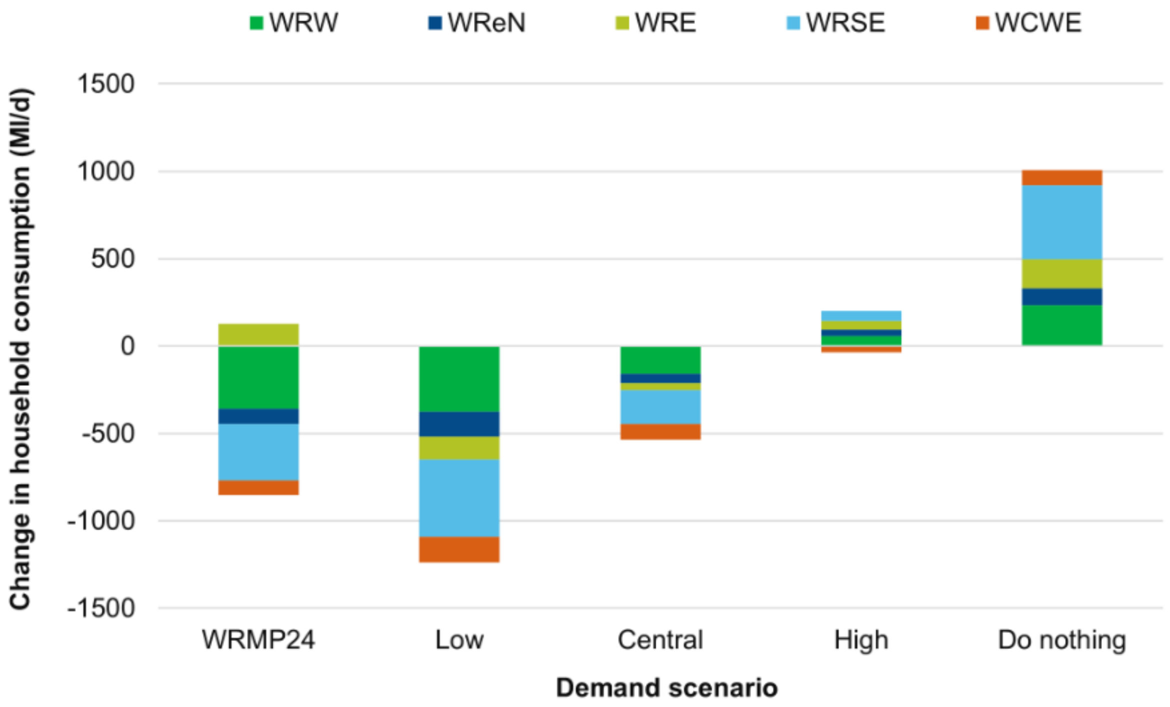


Figure 2.23: A stacked column chart showing the change in household consumption in Ml/d between 2030 and 2055 under the WRMP, Low, Central, High and Do Nothing PCC scenarios. The WRMP24 population forecast was used for each scenario. The stacked boxes show the regional distribution of the household consumption. A positive (negative) change in consumption indicates an increase (decrease) of consumption in a region.

Figure 2.23 shows the change in household consumption between 2030 and 2055 under the WRMP24, Low, Central, High and Do Nothing PCC scenarios. The Low scenario shows the largest combined regional total reduction in household consumption of 1330 Ml/d from 2030, and every region shows a lower household consumption than 2030. The Central scenario also shows a combined regional total reduction in household consumption of ~540 Ml/d by 2055 with every region showing a lower consumption than 2030. The WRMP24 scenario shows the decrease in household consumption as in line with water company plans. WRMP24 closely matches the Central (110 l/h/d) PCC scenario but forecasts a small increase in household consumption in WRE (~50 ml/d). This is mainly driven by an increase in household consumption in the Ruthamford Central, Ruthamford South and Ruthamford North WRZs. The High and Do Nothing scenarios both show an increase in household consumption (and therefore additional demand) at 2055 when compared to 2030, where population growth is occurring, but PCC reductions are not acting enough to reduce demand. Regionally, WRSE and WRW make up most of the consumption change across the scenarios, with WReN and WCWE making up the least.

2.4.6 Non-household demand & water efficiency

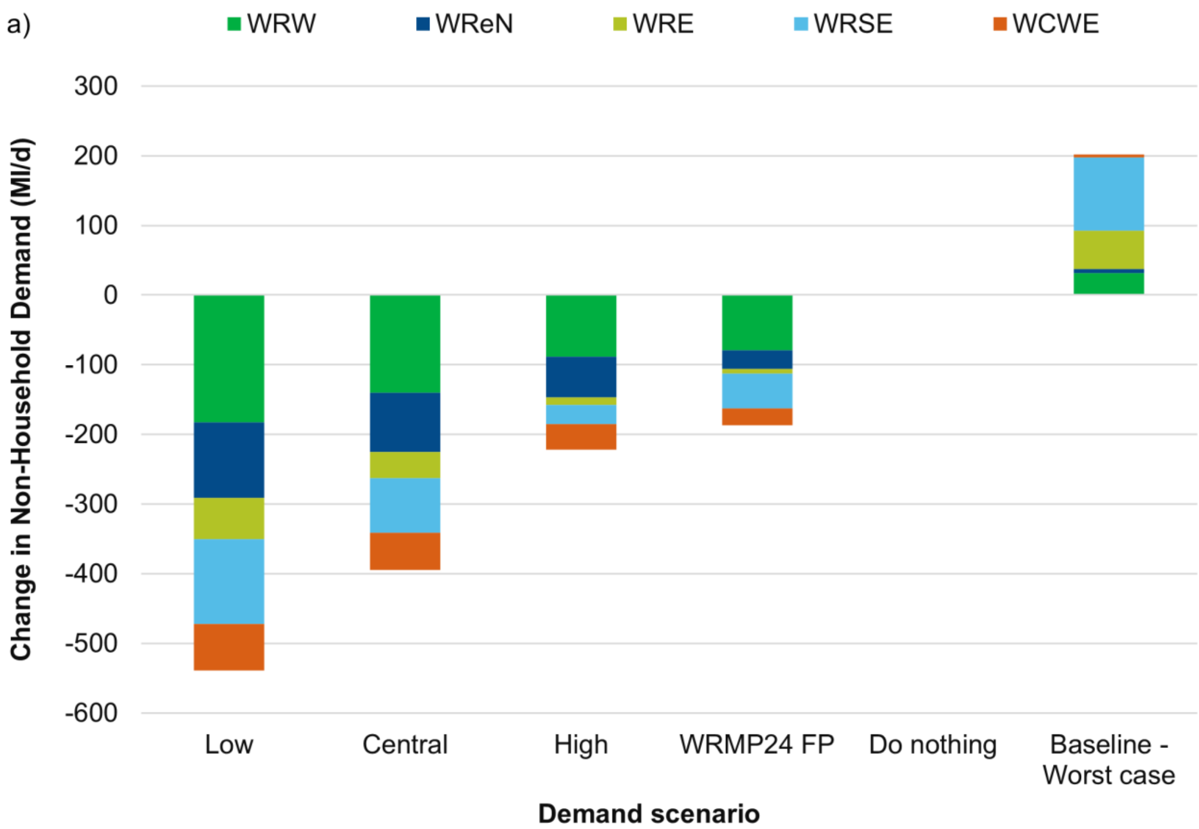
Water companies not only supply household customers, but non-household customers too, accounting for 1.2 million business customers and approximately 20% of total public water supply. Water savings can also come from helping non-household customers – such as businesses and industries – to use water more efficiently. This means that water efficiency in businesses should improve alongside reductions of household use (PCC).

For the past decade, non-household water consumption has been reducing nationally, but with growth starting to occur in sectors including the chemical industry (to support growing pharmaceuticals, construction, energy industries), energy (hydrogen, carbon capture storage, battery factories) leisure and artificial intelligence (requiring data centres), we are starting to see an increased demand for water. This has the potential to be compounded by recent geo-political instability which increases the chance of the UK government building domestic capacity to reduce reliance on volatile international markets, particularly in energy, food production and manufacturing.

The current best estimate of future non-household demand is reflected in water resource management plans and indicates a 9% reduction in non-household demand by 2049-50 nationally (England): short of the Environmental Improvement Plan (EIP) target of 15% by 2050.

This competing nature of increasing non-household demand efficiency to hit targets whilst balancing the additional requirements of water-using sectors to support growth creates uncertainty that we start to explore here with sensitivity scenarios.

In all National Framework end-member scenarios, we expect a reduction in non-household demand from the 2030 baseline. The WRMP24 plans for non-household are set out to be 196 Ml/d less than the 2030 baseline of 2740 Ml/d by 2050. These demand savings to reduce NHH demand to WRMP24 forecasted reduction targets (~9% NHH reduction by 2050) are 6% below the EIP statutory 15% reduction target. The only scenario where additional water would be required by 2055 is if reductions do not happen and current non-household demand begins to increase as per baseline 2055 forecasts. This amounts to 382 Ml/d of additional water required by 2055 – we have added this as a worst-case scenario.


a)
WRW
WReN
WRE
WRSE
WCWE
300
200
100
0
-100
-200
-300
-400
-500
-600
Change in Non-Household Demand (Ml/d)
Low
Central
High
WRMP24 FP
Do nothing
Baseline - Worst case
Demand scenario

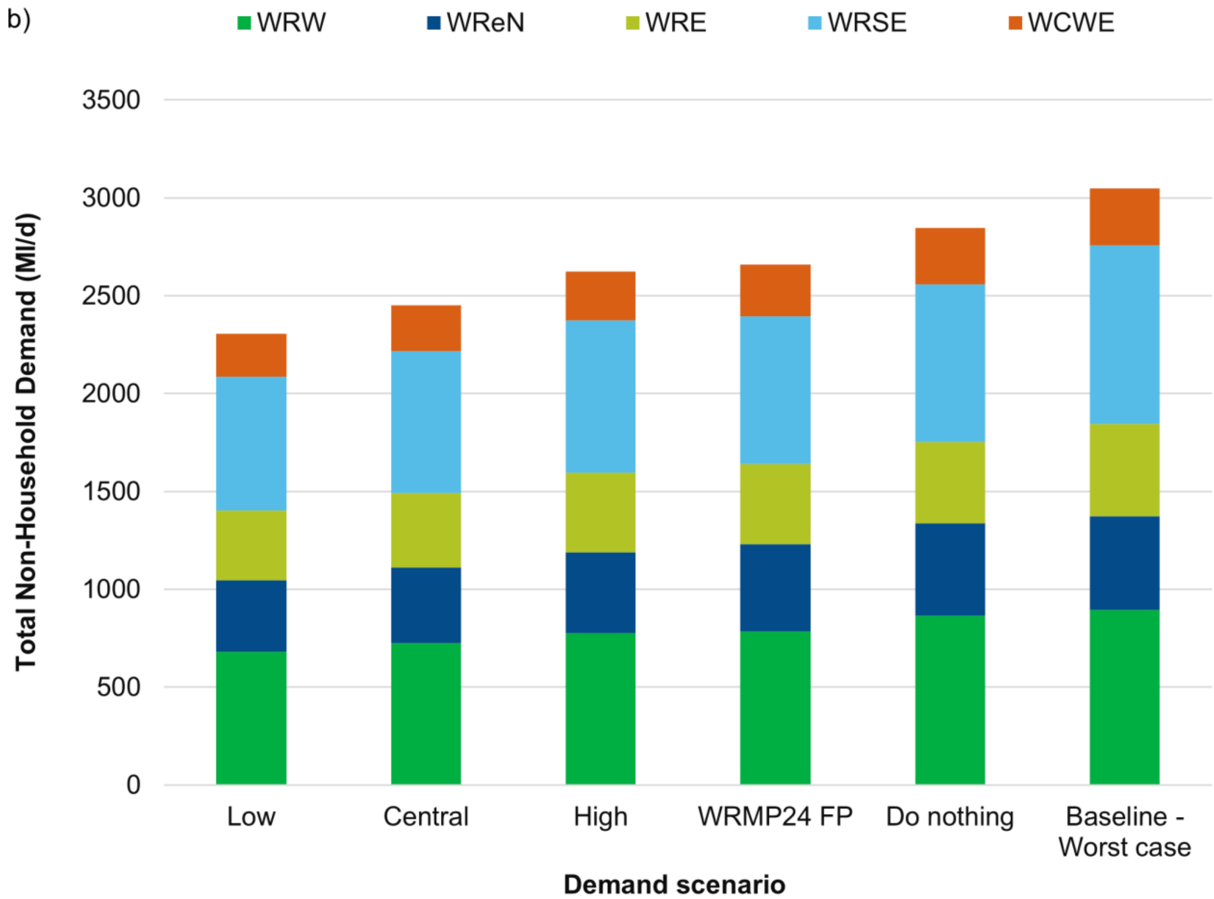

b)
WRW
WReN
WRE
WRSE
WCWE
3500
3000
2500
2000
1500
1000
500
0
Total Non-Household Demand (Ml/d)
Low
Central
High
WRMP24 FP
Do nothing
Baseline - Worst case
Demand scenario

Figure 2.24 a and b show non-household consumption in each of the end member scenarios as investigated in the main report, with additional worst-case and WRMP24 final plan scenarios. Figure 2.24a shows the difference from the 2030 baseline for these scenarios, whereas Figure 2.24b is showing the total non-household demand.

Figure 2.24 a and b are stacked column charts showing the different region's non household consumption totals for six different scenarios: Low, Central, High, WRMP24 Final plan (FP), Do Nothing and Baseline – worst-case. In **Figure 2.24a** we have plotted the difference between WRMP24 Baseline (BL) at 2030 and each scenario at 2055. There is a reduction in non-household consumption observed Low, Central, High and WRMP24 scenarios (from ~515 Ml/d in the Low scenario to 182 Ml/d in WRMP24 nationally). The largest reductions are seen in WRW, WRSE and WReN. There is no change to non-household consumption observed under the Do Nothing scenario (Do Nothing 2055 matches WRMP24 BL 2030). We observe an increase in non-household consumption under the Baseline – worst-case scenario to ~200 Ml/d nationally, with WRSE and WRW making up most of the total. For **Figure 2.24b** we have plotted the total regional non-household consumptions at 2055 over the scenarios. The Low scenario has the lowest consumption, 2306 Ml/d, and this increases to 3047 Ml/d for the Baseline – worst-case.

We can see the plans for reduction in **Figure 2.24a**, where WRW and WRSE are making the largest reductions to their non-household demand. The worst-case additional demand is driven by WRSE.

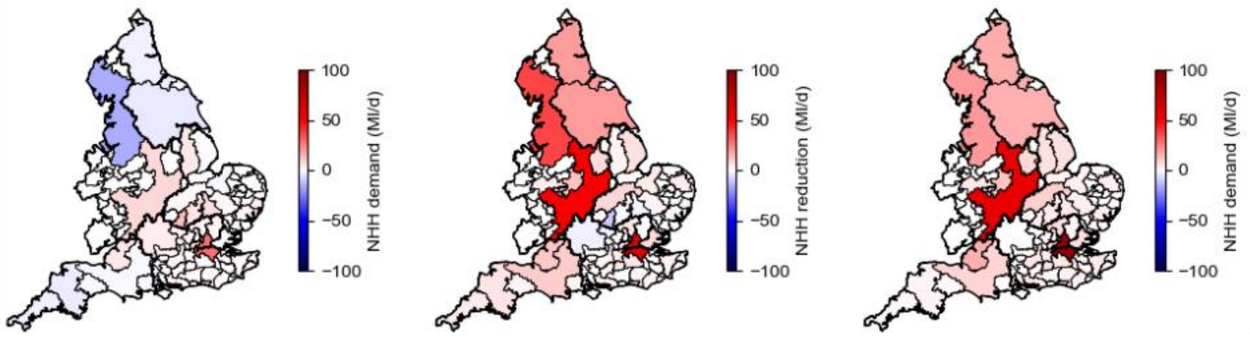


Figure 2.25: (Left) The baseline growth in non-household (NHH) demand between 2030 and 2055. (Centre) The planned reductions in non-household demand at 2055. (Right) The growth in NHH demand in the worst-case scenario. The worst-case scenario assumes no reduction in NHH demand and an increase in non-household demand.

Figure 2.25 is three maps of England, the first shows how the WRMP24 baseline is forecast to grow between 2030 and 2055. The largest non-household growth is observed in WRE and WRSE. A reduction in non-household demand is seen in the WRW, WReN and WCWE. The second map shows the WRMP24 planned reductions in non-household consumption at 2055 from the non-household consumption in the 2030 WRMP24 baseline plan (with higher planned reductions in red). The largest reductions are observed in WRW, WReN and WCWE. The third map shows a worst-case scenario that combines the first and second map, reflecting the WRMP24 additional water needs due to baseline growth in non-household demand and where the WRMP24 planned non-household reductions do not occur. The worst-case scenario highlights that the largest additional water need for non-household demand is seen in London and SVT – Strategic Grid.

As highlighted in the maps above, when discussing non-household demand, we can explore the impact if companies under deliver on their WRMP24. Taking WRMP24 as our reference point, if there is no change (planned reductions do not occur) from current non-household demand, then national non-household consumption will be 180 Ml/d higher than planned for in WRMP24 by 2055 (centre map). If we then assume our worst-case where non-household demand also increases due to baseline growth (left map), this will mean a 382 Ml/d national shortfall from company plans by 2055 (right map).

It is important to note that results presented above do not explore the risk around non-household demand seasonal peaks which is particularly significant for sectors such as food production, data centres etc. The results do not explore the risk of non-public water users moving to non-household public water supply in times of drought or if abstraction limits are reduced. They also do not explore non-potable sources of supply that could be used to offset these demands.

Data centres are fundamental to growth, industry and society and are classed as Critical National Infrastructure. Data centres store information, support online services from artificial intelligence (AI) to managing email and messaging. The government has committed to a 10-year investment commitment in AI infrastructure, beginning in Spring 2025, including the creation of AI growth zones (AIGZs). As AI increases, this will generate greater demand for data centres, with a potential large and rapid increase in the number of data centres, with many expected to be built by 2030. Data centres can require a large amount of water for cooling processes and there is the potential for new, large demands of water as more data centres are built. There are many ways of cooling data centres, all of which consume different amounts of water. Water cooling systems can be open or closed loop, with closed loop systems being more water efficient. Direct to chip liquid cooling systems, using either water or a special liquid coolant, are also gaining popularity. Air cooling systems are likely to be used less frequently as chips in data centres are becoming hotter. According to the techUK-Environment Agency survey undertaken in 2025, where we surveyed 73 data centres, 55% use dry (waterless) cooling, 44% use hybrid and only 5% are water cooled. There will be an inevitable trade off between water and power consumption required for data centres. In general, cooling methods that consume less water, tend to consume more power, highlighting the importance of a holistic assessment of resource consumptions, constraints and environmental impact when cooling processes for data centres are being selected.

Based on Environment Agency abstraction records, and supported by the techUK-Environment Agency survey, most current data centres that require water for cooling, use public water supply as provided by water companies through non-household demand. There has so far, been limited information available on the current water consumption of data centres. Through collaboration with the Market Operator for the non-household retail market (MOSL) and Department of Science, Innovation & Technology (DSIT), we have undertaken preliminary analysis of historic water consumption data to build an understanding of current water usage and trends of water usage across data centres. Using datasets provided by DSIT and MOSL that highlighted individual data centres and water consumption respectively, we collated a list of data centres with water consumption information where it was available, capturing ~200 data centres. There were challenges faced in collating this list due to inconsistencies, missing information and misclassification across the two datasets. As a result, we are missing water consumption information on ~100 data centres and estimates of current consumption of data centres presented here are likely to be an underestimate.

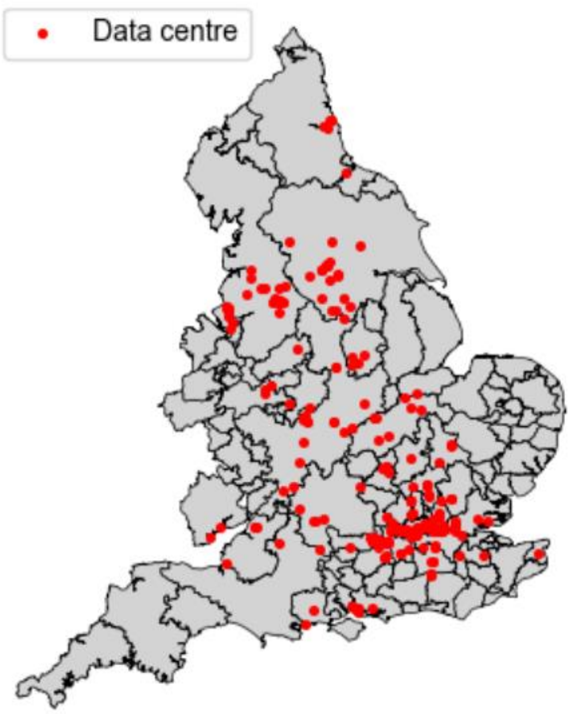


Figure 2.26: Map showing the location of data centres within England from the data provided by DSIT. Majority of the data centres are in the southeast.

Figure 2.26 is a map of England showing the location of data centres with red dots. They are highly saturated around London and WRSE. A fair amount in WRE and WRW and only a few are in WReN and WCWE.

According to DSIT, there are approximately ~300 data centres in England, with 57% of these located in the southeast as shown in **Figure 2.26**. Of the ~200 data centres where we have water consumption information, 38 of the top 50 water consuming data centres are also in the southeast.

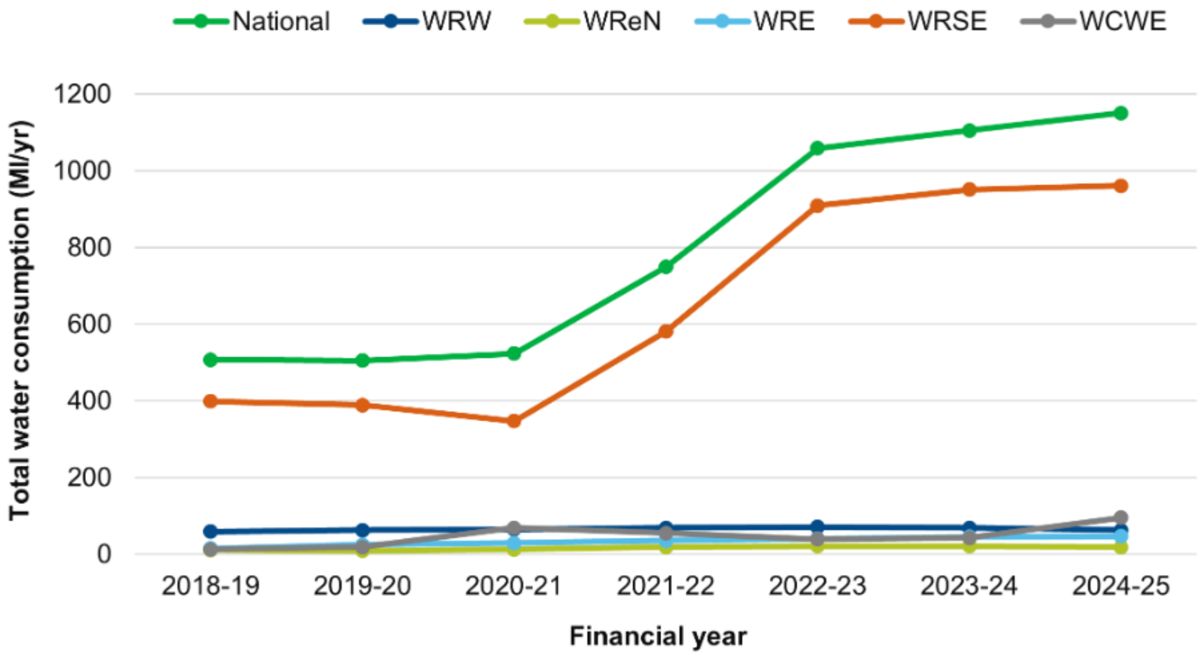


Figure 2.27: The estimated national water consumption of data centres in England from 2018 to 2025 in Ml/year (assumed to be an underestimate). The national total is broken down into water resource region. WRSE is responsible for the largest contribution to the national total.

Figure 2.27 is a stacked line chart showing the total water consumption in Ml/year of data centres by region from 2018-19 to 2024-25. The national total is plotted and ranges from 500 Ml/d to 1150 Ml/yr over the period. WRSE sits approximated 100 Ml/yr below the national line; all other regions remain below 100 Ml/yr.

According to our list of ~200 data centres, overall data centre water consumption in the 2024-2025 financial year is (under)estimated at 1125 megalitres (Ml). Whilst we can consider this to be small nationally (<1% of national non-household water consumption), there is significance regionally**. Figure 2.27** shows the annual data centre water consumption over time. 83% of the 24-25 water consumption observed was consumed by data centres in the already water-scarce WRSE region (937 Ml), with water consumption increasing dramatically by 170% in this region from 2021 to 2025. On a national scale the water consumption from data centres increased by 120% over the same period. There is also significance seasonally, with clear summer peak demand in water consumption as shown in **Figure 2.28** which could pose the largest risk to regions. We observe peak water consumption to correlate with mean UK temperature, showcasing that hybrid systems are being used for cooling of data centres. This highlights the importance of assessing data centre water demands locally and seasonally, particularly in the context of climate change and drought planning.

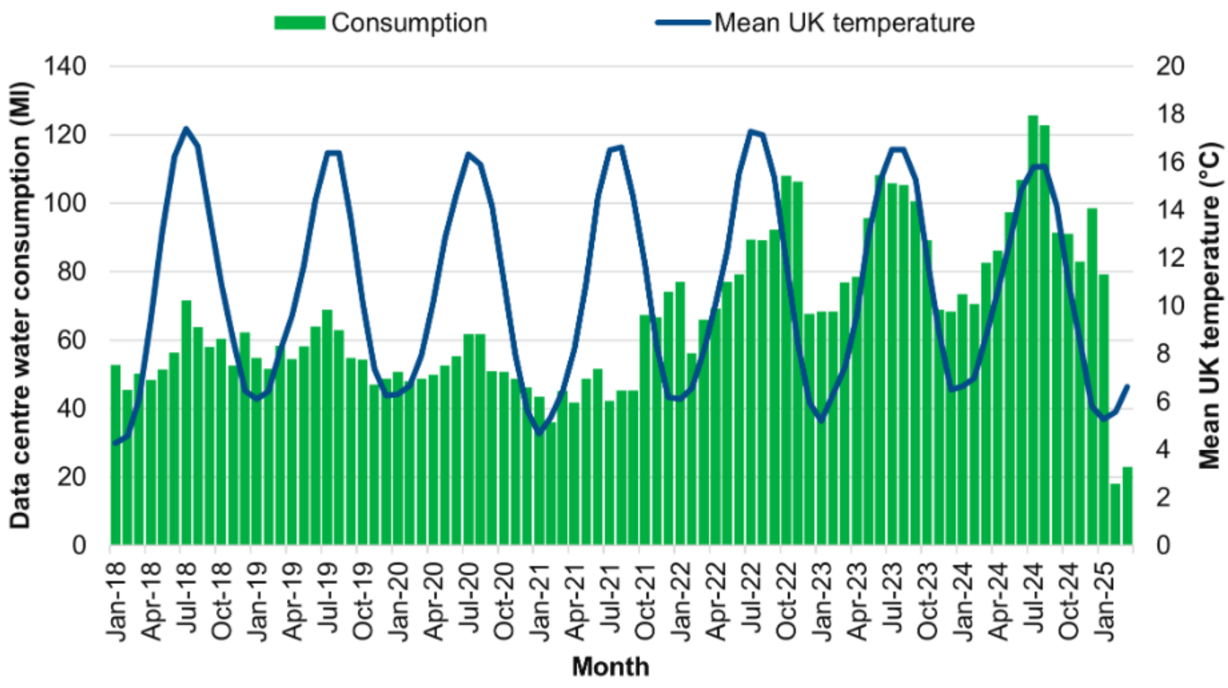


Figure 2.28: The monthly water consumption of data centres in England from January 2018 – March 2025. The monthly average UK temperature is overlaid in blue.

