# Final Draft Water Resources Management Plan 2024: Annexes 7a-7e

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WATER for LIFE

from Southern Water

# 1. Annex 7a: Growth Forecast Methodology

# Population & Property Forecasts

## Methodology & Outcomes

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# Acknowledgements

Demographic statistics used in this report have been derived from data from the Office for National Statistics, licensed under the Open Government Licence v.3.0.

Note: throughout this document the term ‘forecast’ is used as a generic term to encapsulate the range of trend projections and plan-led forecasts presented in the analysis.

*The authors of this report do not accept liability for any costs or consequential loss involved following the use of the data and analysis referred to here; this is entirely the responsibility of the users of the information presented in this report.*

# Contents

# 1 Introduction

## Context

1.1 The UK is at a watershed moment in its political, economic and demographic history. The country's decision to exit the European Union (EU) and the electoral mandate given to the new government, has been quickly followed by the unprecedented impact of the Coronavirus pandemic. Predicting when and how the UK recovers from the current crisis and the economic and demographic futures that will result, presents a real challenge. Amidst this uncertainty, the UK government has clearly stated its determination to accelerate the rate of house building, introducing targets and incentives to ensure that an aspirational objective of 300,000 new homes per year is achieved[1].

1.2 Robust evidence on future housing growth and demographic change, are key components of the Water Resources Planning Guidelines (WRPG)[2,3], issued by the Environment Agency (EA) and Natural Resources Wales, in collaboration with the Department for Environment, Food and Rural Affairs (Defra), the Welsh Government and Ofwat. These guidelines for the development of Water Resources Management Plans (WRMP) are now accompanied by similar documentation for the development of Drainage and Wastewater Management Plans (DWMP)[4], for which housing and demographic evidence is of equal importance.

1.3 A key enhancement to previous WRMP cycles is the EA's development of a new national framework for water resource management, consisting of five regional water resource planning groups: Water Resources South East (WRSE), Water Resources East (WRE), Water Resources South West (WRSW), Water Resources West (WRW) and Water Resources North (WRN). Evidence on future housing and population growth are critical to the collective business planning process, informing each region's Statement of Regional Resource Position (SRRP) and the WRMP24 statements of each member of the regional alliances.

## Regulatory Guidance

1.4 The WRPG provides a framework for water companies to follow when developing and presenting their WRMPs. The guidelines summarise the key requirements for population, property and occupancy forecasts that feed into WRMP evidence, emphasising the importance of using housing growth evidence from Local Plans:

[1] MHCLG, Planning for the Future (March 2020)
[2] Water Resources Planning Guideline (May 2016)
[3] Water Resources Planning Guideline, Interim Update (July 2018)
[4] Drainage and Wastewater Management Plans (September 2019)

*"For companies supplying customers wholly or mainly in England you will need to base your forecast population and property figures on local plans published by the local council or unitary authority." (section 5.3)*

1.5 The WRPG acknowledges that councils may be at different stages of Local Plan development but states if a local council has:

- *"….a published adopted plan that is not being revised, you must take account of the planned property forecast. You will need to ensure your planned property forecast and resulting supply does not constrain the planned growth by local councils. If you adjust the planned property forecast and select a higher number, you will need to justify why you have selected a higher forecast and provide evidence.*
- *published a draft plan but it has not yet been adopted you must take account and use this as the base of your forecast. You should discuss with your local council whether it expects to make changes to the forecast for the adopted plan*
- *not started or published a draft plan you should use alternative methods such as household projections from Department of Communities and Local Government or derive your own analysis using methodologies outlined in UKWIR (2016) Population, household property and occupancy forecasting" (section 5.3)*

1.6 The WRPG highlights a number of additional requirements concerning the data inputs and assumptions used in the development of population, property and occupancy forecasts. It requests that water companies should:

- *"Clearly describe the assumptions and supporting information used to develop population, property and occupancy forecasts. You should demonstrate you have incorporated local council information (particularly in relation to their published adopted local plans) in England.*
- *explain the methods you have used to forecast property figures after the planning period used by local councils (for example from years 15 to 25 in the planning period).*
- *demonstrate how you have included other sources of information and amended your forecast accordingly" (section 5.3)*

1.7 The WRPG makes explicit reference to the likely uncertainty associated with demographic forecasts, requiring water companies to:

- *"Clearly describe any limitations in your forecast*
- *Demonstrate that you understand the uncertainty associated with your forecasts*
- *Clearly explain the assumptions, risks and uncertainties associated with the results.*
- *If you are using a planning period beyond 25 years and are basing decisions on this forecast, you should explain the range of uncertainties this long-range forecast will have and how your plan will adapt to these." (section 5.3)*

1.8 WRMP demographic evidence must include an indication of the size of the population not captured in published statistics, with the guidance requesting that water companies should:

*"explain the assumptions about how you have derived unaccounted population" (sect. 5.3)*

1.9 Finally, the WRPG requests that the methodology for allocation of population and property forecasts to Water Resource Zones (WRZs) is made explicit, requesting that water companies:

*"describe how you have allocated populations to the geographically different WRZs, e.g. using neighbourhood plans or census data to further subdivide the populations" (sect. 5.3)*

1.10 To support the WRPG demographic guidance, UKWIR has produced a suite of documents which provide advice on the development of population, property and occupancy forecasting.[5] The UKWIR documentation is in three forms: a **Guidance Manual**; a **Worked Example**; and a **Supplementary Report**. The latter includes a review of engagement with key industry stakeholders and a technical review of potential forecasting approaches that underpin the WRMP guidance methodology. The UKWIR Guidance Manual is not prescriptive in terms of methodological recommendations. It provides guidance on the issues that should be considered at each stage of development but provides scope for water companies to consider and apply methods they deem to be appropriate.

# This Document

1.11 Edge Analytics is a Data Science specialist, applying a combination of research, data, technology and analytical models to generate insight that better informs business planning and decision-making. Edge Analytics has a particular expertise in demographic modelling and forecasting and has developed a suite of products to meet the regulatory requirements for evidence-based planning in the water industry.

1.12 This document provides a guide to the **VICUS** methodology that has been used to configure and deliver housing and population growth evidence to the water industry's new regional planning framework, informing WRMP and DWMP processes for individual water companies.

1.13 Section 2 provides an overview of the **VICUS** framework, plus a summary of the mix of data sources required to inform the forecasting process: a combination of water industry data, Local Plan housing evidence (**Consilium**), plus population and related demographic statistics.

1.14 Section 3 describes the forecasting methodologies employed to derive and present the suite of scenarios, at macro- and micro-level and for a horizon that stretches to 2100.

1.15 Section 4 summarises the format and content of the forecasting output that has been produced to inform the WRMP and DWMP planning process, at regional, WRZ and micro-scales.