Figure 2.28 is a combination chart with columns denoting the monthly water consumption of data centres in England and a line showing the monthly average temperature of the UK. Both are plotted over time spanning quarter yearly intervals from January 2018 to January 2025. Generally, the mean temperature emulates an oscillating wave with a peak in July and a trough in January. A similar pattern is seen by water consumption over the period, more strongly from 2022-2025.

As we expect our current water consumption of data centres is an underestimate, we also explored an upper and lower bound for current consumption using assumptions of water consumption for the missing ~100 data centres. This produced a lower bound estimate of 1760 Ml to an upper bound estimate of 3530 Ml in 2024-25. This uses an average consumption across the 200 data centres for the lower bound (5.7 Ml) and an assumption that all missing data centres are hybrid cooled with a higher consumption of 21.5 Ml for the upper bound. Under all estimates, national consumption is <1% of non-household demand. For the southeast, the estimates for current consumption of data centres account for between 0.5 and 0.9% of their total non-household water consumption annually.

Water company forecasts for future non-household demand that we model in this report are unlikely to capture the potential future needs of data centres. This is due to how quickly this sector is growing and due to a lack of information on where and when data centres will be built and most importantly, what cooling methods they plan to utilise. Data is vital for long term planning and identifying opportunities for collaboration between sectors and without it we are unable to accurately model or predict future water needs.

There are large variations in water use within the sector, and more transparency is needed to aid our understanding.

While many data centres will look to water companies for reliable provision of water supplies, there are also opportunities to explore using water abstracted directly from the environment as sources of water for cooling. However, neither of these sources are guaranteed as water companies use supplies to ensure resilience for customers, and some catchments are already closed to new abstraction. With this sector potentially growing so quickly, the demand for water may occur before significant infrastructure (strategic resource options) will have come online (pre-2030). Some water companies have already refused applications for water from data centres. Instead, data centres will need to look to other sources of water for supply, for example use of water recycling through rainwater harvesting or non-potable effluent and/or collaboration with other water users.

2.4.7 Leakage reduction

Reducing the volume of water lost from pipes is another key strategy. This involves finding and fixing leaks more quickly, managing pressure in the system, and replacing old pipes. It also includes reducing losses from household supply pipes, which are the customer’s responsibility. The water industry in England has committed to reducing leakage by 50% by 2050 from 2017 to 2018 levels. We assume leakage remains constant beyond 2049-50 for the remainder of the modelling period (up to 2055), as further reductions could not be guaranteed without additional investment from water companies beyond the statutory target date.

Total leakage in England in 2017-18 from WRMP24 tables was 3110 Ml/d. Our end member scenarios equate to a 40% reduction from this value, totalling 1870 Ml/d leakage in our high scenario, a 50% reduction in our central scenario equates leakage to 1560 Ml/d, and the biggest reduction of 60% for our low scenario, leaving the leakage total at 1200 Ml/d. Under the WRMP24 leakage reduction, nationally we estimate leakage to account for 1500 Ml/d. Our work assumes a 2030 baseline for the National Framework of 2100 Ml/d leakage, implying that leakage reduction forecasted in plans up to 2030 has been achieved.

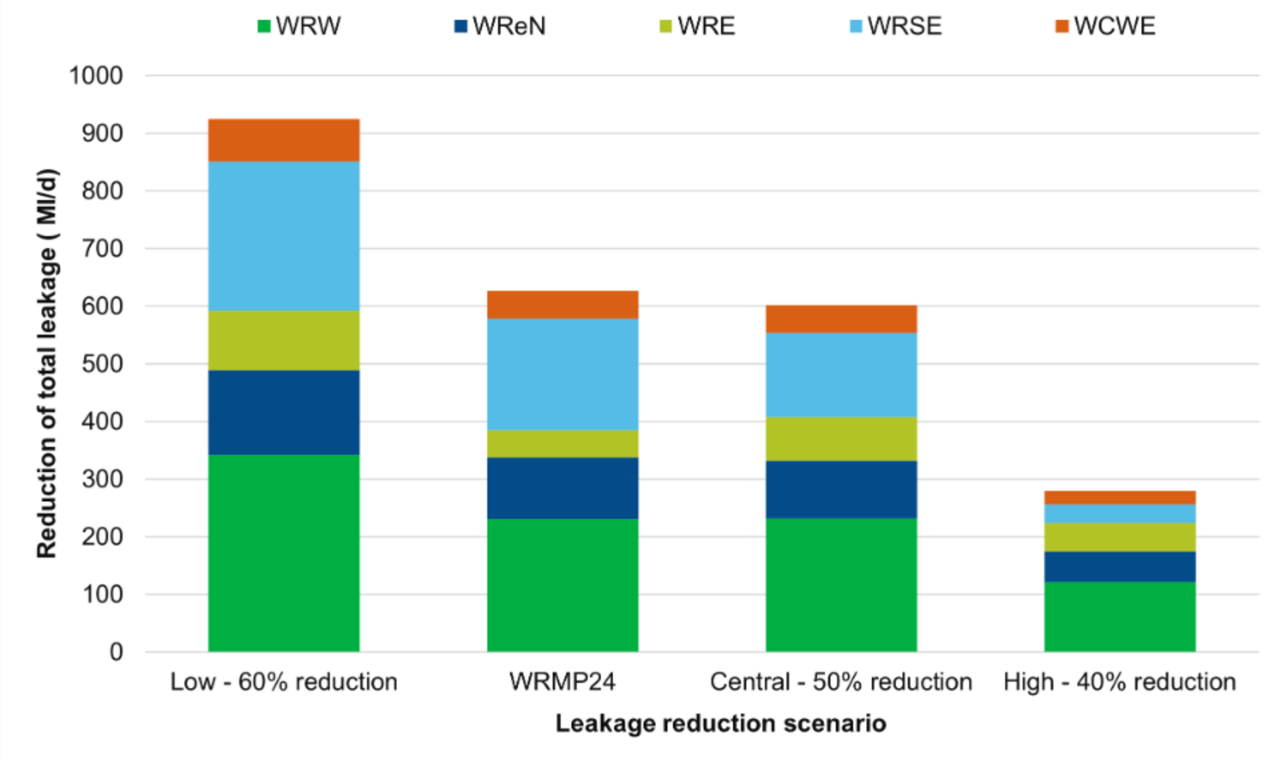


Figure 2.29 is a stacked bar showing the total water saved in Ml/d in each region by 2050 through leakage reductions scenarios: 60% reduction, reductions currently planned for (WRMP24), 50% and 40% reductions. Reductions shown have been made from a WRMP24 baseline in 2030.

In **Figure 2.29** we can see the companies are already planning – WRMP24 - for a significant reduction in leakage after 2030; a total of 626 Ml/d saved across all regions by 2050. This is on top of a planned reduction of 1012 Ml/d from 2018 to 2030. We can see if companies push to achieve 60% reduction, an additional 298 Ml/d of water is saved. The fourth bar shows the vulnerability of underachieving on leakage reduction targets, creating a 346 Ml/d shortfall from WRMP24 plans if only a 40% leakage reduction is achieved. This is a significant amount of water that would need to be found elsewhere. This highlights the importance of leakage targets being achieved. The most water gained back through leakage reduction is in WRSE and WRW, in comparison to lesser gains in WCWE and WRE.

For further regional breakdowns, please refer to [Appendix B of the National Framework for Water Resources 2025].

2.4.8 Demand side actions: temporary use bans and non-essential use bans

Temporary use bans – formerly known as hosepipe bans – are implemented to reduce peak household water usage during times of scarcity, helping to conserve supply.

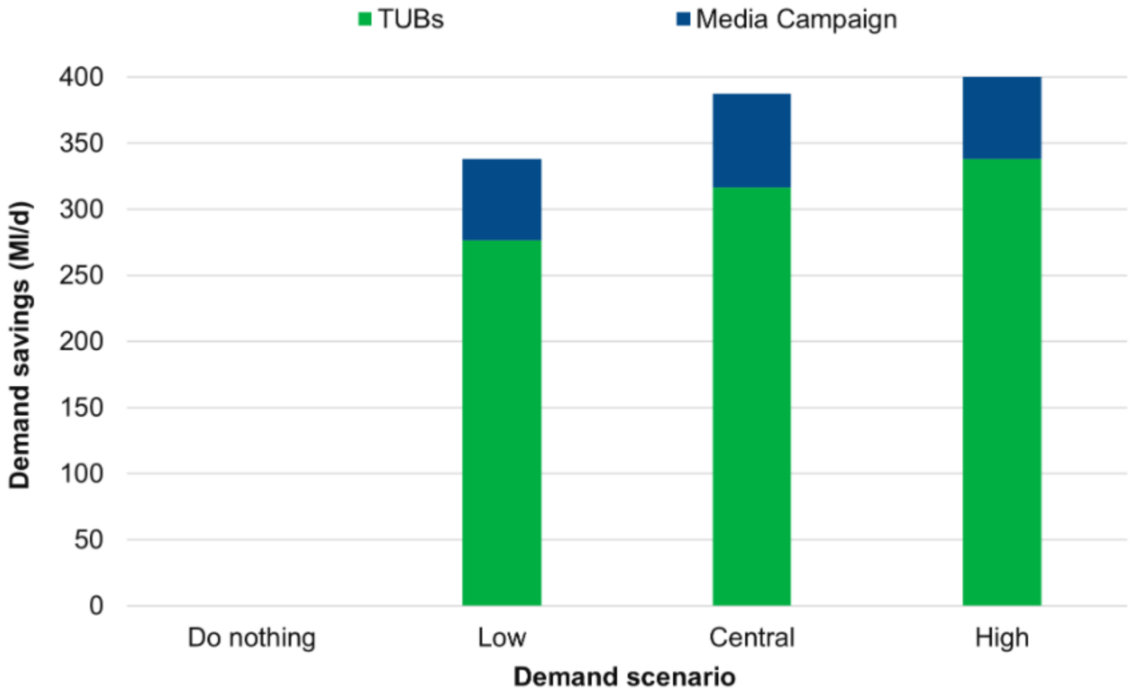


Figure 2.30 shows the national benefit (water demand savings in Ml/d) of introducing media campaigns and temporary use bans (TUBs) in 2055 under the four end-member scenarios: Do Nothing, Low, Central and High.

Figure 2.30 outlines the demand savings from media campaigns and TUBs included in the end-member scenarios for the main report. End-member scenarios exclude non-essential use bans (NEUBs) as they are rarely implemented. No demand savings are implemented in the Do Nothing scenario hence the DO benefit is 0 Ml/d. In the low, central and high scenarios, we applied the percentage demand savings from WRMP24 to the modelled household and non-household consumption giving 338 Ml/d savings under our low demand scenario, 387 Ml/d gained back in the central demand scenario and 414 Ml/d under a high demand.

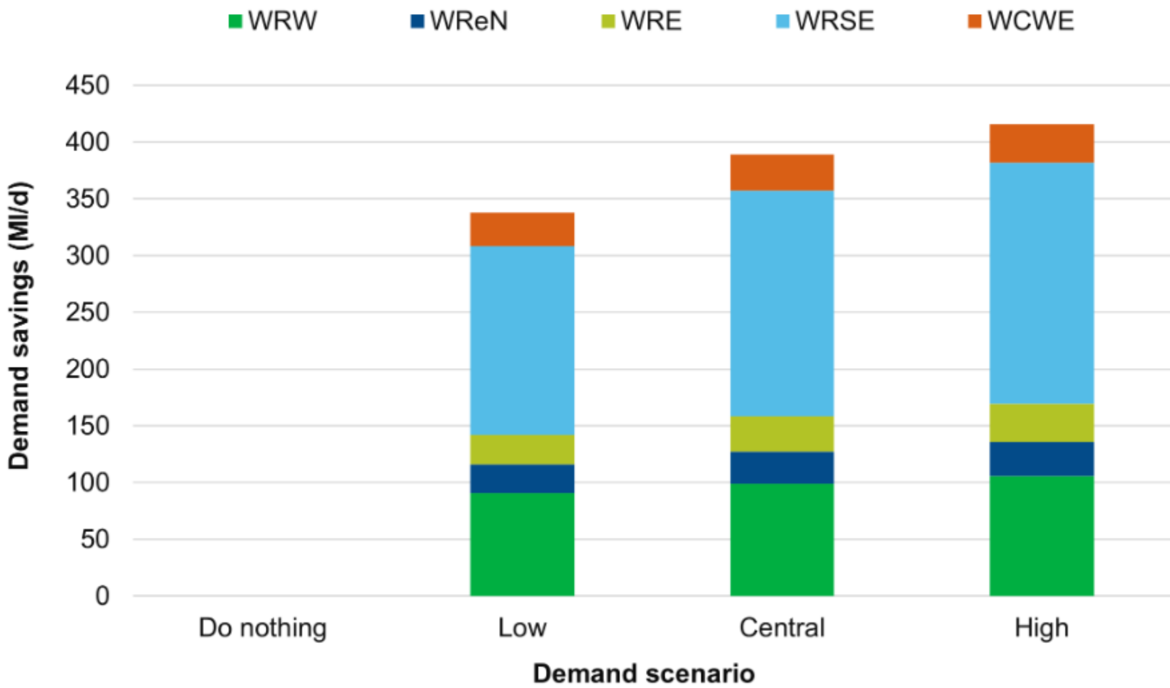


Figure 2.31 is a stacked column chart that shows the total demand savings benefits in Ml/d when media campaigns and TUBs are implemented in 2055 across each demand scenario (Do Nothing, Low, Central and High) and split regionally. Only Low, Central and High scenarios see a benefit, ranging from 346 Ml/d to 423 Ml/d nationally. Most of the benefit is observed in WRW (91 to 106 Ml/d) and WRSE (166 to 212 Ml/d) across the scenarios.

The following analysis is additional and was not included in the National Framework Main report. It involves investigating the potential benefit from implementing non-essential use bans (NEUBs) under the end-member scenarios as set out in the National Framework.

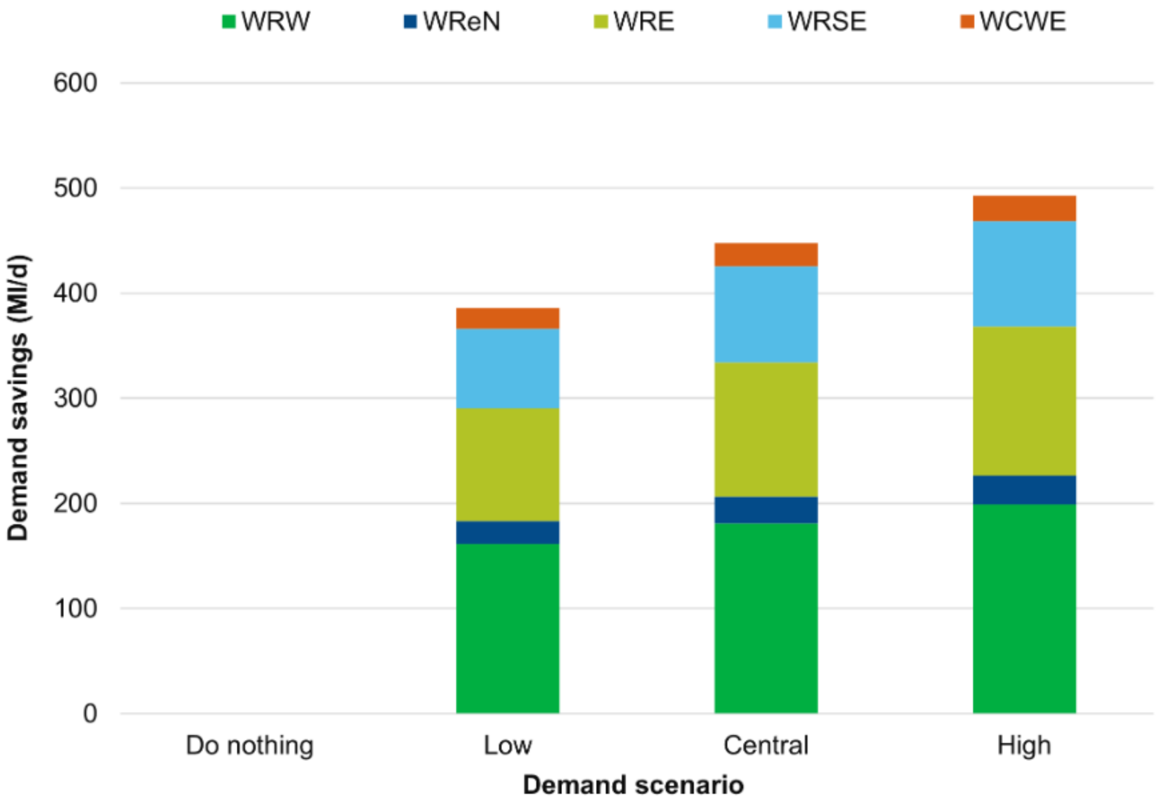


Figure 2.32 shows the total water saved in Ml/d across our end-member scenarios of Do Nothing, Low, Central and High when NEUBs (only) are implemented at 2055.

Nationally, the total demand savings from NEUBs is 370 Ml/d under our Low scenario, 432 Ml/d in the Central scenario and 475 Ml/d under our High scenario. The regional split shows WRW benefits the most from NEUBs being issued. Similarly to TUBs and media campaigns, the largest benefit from implementing NEUBs is seen in WRSE.

If we combine this with our demand savings for TUBs and Media campaigns under the same scenarios, the national demand savings are 710 Ml/d under Low, 821 Ml/d under Central demand and 892 Ml/d under our High scenario.

National savings presented here assume that all water companies would implement either media campaigns, TUBS or NEUBs at the same time. This is unlikely, whereby drought will impact different geographical areas at different times, in different ways.

2.4.9 Supply side actions: drought permits and orders

During extended dry periods, drought permits and orders can allow increased water abstraction.

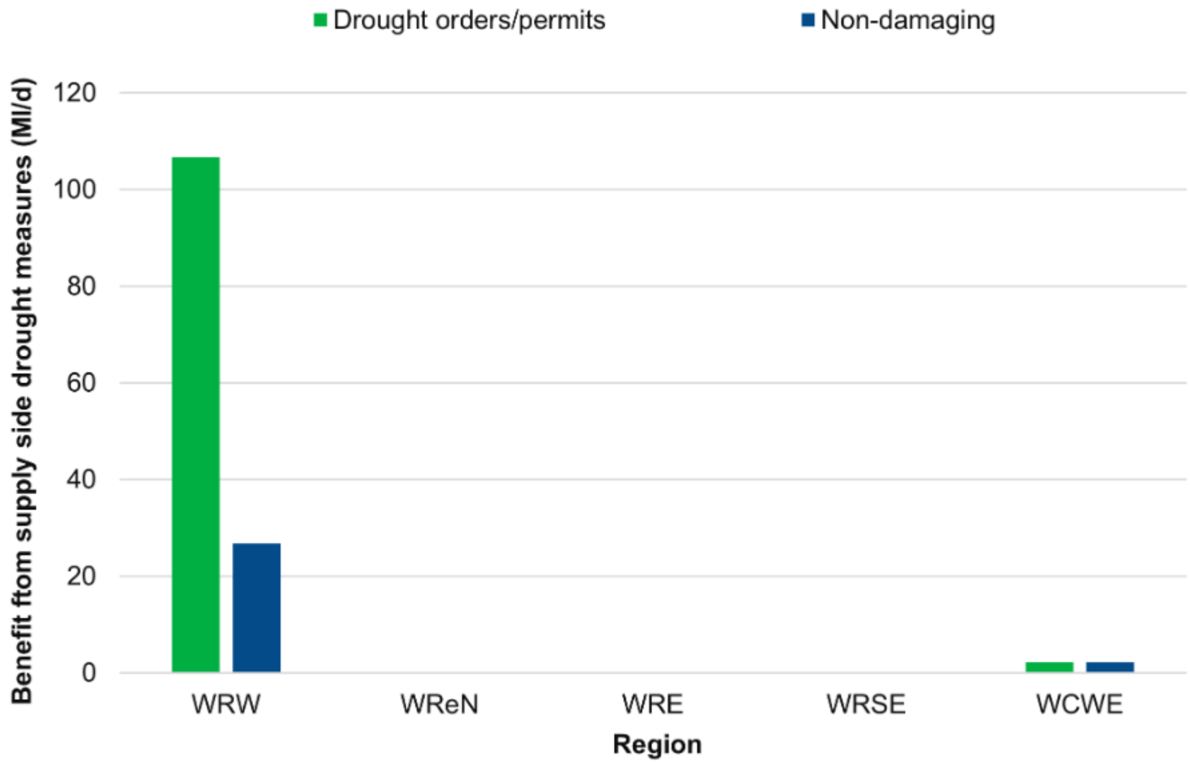


Figure 2.33 illustrates the benefits of implementing all drought orders/permits and non-damaging drought orders/permits in Ml/d at 2055. Of all the regions assessed, only WRW and WCWE have permits that continue to deliver benefits through to 2055, amounting to 109 Ml/d. Notably, WRW would experience a loss of 80 Ml/d if permits deemed damaging were withdrawn.

2.4.10 An updated reasonable worst-case scenario

To add to the end-member compound scenarios explored in the main report of the National Framework, we have also explored what we refer to as an updated reasonable worst-case scenario and compare to the Do Nothing and 'High water needs' scenario. We considered the 'High' water needs scenario to be a reasonable worst-case scenario as per the main report, this can be taken as an updated version of this scenario. Note, this scenario assumes full delivery of supply schemes as per WRMP24.

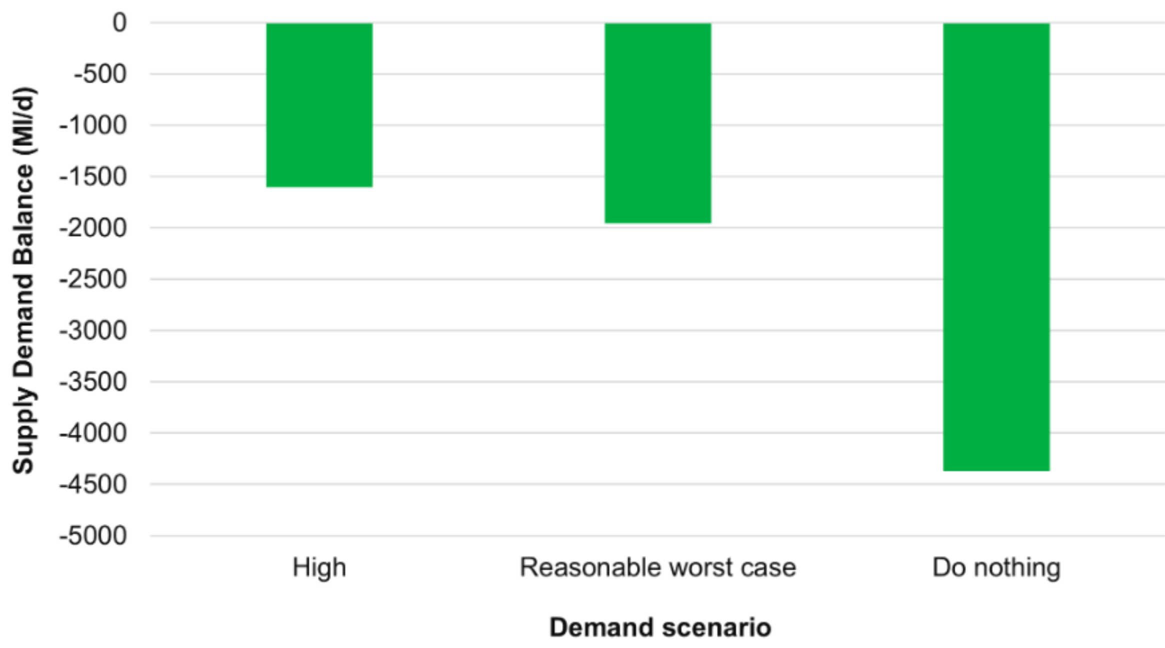


Figure 2.34: The change in supply demand balance at 2055 from the 2030 WRMP24 baseline under the High water needs, updated reasonable worst-case and Do Nothing scenarios.

Figure 2.34 shows the change in supply demand balance at 2055 compared to the 2030 WRMP24 baseline for each of the worst-case scenarios. The Do Nothing scenario had the largest deficit of 4370 Ml/d followed by the updated reasonable worst-case scenario and high water needs scenario with deficits of 1956 Ml/d and 1604 Ml/d respectively. Therefore, the updated reasonable worst-case scenario provides an additional deficit of 352 Ml/d nationally when compared to the high water needs scenario as outlined in the main report. Note that the national deficit observed in the main report for the high water needs scenario was 1565 Ml/d, we observe an increase to 1604 Ml/d reported here. This is related to an updated OxCam population scenario, creating another 39 Ml/d of additional demand.

We designed the reasonable worst-case scenario by selecting model parameters that feasibly maximise reduction of the supply demand balance by increasing demand and reducing supply. Note however that this scenario assumes all supply schemes (resource options) as per WRMP24 preferred plans are fully delivered (and on time). The Do Nothing scenario does not provide a realistic worst-case as it assumed that water companies will take no actions to change the water supply in the next 30-year period. However, we include it in this section for comparison.

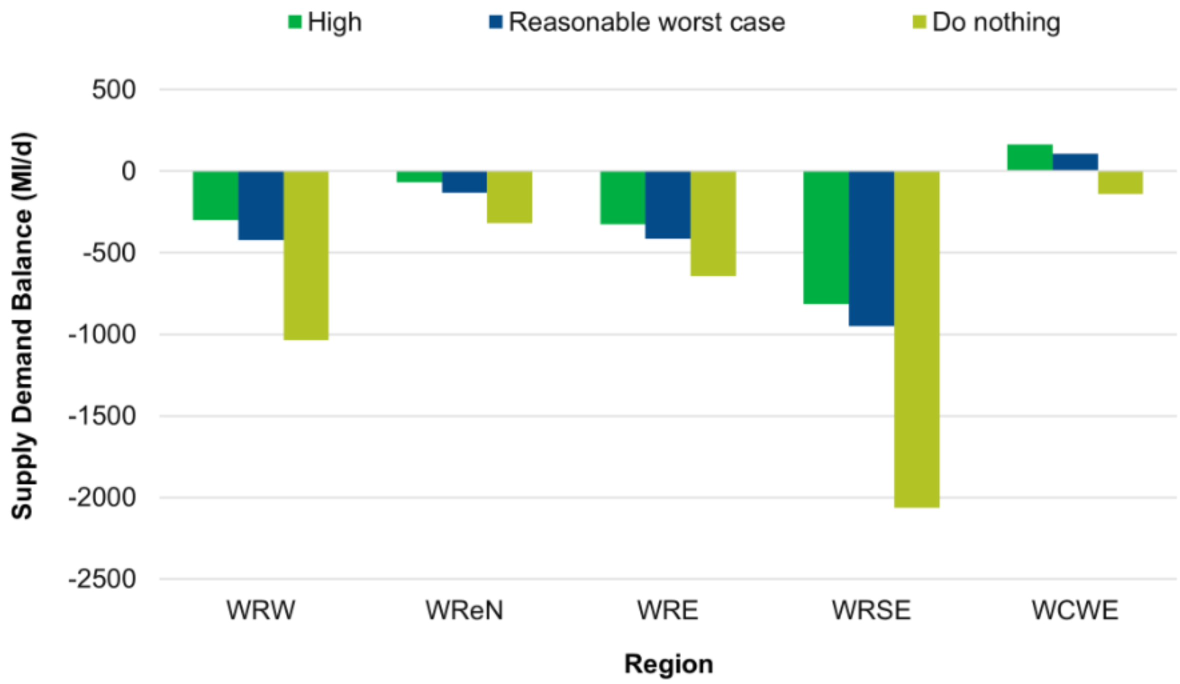


Figure 2.35: The supply demand balance at 2055 for the high, reasonable worst-case, and Do Nothing scenario clustered by region.

Figure 2.35 shows the regional distribution of the supply demand balance at 2055 for the High water needs, updated reasonable worst-case and Do Nothing scenarios. For all regions, we observe approximately 50-130 Ml/d of extra deficit (additional water required) under the updated reasonable worst-case when compared to high water needs scenario. WCWE is affected the least with an extra deficit of 56 Ml/d and WRSE is affected the most with an additional deficit of 134 Ml/d between these scenarios.

3 Assessing current and future non-public water supply needs

All the results up to this point have focused on public water supply, which miss an important part of how water is used in England. This section considers the water demands from those that abstract water directly from the environment for uses other than public water supply including purposes such as irrigation or industrial production and cooling.

The pressure on water resources extends across sectors that use water not supplied by water companies through direct abstraction. It is important that regional water resources groups work with these sectors to develop a better understanding of their water needs and explore solutions to meet existing and future demand, as well as protecting the environment.

The current resilience to drought of sectors outside public water supply is far less understood than the resilience of public water supply. These sectors will also be facing pressures from climate change; they need to reduce abstraction to protect the environment as well as changing patterns of demand in their sector. Water supplies that have been reliable in the past may not be reliable in the future. It is possible that sectors could help increase the resilience of public water supplies e.g. navigation authorities can play an important role in moving water through the canal network.

This section provides the technical detail behind Section 3.3 of the National Framework for Water Resources, including datasets and the modelling approach taken as well as further breakdown of current and future estimated consumption within key non-public water supply sectors.

3.1 Data and modelling approach

We sourced data on Surface Water Abstractions (SWABs) and Groundwater Abstractions (GWABs) from an extract taken from the Environment Agency owned Water Resources Geographical Information System (WRGIS) database in October 2024.

The WRGIS database is a snapshot of national water resource information and pulls upon data from individual Catchment Abstraction Management Strategies (CAMS) to calculate water availability on a waterbody. The WRGIS does this by looking at the balance between the natural flow in the river, the quantity needed to support the ecology and the water that can be licensed for abstraction. The WRGIS includes all abstractions in our licensing system, including those that were previously except i.e. trickle irrigation and navigation. The dataset extract included the following key attributes: licence number; purpose code; licence holder; Recent Actual (RA) point purpose quantity in m^3 per year (a), and Fully Licensed (FL) point purpose Abstraction (in m^3 per year and consumptive factor. Recent actual (RA) abstraction data (m3/a) is calculated from 6 years of typical use, this extract is reflective of recent actual abstraction between 2016 and 2021, but this will depend on catchment. Where non-typical values such as null returns are observed or abstractors do not submit returns, local Environment Agency Area teams will use their best judgement to calculate a recent actual abstraction volume in m3/year. Data has been converted from m^3 per year to megalitres per day (Ml/d) for the purposes of this study.

To account for consumption, we could either use consumptive factors through the Environment Agency licensing system to assess charging (taken from NALD), or more accurate consumptive factors held in local area knowledge and contained in WRGIS (provided through CAMS/RAMS ledgers). Our work here uses WRGIS consumptive factors.

The Ml/d figures do not represent peak usage but assumes usage is spread evenly across the year. It is given only for comparison with the figures used to describe public water supply needs. In practice, certain sector demand e.g. spray irrigation is seasonal, and annual quantities tend to be used over a relatively short period of time in the summer. In contrast, industrial water abstraction tends to be steadier throughout the year. Licences linked to saltwater abstractions and tidal waters were removed as these relate to coastal and estuary sources that fall outside the scope of freshwater resource planning.

For the purposes of high-level analysis based on consumptive need, abstraction licences related to navigation have been excluded. This is because not all abstractions and transfers to support navigation have been represented in the WRGIS abstraction datasets used in this assessment; some navigation transfers may have been accounted for elsewhere as complex activities in the WRGIS. For more information on abstraction related to navigation, please refer to Section 3.2.3 of this report.

To isolate non-public water supply demand, licences held by water companies were excluded from the dataset. This ensured that abstraction volumes attributed to the water supply sector reflected private supply, allowing for a clearer understanding of water demand outside of regulated public provision.

A consumptive factor as indicated in the WRGIS database for each abstraction licence, was applied to RA and FL abstraction volumes to account for the proportion of water that is not returned to the environment after use. This adjustment reflects the volume of water consumed and the volume returned to the environment, which is, particularly important for sectors where water is lost through processes such as evaporation or incorporation into products. By applying sector-specific consumptive factors to both RA and FL abstraction figures, the analysis provides a more accurate representation of water consumed, and therefore, the pressure exerted on water resources under different demand scenarios. As an example, aquaculture used for fish and water cress farms returns almost all water abstracted back to the environment, so its consumptiveness factor is very low, therefore exerting lower pressure on downstream water resources. This analysis made up the ‘Baseline’ scenario which represents average annual consumptive abstraction from 2016 to 2021.

For the first National Framework for Water Resources (2020), Wood Plc led a consortium to investigate the key drivers and uncertainties influencing water demand beyond the public water supply. The study focused on understanding how water use across various sectors and subsectors outside the water industry may evolve over time through a range of growth scenarios. From this analysis, we developed best and upper estimates of future demand to explore potential changes in non-public water consumption through to 2050. ‘Best estimate’ represents our assessment of the most likely estimate based on the evidence available. ‘Upper estimate’ illustrates a reasonable upper estimate of possible water consumption. The growth factors were provided for the sectors below and we outline them in **Table 3.1**:

- spray irrigation
- horticulture
- food and drink manufacturing
- electricity production
- paper and pulp
- chemicals manufacturing

We also explored a specific agricultural upper estimate as developed through the Agricultural Supply-Demand Balance Assessments (SDBA), which assumes a higher growth for spray irrigation and ‘general’ agriculture based on ‘Uncontrolled demand, Regionalisation’ as adapted from Knox et al (2018)., interpolated for the 2050s. The change factors are included in **Table 3.1**.

Table 3.1 Growth factors as a % utilised to estimate future non-public water consumption for a range of sectors. Where available, more up to date growth factors were used for WRSE.

	Best Estimate	Upper Estimate	Upper Agriculture Estimate
Food and Drink	125	154	N/A
Chemicals	122	157	N/A
Paper and Pulp (WRSE)	112 (170)	125 (170)	N/A
Spray Irrigation	144	174	217
Horticulture (WRSE)	201 (132)	201 (132	145 (132)
Other Agriculture	100	100	145
Power	122	166	N/A

These sectors were selected as they cover a significant proportion of current water use (in total, >60% of consumptive freshwater direct abstraction arising from outside of the water industry). The results, based on best and upper growth estimates across England, show potential changes to spray irrigation, horticulture, electricity production, paper and pulp, chemicals and food and drink. We have adjusted growth estimates for specific regions where more up to date information was available on future water use (e.g. WRSE). Please refer to Appendix 5 of the 2020 National Framework for the detailed approach taken to develop growth factors and the associated uncertainty. A limitation of this approach is that it does not represent new and emerging demands, such as from new industries or technologies. Where sector-specific growth factors were unavailable, we assumed that abstraction volumes remained the same as current.

To assess potential future water demand across non-water company sectors for the second National Framework, we applied these growth factors to both RA and FL values. For the sectors where there is no ‘best’ or 'upper' estimate growth factor, we have used the current baseline. This approach enables a comparative analysis of future abstraction pressures under various scenarios.

The licences were allocated to the water resources regional groups as per ‘primary allocated regions’, in line with National Framework 2.0 Environmental Destination. This assumes a regional group takes ownership of certain WFD management catchments based on geographical extent.

We compared future estimates of non-public water needs to the amount of water existing abstractors are currently licensed to take (fully licensed, adjusted for consumptiveness). We also compared future estimates to the amount of water they could be licensed for when environmental requirements have been considered under the Full Environmental Destination planning scenario (under a drier range climate scenario in the 2050s, fully licensed, adjusted for consumptiveness, referred to in graphs as NF2 ED FL). For more information on this scenario, please refer to the National Framework for Water Resources Environmental Destination Technical Report.

3.2 Current non-public water supply needs

This section provides an overview of current non-public water use across England and offers regional planning groups insight into the sectors they should engage with when developing their regional water resource plans.

This section starts by looking nationally at total abstraction from freshwaters is used. We then explore how much of that water use is consumed and can be considered consumptive (referred to in figures as ‘adjusted for consumptiveness’). It compares fully licensed and recent actual volumes used for public water supply with the volumes used for other sectors (outside of public water supply) nationally and by region. The analysis uses data on historical abstraction provided by abstractors as part of their annual abstraction returns between 2016 and 2021.

We present a picture of how water is used across England, which provides the regional groups with information on the sectors they should be working with when developing their regional plans.

Water users who abstract directly from the water environment are currently licensed for 132,000 Ml/d including water companies. This reduces to 114,000 Ml/d when water companies are excluded. When we focus on recent actual abstraction from fresh waters only (rivers and groundwater, excluding coastal and estuaries), this amounts to 28,000 Ml/d. This demand is forecast to increase to 33,000 Ml/d by the 2050s (not adjusted for consumptiveness).

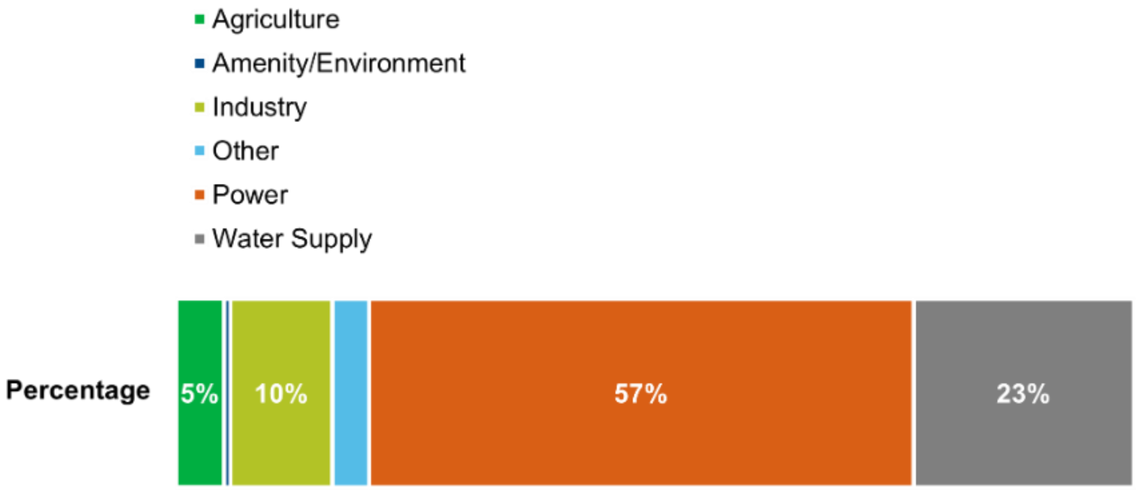


Figure 3.1 is a 100% stacked bar chart showing the current estimated proportion of abstraction with abstraction volumes (Ml/d) from the water environment by primary sectors including water companies (not adjusted for consumptiveness and based on fully licensed volumes). Primary sectors include agriculture (5%), amenity/environment (1%), industry (10%), other (4%), power (57%) and water supply (23%).

Outside of public water supply, approximately 80% of total freshwater abstraction is accounted for by power (predominantly hydropower) and aquaculture (included in agriculture above). These sectors and other water abstractions can be considered non-consumptive, or partially consumptive, which means that the water they use is put back into the system close to where it is taken. From this point on, we focus attention on water use that is considered consumptive, or partially consumptive where water is removed from the system and most significantly affects water availability. Consumptiveness can be complex to estimate, and is variable across sites, even sites using water for a similar purpose. For this report, we use consumptiveness factors provided in the WRGIS.

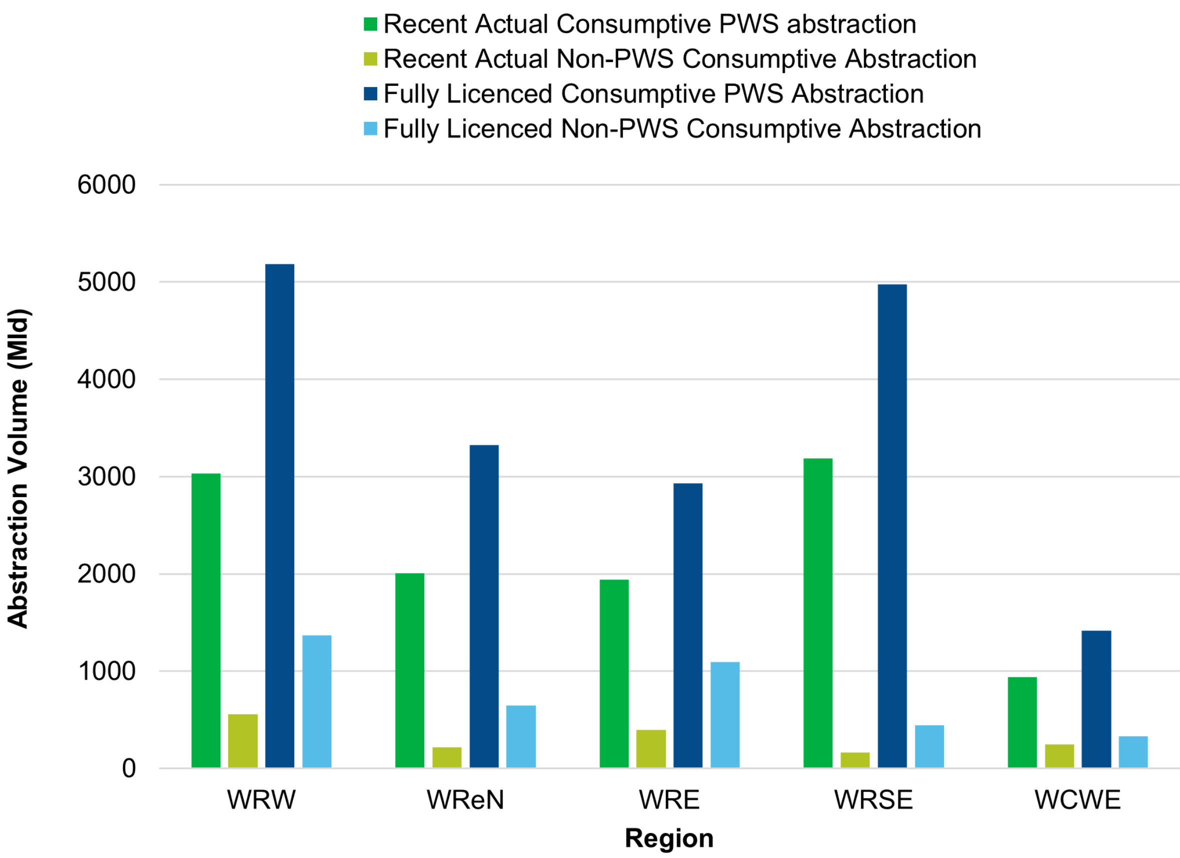


Figure 3.2 shows a comparison of estimates of current consumptive abstraction from public water supply and estimates of current consumptive abstraction from other sectors (non-public water supply) in Ml/d across regional groups. This is split by the volume used on average (recent actual abstraction) and the maximum that can be taken (the total volume on licences or 'fully licensed'.) In each region, totals for public water supply abstractions are considerably higher than for non-public water supply.

Figure 3.2 shows the dominance of public water supply abstraction in each region whether by recent use or by fully licensed volume. This figure does mask the significance of some non-public water supply abstractions in specific regions at certain times of year. For example, WRE see very large demands from irrigation that occur in the summer, when water is most under pressure, which can be equivalent to local public water supply demands in specific catchments.

Figure 3.3 are 100% stacked bar charts showing the current estimated proportion of abstraction from freshwater by purpose and adjusted for consumptiveness, excluding navigation. The charts show both excluding and including public water supply for Fully Licensed and Recent Actual abstractions.

Public water supply (provided through water companies) is the largest water abstractor, ranging from 87% under fully licensed to 91% under recent actual abstraction rates (and adjusted for consumptiveness.

If public water supply use is excluded, under recent actual abstraction rates (and adjusted for consumptiveness), the industry sector uses the most water nationally at 37%, followed by agriculture (30%) and then power (23%). Under fully licensed quantities (adjusted for consumptiveness) the split is very similar to recent actual, with the industry sector at 34%, agriculture at 33% and power generation reduced to 20%.

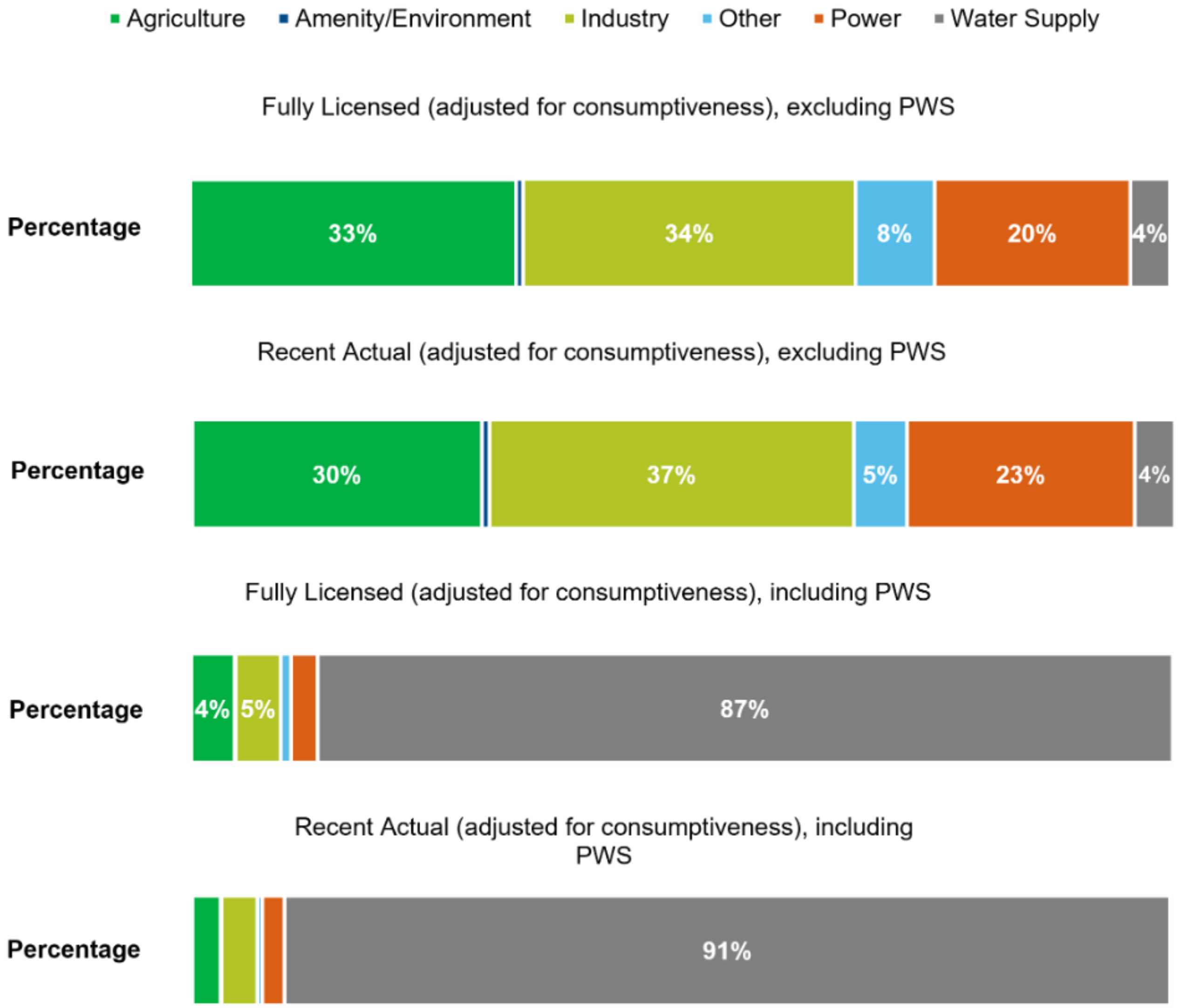


Figure 3.3: Proportion of licensed and recent actual consumptive non-public water abstraction by sector

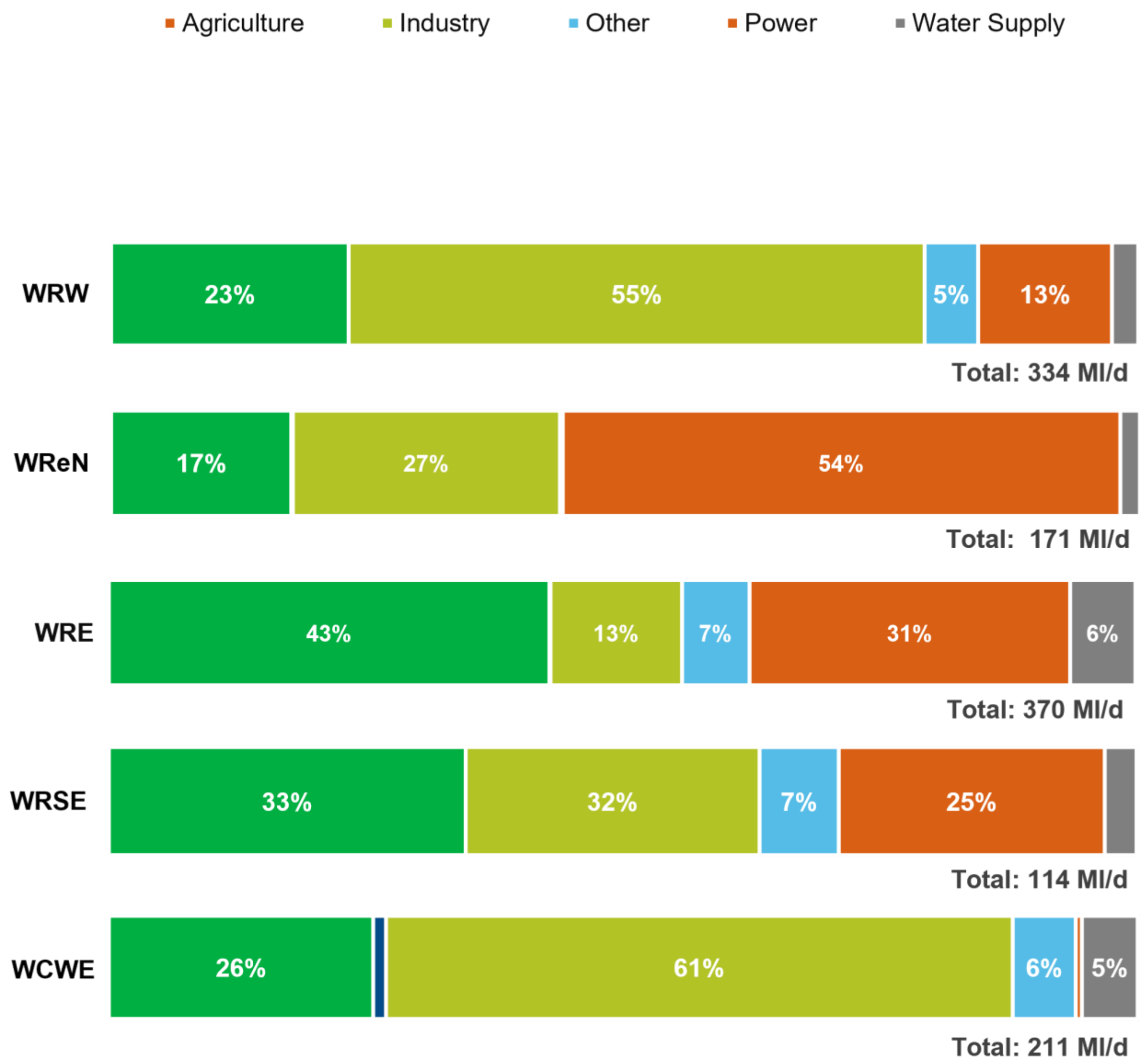


Figure 3.4 is a 100% stacked bar showing the proportion of recent actual consumptive non-public water abstraction for each primary sector by regional group. The primary sectors are Agriculture, Amenity/Environment, Industry, Power, Water Supply and Other.

Figure 3.4 shows the current recent actual consumptive water abstraction from freshwater outside the water industry, excluding navigation. The graphs show how this differs across the regional groups. In the Water Resources West region, industry is the biggest non-public water supply water user at 56%, followed by agriculture at 23%. This is a similar pattern in the West Country Water and Environment region, with industry the biggest non-public water supply user in the region at 61%, followed by agriculture at 26%. In Water Resources East, agriculture is the largest non-PWS water user at 43%, followed by the power generation sector at 31%. For Water Resources North region, the largest non-PWS user is the power generation sector at 54%, followed by industry at 27%, and agriculture at 17%. In the Water Resources South East region, agriculture use at 32% is the largest water user outside of public water supply, closely followed by industry at 31%. Water

Resources East and Water Resources West have the highest current consumptive water abstraction across the regional groups with 372 Ml/d and 337 Ml/d respectively.

3.2.1 Agricultural water demand

This section looks in more depth at agricultural water demand across England. Within what we term ‘agricultural water demand’ are a range of different types of use. The categories used below are those recorded in the Environment Agency’s abstraction records. Nationally, agricultural water use is dominated by spray irrigation as shown in, **Figure 3.5** ‘General’ agriculture typically represents livestock and ‘other’ includes a range of uses including amenity, forestry, zoos and orchards.

Figure 3.5: Current estimated consumptive agricultural water abstraction use nationally.

Figure 3.5 shows the current estimated consumptive uses for agricultural water abstraction use nationally. The different uses are aquaculture, general, horticulture, other agriculture and spray irrigation. Spray irrigation is used for 66% and the next main uses are general and aquaculture using 20% and 13% respectively.

Agricultural water use varies significantly across regions, both in terms of total volume and usage type. **Figure 3.6** illustrates the current breakdown of agricultural water use by region, highlighting both total consumption and the distribution across different agricultural activities.

Figure 3.6 highlights that the WRE region shows the highest level of direct abstraction for agricultural purposes, with 159 Ml/d consumed per year (assuming agricultural water use is profiled evenly across the year) - 90% of which is attributed to spray irrigation. In contrast, total agricultural water use in other regions ranges between 30 and 76 Ml/d. Notably, the WCWE region stands out due to its high aquaculture and ‘general’ agricultural demand and minimal spray irrigation. This is because livestock, fish and water cress farming is the dominant agricultural activity in the region. 96% of aquaculture abstraction in

WCWE is non-consumptive as water is returned to source after use, with current consumptive abstraction for this sector at 42 Ml/d.

A significant component of livestock water demand is met from mains supplies and therefore excluded from this analysis. Previous work for Defra has estimated that the total volume of water used for livestock is like that used for spray irrigation nationally (when mains water is included). WCWE will need to work with the agricultural sector to understand this demand and the risks it poses for water supply in that region.