[5] WRMP19 - Methods - Population, Household Property and Occupancy Forecasting (December 2015)

# 2 Framework & Data Inputs

## Forecasting Framework

2.1 The VICUS forecasting framework for the configuration and delivery of population and property forecasts is illustrated below (Figure 1).

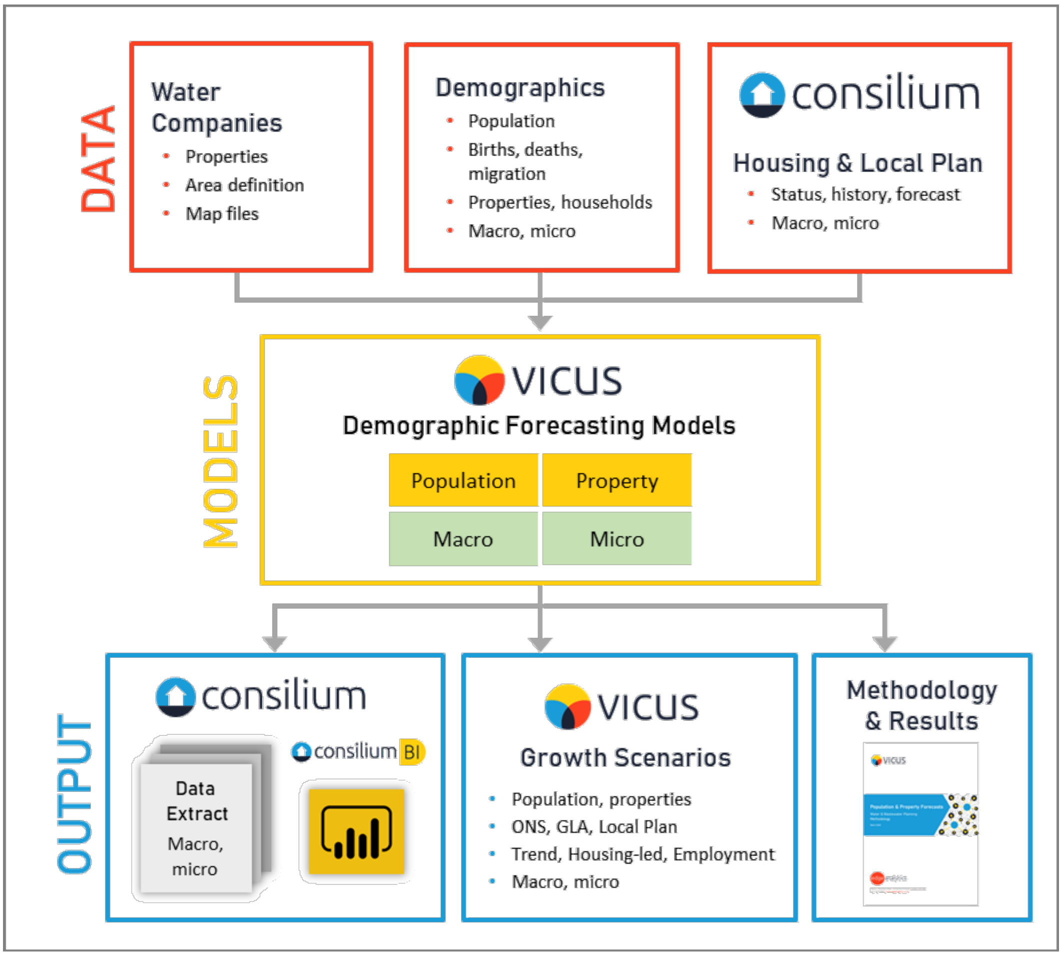



Figure 1: VICUS Forecasting Framework

2.2 Robust and timely data inputs are key to the forecasting process, including precise area definitions for water company geographies; Local Plan evidence from all local authorities; plus, historical and base-year demographic statistics on population, births, deaths, migration and properties.

2.3 The VICUS model combines all data inputs within best practice forecasting methodologies, enabling macro- and micro-level population and property growth scenarios to be derived under a wide range of assumptions, for scenario horizons that stretch to 2100.

2.4 The forecasting framework integrates key housing-led scenarios, alongside complementary evidence produced by the Office for National Statistics (ONS), the Greater London Authority (GLA) and the Welsh Government (WG).

2.5 Outputs from the process are delivered as (Microsoft Power BI) Dashboard summaries to encourage wider consumption; as detailed datasets to enable further scrutiny and analysis; and as documentation to ensure transparency and robustness of methodology.

## Water Company Data

2.6 Water company geographies do not conform to the administrative areas for which population and other demographic statistics are typically available (e.g. district, ward, output area), so area-matching is a critical component of the forecasting framework.

2.7 Boundary files have been provided by individual water companies, for Water Resource Zone (WRZ) geographies (Figure 2) and for a variety of other water and wastewater areas. The Royal Mail's Postcode Address File (PAF) has provided the postcode-level property distributions from which the detailed 'lookup' between water industry and administrative geography has been made, enabling population and property growth forecasts to be apportioned for WRMP and DWMP purposes.