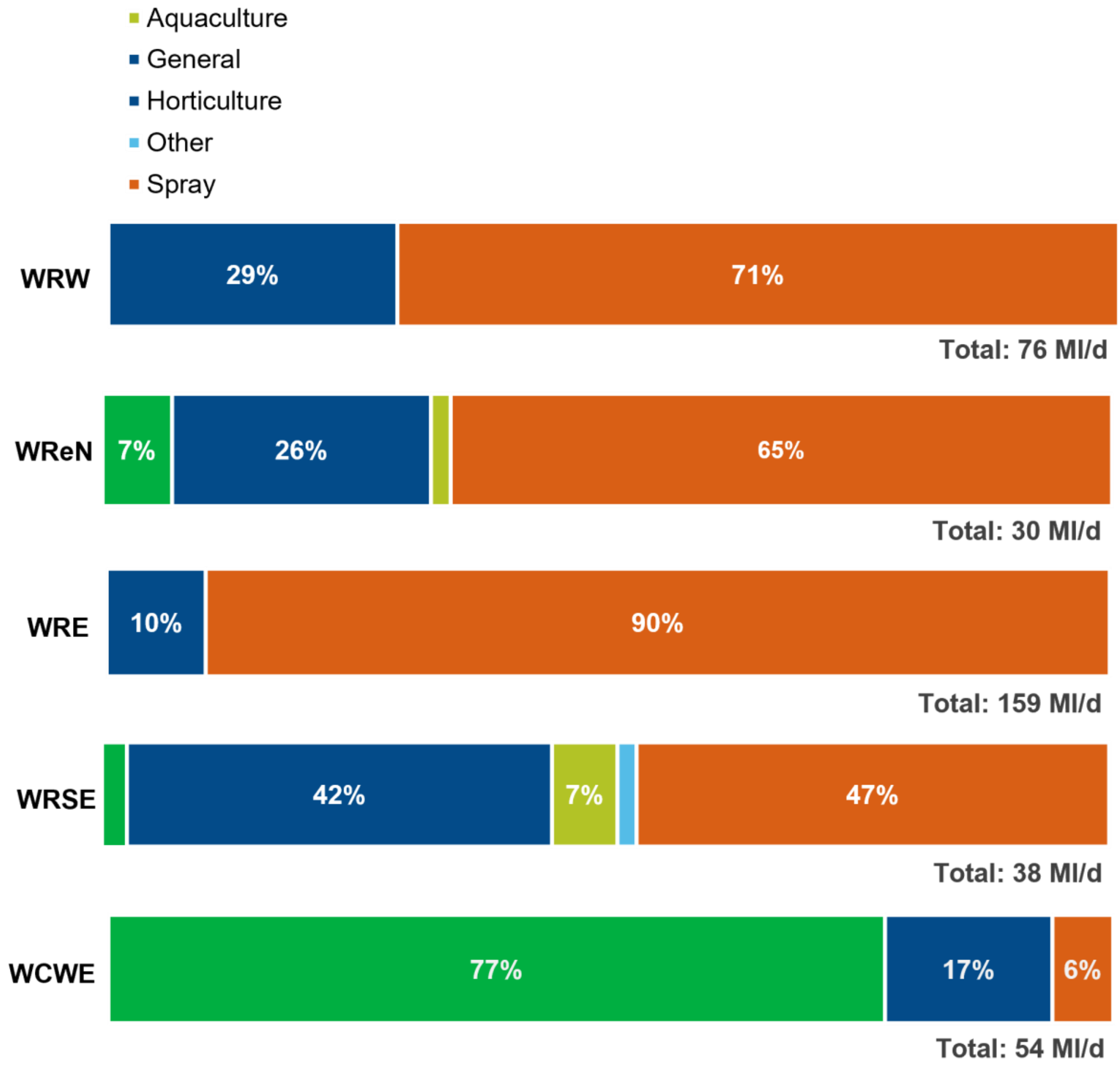


Figure 3.6: Current consumptive agricultural water abstraction uses by region including aquaculture, general, horticulture, other and spray irrigation. In most regions, most of the use is spray irrigation and general; in WCWE aquaculture uses 77% of agricultural abstractions and then 17% general and 6% spray irrigation.

The Agricultural Supply-Demand Balance Assessments (SDBA), available from the Environment Agency's Water Hub or upon request via WRAgriculture@environment-agency.gov.uk, should be prioritised over the calculations presented here, as they provide a more detailed and locally nuanced analysis. Developed by WSP, the SDBA methodology was applied to 25 catchments, covering 80% of licensed spray and trickle irrigation volumes in England and 72% of all consumptive agricultural licensed water volumes nationwide.

3.2.2 Industrial water demand

This section looks in more depth at industrial water demand across England. Industrial water demand is large and varied with many subsectors. This category includes minerals, breweries, golf, metal, other extractions, paper and printing, chemicals, and food and drink.

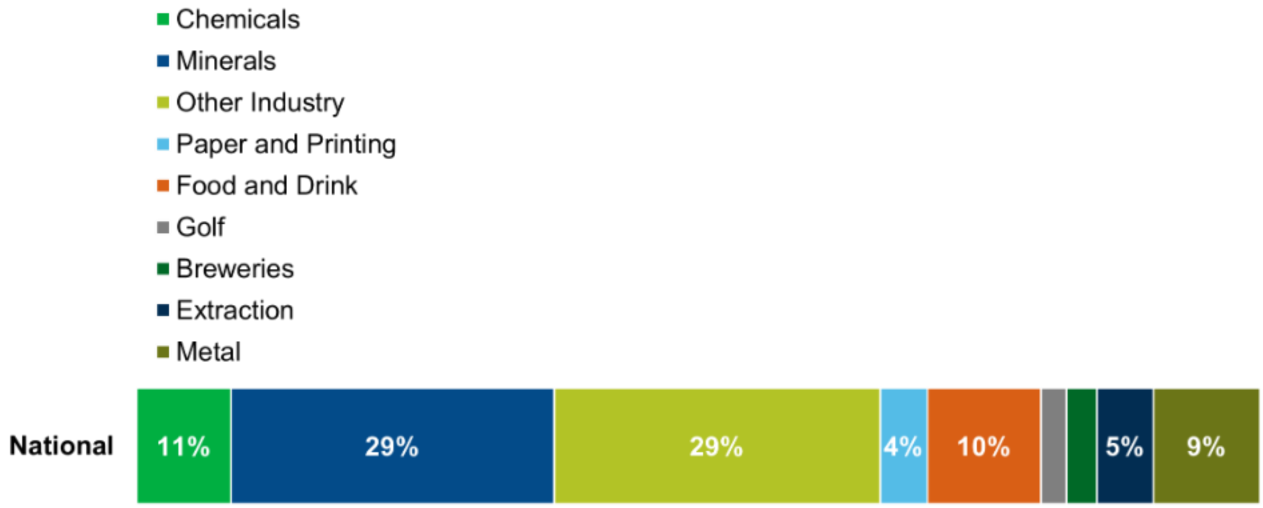


Figure 3.7: is a 100% stacked bar chart showing the split of current estimated consumptive abstraction nationally across the industrial sector

Nationally, as shown in **Figure 3.7**, water use across industrial sectors is dominated by the minerals sector, which accounts for 29% of total industrial consumption. The mineral products sector use water for washing mineral-based products e.g. bricks, tiles, ceramics and concrete. This increases to 34% if including extraction (water used in the removal of any mineral from the earth). This is followed by other industry at 24%. Other industry refers to use of water for any other industrial, commercial or public service not specified anywhere else. The food and drink sector (including breweries) contributes 13%, while chemicals and paper and printing represent 9% and 4%, respectively. Sectors that contribute a small volume to the national figure are not labelled however they can be significant locally.

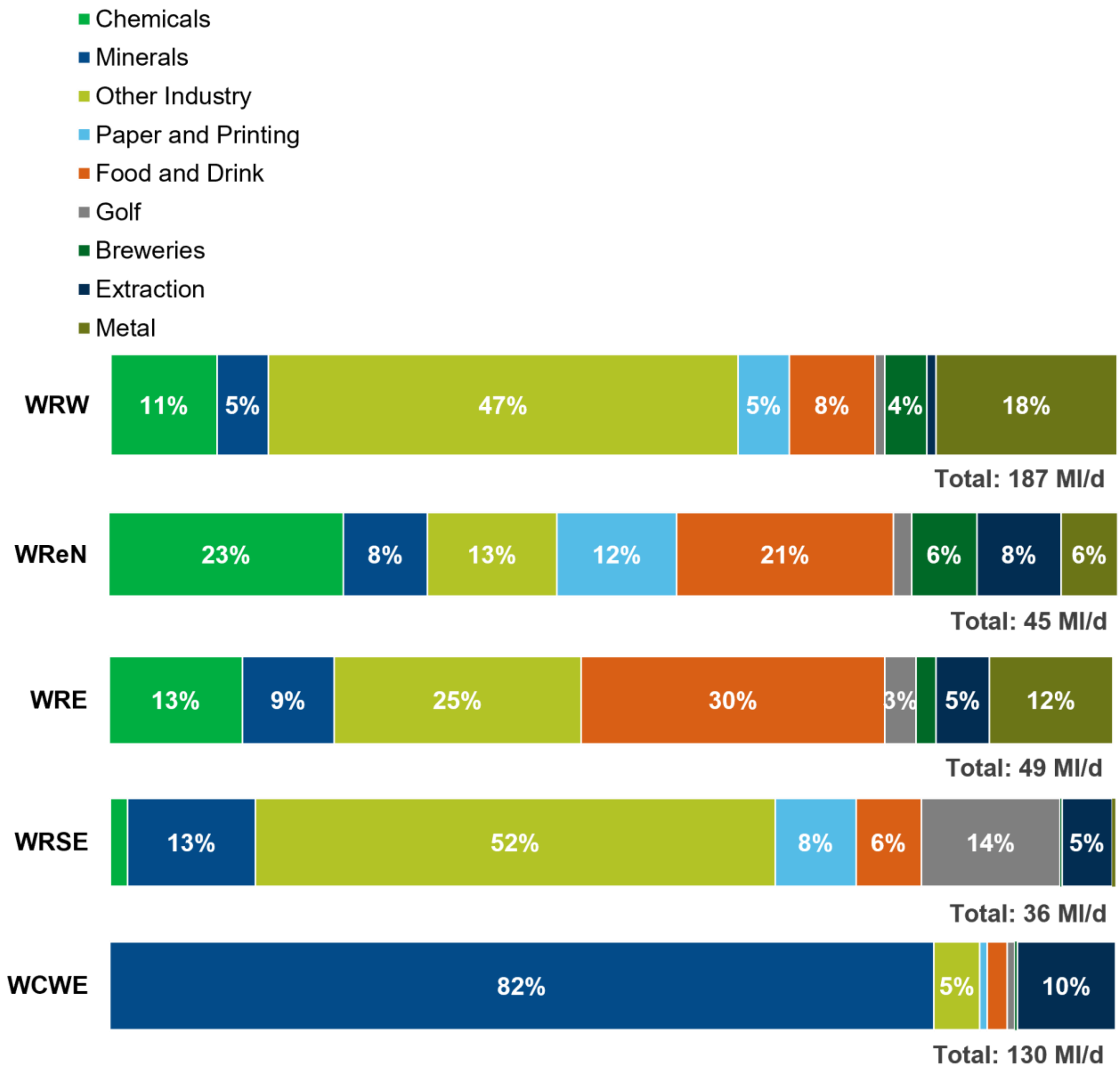


Figure 3.8 is made up of five 100% stacked bars showing the split of current estimated consumptive abstraction nationally across the industrial sector for each regional group.

Figure 3.8 shows clear regional differences. Water uses that look small nationally become significant regionally, and even more so locally. This is because, in contrast with agriculture that is characterised by many small water users, industrial abstraction is typically driven by a smaller number of larger water users.

Figure 3.8 shows that WRW records the highest total abstraction for industry, driven primarily by activity in other industry, metals, and chemicals sectors. Note, WRE has significant use for navigations which are not fully represented in **Figure 3.8**. We consider these further in Section 3.2.3. WCWE is dominated by the minerals sector, which is characterised by a small number of large abstractions. In WReN, the main abstractions are associated with the food and drink and chemicals sectors, followed by paper and printing.

WRE shows notable abstraction from the food and drink sector, which will be associated with the region's significant agricultural demand in the region. This includes co-located food processing operations, such as potato processing. WRE also has large abstractions from the chemicals and metals sectors.

3.2.3 Navigational water demand

The navigation sector is a major user of water and has a unique role in water resources management. We have not included navigation in our national non-public water supply demand figures because not all abstractions and transfers to support navigation have been represented in the WRGIS abstraction datasets used in this assessment, some transfers may have been accounted for as complex activities elsewhere and so our datasets are incomplete. This section looks in more detail at the demand associated with navigation based on the data that we do have available, but these figures could be an underestimate.

Waterways used for navigation have the potential to move a large volume of water from one place to another (and therefore facilitate water transfers). They can also be used to supply water abstractors directly. Due to the volume of water involved in navigations there is also scope to free up water for other purposes. For example, reducing the water that is lost through leakage in a canal network. This can be significant and will reduce the amount of water that has to be taken from other sources to supply that network.

The Canal and River Trust (CRT) is the dominant user of water in this sector but is not the only navigation body. CRT is not just a user of water to maintain water levels in its canals; it is also a supplier of water to third parties from its canals, and it is a conveyor of water in current and proposed and potential future transfer schemes to support public water supplies.

Evidence from recent droughts highlights the significance of the navigation sector and the growing impact of prolonged dry conditions. During the 2025 drought, over 20% of the CRT network was closed due to low water levels, affecting 400 miles, primarily in northern and central England. This compares with 15% of the network closed during the 2022 drought. The closures have had notable economic and social consequences. Canal boat holidays have been cancelled, affecting tourism-dependent communities, and liveaboard boaters have been forced to relocate to avoid long-term closures (Canal & River Trust, 2025).

Whilst the annual average abstraction metric is a useful means of comparing water demand across sectors, it will not give a feel for potential daily peak abstractions. These are likely to be significantly higher than the averages observed across a year.

The data for navigation authorities includes those who abstract water for Navigation purposes – under Navigation (NAV) and Other Industrial/Commercial/Public Services (OTI) purpose codes as well as for other purposes outside of navigation. All volumes mentioned here are the recent actual annual non-consumptive abstraction totals unless stated otherwise. The recent actual non-consumptive abstraction total of all abstractions (for any purpose) by licensed navigation authorities nationally is 3510 Ml/d.

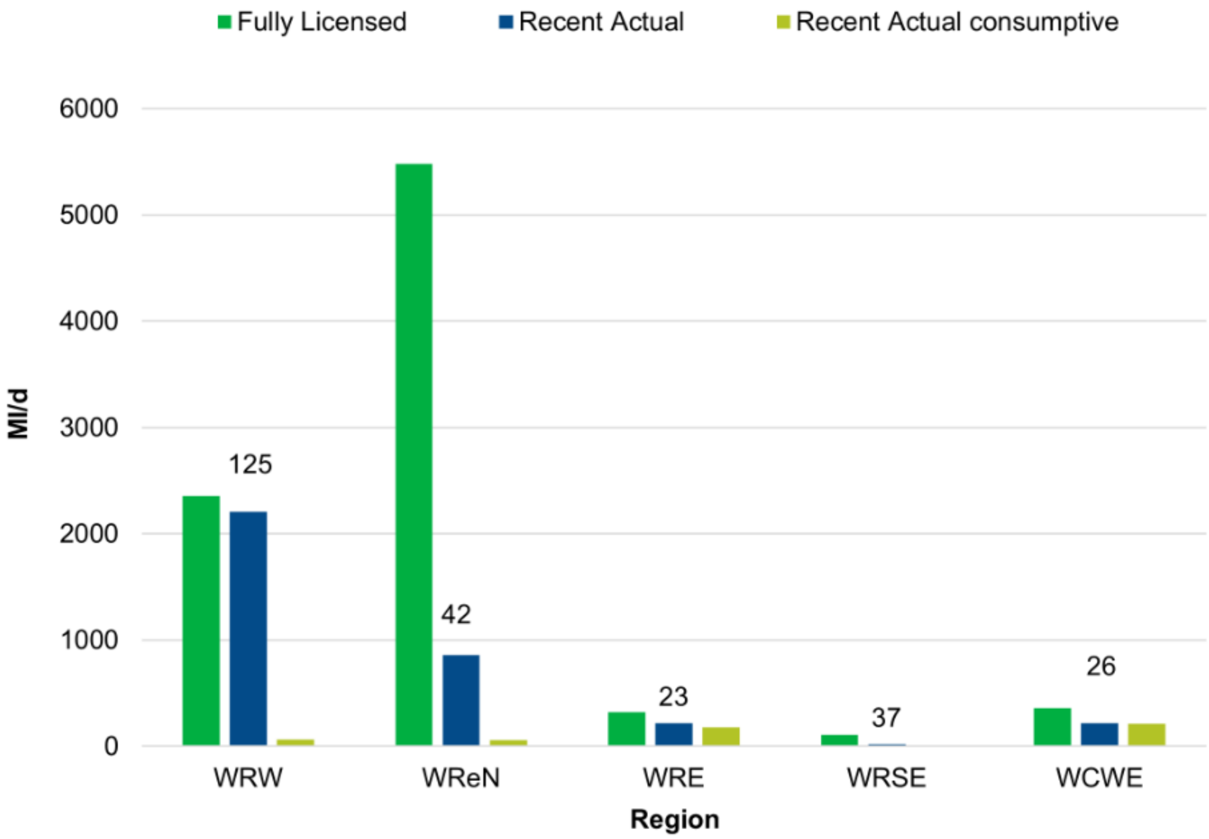


Figure 3.9 shows the total number (above the bars) and volumes of abstraction licences (Ml/d) for all purposes by navigation authorities across regions. Of the total abstractions, we can see most of these are licensed for WRW, despite a lower fully licensed abstraction total.

Figure 3.9 is a clustered column chart showing Fully licensed, Recent actual and recent actual consumption abstraction totals for all purpose abstractions by licensed navigation authorities by region. For WRE, WRSE and WCWE, the totals are less than 500 Ml/d, whereas WRW has fully licensed and recent actual (non-consumptive) totals of 2275 Ml/d and 2175 Ml/d respectively. In WReN, their fully licensed total is 5475 Ml/d, 4620 Ml/d more than their recent actual total meaning they are licensed to abstract a lot more water than they do. We also highlight the total numbers of licenses, with WRW much higher licences than any other region.

There are several navigation authorities, but Canals and River Trust (CRT) is the largest contributor, accounting for 93% of the total abstracted by navigation authorities. In the previous National Framework, the total for all abstractions (of any purpose) by CRT was estimated at 1,255 Ml/d. Our dataset estimates this to be 3280 Ml/d. The increase we see could be due to a range of factors, most likely related to limited information during the publication of the first National Framework due to the recent onboarding of navigations into our licensing system (and subsequently WRGIS) as they had been previously exempt.

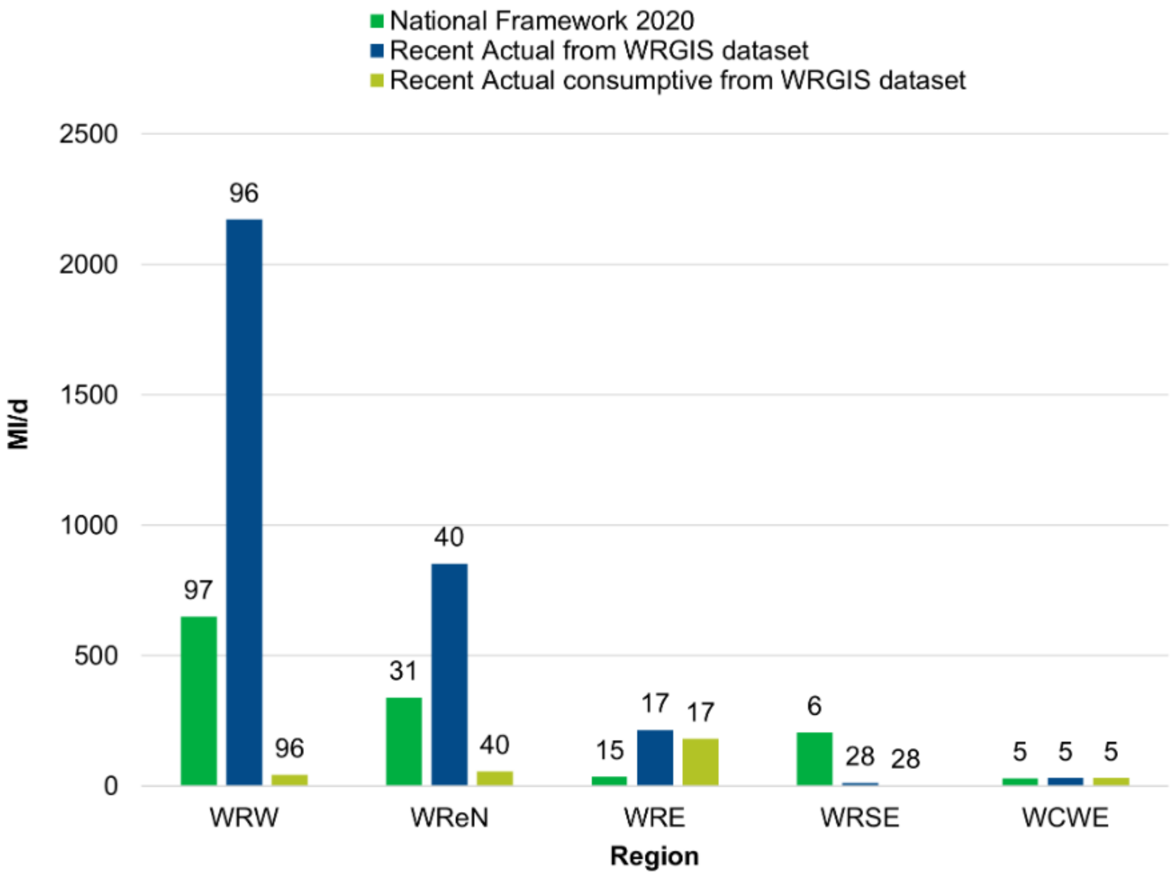


Figure 3.10 takes the data from 2020 National Framework for Water Resources and compares this to the CRT data for the number and volumes of abstraction licences (Ml/d) by region in the WRGIS dataset.

Figure 3.10 is a clustered column chart comparing CRT abstraction totals from the first National Framework; recent actual non-consumptive totals from WRGIS dataset and recent actual consumptive totals from WRGIS dataset for each region. The recent actual non-consumptive totals from the WRGIS dataset are much higher than the 2020 National Framework in WRW (~2200 vs 650 Ml/d), WRE (215 vs 35 Ml/d) and WReN (~850 vs 340 Ml/d). In WRSE, they are much lower (12 vs 205 Ml/d) and in WCWE they match between datasets. We can see that the total number of licences is very similar across the two frameworks, with most regions matching up. Nationally, there are an additional 32 licences in the WRGIS dataset.

We now discuss the abstraction volumes specifically for navigation purposes across all navigation authorities. To obtain navigation totals we include secondary purpose codes for Navigation (NAV) and Other Industrial/Commercial/Public Services (OTI) in the dataset.

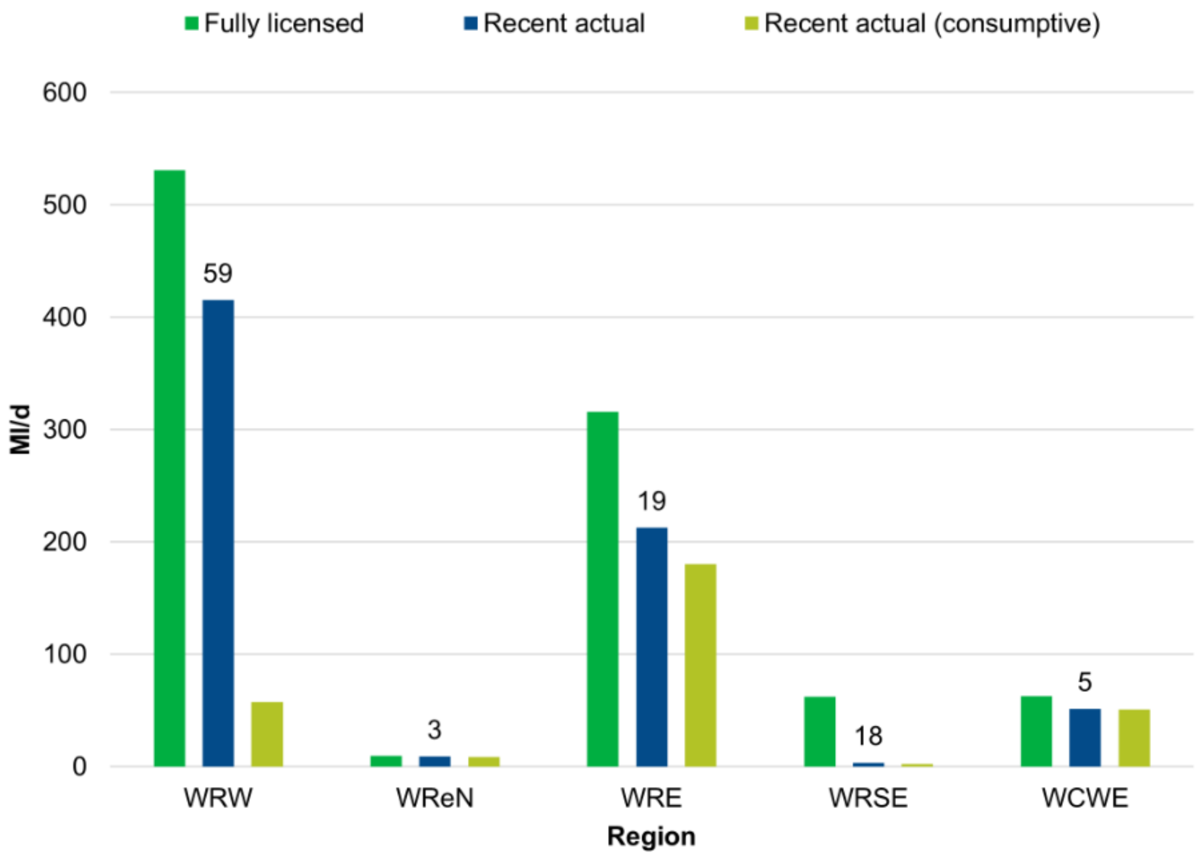


Figure 3.11 is a clustered column chart summarising the WRGIS dataset representing total number and volume of licenses (Ml/d) for Navigation purposes by all licensed navigation authorities by region. We include the fully licensed (non-consumptive), recent actual (non-consumptive), and recent actual consumptive totals.

The national recent actual (non-consumptive) total of water abstracted for navigation purposes is 693 Ml/d. Based on this data in **Figure 3.11**, WRW accounts for the largest share, with total volume more than all other regions combined (531 Ml/d fully licensed, 415 Ml/d recent actual and 58 Ml/d recent actual consumptive). This is followed by WRE with 316 Ml/d fully licensed, 213 Ml/d recent actual and 180 Ml/d recent actual consumptive. WRW also has the highest total number of licenses (59). They are followed by WRE (19), WRSE (18) and WCWE (5). WReN has the lowest number of licenses at 3.

	Recent Actual non-consumptive - Ml/d	Recent Actual consumptive - Ml/d	Fully Licensed non-consumptive (Ml/d)	Total licence number
All Navigation authorities	3470	520	8579	253
All Navigation authorities - (NAV&OTI)	693	299	981	104
CRT	3283	311	8189	186
CRT - (NAV&OTI)	648	255	871	83

Table 3.2 shows national recent actual and fully licensed annual average abstraction for navigation authorities. We include total abstracted for any purpose by navigation authorities, abstraction totals for navigation purposes by navigation authorities and the same for the Canals and Rivers Trust. We also include the total licence numbers in each case. The consumptive totals can be seen to be considerably lower, implying the amount of water consumed and not returned to the environment is much lower than how much authorities can abstract.

Please note that abstraction information from the Broads Authority, one of the largest three navigation authorities in England, is not included. Therefore, the abstracted volume in WRE is likely to be an underestimate.

It is important for regional groups to work closely with navigation authorities in their geographic patches to understand both current and future demands for this sector.

3.2.4 Golf

It is estimated that 60% of golf courses use mains potable water for irrigation, with the rest relying on direct abstraction. Recent actual direct abstraction figures show that golf courses nationally abstract around 10 Ml/d, based on a national annual average, adjusted for consumptiveness. This accounts for approximately 820 licences and excludes any use of public water supplies for golf courses. This peaks to 24 Ml/d in summer.

Of this, approximately 98% is used for spray irrigation, either applied directly or stored for later use as highlighted in **Figure 3.12**. Notably, 50% of this abstraction occurs within the WRSE region, highlighting its significance in regional water resource planning.

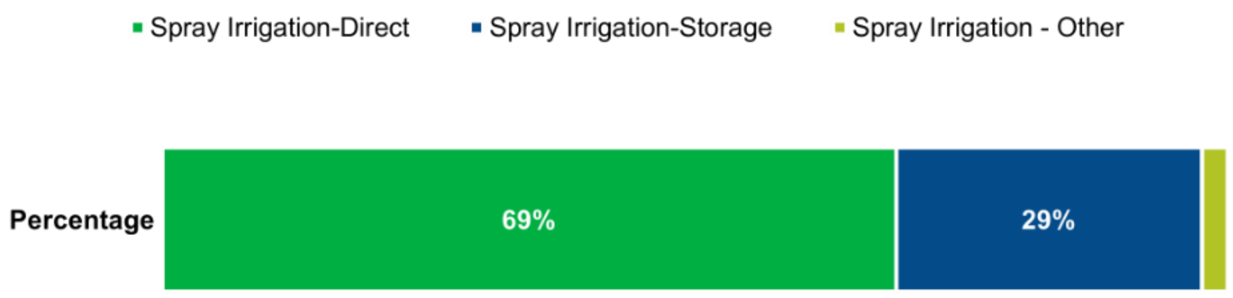


Figure 3.12. Uses of water directly abstracted by golf courses nationally. 69% is used for direct spray irrigation and 29% by spray irrigation storage.

3.3 Future non-public water supply needs

This section examines potential future changes in water use across sectors outside of the public water supply. Compared to public water services, the resilience of these other sectors to drought is not well understood. They are likely to face increasing challenges due to climate change, the need to reduce water abstraction for environmental protection, and evolving demand patterns within their industries. Water sources that have historically been dependable may become less reliable in the future. It is therefore essential that water-dependent sectors actively participate in regional water planning to contribute to long-term solutions.

For information on how these future estimates were derived, please refer to Section 3.1.

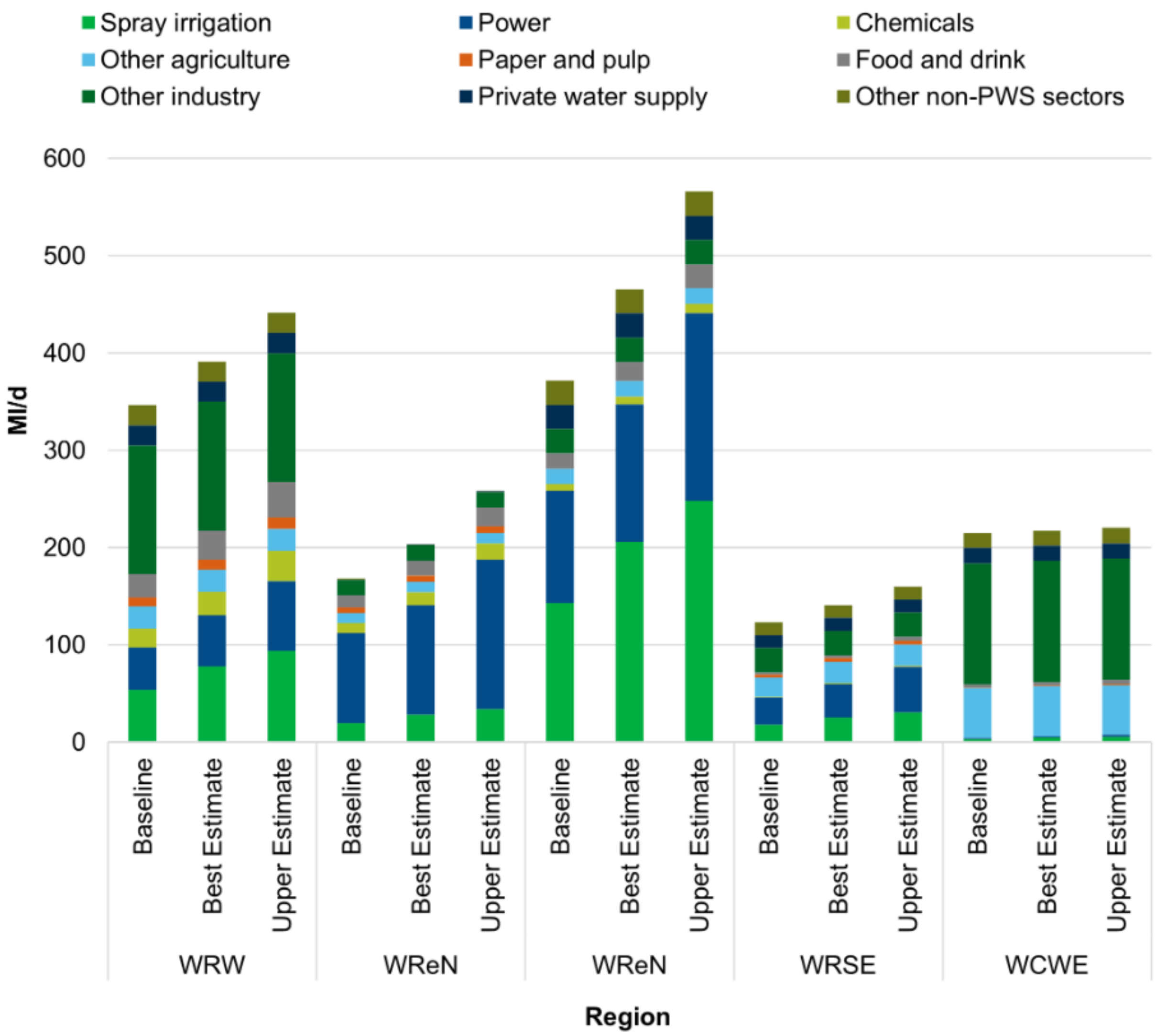


Figure 3.13: Potential range of non-public water supply demands in Ml/d by the 2050s across the regional groups. It shows the Baseline, Best Estimate and Upper Estimate scenario for each region, with different uses as stacked bars: Spray irrigation, power, chemicals, other agriculture, paper and pulp, food and drink, other industry, private water supply and other non-PWS sectors.

Figure 3.13 shows the potential changes in water consumption for different sectors to the 2050s. The graph shows 3 scenarios to illustrate a reasonable range of possible water consumption: Baseline, which equals recent actual abstraction (2016-2021); best estimate; and upper quartile. Overall, it shows that there is likely to be an increase in demand for water not supplied by water companies. Of the sectors we have explored in detail, nationally, spray irrigation has a high projected increase in water consumption from a baseline consumptive recent actual abstraction of 240 Ml/d to a reasonable upper estimate of 410 Ml/d in the 2050s; a potential increase of 170 Ml/d. This is closely followed by the power generation (electricity production) sector, demonstrating a potential upper estimate increase of 60 Ml/d of water consumption by the 2050s to 340 Ml/d from a baseline position of 280 Ml/d. Nationally, the food and drink, chemicals and paper and pulp sectors show a potential upper estimate increase of 30, 20 and 5 Ml/d of water consumption respectively; increasing to 90, 60 and 24 Ml/d respectively by the 2050s. In total across all sectors, nationally, this equates to an additional non-public water need of around 300 Ml/d (adjusted for consumptiveness) by the 2050s.

This analysis does not include other industry sectors, which currently account for the highest proportion of non-PWS use (37%) at 320 Ml/d recent actual water consumption. If these demands were to increase by 6% (based on national average projections of non-household water use supplied by water companies in their WRMPs), this would equate to 19.2 Ml/d of additional non-public water demands.

For more national and regional high-level results, including a comparison to national licensed and potential future licensed volumes, please see the main report of The National Framework for Water Resources 2025. For more detailed sector information please see the following sections.

Comparison of future estimates of non-public water needs and potential future licensed volumes, taking account of potential climate impacts and environmental requirements, highlights the importance of promoting water rights trading amongst non-PWS users. Water rights trading within and across sectors, as well as within regions (and even across regions in some geographies), has the potential to help ensure water is available when it is needed for non-public water users in the future.

3.3.1 Agriculture demand – spray irrigation

Spray irrigation is primarily used for outdoor root vegetables and salad crops, supplementing rainfall during the summer months. Demand is highest in the drier regions of England, particularly East Anglia and in areas where crops are particularly sensitive to water stress. The theoretical water demand for irrigation fluctuates annually based on weather conditions (rainfall levels, temperature). However, during dry summers, many farmers apply less water than the theoretical optimum. This is often due to limitations in equipment, water resource constraints such as licence conditions on peak abstraction rates, restrictions for environmental protection, or economic considerations, since the agronomic optimum does not always align with the economic optimum.

The highest demand for spray irrigation is in the drier parts of England, particularly East Anglia. Climate change projections for drier summers suggests that spray irrigation demand is likely to increase in the longer term.

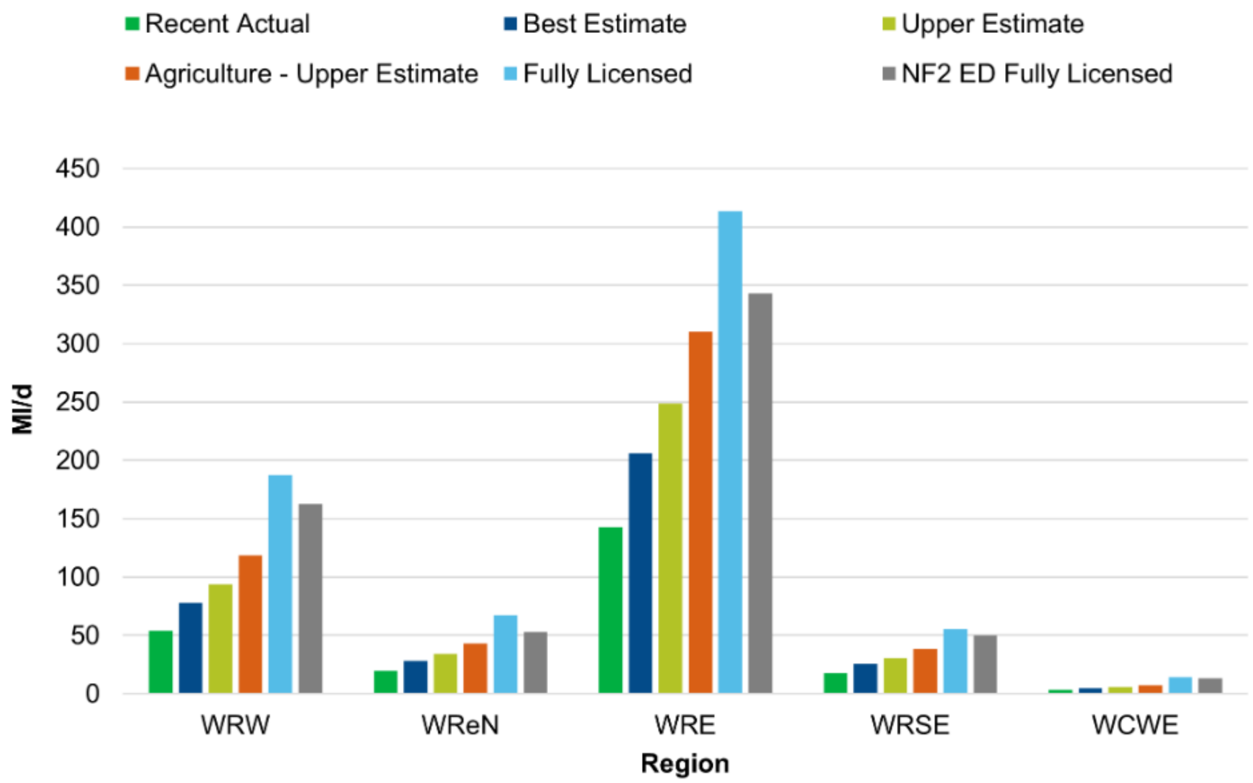


Figure 3.14: The potential water demand for spray irrigation under recent actual, best estimate, upper estimate, agriculture-upper estimate, fully licensed and National Framework (NF2) Environmental Destination fully licensed in Ml/d across the regional groups.

Figure 3.14 shows possible changes in spray irrigation demand under the 3 scenarios, compared to the current baseline consumption. This could range from the baseline of 238 Ml/d to 737 Ml/d under fully licensed conditions to a best estimate of 342 Ml/d. The greatest potential best estimate increase is in WRE which could make up 206 Ml/d of the total best estimate, an increase of 63 Ml/d from baseline. It could be significantly higher than this in a dry year and at peak times of the year. All future estimates, including the agriculture upper estimate, do not exceed either fully licensed volumes or fully licensed volumes when future environmental requirements are accounted for (NF2 ED FL).

There are a range of factors driving the likely increase in water demand for irrigation. These include some of the same pressures facing public water supply such as increases in population (and subsequent increase in food demand), climate change (leading to hotter, drier summers that increase irrigation needs), and regulatory pressures including sustainable abstraction. Some are more specific to the sector such cropping, crop yield and waste, the balance between imports and exports, irrigation practices and efficiency and sustainability standard.

There is significant uncertainty around these figures as demands will be affected by a wide range of broader factors. These include future food policies, diet trends, the proportion of food that gets wasted, how efficiently irrigation is used and quality standards for the end product (less irrigation can affect the appearance of crops).

The Agricultural Supply-Demand Balance Assessments (SDBA) should be prioritised over the calculations presented here, as they provide a more detailed and locally nuanced analysis. Developed by WSP, the SDBA methodology was applied to 25 catchments, covering 80% of licensed spray and trickle irrigation volumes in England and 72% of all consumptive agricultural licensed water volumes nationwide. These are available from the Environment Agency's Water Hub or upon request via WRAgriculture@environment-agency.gov.uk.

3.3.2 Industrial demand - food and drink

The food and drink sector is very diverse. It includes a wide range of water uses including water used in breweries, potato processing, water bottling, dairy, confectionary, ready meals, soft drinks, meat, seafood and alcoholic beverages. Due to this diverse sector, generating projections for the industry is challenging. Just like in other sectors, sector-based engagement and working at the regional level is going to be important for understanding local pressures and needs.

Food and drink is the largest manufacturing sector in the UK with output growing by over 21% since 1990. The sector is present across the whole of England, with WRW, WRE and WReN comprising the highest water needs for this sector.

Although the industry has grown since 1990, overall water consumption (both public water supply and non-public water supply) has reduced to a combination of economic conditions and a commitment by the industry to cut its water consumption. Factors affecting water consumption include consumer demand, diet and eating trends, food waste and improvements to processes and water efficiency. Further political and economic factors exist such as import tariffs, regulations and standards. Population growth is also likely to play a part in increased consumption of food and associated water use.

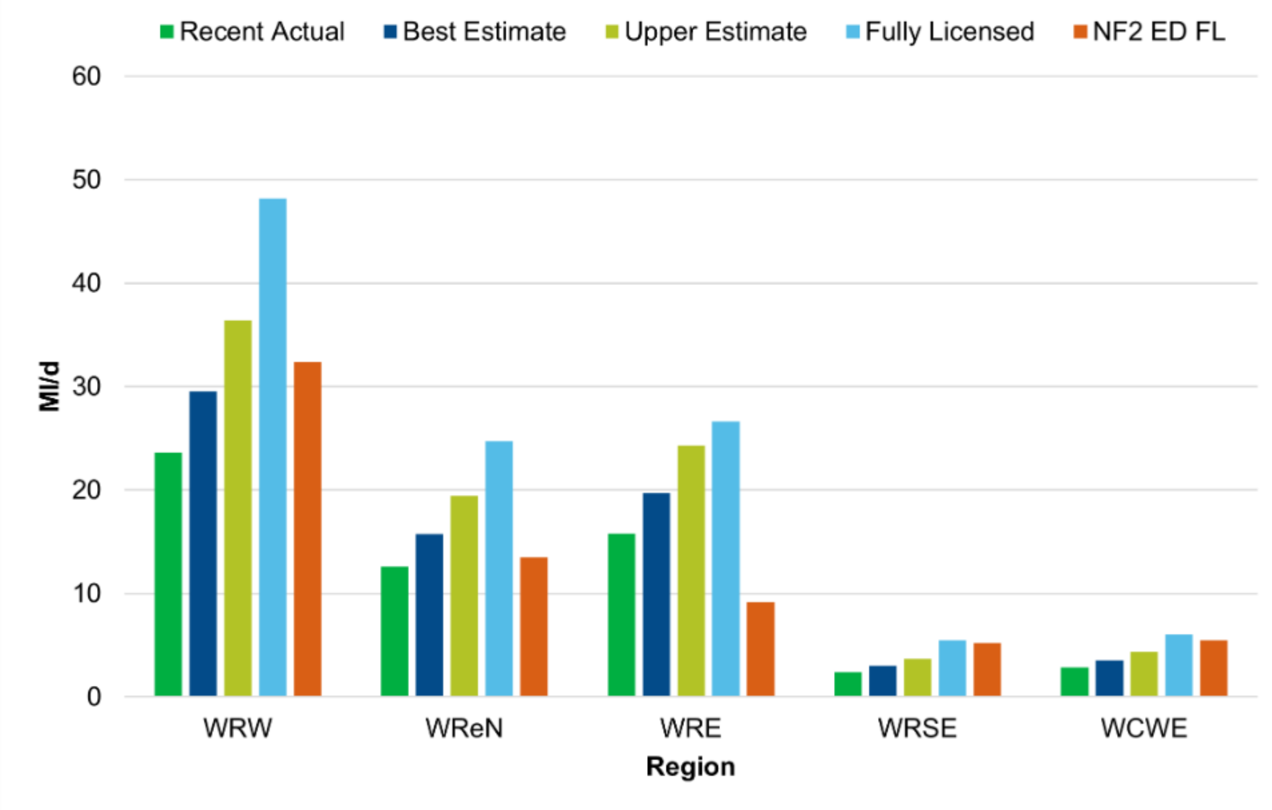


Figure 3.15: The potential water demand for food and drink manufacturing under the baseline (recent actual), best estimate, upper estimate, fully licensed and National Framework (NF2) Environmental Destination fully licensed in Ml/d across the regional groups.

Projections indicate that water needs for the food and drink industry could range from the baseline of 57 Ml/d to 111 Ml/d. The best estimate is 72 Ml/d. The greatest potential best estimate increases from baseline are in WRW at 6 Ml/d and WRE at 4 Ml/d. The smallest increase is estimated to be in WRSE. Upper estimates do not exceed current fully licensed volumes, however they do exceed the total volume of future licences when environmental requirements are accounted for in WReN, WRE and WRW. This is also true for WReN and WRE under best estimates.

3.3.3 Industrial demand – paper and pulp

Paper mills are located across England with the primary clusters in the southeast (north Kent) and northwest (Greater Manchester). Mills are also dispersed across the south west, Lake District, Northumberland and the midlands.

Water is vital for the paper industry. It is used directly in papermaking and to cool down the mill equipment. Water for this sector is not only taken through direct abstraction of surface water or groundwater; a considerable amount of water is also taken from the mains supply. Much of this water is returned to the environment and is therefore considered only partially-consumptive.

There was a significant decrease (~40%) in UK paper production between 2001 and 2010 with only small increases in production more recently. Recent trends in water use show a general reduction in line with a reduction in production. Changing products, a declining newsprint market and increasing demand for speciality paper could also have an impact on water use. Improvements in environmental performance, efficiency and improving sustainable practices are likely to have contributed toward a downward trend in water use.

Factors affecting consumption include consumer demand; sustainability, recycling and plastic use trends; process improvements and technology; political, legal and economic factors; social attitudes and environmental awareness and pressure.

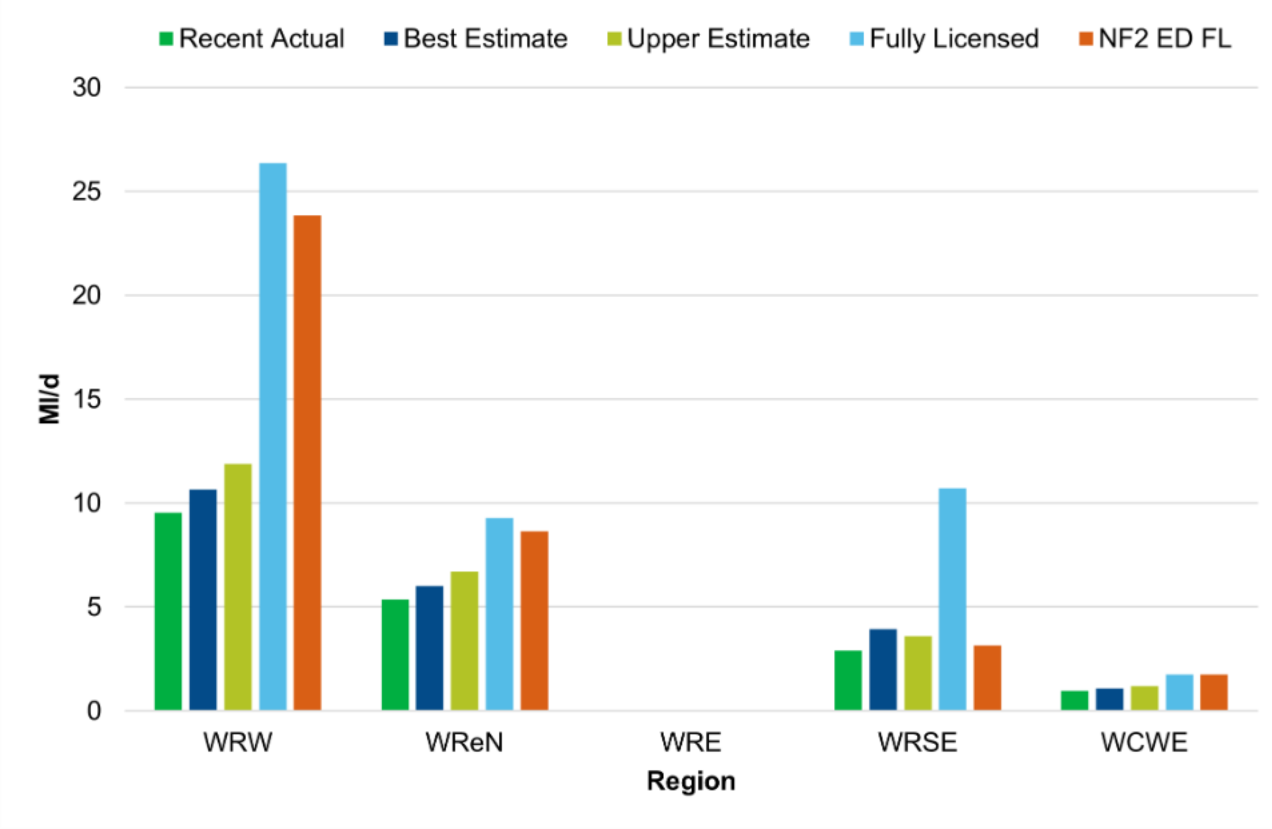


Figure 3.16: The potential water demand in Ml/d for paper and pulp manufacturing under the baseline (recent actual), best estimate, upper estimate, fully licensed and NF2 Environmental Destination fully licensed across the regional groups.

Projections suggest that future water use could range from a baseline of 19 Ml/d to a maximum of 62 Ml/d, with the best estimate currently standing at 22 Ml/d and an upper estimate at 24 Ml/d. We observe the largest demands in WRSE, WReN and WRW. If the upper range of demand increases occurs in WRSE, it could exceed the total volume of future paper and pulp licences when environmental requirements are accounted for.

3.3.4 Industrial demand – chemicals

The chemicals manufacturing sector is large and complex. It is an integral part of UK manufacturing. It is highly diverse producing products from shampoos, cosmetics, perfumes and soaps to industrial products derived from petrochemicals (rubber, plastic) and dyes. It is responsible for providing products which are critical to a wide variety of business operations, including energy production, pharmaceuticals, construction and water treatment. Water is essential to the chemical sector as not only a raw material, but also for cooling processes, environmental protection and to prevent major safety incidents.

Chemicals manufacturing takes place across the whole of England There is little recent data on the total water consumption by the sector, but it is estimated that approximately 75% of consumption comes from mains water (public water supply). Based on direct abstraction, the main clusters in England are in the north west, Humberside and Teesside. The clustering of sites is important as companies can be located close to their suppliers and end-users of their products. The greatest water use is in WRW.

Factors and pressures affecting water consumption include consumer demand for chemicals and related products such as plastics, energy prices, process improvements, social, economic and political changes, exports, changes to manufacturing locations, as well as environmental and technological changes.

A report by the Chemistry Council predicted a 50% increase in chemical production in the UK between 2013 and 2030. The sector has been facing challenges due to high energy costs and reduced workforce because of socio-political changes; with forecasts suggesting lower growth forecasts as a whole sector. However, certain parts of the sector such as pharmaceuticals are seeing significant growth locally. Water consumption does not necessarily grow in proportion to output. We explore a range of forecasts, from a recent actual to a best and upper estimate.

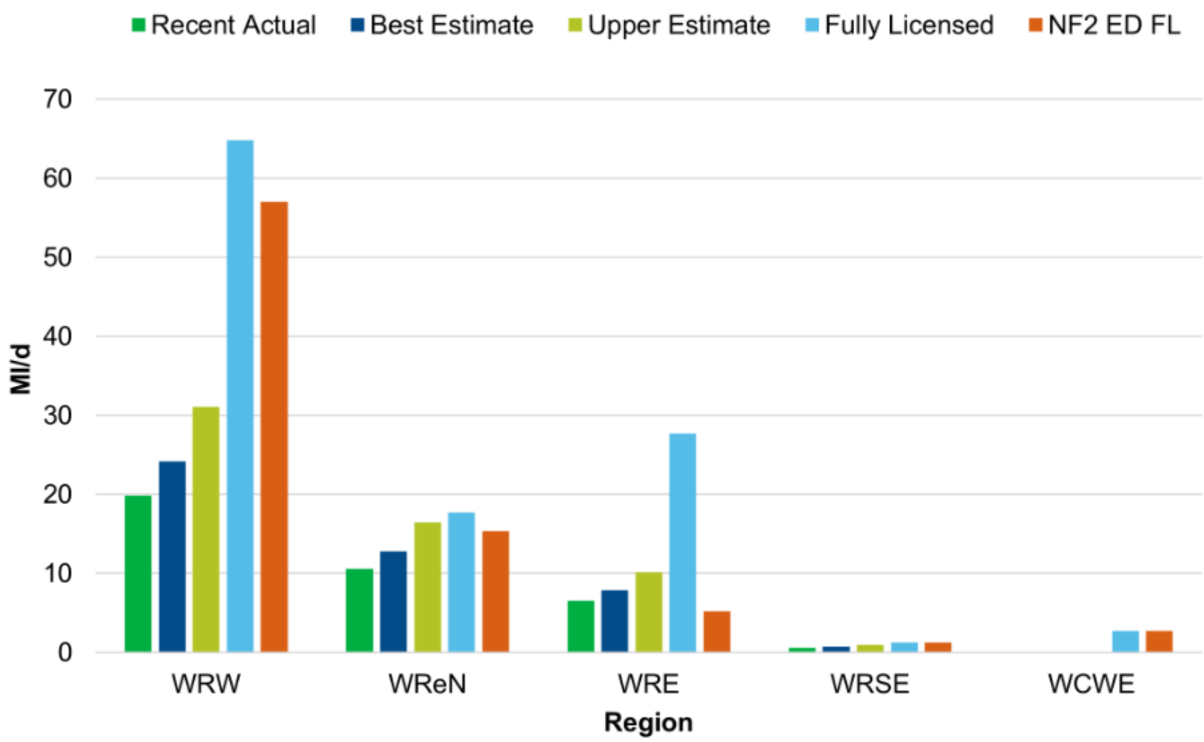


Figure 3.17: The potential water demand in Ml/d for chemical manufacturing under the baseline (recent actual), best estimate, upper estimate, fully licensed and NF2 Environmental Destination fully licensed, across the regional groups.

Figure 3.17 shows possible changes in demand for non-public water supply water by the chemicals industry under the 3 scenarios. This could range from the baseline of 37 Ml/d to 113 Ml/d under a fully licensed scenario with a best estimate 46 Ml/d and upper estimate of 59 Ml/d. The greatest potential best estimate increase is in WRW with an increase of 4 Ml/d to 24 Ml/d.