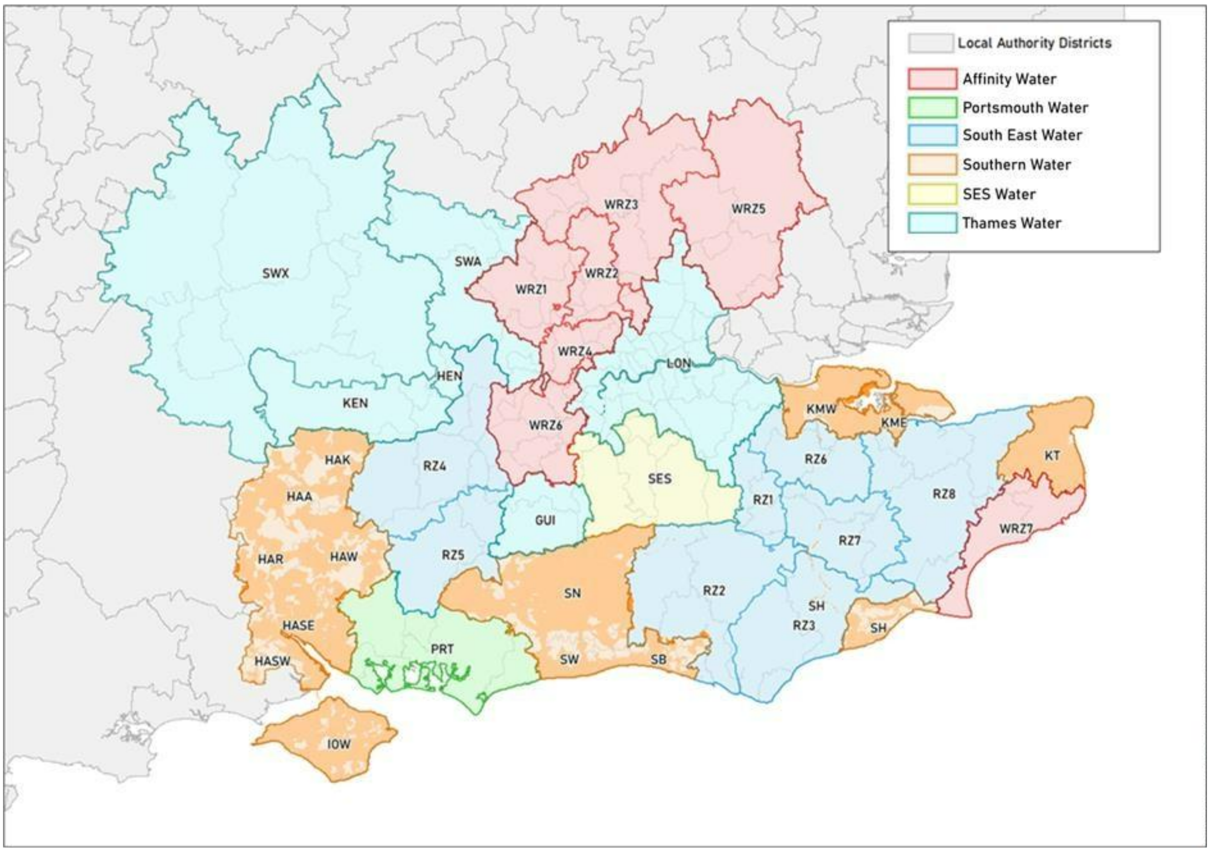



Figure 2: WRSE Water Resource Zone Geography

# Demographic Data & Assumptions

## Population

2.8 Data on *historical* population change are drawn from ONS mid-year population estimates (MYE). This data records population by single year of age (0–90+) and sex, with 2018 being the latest MYE available.

2.9 Successive ONS sub-national population projections (SNPP) have different base population (e.g. the 2018-based projections have a 2018 base year). For ease of comparison, the scenarios presented within the VICUS framework have been recalibrated to ensure a consistent 2018 base-year population.

2.10 In the formulation of its growth scenarios, the Greater London Authority (GLA) has produced a modified set of MYE for its London boroughs, taking account of issues associated with the incorrect treatment of children in estimated migration flows to and from individual boroughs.

## Fertility & Mortality

2.11 Historical statistics on births (by sex) and deaths (by age and sex) are drawn from the ONS MYE dataset. Age-specific fertility rates (ASFR) and age-specific mortality rates (ASMR) are derived from these historical birth and death statistics, in combination with area-specific population data.

2.12 Long term assumptions on changes in age-specific fertility and mortality are determined by the ONS National Population Projection (NPP) series, the latest of which is the 2018-based round of projections.

2.13 Forecasts of future births and deaths are based on the application of ASFR and ASMR schedules (and their associated long-term assumptions) to the changing 'population-at-risk' in an area.

## Migration

2.14 Historical statistics on both internal and international migration are drawn from the ONS MYE dataset, providing inflow and outflow data by five-year age group and sex.

2.15 Different scenarios apply different assumptions on the future impact of migration, typically drawn from the 2001–2018 historical time-period (e.g. 5-year history, 10-year history, 18-year history).

2.16 Forecasts of internal migration are based on the application of age-specific migration rate schedules to the changing 'population-at-risk' in an area. International migration is forecast as a fixed annual balance between emigration and immigration effects.

2.17 ONS and GLA scenario assumptions on migration are reproduced within the VICUS framework. Housing-led scenarios use migration as the balancing factor which matches population growth to planned changes to an area's housing stock.

## Households & Properties

2.18 The household and dwelling (property) implications of each population growth trajectory are estimated through the application of household representative rates, communal population statistics and a dwelling vacancy rate.

2.19 A household representative rate is defined as the *"probability of anyone in a particular demographic group being classified as being a household representative"*. The household representative rates used in the VICUS framework have been drawn from the Ministry for Housing, Communities and Local Government's (MHCLG) 2014-based household projection model, which is underpinned by the ONS 2014-based sub-national population projection.

2.20 Following the financial crash of 2007/08, there has been a reduction in the rate of household formation amongst young adults. In the housing-led scenarios presented within the VICUS framework, the potential for a return to higher rates of household formation amongst young adults is considered, returning household representative rates to their 2001 levels by 2039.

2.21 Forecasts of household and property numbers exclude the population 'not-in-households', i.e. those living in communal establishments[6]. These data are drawn from the MHCLG 2014-based household projections, using statistics from the 2011 Census. For ages 0–74, the number of people not-in-households in each age group is fixed throughout the forecast period. For ages 75–85+, the proportion of the population not-in-households is recorded, so the population not-in-households for ages 75–85+ varies across the forecast period depending on the size of the age-group population.

2.22 The relationship between household and properties is modelled using a 'vacancy rate', sourced from the 2011 Census.

2.23 All scenarios have been calibrated to ensure a consistent 2020 property total. The base year property total for each individual output area (OA) has been drawn from the Royal Mail's PAF. As a validation step and to avoid inappropriately small property numbers, 494 OAs (out of a total of 181,408 in England & Wales) had their PAF address count total replaced with a 2011 Census dwelling count.

## Labour Force & Jobs

2.24 The relationship between population change and employment is modelled using key assumptions on economic activity, unemployment and commuting.

2.25 Economic activity (participation) rates are the proportion of the population that are actively involved in the labour force, either employed or unemployed and looking for work. For each area, economic activity rates by five-year age group (ages 16–89) and sex have been derived from Census statistics, with forecast adjustments made in line with the Office for Budget Responsibility's (OBR) analysis of labour market trends in its 2018 Fiscal Sustainability Report[7].

[6] Communal establishments include prisons, residential care homes, student halls of residence and certain armed forces accommodation.
[7] OBR, Fiscal Sustainability Report 2018

2.26 The unemployment rate is the proportion of unemployed people within the total economically active population. For each local authority area, historical unemployment rates are sourced from ONS model-based estimates, utilising data on unemployment benefit claimant counts.

2.27 A commuting ratio indicates the balance between the level of employment and the number of resident workers within a local authority area. A commuting ratio greater than 1.00 indicates that the size of the resident workforce exceeds the level of employment available in the area, resulting in a net out-commute. A commuting ratio less than 1.00 indicates that employment in the area exceeds the size of the labour force, resulting in a net in-commute.