We observe the largest demands in WRE, WReN and WRW. All estimates are within the total volume of current fully licensed. However, when future environmental requirements are accounted for, all estimates in WRE could exceed the total volume of licences; in WReN this occurs only under the upper estimate.

3.3.5 Power

The electricity sector involves many operators and there are complex links between commercial, policy and technical drivers of change. We have considered water used in thermal power generation and its consumptive use of freshwater. There is a growing range of electricity generating technologies, some of which require no water to operate such as wind and solar photovoltaic generation, but the sector is still dominated by thermoelectric generation (including gas, nuclear and thermal renewables). Thermoelectric power stations use water for a range of purposes, but most is used for cooling the exhaust heat from the generators. For this reason, the UK power station fleet has developed in clusters driven in part by access to available water (rivers, estuaries and coastal regions). The amount of water used by power stations depends on the technology they use. For water cooled plants, the gross water usage significantly outweighs the consumptive process requirements.

For the electricity production sector, evaporative cooling forms the largest consumptive use of water directly abstracted (66%), with 51% of this located in Water Resources East, 35% in Water Resources North and 14% in Water Resources South East. This water is taken at 10 sites.

Changes to this sector can be driven by politics, the market, economics, social, environmental and technological changes. Demand for electricity, the mix of electricity generation plans and technology will also affect the amount of water consumed. All scenarios explored here point to a significant increase in electricity demand over the coming decades driven by a range of factors, the biggest being decarbonisation targets.

The government has committed to a clean power system by 2030, with at least 95% of electricity generated from low carbon sources by 2030. Alongside the government’s commitments to net zero targets (NZT), we expect to see demand for low carbon energy generation increase significantly from all sectors over the coming decades with an associated increased demand for water.

The production of hydrogen as a power source and the use of carbon capture and storage (CCS) is likely to be fundamental in achieving these goals, as is the use of Small Modular Reactors (SMRs) and the use of biofuels. A significant amount of our energy is likely to be produced by nuclear power (gigawatt scale and SMRs) by 2050. These technologies will require reliable access to water and significant investment in water supply infrastructure. Hydrogen production and the implementation of carbon capture storage require significant volumes of water.

To inform planning, the Environment Agency commissioned AECOM to produce the National Framework for Water Resources – Water and Energy report. This builds on the original 2020 National Framework and provides insights into the water needs of the emerging low carbon energy sector between 2025 and 2050.

The estimates for hydrogen at 2030 are based on announced schemes as of January 2024 from the International Energy Agency (IEA) database which are available at a more local scale. The estimates for 2035 and 2050 for hydrogen are based on UK NZTs and the UK Government's predicated increase in hydrogen demand through to 2050. The estimates for 2035 for carbon capture storage, are based on announced schemes from the IEA database, with an assumption of capacity added each year (1 GWe (net) of power CCS capacity), based on NZT estimated maximum build rate of 2 GWe/year. At 2050, the capacity has been estimated by doubling NZT predictions for gas power CCS capacity. For further information, please refer to the AECOM Water & Energy report, this is available upon request via wrnationalframework@environment-agency.gov.uk.

The work estimates that the national consumptive water needs for hydrogen production and carbon capture storage could amount to 278 Ml/d by 2030, 354 Ml/d by 2035 and 767 Ml/d by 2050 as shown in **Figure 3.18** which highlights the breakdown across hydrogen and carbon capture. For 2030, the estimated water needs can be broken down regionally, as we present in **Figure 3.19**, demonstrating most of the needs could be required in Water Resources North and Water Resources West regions, dominated by carbon capture storage. There are minimal schemes proposed in West Country Water and Environment regional group by 2030 at the time of the AECOM Water & Energy report publication.

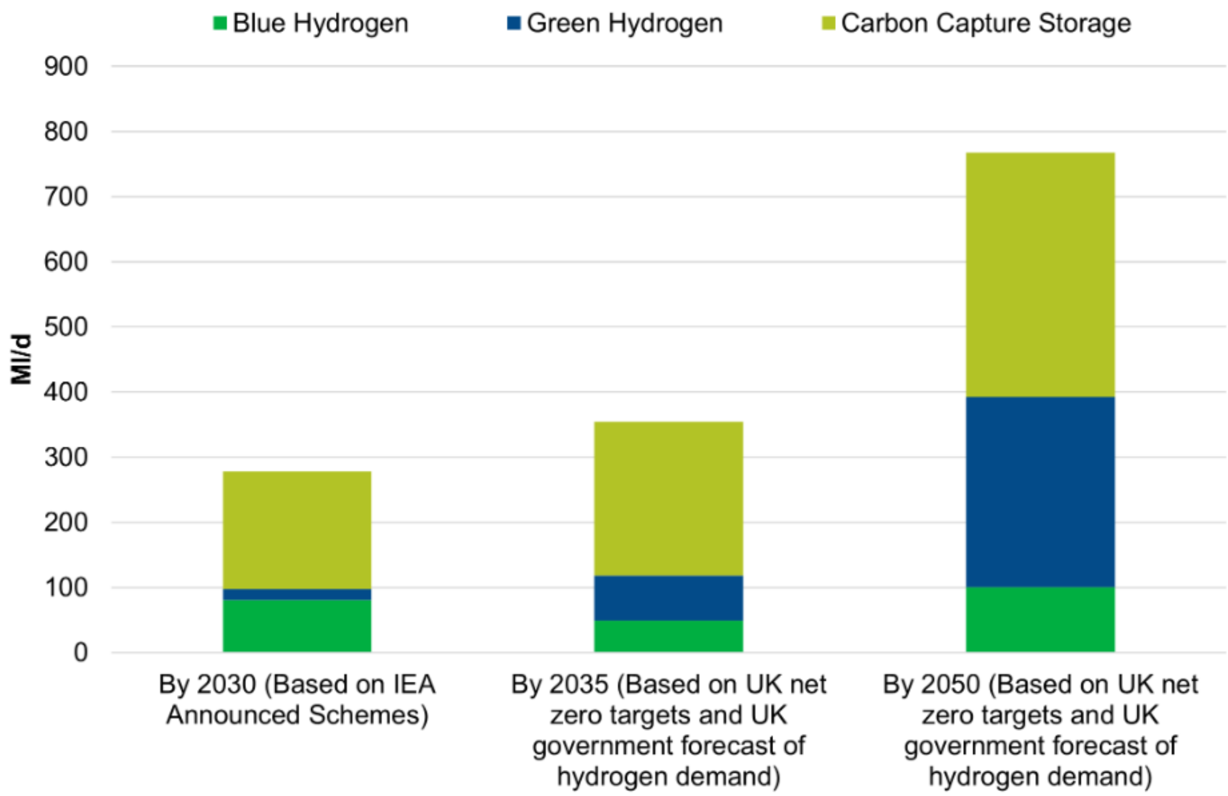


Figure 3.18 Estimated additional national consumptive water requirements in Ml/d by 2030, 2035 and 2050 for blue and green hydrogen and carbon capture storage. The water requirements increase over time. Water requirements are highest for carbon capture storage in 2030 and 2035 (180 to 236 Ml/d). By 2050, carbon capture requires an additional 374 Ml/d, green hydrogen requires 293 Ml/d and blue hydrogen requires 100 Ml/d.

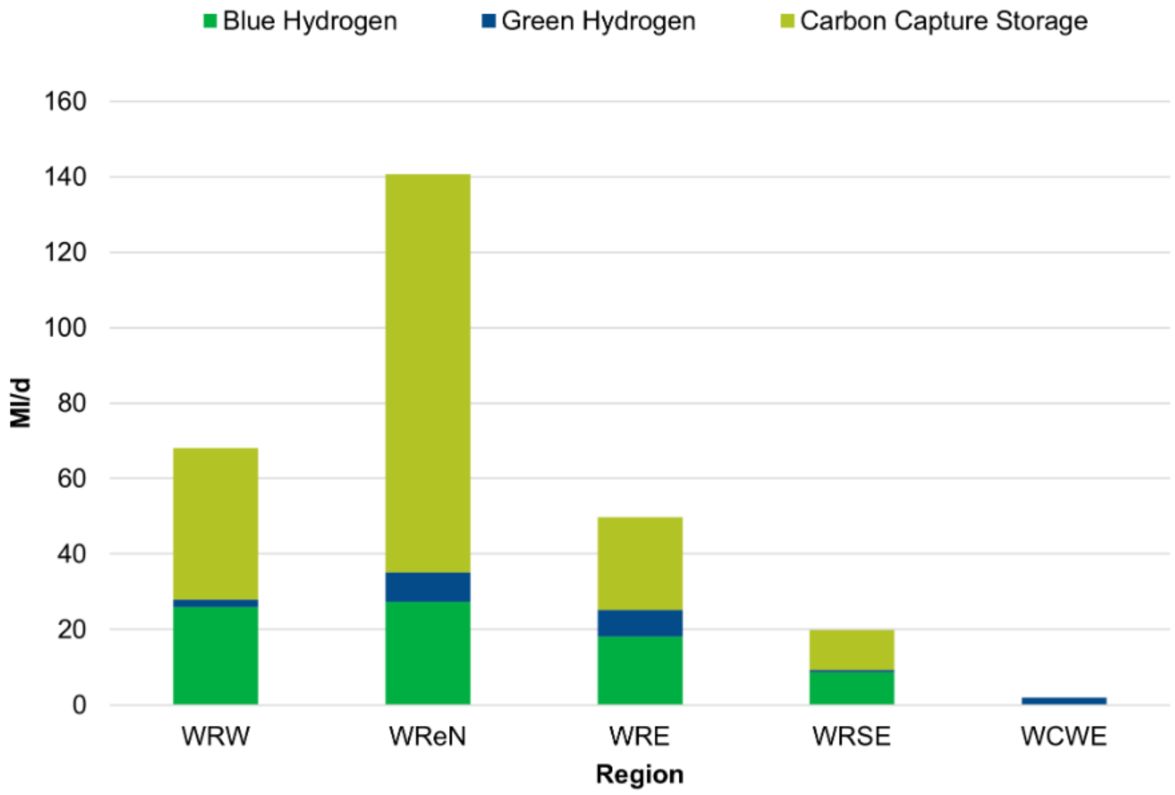


Figure 3.19 Estimated additional regional consumptive water requirements in Ml/d by 2030 for blue and green hydrogen and carbon capture storage based on announced schemes as of January 2024 from the IEA database. We observe the largest demand in WReN (~140 Ml/d in total, made up of 106 Ml/d for carbon capture storage), followed by WRW (68 Ml/d) and WRE (~50 Ml/d). Across the regions carbon capture storage requires the most demand, green hydrogen the least. WCWE has no additional demand required for any of the schemes.

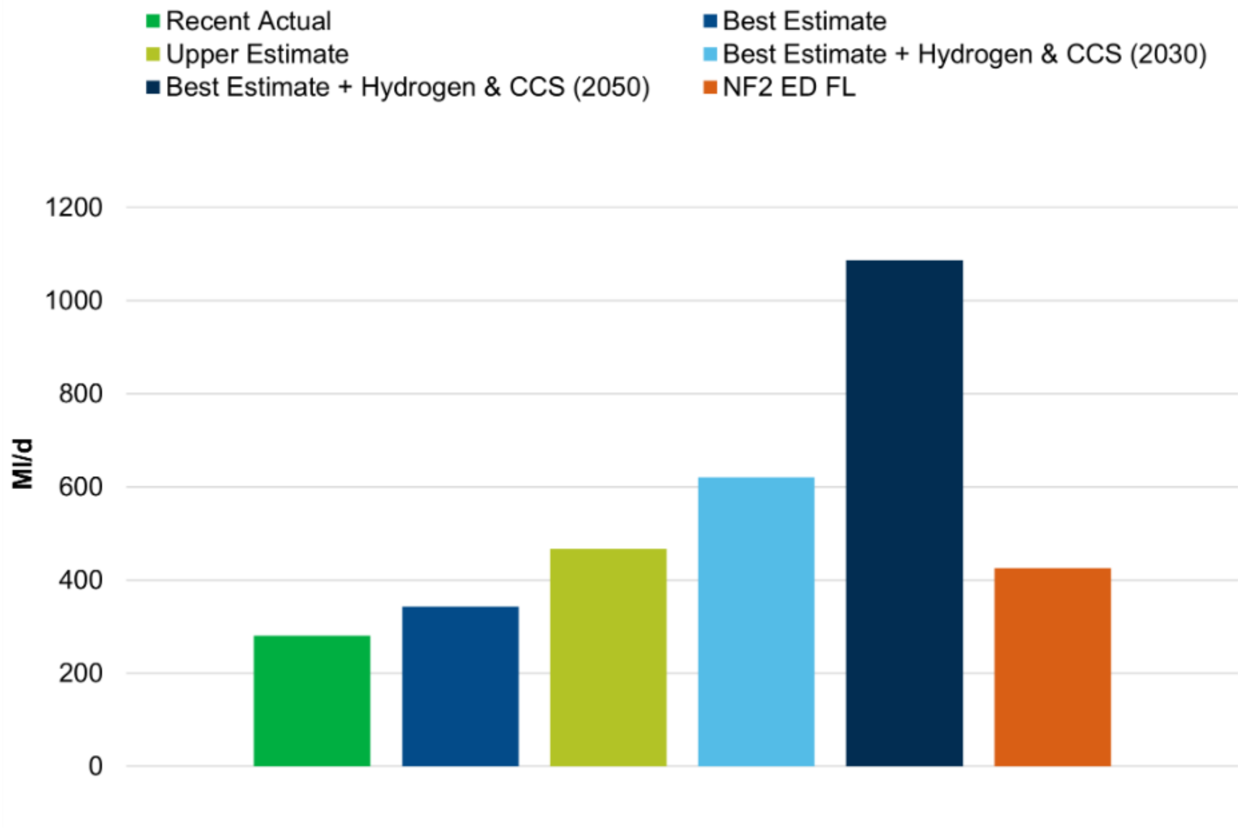


Figure 3.20: The national annual average consumption of water in Ml/d for power generation under the baseline and five other scenarios, including the two ran for the 2025 main report of National Framework for Water Resources, a fully licensed and two estimates that include potential hydrogen and carbon capture storage requirements as an addition to best estimate.

Figure 3.20 is a clustered column chart showing the annual average consumption of water in Ml/d for power generation nationally under recent actual, best estimate, upper estimate, best estimate + hydrogen & CCS (2030), best estimate + hydrogen & CCS (2050), fully licensed and NF2 Environmental Destination fully licensed.

Baseline (recent actual) indicate an average current consumptive water use for power generation at 281 Ml/d. Our best and upper estimates for national consumptive water demand for the power sector are 343 Ml/d and 466 Ml/d respectively and sit under the fully licensed amount of 558 Ml/d as shown in **Figure 3.20**. These are based on applying growth factors to existing licences for power and do not significantly account for H_2 or CCS, as these represent new and emerging sources of demand (minimising the risk of double counting for growth). When considering our 2030 and 2050 estimates for hydrogen and carbon capture in addition to our best estimates, this increases to 621 and 1249 Ml/d respectively as shown in **Figure 3.20**. We do not add the hydrogen and carbon capture estimates to our ‘upper’ estimate scenario as this growth factor already accounts for consumption related to new green energy technologies including carbon capture storage. By adding hydrogen and carbon capture estimates to our ‘best estimate’, there is still a risk of double counting for growth in general; as this assumes that all current abstraction for power would increase by 122% on top of the emerging demands for hydrogen and carbon capture; we consider this to be an upper limit.

As highlighted in the AECOM report, the JEP forecast for water consumption for the power sector through to 2050 explores four future scenarios, under which annual average water consumption is expected to increase in all of them. This is in part due to demand for hydrogen production and changes to the estimated make-up of power generation in the UK to 2050. Their highest forecast under the 'System Transformation' scenario, projects an estimated annual average consumption of 641 Ml/d by 2050, with a range from 104 to 353 Ml/d. Our estimates are generally in line with these forecasts (343 to 621 Ml/d), except for our highest estimate of 1087 Ml/d which includes hydrogen and carbon capture forecasts in 2050 as an addition to our best estimate in 2050 which should be considered an upper limit.

The greatest potential increases are in Water Resources East and Water Resources North regional groups with 76 and 61 Ml/d respectively under upper estimates. If either the best or upper estimate demand increase occurs in the north, it will exceed current licensed volume in this sector. If we add the estimated 2030 demands for hydrogen and carbon capture onto the best estimate, it will exceed the current licensed volume in this sector in Water Resources South East by 4 Ml/d and Water Resources North by 149 Ml/d.

Whilst comparing potential growth to current licensed volumes here, abstractors should not assume they can always meet future growth by using volumes of water held on their current licences that has been historically unused. It may be that in some catchments; an increased amount of abstraction could lead to further deterioration of environmental issues. To understand what water may be available in the future, we can also compare potential future needs to the amount of water existing licence holders can use once environmental requirements have been considered under the Full Environmental Destination planning scenario (under a drier range climate scenario in the 2050s) as highlighted in **Figure 3.21** under 'NF2 (National Framework 2) Environmental Destination FL (fully licensed). Under all potential future needs for power in WRSE and WReN, they will exceed the total volume of licences within the power sector when environmental requirements are accounted for. For WRW, this is the case only under the best estimate scenario that includes hydrogen and CCS water needs at 2030.

This comparison of future estimates of non-public water needs and potential future licensed volumes, taking account of potential climate impacts and environmental requirements, highlights the importance of promoting water rights trading amongst non-PWS users. Water rights trading within and across sectors, as well as within regions (and even across regions in some geographies), has the potential to help ensure water is available when it is needed for non-public water users in the future.

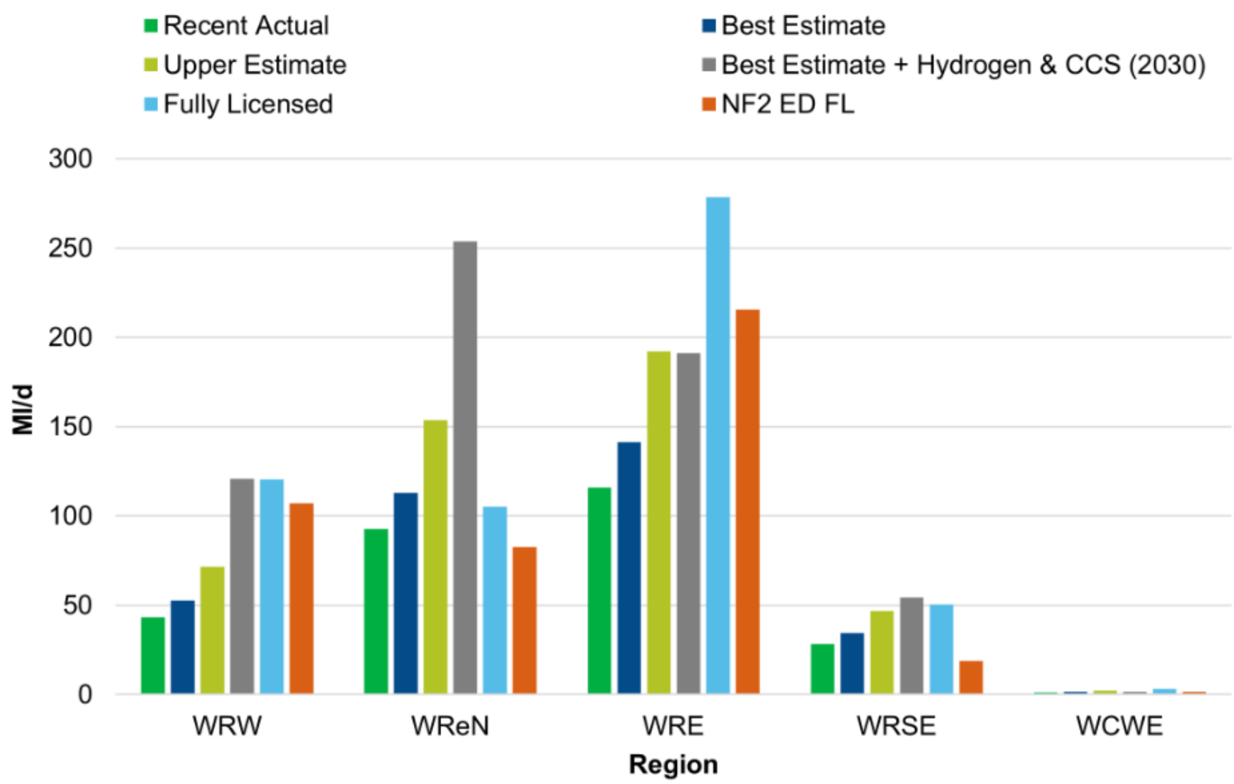


Figure 3.21: The potential water demand in Ml/d for power generation under the baseline (recent actual), best estimate, upper estimate, best estimate + hydrogen & CCS (2030), fully licensed and NF2 Environmental Destination fully licensed, across regional groups. The highest demand estimates are observed in WReN (under the best estimate with hydrogen and CCS ~ 250 Ml/d), WRE (upper estimates and best estimates with hydrogen and CCS ~200 Ml/d) and WRW (best estimates with hydrogen and CCS ~121 Ml/d).

Perhaps more so than any other sector, water needs for electricity generation will vary greatly based on what changes at a small number of sites. There is greater uncertainty associated with these estimates than other sectors because freshwater demand will be governed by the mix of sources and the use of emerging technologies (hydrogen, carbon capture storage) that could increase water demands significantly.

The changes this sector is facing will bring both challenges and opportunities for water management. Meeting the challenges of the water resource needs of achieving UK net-zero efficiently, will require innovative approaches and join-up across sectors and users bound together in water sharing agreements. For example, joining up desalination or water reuse with renewable energy sources to use electricity generated from renewable sources for water treatment when electricity demand is low. The water industry and regulator's engagement with the sector is critical to understand water availability and ensure that regional water resources groups can effectively plan for future use and options for securing water supplies.

4 Understanding water availability under water needs of public water supply, non-public water supply and the environment under climate change

The Environmental Destination for water resources identifies where, and by how much, water abstraction needs to change to achieve and maintain a healthy water environment, both now and in the future. The Environmental Destination was recently updated for the National Framework for Water Resources 2025 as outlined in the technical report here, the report presents the methodology, scenario information and results of the modelling work that we carried out to understand what long-term abstraction reductions may be needed to meet environmental flow thresholds under different scenarios of climate, growth required for public and non-public water supply and a range of potential future environmental requirements .

The work here looks to build on the technical work undertaken as part of Environmental Destination for the NFWR2025, and assess where, and how much water could be available to support future, sustainable growth across key catchments in England.

The Environmental Destination work explored scenarios under low flow, drought conditions (Q95), we have taken this a step further and have quantified water availability (surplus/deficit) under select ED scenario outputs at a range of flow conditions (Q30, Q50 and Q70). This will highlight potential innovative and sustainable opportunities for all abstractors to meet future water resource needs.

We selected two of the Environmental Destination scenario outputs to explore including:

1. "Do Nothing": Phase 1 (P1) Full 2050 – full environmental requirements under a changing climate, with best estimate non-public water supply growth but no public water supply reductions (WRMP24 baseline)
2. "Considering water company actions": Phase 2 (P2) Full 2050 – full environmental requirements under a changing climate, with best estimate non-public water supply growth, considering water company delivery of actions and consequent reduction in public water supply (WRMP24 final plan)

These scenarios are outlined in **Table 4.1** below.

Table 4.1 Details of the two Environmental Destination scenarios that are explored in this study

Scenario Name	Year	Public water supply	Non-public water supply	Environmental Destination planning scenario	Climate (eFlag replicate)
P1 Full 2050	2050	WRMP24 Baseline Distribution Input	Best estimate growth factor	Full	RCM04
P2 Full 2050	2050	WRMP24 Final Plan Distribution Input (except where negative values)	Best estimate growth factor	Full	RCM04

‘Full’ environmental requirements include greater environmental protection for Sites of Special Scientific Interest (SSSIs) rivers and wetlands, principal salmon and chalk rivers as well as further protection for headwaters in chalk rivers and SSSIs. It assumes we will achieve good status for all WFD waterbodies (including those currently exempt) in line with government policy and supported commitments.

RCM04 is defined as a wetter range of potential future natural flows and whilst it is the second average wet side projection, is not an outlier.

For further information on the full details of scenarios including growth factors and climate, datasets, methods, assumptions, limitations and caveats, please refer to the NFWR2025 Environmental Destination technical report.

4.1 A Do Nothing scenario (P1)

The following maps highlight potential availability of water under low (Q95) to high (Q30) flow at a national scale under a Do Nothing scenario as described above.

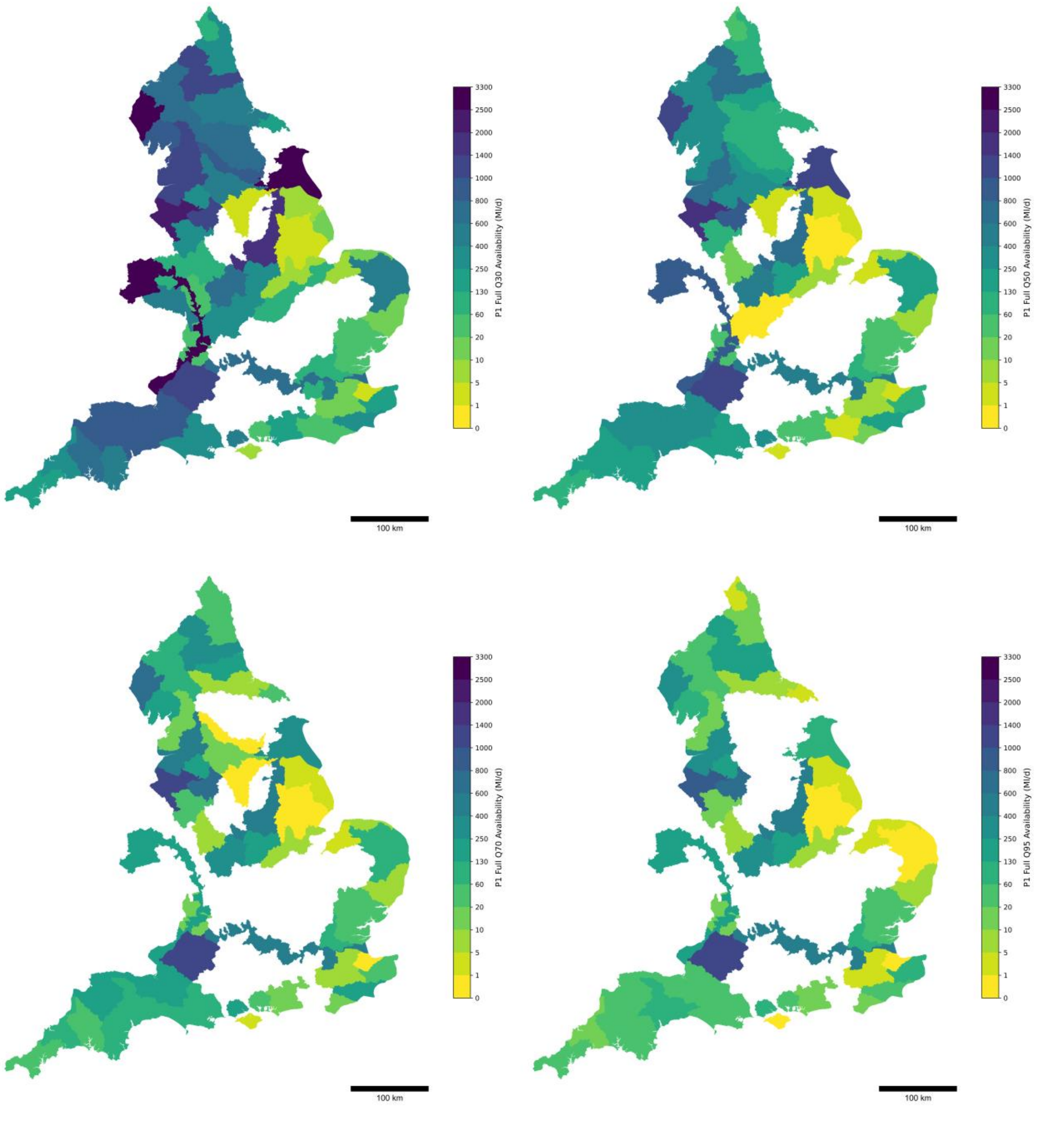
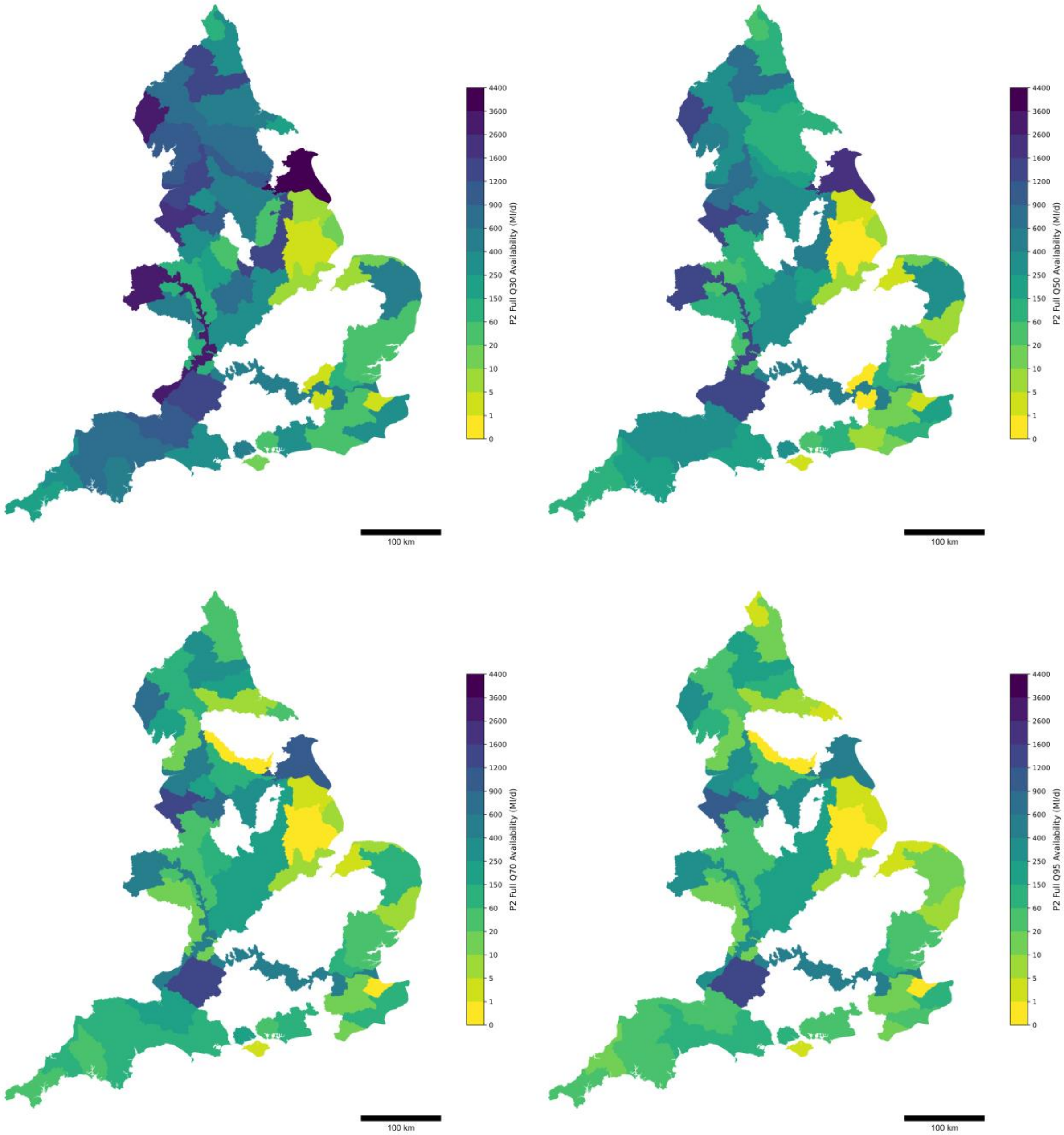


Figure 4.1. Potential water availability across catchments under a 'Do Nothing' scenario, for a range of flow percentiles (top left: Q30, top right: Q50, bottom left: Q70 and bottom right: Q95. Potential water availability in Ml/d is taken as the maximum availability across all water bodies in each catchment at the specified flow percentile. Data for Figure 4.1 is provided in Table 4.2 at the end of the section.

4.2 Considering water company actions (P2)



The following maps highlight potential availability of water under low (Q95) to high (Q30) flow at a national scale under a more optimistic scenario, where water company actions are considered, as described above.

Figure 4.2. Potential water availability across catchments under a 'considering water company actions' scenario, for a range of flow percentiles (top left: Q30, top right: Q50, bottom left: Q70 and bottom right: Q95. Potential water availability in Ml/d is taken as the maximum availability across all water bodies in each catchment at the specified flow percentile. Data for Figure 4.2 is provided in Table 4.2 at the end of the section.

4.3 Water availability across water resource regional groups

We explored water availability under a range of flows across the five water resources regional groups, highlighting key catchments identified as either potential areas for sustainable growth or areas where we expect sustainable abstraction reductions to be the highest (>100 Ml/d) across England.

Work carried out for the Environment Agency's National Framework for Water Resources 2025 mapped out where and when future energy sector growth is likely to increase, focusing on low carbon technologies such as blue and green hydrogen and carbon capture and storage (CCS). The work estimated that the water needs for carbon capture and storage (CCS) and hydrogen production alone may amount to 767 Ml/d by 2050. This work specifically highlighted IEA proposed low carbon schemes, their proposed locations and estimated process water requirements. It also compared the requirements to water available in proposed locations based on abstraction licensing strategy (ALS) information at low flows (Q95), highlighting where water was available or not to support the proposed schemes.

The Environmental Destination for water resources was recently updated for the National Framework for Water Resources 2025 which identified where, and by how much long-term abstraction needs to reduce across a range of future scenarios. For the purposes of this study, we have focused on catchments where reductions are expected to be the highest (>100 Ml/d) across England based on Q95, upper range, worst-case modelled conditions (phase 1 2050 fully licensed upper range (max of wetter/drier) scenario).

By assessing water availability across catchments under higher flows (Q30, Q50 and Q70) and not just under drought conditions (Q95), there are potential opportunities to be found that could either provide new sustainable sources of water required for sustainable growth in a range of sectors including energy or provide alternative, sustainable sources of abstraction to replace current environmentally unsustainable abstraction that is negatively impacting catchments.

Potential opportunities could take form in different ways, but in general, involve using water when and where it may be available sustainably (during higher flows) in combination with some form of storage.

Water users specifically looking for new sources of water will need to consider the most environmentally sustainable and efficient options and consider if taking water from the environment (and how it is stored or used conjunctively with other sources) is the best option to provide a secure, reliable sustainable long-term supply

We present water availability in Ml/d, in maps at the catchment scale, taking the maximum availability across all water bodies in each catchment at the specified flow percentile.

4.3.1 Limitations and caveats

There are limits and caveats to the water availability data presented here. Water availability data presented here are for strategic, planning purposes only.

We produced datasets through WRGIS which reflect a snapshot in time, it does not represent catchments in as much detail as more locally specific models can. WRGIS also may differ in the assumed distribution of the impact of abstractions. Any assessment of water availability for abstraction licensing is subject to local assessment and is dealt with on a case-by-case basis by the Environment Agency.

WRGIS projections are based on simple flow duration curve analysis, they do not consider potential adaptations in the time series operation of abstractions, reservoirs, transfers or augmentation schemes. Future projections using the WRGIS do not consider any change to future (reservoir) storage or compensation flows, or any change to the location or potential reuse of discharge. Projections are based current licensed abstractions and do not consider future requirements e.g. of energy sector.

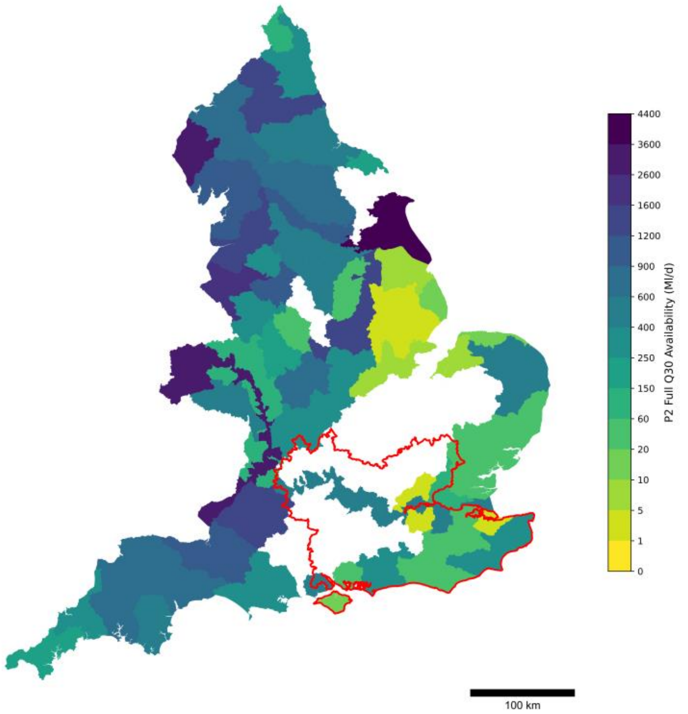
Water availability presented in maps and discussed in commentary is taken as the maximum availability across all water bodies in the specified catchment (catchment abstraction management strategy (CAMS) areas) relative to the downstream critical water body at the specified flow percentile.

Catchments presented in maps include water availability in transitional and coastal (TraC) catchments; these are likely to be an **overestimate** across all specified flows due to a range of factors.

Firstly, availability in TraC catchments presented here, reflect the transitional and seaward transitional water bodies (estuaries) where there is freshwater inflow; they do not include coastal reaches. These flows will include main river inputs and single catchment tributaries that release directly into the estuary or coastal areas. These may be numerous and their combined flow into TraCs could be substantial but are an aggregation of individual sources, channels and outflows that may be unsuitable for abstraction.

The environmental flow indicator (EFI) excludes minor, single catchment tributaries that release into the estuarine areas, but these are automatically assigned ASB12 for flow protection. Approximately 11.5% of transitional water bodies are currently failing EFI standards for freshwater in-flow compliance at ‘low’ abstraction sensitivity band ASB11. There is potential that some transitional water bodies should be re-assigned to higher sensitivity bands of ASB12 (medium) and ASB13 (high), requiring greater protection of freshwater in-flows into the estuary and thus reducing water availability in the freshwater water body immediately upstream. This work is currently ongoing by the Environment Agency. More flow could also be required to protect seasonal migration patterns of eel, salmonid and other species.

4.3.2 Water Resources South East (WRSE)



Water Resources South East regional group have some of the highest expected sustainable abstraction reductions across England. Key catchments in WRSE where reductions are expected to be >100 Ml/d by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions include Arun & Western Streams (106 Ml/d), Colne (228 Ml/d), Darent (151 Ml/d), Lee (422 Ml/d), Stour (172 Ml/d), Test & Itchen (104 Ml/d) and Thames Corridor (219 Ml/d).

Figure 4.3. Potential catchment water availability in Ml/d for future use under a 'Full' Environmental Destination Planning scenario for a scenario where water company actions are accounted for (P2), under the Q30 flow percentile. Water Resources South East regional group boundary is highlighted in red. Data for Figure 4.3 is provided in Table 4.2 at the end of the section.

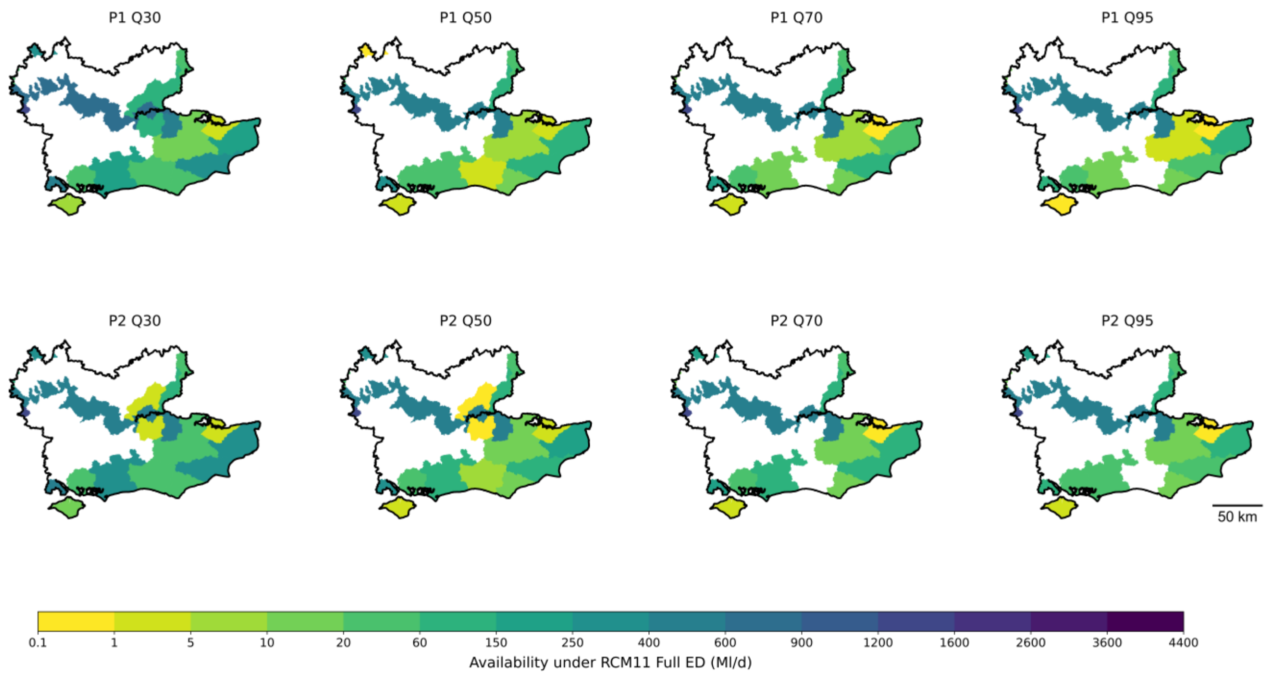


Figure 4.4. Potential water availability in Ml/d for future use across catchments that fall within Water Resources East under a ‘Full’ Environmental Destination Planning scenario for a ‘Do Nothing’ scenario (top) and a more optimistic scenario where water company actions are accounted for (bottom), for a range of flow percentiles (left to right: Q30, Q50, Q70 and Q95). Potential water availability in Ml/d is taken as the maximum availability across all water bodies in each catchment at the specified flow percentile. Data for Figure 4.4 is provided in Table 4.2 at the end of the section.

Catchments in the south east water resources region have limited availability under low flow conditions in both scenarios (Q70-Q95), with most catchments showing either minimal availability (e.g. London, North Kent, Isle of Wight) or up to 10s of Ml/d (e.g. Arun and Western Streams, Stour, Medway).

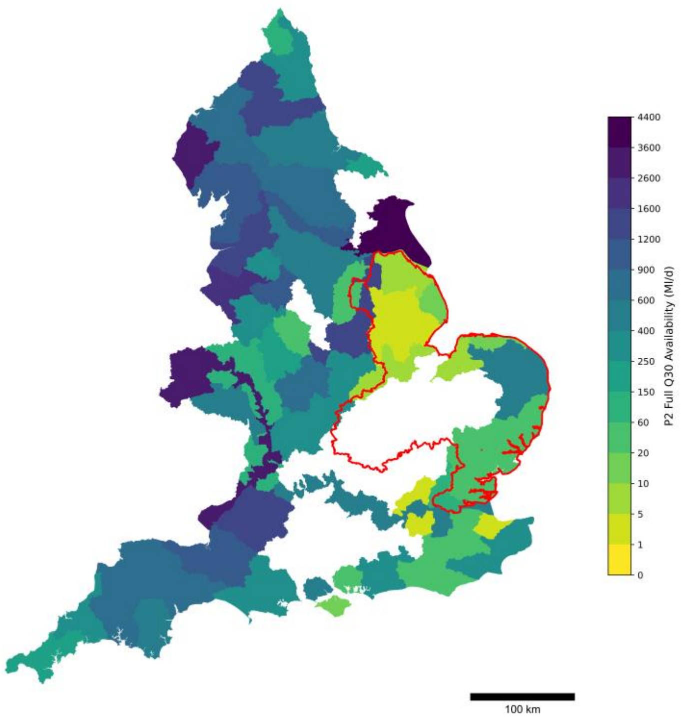
Under higher flow conditions (Q30-Q50) and where water company demand management actions are accounted for, this increases to 10s of Ml/d (Isle of Wight) or 100s of Ml/d (Arun and Western Streams, Rother, Stour if TRaCs are included), with availability predominantly in the south east river basin district.

A minority of catchments have a maximum availability of 100s of Ml/d under low and high flow conditions (Darent, Thames Corridor, Roding, Beam & Ingrebourne). For Thames Corridor, this is in driven by water provided by TRaC water bodies in the London catchment alone.

Many catchments in the south east have no water availability under any Q30, Q50, Q70 and Q95 flows including Cherwell, Thame & Wye, Colne, Cotswolds, Kennet & Vale of White Horse, Loddon, Mole, Upper Lee and Wey. Ongoing planning work and assessments linked to Habs regs suggest it is also unlikely that there is any water available in the Test & Itchen catchment.

Medway and London catchments have a maximum of 94 and 29 Ml/d abstraction reduction required respectively by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions. They have also been identified as a potential area for green energy. Based on proposed green energy scheme requirements highlighted by AECOM for Medway and London (~5 and ~11 Ml/d respectively), and compared to this indicative modelling, it is likely that potential water is only available under high flow conditions or under a scenario where public water demand has significantly reduced (~110 l/h/d). If water is only available under high flow conditions in these catchments, it may be necessary to consider water storage or increase development of sustainable sources in the region.

4.3.3 Water Resources East (WRE)



Key catchments in WRE where abstraction reductions are expected to be >100 Ml/d by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions include Cam and Ely Ouse (including South Level) (131 Ml/d) and Broadland Rivers (127 Ml/d).

Cam & Ely Ouse including South Level, Nene, Old Bedford including the Middle Level and Upper and Bedford Ouse catchments show no availability under any Q30, Q50, Q70 and Q95 flows.

Figure 4.5. Potential catchment water availability in Ml/d for future use under a 'Full' Environmental Destination Planning scenario for a scenario where water company actions are accounted for (P2), under the Q30 flow percentile. Water Resources East regional group boundary is highlighted in red. Data for Figure 4.5 is provided in Table 4.2 at the end of the section.

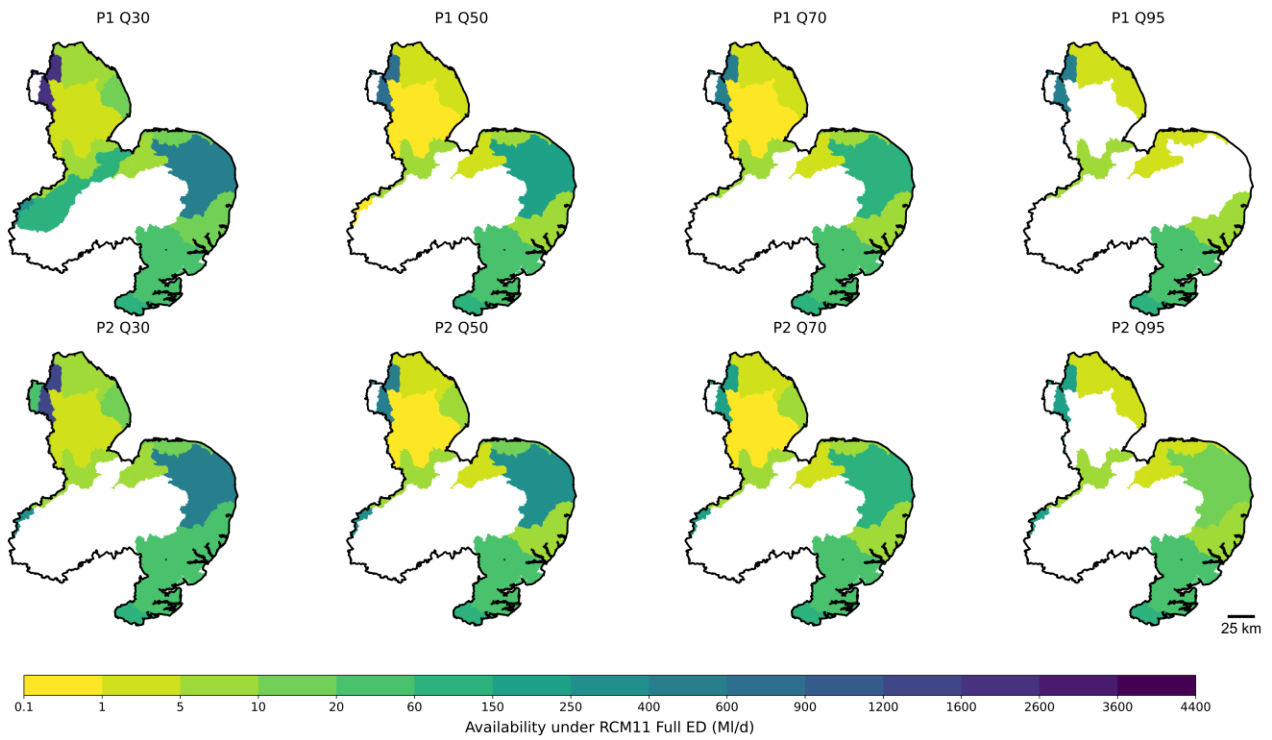


Figure 4.6. Potential water availability in Ml/d for future use across catchments that fall within Water Resources East under a 'Full' Environmental Destination Planning scenario for a 'Do Nothing' scenario (top) and a more optimistic scenario where water company actions are accounted for (bottom), for a range of flow percentiles (left to right: Q30, Q50, Q70 and Q95). Potential water availability in Ml/d is taken as the maximum availability across all water bodies in each catchment at the specified flow percentile. Data for Figure 4.6 is provided in Table 4.2 at the end of the section.

The rest of the catchments in the east water resources region have no availability for new consumptive abstraction under dry/low flow conditions in both scenarios (Q95) including North West Norfolk, Witham, North Norfolk and Broadland rivers. At Q70 flows, there is a wider range of availability with some catchments showing minimal (<10 Ml/d) availability (e.g. North West Norfolk, Witham, East Suffolk, North Norfolk) and some with up to 10s of Ml/d (e.g. Broadland Rivers, although only when demand management actions are accounted for).

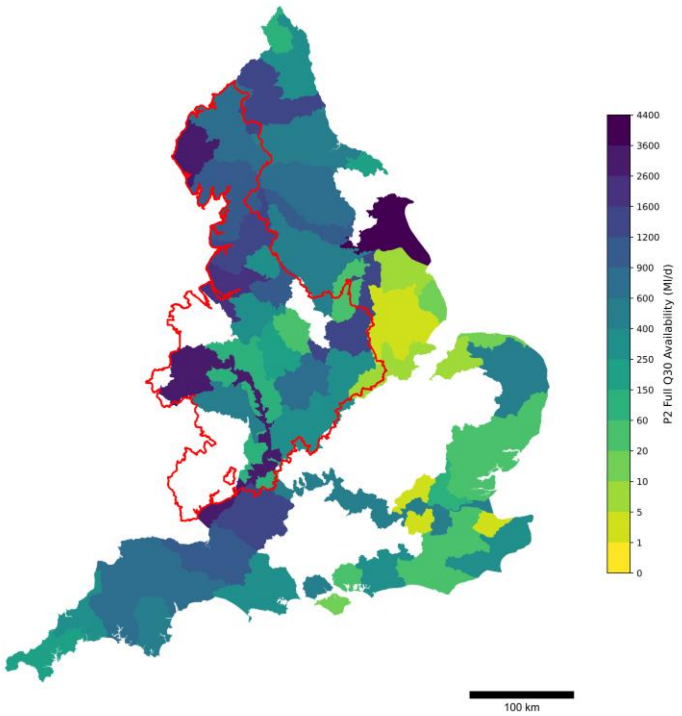
Based on this indicative modelling, under higher flow conditions (Q30-Q50) and where optimistic water company demand management actions are accounted for, for some catchments water may be available on the order of 10s of Ml/d (East Suffolk, North Norfolk) or ~100 of Ml/d (Broadland Rivers), with availability predominantly along the coastline, driven by water provided by TRaC water bodies. This is subject to local assessment, whilst water may be available in the Broadlands at higher flows, opportunities are becoming more restrictive, and abstractors should consider alternatives such as licence trading.

Catchments that sit in WRE but border other water resources regional groups as highlighted in brackets such as the Lower Trent and Erewash (WRW), Warwickshire Avon (WRW), Soar (WRW), Thames Corridor (WRSE) and Roding Beam and Ingrebourne

(WRSE) display high water availability (100s of Ml/d) across all flow conditions where water company demand management actions are accounted for. These are discussed further in their relevant regional group sections.

Significant low carbon schemes requiring ~50 Ml/d have been proposed within the Louth, Grimsby and Ancholme catchment in WRE according to AECOM. The catchment also has a maximum abstraction reduction requirement of 83 Ml/d by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions. Based on this indicative modelling, there may not be enough water available at higher or lower flows across both scenarios (max ~10 Ml/d available) for proposed scheme requirements without further development of sustainable sources in the region.

4.3.4 Water Resources West (WRW)



Key catchments in WRW where abstraction reductions are expected to be >100 Ml/d by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions include Dove (195 Ml/d) and Worcestershire Middle Severn (254 Ml/d).

Figure 4.7. Potential catchment water availability in Ml/d for future use under a 'Full' Environmental Destination Planning scenario for a scenario where water company actions are accounted for (P2), under the Q30 flow percentile. Water Resources West regional group boundary is highlighted in red. Data for Figure 4.7 is provided in Table 4.2 at the end of the section.

The Dove and Idle and Torne catchments in the WRW region have no availability under low flow conditions (Q95-Q70) under both scenarios. The Worcestershire and Shropshire Middle Severn and Teme catchments have no water available at low flows under a worst-case phase 1 scenario. Only at higher flows (Q30-Q50), and where water company demand management actions are accounted for does water availability increase across these catchments, in the order of 10s of Ml/d, increasing to 100s of Ml/d for Worcestershire Middle Severn at Q30. The Derbyshire Derwent catchment has no availability across all flow regimes under both scenarios.

The majority of catchments in WRW have a maximum availability of 10s to 100s of Ml/d under low and high flow conditions (South Cumbria, Tame Anker and Mease, Northern Manchester, Warwickshire Avon, Soar, Wear) in a scenario where water company demand management actions are accounted for. For some, this increases to a maximum availability of 1000s of Ml/d under Q30 flow conditions (Severn Corridor, Derwent & West Cumbria, Lower Mersey & Alt, Lower Trent & Erewash, Tyne, Ribble, Douglas and Crossens, Upper Mersey and Lune and Wyre).

The Lower Trent and Erewash and Weaver and Dane catchments have been identified as potential areas for green energy. It is important to note that they have a maximum of 82 and 39 Ml/d abstraction reduction required respectively by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions.

Under both scenarios and, under low flow conditions (Q95-Q70), both catchments have potential water available, up to 10s of Ml/d for Weaver and Dane and 100s of Ml/d for Lower Trent and Erewash. Under higher flows (Q50-Q30), water availability increases an order of magnitude for both; this is primarily driven by water provided by TRaCs in the case of Lower Trent and Erewash.

Based on proposed green energy scheme requirements highlighted by AECOM for Lower Trent and Erewash and Weaver and Dane (~54 and 34 M/d respectively), whilst there would be enough potential water available across all flow conditions in the Lower Trent and Erewash, there would likely be potential water available in Weaver and Dane only under high flows (Q30-Q50) of a phase 1 scenario and potentially across all flow conditions under a phase 2 scenario. If water is only available under high flow conditions in the Weaver and Dane, it may be necessary to consider water storage or increase development of sustainable sources in the region.