## Consilium Local Plan Data

2.28 The development of growth forecasts to inform WRMP24 plans must be underpinned by evidence on Local Plan housing growth for those Local Planning Authorities (LPA) that overlap the WRZ geography. The Local Plan development process is often lengthy and complex, with each LPA at a different stage of plan development. MHCLG and Homes England continue to apply pressure to accelerate housing delivery, whilst the UK's exit from the EU and the current pandemic crisis, create considerable uncertainty regarding future economic and demographic change.

2.29 Edge Analytics' **Consilium** database has been developed to enable the collection, processing, organisation and delivery of Local Plan evidence, for all LPAs across the UK (including National Parks and Development Corporations). Data is collected at a macro level, providing Local Plan evidence for individual LPAs, and at micro level, providing site-specific housing growth locations.

2.30 Local Plan evidence comes in a variety of forms, with considerable variation between LPAs. The Consilium database has sought to bring order, coherence and consistency to the evidence, with a classification of housing documentation and statistics detailed below (Table 1). This classification reflects the format and content of LPA evidence and includes historical **completions**, housing **need**, housing **requirement**, housing **supply** and planned **delivery**.

2.31 For each LPA that falls within WRZ boundaries, Consilium provides a summary of all Local Plan housing evidence, presenting information on: Local Plan status; historical and planned housing growth trajectories (including LPA and MHCLG completion statistics); housing need; housing requirements and targets; plus housing growth locations (site data). Also included within Consilium is the MHCLG's Housing Delivery Test and the latest LPA 5-year land supply calculations.

2.32 The site data provides geocoded information on housing growth locations, the number of planned units and the likely phasing (timing) of development. This information is key to the configuration and calibration of the micro-level, 'bottom-up' forecasts.

2.33 A 'Status Log' indicating the date at which Local Plan information was last accessed for each LPA is provided in Appendix B.

Table 1: Consilium – Housing Data Classification

| | | |
|---|---|---|
| **1** | Completions | Historical housing completions (net), sourced from Local Authority data and the MHCLG (Live Table 122). |
| **2** | Local Housing Need (LHN) | Minimum housing need, as calculated using the MHCLG 'standard method', which is based on the 2014-based household growth projections, with an adjustment to account for affordability. |
| **3** | Objective Assessment of Need (OAN) | A measure of future need, as calculated by the planning authorities (used prior to the introduction of the LHN). |
| **4** | Requirement | As set out in the NPPF, the housing requirement (provision target) identifies the extent to which the identified need can be met over the plan period. |
| **5** | 5 Year Supply | The 5-year land supply is a calculation of whether there is a deliverable supply of homes to meet the planned housing requirement over the next 5 years. |
| **6** | HLA | The land availability assessment is carried out by planning authorities to assess the availability, suitability and achievability of sites and broad locations for potential housing development. |
| **7** | Planned Delivery | Planning authorities should produce a trajectory of expected housing delivery over the plan period, with the anticipated rate of development for specific sites (where appropriate). Housing trajectories are often published as part of the Local Plan and are updated annually in monitoring/land supply reports. |

2.34 Consilium data is sourced from published documentation/statistics or directly from Councils, if not readily available. All site data is converted to a standard Consilium format, with all housing growth sites given a geocode (if not provided by the original source information).

2.35 Accompanying the forecasting outputs, the following Consilium data is provided:

- MS Excel spreadsheets / database extracts
- All relevant Local Plan documentation
- GIS files of housing growth sites (where available)
- Consilium-BI Dashboard powered by Microsoft's Power BI technology.

2.36 Examples of the macro- and micro-level Consilium data extracts are provided (Figure 3, Figure 4), together with an example of the Consilium-BI area reports: 'Housing & Population Growth History' and 'Local Plan Status & Housing Growth' (Figure 5, Figure 6).

## Consilium: Local Plan Summary

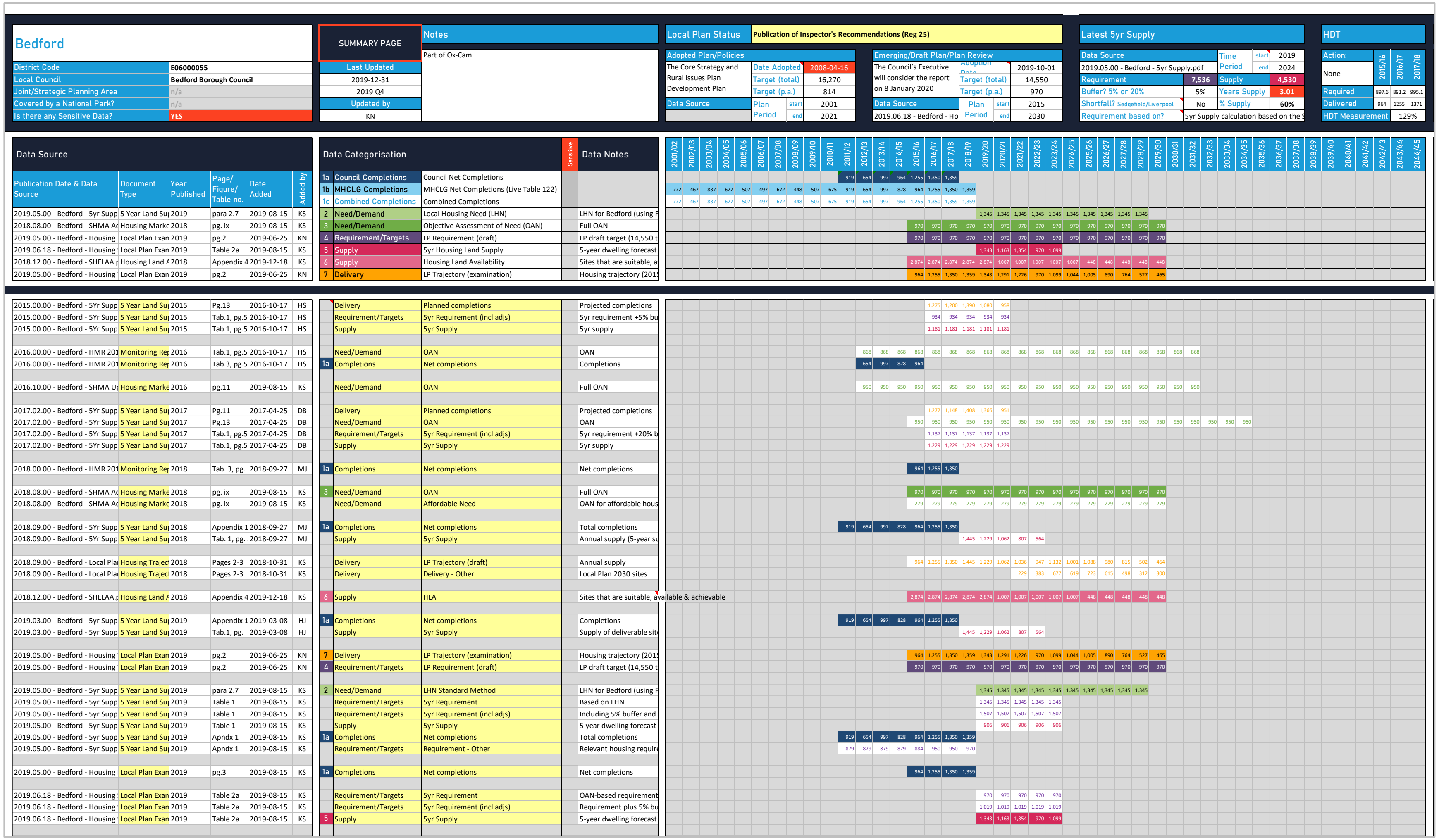



Figure 3: Consilium – Local Plan Summary – Example Only

## Consilium: Housing Growth Locations

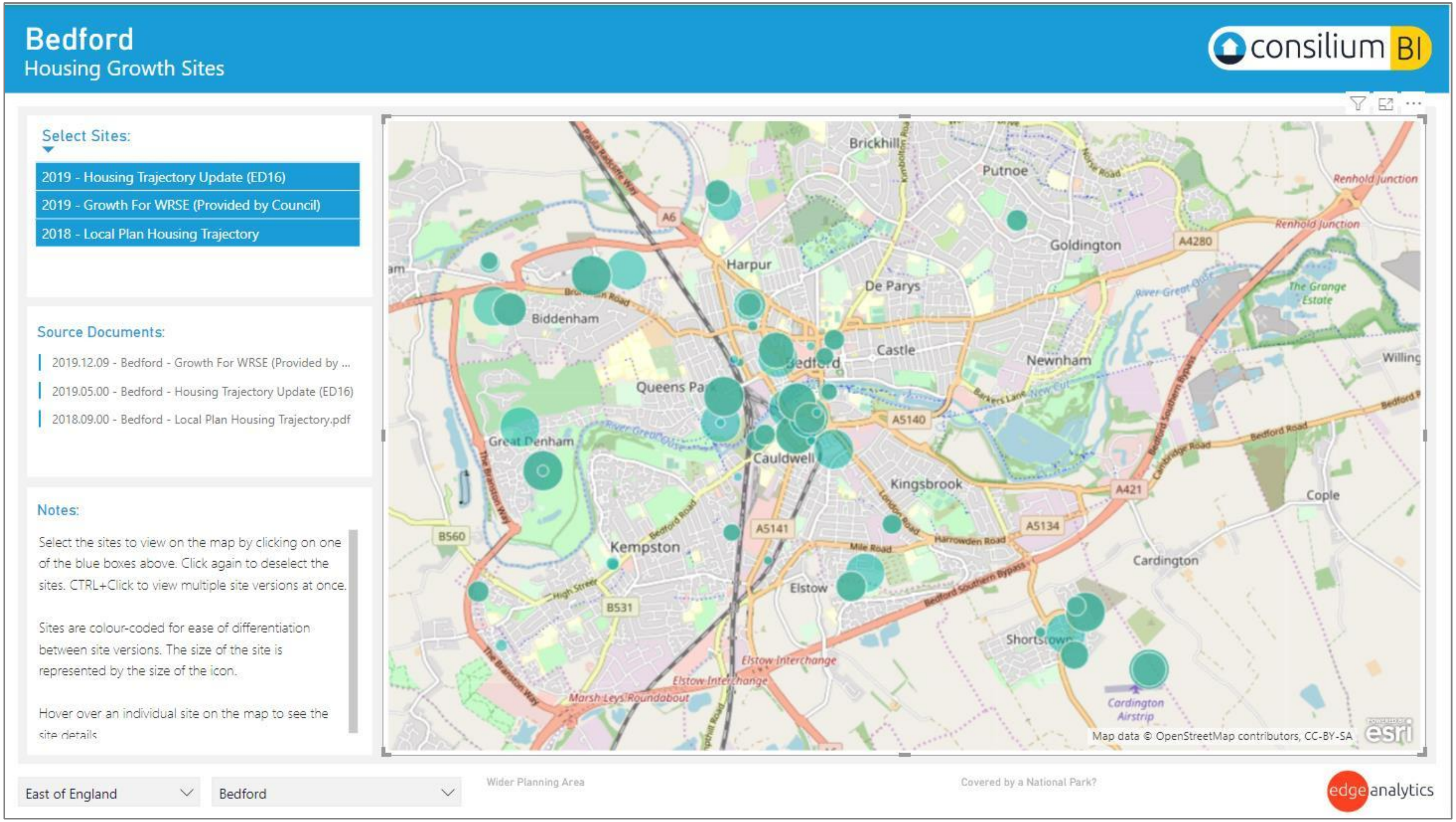



Figure 4: Consilium – Site Data – Example Only

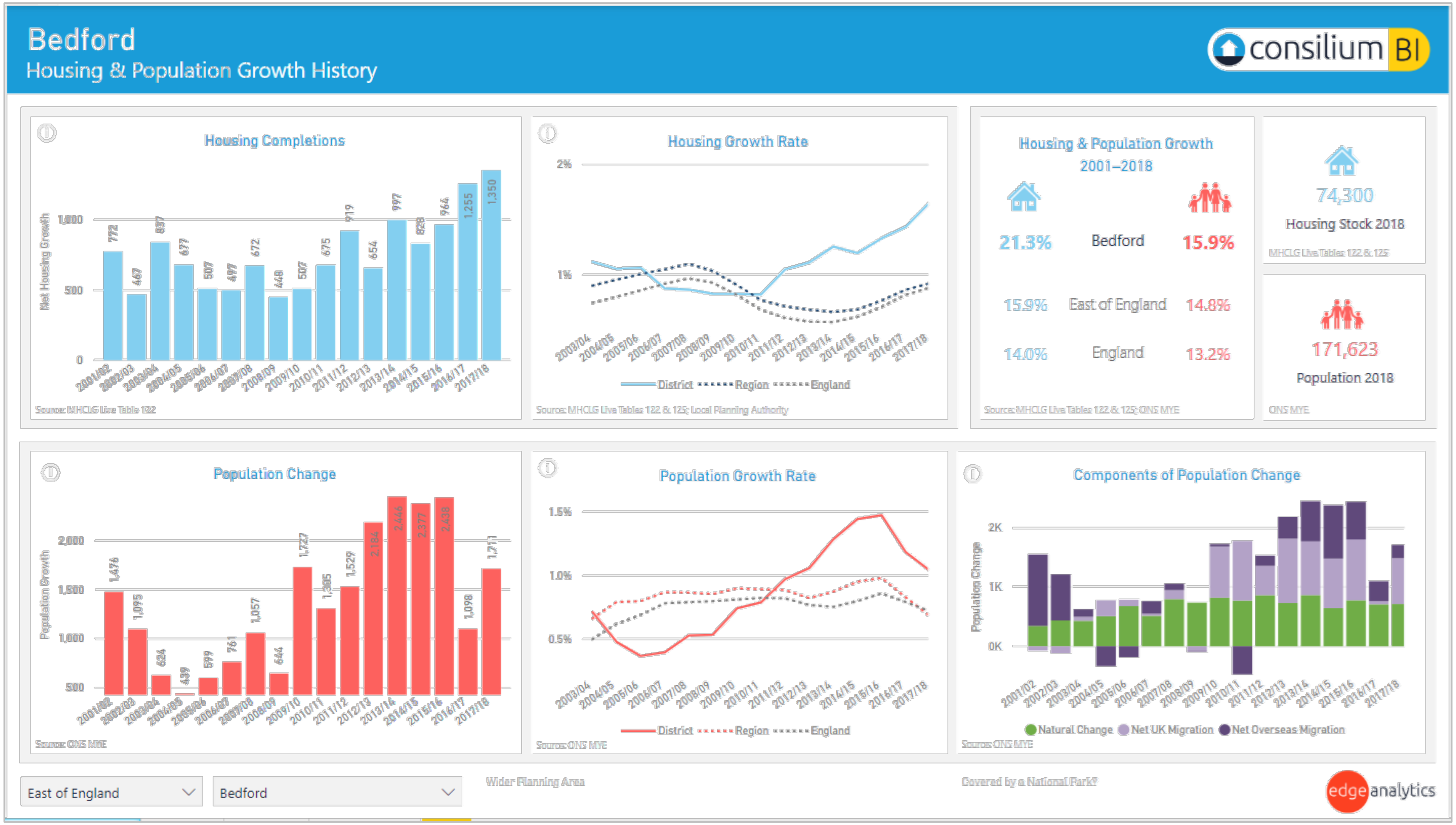



Figure 5: Consilium-BI Dashboard – Area History – Example Only

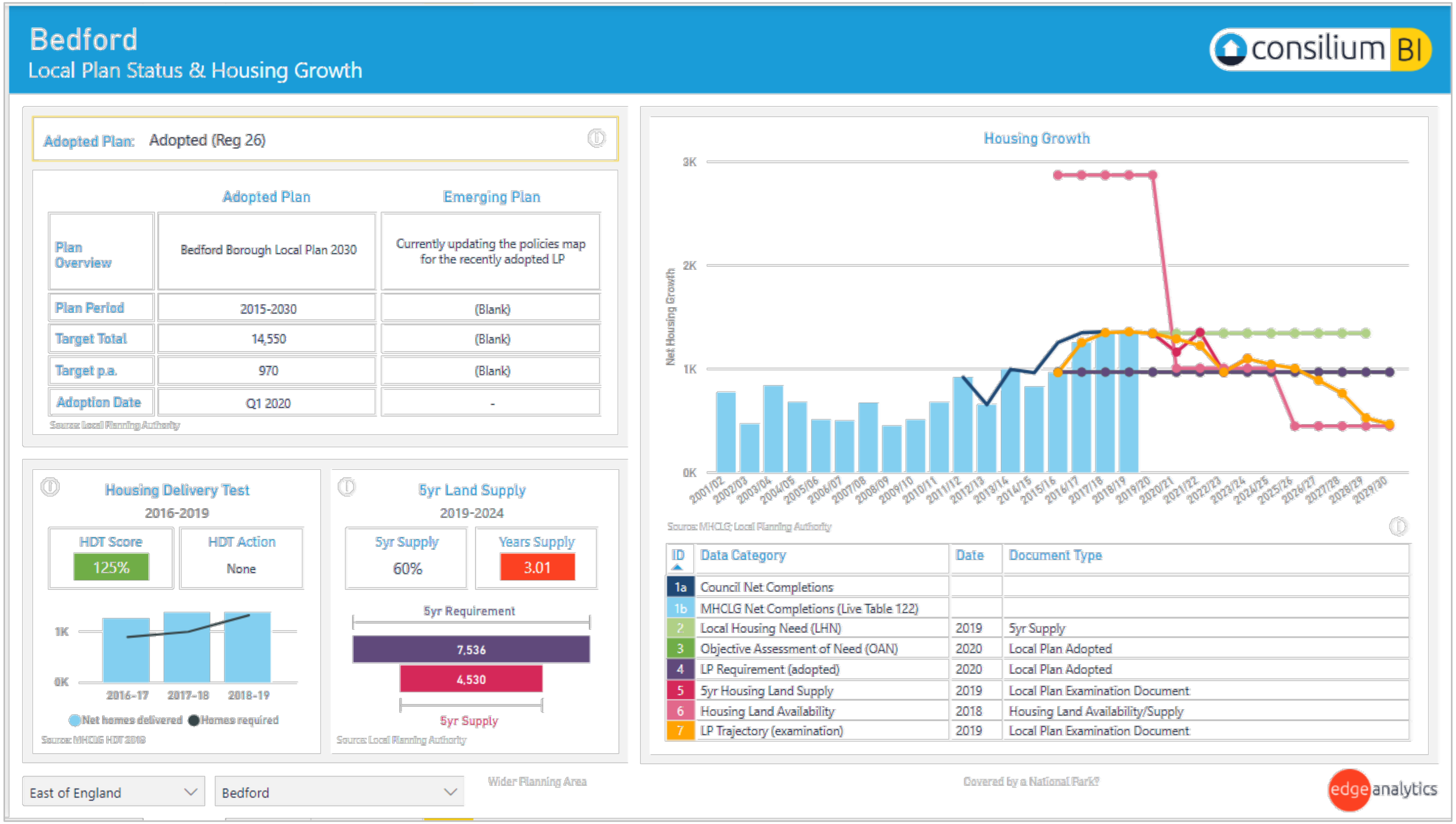



Figure 6: Consilium B- Dashboard – Local Plan Status – Example Only

# 3 Methodology

## Forecasting Models

3.1 The VICUS modelling framework combines a database of data inputs with a suite of forecasting software, enabling macro- and micro-level population and property growth scenarios to be derived under a wide range of assumptions, for scenario horizons that stretch to 2100 (Figure 1). The forecasting framework integrates housing-led scenarios, alongside trend projections which include published output from ONS, GLA and WG.

3.2 The key element of the framework is the cohort-component model, which uses fertility, mortality and migration components to derive population projections by single year of age, for each year of a (flexible) forecast period. The cohort-component method has a long and established history in demography and is widely used by national statistical agencies and the research community.

3.3 The household model and labour force models are separate software components, but they have a high degree of dependency upon population outputs from the cohort component model, enabling the derivation of property and employment forecasts.