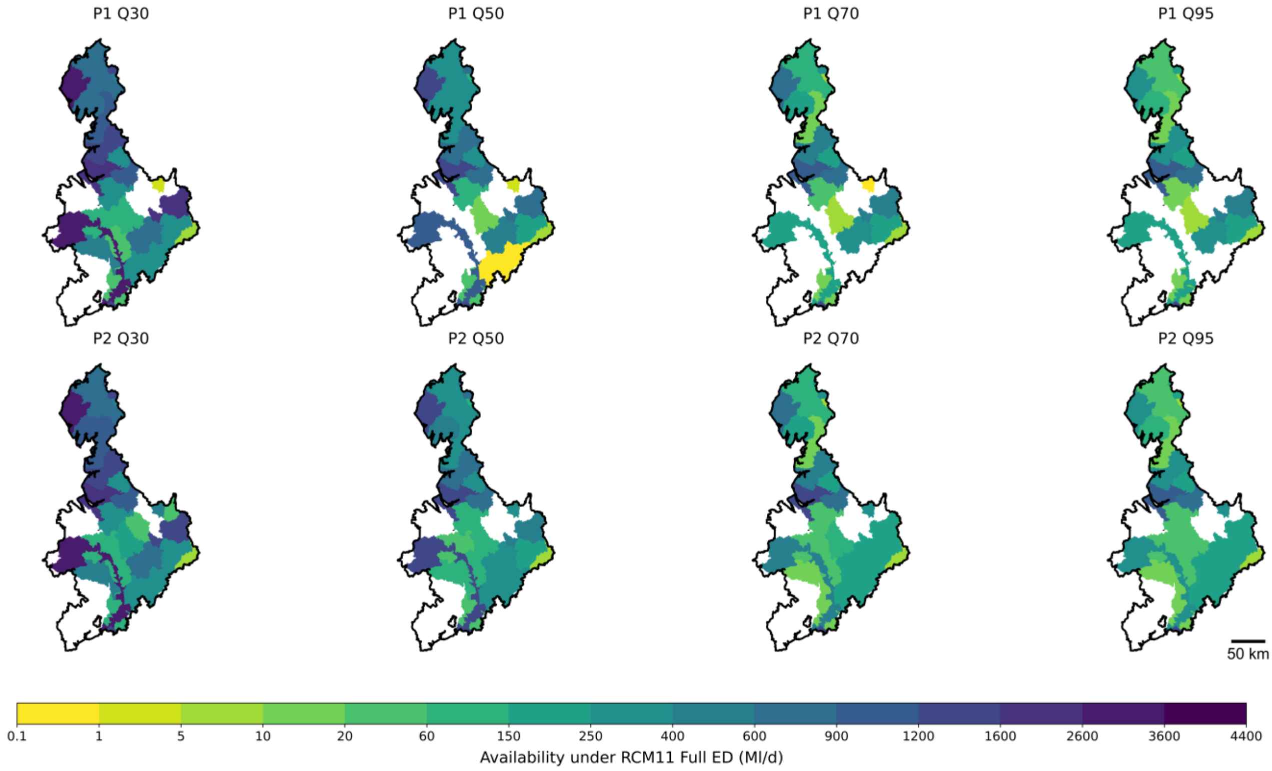
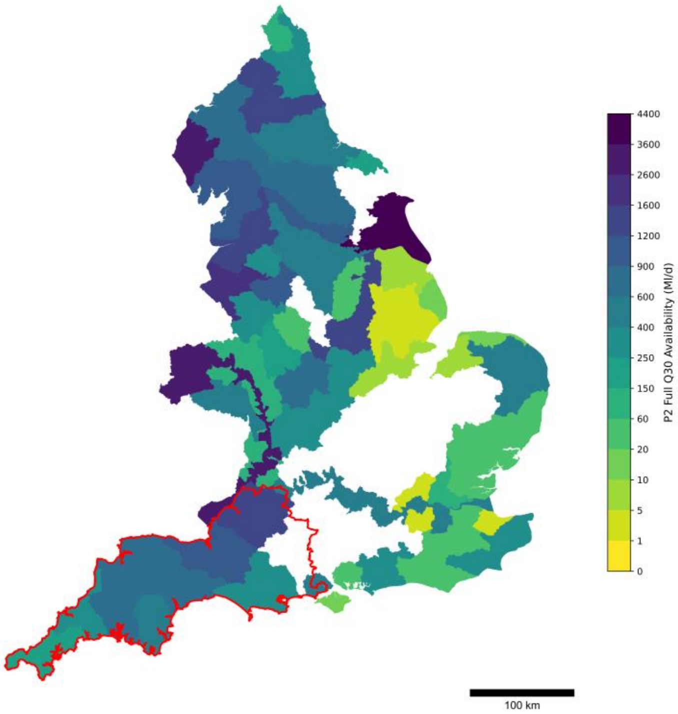


Figure 4.8. Potential water availability in Ml/d for future use across catchments that fall within Water Resources West under a 'Full' Environmental Destination Planning scenario for a 'Do Nothing' scenario (top) and a more optimistic scenario where water company actions are accounted for (bottom), for a range of flow percentiles (left to right: Q30, Q50, Q70 and Q95). Potential water availability in Ml/d is taken as the maximum availability across all water bodies in each catchment at the specified flow percentile. Data for Figure 4.8 is provided in Table 4.2 at the end of the section.

4.3.5 West Country Water & Environment (WCWE)



Key catchments in WCWE where abstraction reductions are expected to be >100 Ml/d by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions include Hampshire Avon (133 Ml/d).

The Hampshire Avon is the one catchment in WCWE where ongoing planning work and assessments suggest it is unlikely that water would be available under any scenario or flow condition.

Figure 4.9. Potential catchment water availability in Ml/d for future use under a ‘Full’ Environmental Destination Planning scenario for a scenario where water company actions are accounted for (P2), under the Q30 flow percentile. West Country Water & Environment (WCWE) regional group boundary is highlighted in red. Data for Figure 4.9 is provided in Table 4.2 at the end of the section.

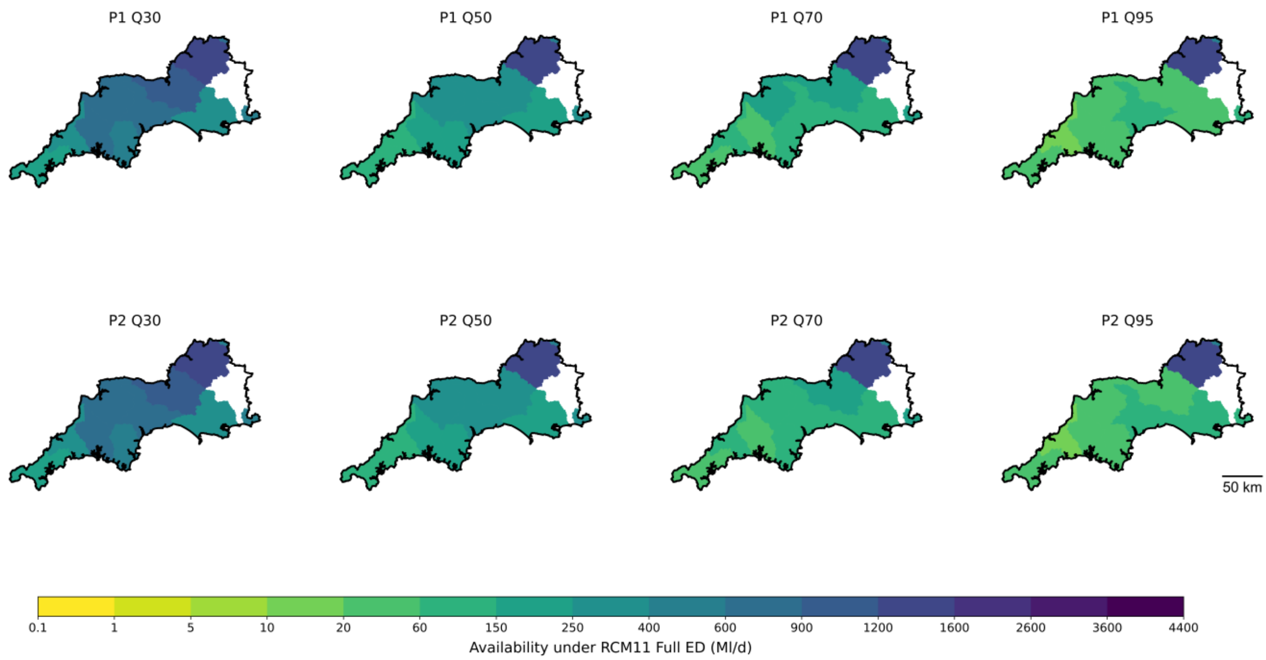
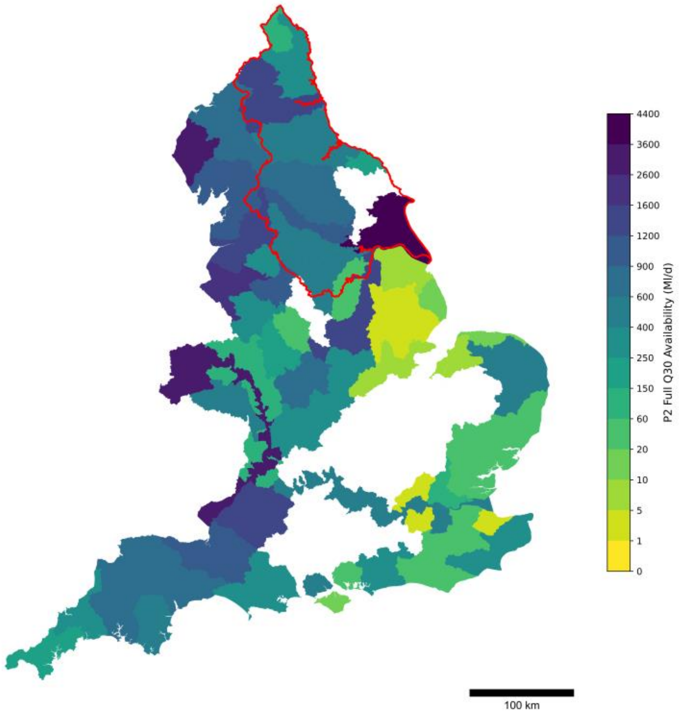


Figure 4.10. Potential water availability in Ml/d for future use across catchments that fall within West Country Water and Environment (WCWE) under a 'Full' Environmental Destination Planning scenario for a 'Do Nothing' scenario (top) and a more optimistic scenario where water company actions are accounted for (bottom), for a range of flow percentiles (left to right: Q30, Q50, Q70 and Q95). Potential water availability in Ml/d is taken as the maximum availability across all water bodies in each catchment at the specified flow percentile. Data for Figure 4.10 is provided in Table 4.2 at the end of the section.

All other catchments in WCWE have a maximum potential availability of 10s of Ml/d under low flow conditions across both scenarios. Under higher flow conditions (Q30-Q50), this increases to 100s of Ml/d (e.g. North Devon, South Devon, East Devon, Tamar, South and West Somerset show some of the highest potential availability under high flows). Bristol Avon and Little Avon show high potential availability (~1000 Ml/d) across all flow conditions under both scenarios.

4.3.6 Water Resources North (WReN)



Key catchments in WReN where abstraction reductions are expected to be >100 Ml/d by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions include Derwent (275 Ml/d) and Hull and East Riding (142 Ml/d).

Figure 4.11. Potential catchment water availability in Ml/d for future use under a 'Full' Environmental Destination Planning scenario for a scenario where water company actions are accounted for (P2), under the Q30 flow percentile. Water Resources North (WReN) regional group boundary is highlighted in red. Data for Figure 4.11 is provided in Table 4.2 at the end of the section.

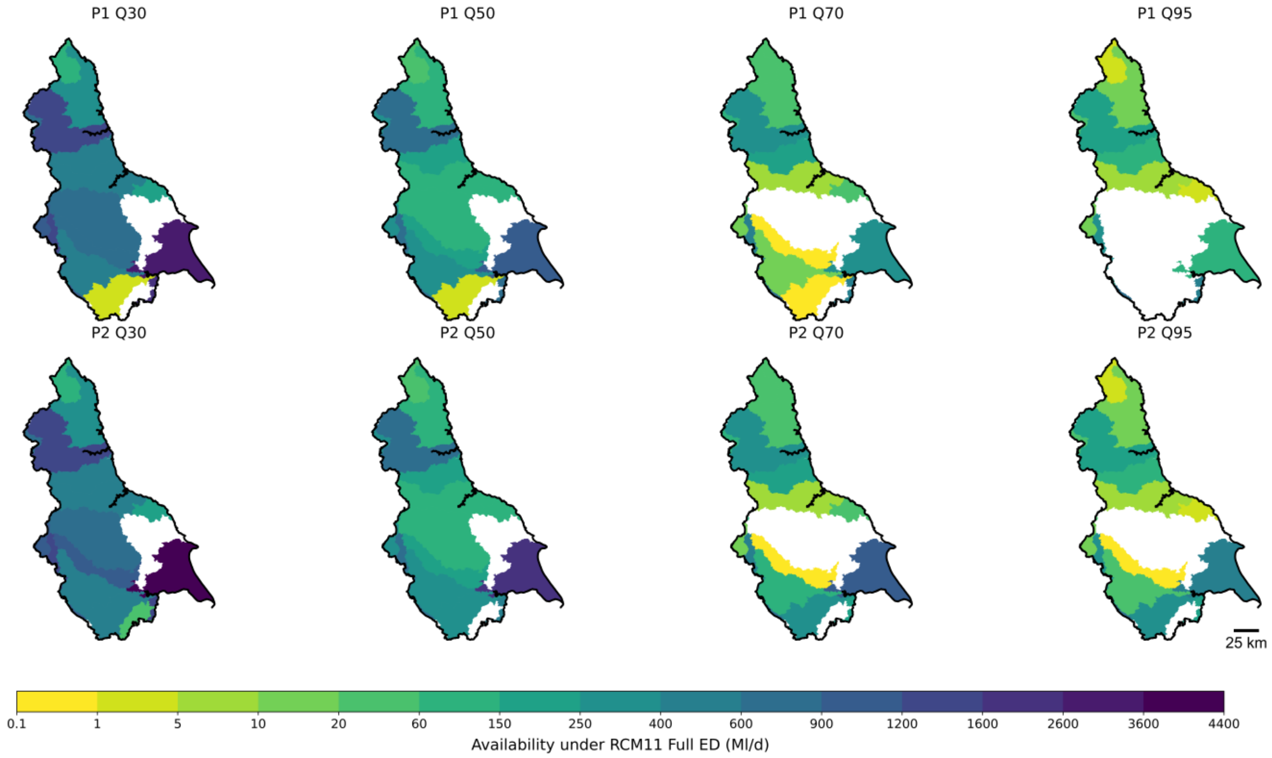


Figure 4.12. Potential water availability in Ml/d for future use across catchments that fall within Water Resources North (WReN) under a 'Full' Environmental Destination Planning scenario for a 'Do Nothing' scenario (top) and a more optimistic scenario where water company actions are accounted for (bottom), for a range of flow percentiles (left to right: Q30, Q50, Q70 and Q95). Potential water availability in Ml/d is taken as the maximum availability across all water bodies in each catchment at the specified flow percentile. Data for Figure 4.12 is provided in Table 4.2 at the end of the section.

The Derwent catchment shows no availability under any Q30, Q50, Q70 and Q95 flows across both scenarios.

The Swale, Ure, Nidd and Upper Ouse and Wharf and Lower Ouse catchments show potential availability only under high flows (Q30-Q50); there is no water available under low flows (Q70-Q95) across both scenarios. The Don and Rother and Aire and Calder catchments show minimal availability under low flow conditions in worst-case phase 1 scenario, this increases to 10s/100s of Ml/d in a scenario where water company demand management options are accounted for.

The majority of catchments in WReN have a maximum availability of 10s to 100s of Ml/d under low flow conditions (Northumberland Rivers, Eden & Esk, Lune and Wyre, Wear, Tyne) across both scenarios. For some catchments, this increases to a maximum availability of 1000s of Ml/d under Q30 flow conditions (Hull and East Riding, Tyne, Ribble, Douglas and Crossens, Upper Mersey).

Significant low carbon schemes have been proposed within catchments in WReN including Hull and East Riding, Tees and Wharfe and Lower Ouse.

Hull & East Riding and Wharf and Lower Ouse catchments have some of the highest scheme process requirements identified by AECOM (~65 Ml/d). They also have a maximum abstraction reduction requirement of 142 and 11 Ml/d respectively by 2050. Based on indicative modelling, under a worst-case phase 1 scenario and under low flow conditions (Q95-Q70), there is unlikely to be water available in Wharfe and Lower Ouse and only low availability (maximum up to 10s of Ml/d) in Hull and East Riding when including TraCs, without further development of sustainable sources in the region. Under higher flows (Q50-Q30), this does increase to 100s of Ml/d for both catchments. For the phase 2 scenario, where water company demand management actions are accounted for, water availability increases in the Wharf and Lower Ouse catchment across all flow conditions, up to ~900 Ml/d under high flow. Much of the water available in the Hull and East Riding catchment is dependent upon upstream Wharf and Lower Ouse catchment that provides ~1000s of Ml/d, whereas the Hull and East Riding catchment itself has a maximum of ~100 Ml/d available. Based on proposed green energy scheme requirements highlighted by AECOM, there would likely be potential water available in the Wharf and Lower Ouse catchment, but only under high flows (Q50-Q30) of either scenario. If water is only available under high flow conditions in the Wharf and Lower Ouse catchment, it may be necessary to consider water storage or increase development of sustainable sources in the region.

Current requirements for the Hull and East Riding catchment are lower (~4 Ml/d), and there is potential for water to be available within the catchment to support this growth, across all flow conditions, although subject to any upstream changes in availability.

The Tees catchment has proposed green energy scheme requirements of ~50 Ml/d highlighted by AECOM. The catchment also has a maximum abstraction reduction requirement of 63 Ml/d by 2050 under Q95 fully licensed, upper range, worst-case modelled conditions. Under low flow conditions (Q95-Q70) across both scenarios, there is potential water available, up to 10s of Ml/d. Under high flows (Q50-Q30), water availability generally increases to 100s of Ml/d; largely driven by water provided by TraC water bodies. Based on scheme requirements, there is some potential for water to be available to meet them in the Tees, but only in some areas of the catchment and under higher flow conditions (Q30-Q50). If water is only available under high flow conditions in the Tees, it may be necessary to consider water storage or increase development of sustainable sources in the catchment.

Table 4.2 provides the estimated water availability data in Ml/d under Phase 1 and Phase 2 scenarios, under Q30, Q50, Q70 and Q95 flow percentiles for CAMs catchments (maximum availability across all water bodies in the respective catchment and flow percentile). CAMs catchments have been assigned to their primary allocated region. Water availability data presented here are for strategic, planning purposes only. Any assessment of water availability for abstraction licensing is subject to local assessment and is dealt with on a case-by-case basis by the Environment Agency.

CAMS Catchment name	Region	P1 - Q30	P1 - Q50	P1 - Q70	P1 - Q95	P2- Q30	P2 - Q50	P2 - Q70	P2 - Q95
Bristol Avon & Little Avon	WCWE	1257	1257	1257	1257	1257	1257	1257	1257
Dorset: Dorset Stour and Frome, Piddle and West Dorset	WCWE	376	176	110	58	395	196	130	80
East Devon: Exe and Otter, Sid, Axe and Lim	WCWE	854	324	125	73	867	330	126	82
Hampshire Avon	WCWE	0	0	0	0	0	0	0	0
New Forest	WCWE	495	287	185	87	505	295	192	92
North Cornwall, Seaton, Looe and Fowey	WCWE	313	139	73	17	314	140	74	18
North Devon: Tor and North Devon and Torridge and Hartland Streams	WCWE	829	314	153	33	837	316	146	33

CAMS Catchment name	Region	P1 - Q30	P1 - Q50	P1 - Q70	P1 - Q95	P2- Q30	P2 - Q50	P2 - Q70	P2 - Q95
South and West Somerset: Parrett, Brue and West Somerset Streams	WCWE	934	375	161	45	933	375	160	45
South Devon: Teign Torbay and South Hams	WCWE	476	192	88	30	483	181	79	30
Tamar	WCWE	645	164	48	47	645	164	48	47
West Cornwall and the Fal	WCWE	188	77	58	36	188	77	58	36
Broadland Rivers	WRE	456	206	84	0	507	253	130	14
Cam and Ely Ouse (including South Level)	WRE	0	0	0	0	0	0	0	0
East Suffolk	WRE	12	7	6	6	21	6	6	6
Essex	WRE	44	46	49	49	44	46	49	49
Louth Grimsby and Ancholme	WRE	9	2	2	2	5	2	2	2
Lower Trent & Erewash	WRE	1694	678	438	438	1539	534	227	227

CAMS Catchment name	Region	P1 - Q30	P1 - Q50	P1 - Q70	P1 - Q95	P2- Q30	P2 - Q50	P2 - Q70	P2 - Q95
Nene	WRE	77				0	0	0	0
North Norfolk	WRE	17	10	7	1	19	10	7	1
North West Norfolk	WRE	6	4	3	1	6	4	3	1
Old Bedford including the Middle Level	WRE	0	0	0	0	0	0	0	0
Roding, Beam & Ingrebourne	WRE	94	92	91	90	105	102	101	101
Steeping Great Eau and Long Eau	WRE	17	5	4	4	18	7	6	5
Upper and Bedford Ouse	WRE	0	0	0	0	0	0	0	0
Welland	WRE	8	7	7	7	8	8	8	8
Witham	WRE	1	1	0	0	1	1	0	0
Aire and Calder	WReN	538	352	18	0	543	346	149	47
Derwent	WReN	0	0	0	0	0	0	0	0
Don and Rother	WReN	4	2	1	0	460	330	291	286

CAMS Catchment name	Region	P1 - Q30	P1 - Q50	P1 - Q70	P1 - Q95	P2- Q30	P2 - Q50	P2 - Q70	P2 - Q95
Esk and Coast	WReN	158	75	36	1	157	68	24	1
Hull and East Riding	WReN	3093	1078	319	70	4303	1932	981	559
Northumberl and Rivers	WReN	252	98	28	15	252	98	28	15
Swale, Ure, Nidd & Upper Ouse	WReN	623	75	0	0	648	95	0	0
Tees	WReN	507	70	7	6	507	70	7	6
Till	WReN	80	45	23	4	80	45	23	4
Tyne	WReN	1359	747	327	209	1359	747	327	209
Wear	WReN	416	224	155	145	416	224	155	145
Wharfe and Lower Ouse	WReN	884	201	0	0	905	214	1	1
Adur & Ouse	WRSE	35	4	0	0	39	7	0	0
Arun & Western Streams	WRSE	186	25	14	14	284	118	64	28
Cherwell, Thame and Wye	WRSE	0	0	0	0	0	0	0	0
Colne	WRSE	0	0	0	0	0	0	0	0
Cotswolds	WRSE	0	0	0	0	0	0	0	0

CAMS Catchment name	Region	P1 - Q30	P1 - Q50	P1 - Q70	P1 - Q95	P2- Q30	P2 - Q50	P2 - Q70	P2 - Q95
Cuckmere & Pevensey Levels	WRSE	42	17	10	11	43	18	12	11
Darent	WRSE	430	429	428	428	434	433	432	432
East Hampshire	WRSE	41	40	40	39	41	40	40	39
Isle of Wight	WRSE	7	2	1	1	11	4	4	2
Kennet and Vale of White Horse	WRSE	0	0	0	0	0	0	0	0
Loddon	WRSE	0	0	0	0	0	0	0	0
London	WRSE	64	0	0	0	5	1	0	0
Medway	WRSE	15	10	6	3	23	18	14	11
Mole	WRSE	0	0	0	0	0	0	0	0
North Kent	WRSE	3	1	1	0	3	1	1	0
Rother	WRSE	327	139	139	24	342	146	146	26
Stour	WRSE	221	109	45	70	328	216	146	82
Test & Itchen	WRSE	0	0	0	0	0	0	0	0
Thames Corridor	WRSE	732	438	439	439	440	439	440	440
Upper Lee	WRSE	0	0	0	0	0	0	0	0
Wey	WRSE	0	0	0	0	0	0	0	0

CAMS Catchment name	Region	P1 - Q30	P1 - Q50	P1 - Q70	P1 - Q95	P2- Q30	P2 - Q50	P2 - Q70	P2 - Q95
Derbyshire Derwent	WRW	0	0	0	0	0	0	0	0
Derwent & West Cumbria	WRW	2966	1235	634	282	2980	1242	638	284
Dove	WRW	0	0	0	0	30	0	0	0
Eden and Esk	WRW	636	260	108	29	636	260	108	30
Idle & Torne	WRW	0	0	0	0	27	0	0	0
Lower Mersey & Alt	WRW	2493	1539	1173	947	2559	1599	1230	975
Lune and Wyre	WRW	1040	265	11	11	1040	265	11	11
Northern Manchester	WRW	354	260	231	231	364	268	238	238
Ribble, Douglas and Crossens	WRW	1248	613	443	328	1301	658	455	331
Severn Corridor	WRW	3223	984	181	181	3561	1297	444	390
Severn Vale	WRW	58	27	11	11	67	36	18	18
Shropshire Middle Severn	WRW	67	0	0	0	97	47	47	47
Soar	WRW	300	238	210	200	304	241	158	158

CAMS Catchment name	Region	P1 - Q30	P1 - Q50	P1 - Q70	P1 - Q95	P2- Q30	P2 - Q50	P2 - Q70	P2 - Q95
South Cumbria	WRW	845	345	165	100	945	406	198	100
Staffordshire Trent Valley	WRW	63	12	9	9	166	104	72	57
Tame Anker and Mease	WRW	749	410	325	325	719	296	158	158
Teme	WRW	438	0	0	0	446	110	15	15
Upper Mersey	WRW	1054	851	769	769	1078	873	791	771
Warwickshire Avon	WRW	302	0	0	0	339	272	226	226
Weaver and Dane	WRW	269	112	37	15	285	127	53	33
Worcestershire Middle Severn	WRW	43	0	0	0	121	92	47	47

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6 List of abbreviations

AI – Artificial intelligence

AIGZs – AI growth zones

ALS – Abstraction Licensing Strategy

BAU/BAU+ - Business as usual

BL – Baseline

CCS – Carbon Capture Storage

DI – Distribution input

DO – Deployable output

DSIT – Department of Science, Innovation and Technology

DYAA – Dry year annual average

ED – Environmental Destination

EIP – Environmental Improvement Plan

FP – Final Plan (WRMP)

GCM – Global Climate Model

HH – Household

HOF – Hands off flow

IWC – Independent Water Commission

l/h/d – Litres per head per day

LAP – Local Authority Plan

MHCLG – Ministry of Housing, Communities and Local Government

Ml/d – Megalitres per day

NEUBs – Non-essential use bans

NFWR2025 – National Framework for Water Resources 2025

NHH – Non-household

NISTA – National Infrastructure and Service Transformation Authority

NPP – National Population Projection

ONS – Office for National ~Statistics

OT - Outturn

PCC – per capita consumption

RAPID – Regulators’ Alliance for Progressing Infrastructure Development

RCM -Regional Climate Models

RCP – Regional Climate Programme

SRO – Strategic Resource Options

SSSI – Sites of Special Scientific Interest

TraC – Transitional and coastal catchments

TUBs – Temporary Use Bans

UKCP18 – UK Climate projections 2018

UKWIR – UK Water Industry Research

WAFU – Water available for use

WCWE – West Country Water and Environment

WINEP – Water Industry National Environment Programme

WRE – Water resources East

WREW – Water Resources model for England and Wales

WReN – Water Resources North

WRGIS – Water Resources Geographical Information System

WRMP – Water Resources Management Plan

WRSE – Water Resources South East

WRW – Water Resources West

WRZ – Water Resource Zone