3.4 The household model uses a combination of household representative rates, communal population statistics and a dwelling vacancy rate to estimate the household and dwelling (property) implication of each population growth trajectory.

3.5 The labour force model uses key assumptions on age-specific rates of economic activity (participation), unemployment and commuting, to estimate the relationship between population change and employment.

3.6 Importantly, the household and labour force models can be run in 'housing-led' or 'employment-led' mode, using pre-determined forecasts of housing or employment to estimate the likely population growth associated with each. Migration provides the balancing factor, altering population growth to meet annual housing or employment growth targets.

3.7 The 'housing-led' approach is particularly important in the evaluation of alternative trajectories of housing growth derived from the range of Local Plan evidence published by LPAs. A 'housing-led' scenario is also an important element of the suite of output published by the GLA.

3.8 Where data on site-level housing developments is available from an LPA, the 'housing-led' approach reverts to a combined 'top-down' and 'bottom-up' methodology, aligning macro and micro forecasts of population change to the location and phasing (timing) of planned additions to the dwelling stock.

3.9 The use of micro-geographies in the forecasting methodology enables accurate aggregation of all scenario output to water company planning areas.

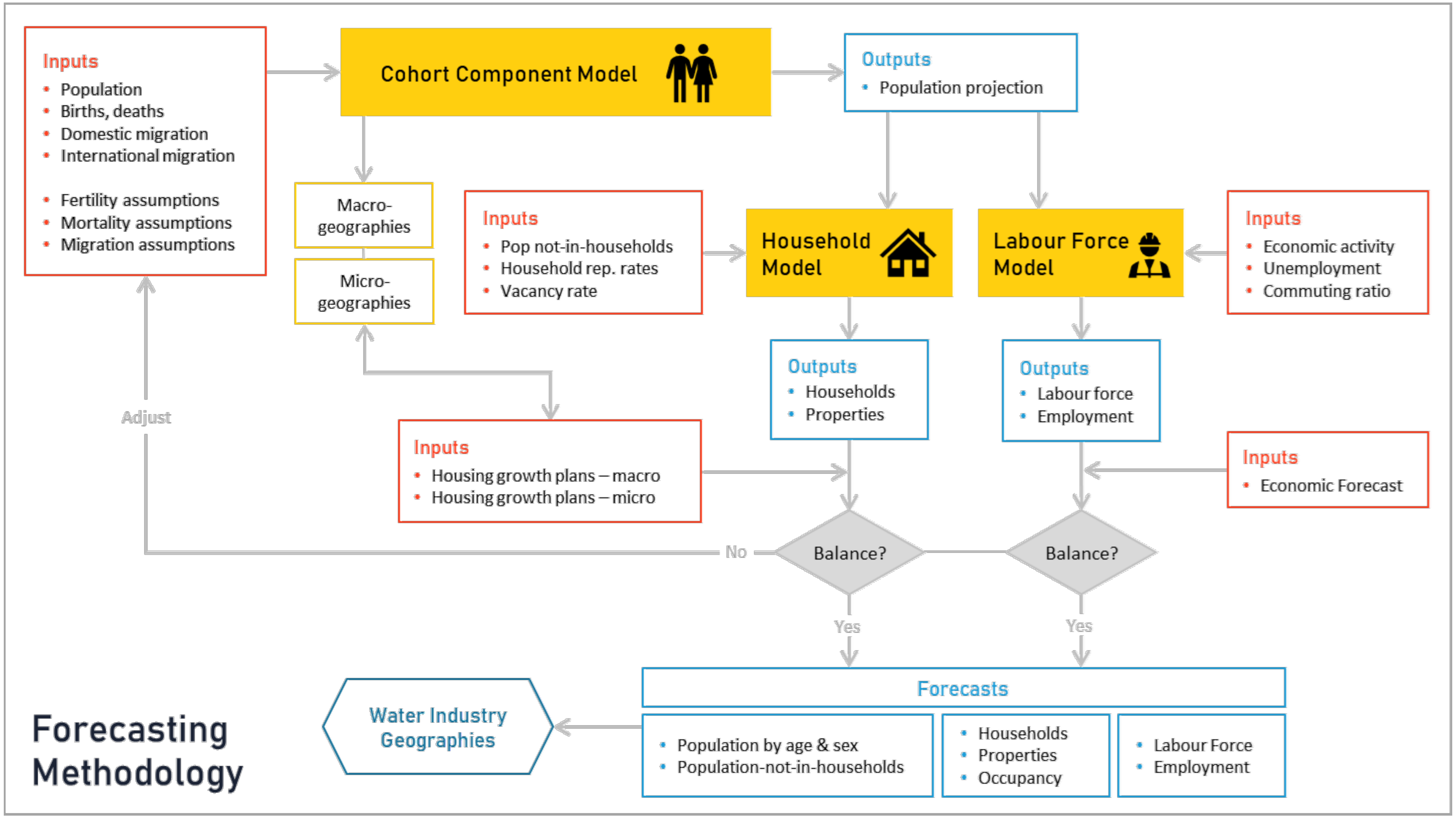



Figure 7: VICUS – Forecasting Methodology

# Scenario Development

3.10 The VICUS framework has been used to configure and calibrate a range of scenarios, for both the 2020–2050 WRMP plan-period, plus the long-term 2020–2100 outlook. Each scenario has a growth trajectory for 2020–2050, coupled with three alternative growth scenarios for 2050–2100.

3.11 The range of outcomes is necessary to enable consideration of the uncertainty associated with the demographic components of population change, the effects of different scales and phasing of future housing growth, plus the impact of alternative data inputs and assumptions applied by ONS and GLA.

3.12 The 2020–2050 scenarios can be broadly classified into three groups (Table 2):

- **Trend projections (ONS, GLA)**
- **Housing-led forecasts (Local Plan, GLA, OxCam)**
- **Employment-led forecasts**

3.13 Growth scenarios for 2050–2100 are underpinned by fertility, mortality and migration assumptions from the ONS 2018-based NPP, configuring a principal, low and high growth outcome (Table 3).

3.14 For ease of comparison, the scenarios presented within the VICUS framework have been recalibrated to ensure a consistent 2018 base-year population (the latest MYE available from ONS). In addition, all scenarios have been calibrated to ensure a consistent 2020 property total, with base year property totals aligning to the Royal Mail's PAF statistics.

3.15 All scenarios produce statistics on population, households, population not-in-households and dwellings (properties) and occupancy. In addition, all 2020–2050 scenarios can produce output on estimated labour force and employment outcomes. A more detailed description of each of the scenarios follows, preceding an illustration of the range of growth outcomes for the WRSE area of operations.

# ONS & GLA Trend Projections

## ONS Projections

3.16 ONS produces its sub-national population projections (SNPP) every two-years, following publication of the 'national' population projection (NPP)[8]. The NPP provides the constraining total for the SNPP. A cohort-component methodology underpins the formulation of the population projections.

3.17 ONS projections are classified by their base-date, with the latest round of projections being the 2018-based scenarios. At each successive round of the ONS projections, revisions to key assumptions on fertility, mortality and international migration are made, with the support of an expert panel of advisors[9]. The impact of these assumptions on the UK national projections in the 2014-based, 2016-based and 2018-based round of projections is illustrated in Appendix D.

[8] ONS Subnational Population Projections for England: 2018-based
[9] National population projections, how the assumptions are set: 2018-based

Table 2: VICUS – Scenario Definition, 2020–2050

| ID | | Scenario | Description | URL |
|---|---|---|---|---|
| Trend Projections | 1 | ONS-14 | ONS 2014-based sub-national population projection (SNPP), using a six-year history (2008–2014) to derive local fertility, mortality and internal migration assumptions, with a long-term UK net international migration assumption of +185k p.a. | ONS 2014 |
| | 2 | ONS-16 | ONS 2016-based Principal sub-national population projection (SNPP), using a five-year history (2011–2016) to derive local fertility, mortality and internal migration assumptions, and a long-term UK net international migration assumption of +165k. In line with the ONS 2016-based national population projection (NPP), this round of projections includes a reduced UK fertility outlook compared to ONS-14 and a dampened rate of improvement in life expectancy compared to ONS-14. | ONS 2016 |
| | 3 | ONS-18 | ONS 2018-based Principal sub-national population projection (SNPP), using a five-year history (2013–2018) to derive local fertility & mortality assumptions and a long-term UK net international migration assumption of +190k. Unlike earlier rounds of SNPP, the 2018-based Principal projection uses a two-year history (2016–2018) of internal migration assumptions, following recent changes to the methodology used for its estimation, which have only covered the latest 2 years. In line with the ONS 2018-based national population projection (NPP), this round of projections includes a reduced UK fertility outlook compared to ONS-16 and a dampened rate of improvement in life expectancy compared to ONS-16. | ONS 2018 |
| | 4 | ONS-18-Alt | ONS 2018-based Alternative Internal Migration sub-national population projection (SNPP), produced by ONS as a comparison with the Principal projection. It uses a five-year average of internal migration (2013–2018), combining 3 years of data based on the old methodology and 2 years based on the new methodology. All other assumptions are consistent with ONS-18. | |
| | 5 | ONS-18-High | ONS 2018-based High International Migration sub-national population projection (SNPP), incorporating a High long-term UK net international migration assumption of +290k p.a., with all other assumptions consistent with ONS-18. | |
| | 6 | ONS-18-Low | ONS 2018-based Low International Migration sub-national population projection (SNPP), incorporating a Low long-term UK net international migration assumption of +90k p.a., with all other assumptions consistent with ONS-18. | |
| | 7 | ONS-18-10Y | ONS 2016-based 10yr Migration (all types) sub-national population projection, using a ten-year history (2008–2018) to derive internal migration assumptions, with all other assumptions consistent with ONS-18. | |
| | 8 | GLA-18-Central | Greater London Authority (GLA) 2018-based Central population projection, incorporating: GLA's own adjustments to the mid-year population estimates of London Boroughs; local fertility and mortality assumptions, trended in line with the ONS 2018-based NPP assumptions; internal and international migration assumptions derived from a 10-year history (2008–2018). This scenario includes projections for London Boroughs and for all other local authority areas. | GLA |
| | 9 | GLA-18-15Y | GLA 2018-based long-term trend projection, incorporating internal and international migration assumptions derived from a 15-year history (2003–2018), with all other assumptions consistent with the Central scenario. This scenario includes projections for London Boroughs and for all other local authority areas. | |
| | 10 | GLA-18-5Y | GLA 2018-based short-term trend projection, incorporating internal and international migration assumptions derived from a 5-year history (2013–2018), with all other assumptions consistent with the Central scenario. This scenario includes projections for London Boroughs and for all other local authority areas. | |
| Housing-led Forecasts | 11 | GLA-Housing | GLA 2018-based Housing-led projection, based on data from the 2016 Strategic Housing Land Availability Assessment (SHLAA). Beyond 2041, housing growth is aligned to the 2035–2041 average. Whilst the housing-led approach is applied to each London Borough, the population projection for Greater London, in total, remains consistent with the Central scenario. This scenario includes projections for London Boroughs only and is combined with the Central scenario for all other local authority areas when aggregated to WRZ geographies. | GLA Housing |

| ID | | Scenario | Description | URL |
|---|---|---|---|---|
| Housing-led Forecasts | 12 | Completions-18Y | A Housing-led scenario, with population growth underpinned by a continuation of the rate of housing growth recorded in each local authority's 18-year completions history (2001–2019). | MHCLG Live Table 122 |
| | 13 | Completions-5Y | A Housing-led scenario, with population growth underpinned by a continuation of the rate of housing growth recorded in each local authority's 5-year completions history (2014–2019). | |
| | 14 | Housing-Need | A Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's Local Housing Need (LHN) or Objectively Assessed Housing Need (OAHN). Following the final year of data, projected housing growth in non-London areas returns to the ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050. | |
| | 15 | Housing-Need-r | A Housing-led scenario, consistent with the Housing-Need scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. | |
| | 16 | Housing-Req | A Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's housing Requirement. Following the final year of data, projected housing growth in non-London areas returns to the ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050. | |
| | 17 | Housing-Req-r | A Housing-led scenario, consistent with the Housing-Req scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. | |
| | 18 | Housing-Plan | A Housing-led scenario, with population growth underpinned by each local authority's Local Plan housing growth trajectory. Following the final year of data, projected housing growth in non-London areas returns to the ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050. | |
| | 19 | Housing-Plan-r | A Housing-led scenario, consistent with the Housing-Plan scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. | |
| Employment-Led Forecasts | 20 | Employment-1 | An Employment-led scenario with 1.0% pa growth in London to 2030 and 0.5% pa thereafter; 0.8% pa growth in the South East and East of England to 2030, 0.4% thereafter. | |
| | 21 | Employment-2 | An Employment-led scenario with 0.5% pa growth in London to 2030 and 0.25% pa thereafter; 0.4% pa growth in the South East and East of England to 2030, 0.2% thereafter. | |
| OxCam Housing-Led Forecasts | 22 | OxCam-1a-r | 'New Settlement' 23k dpa scenario, with c.4.2k dpa above Housing Plan distributed between Cherwell (20%), Aylesbury Vale (20%), Central Bedfordshire (40%), South Cambridgeshire (20%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. | |
| | 23 | OxCam-1b-r | 'Expansion' 23k dpa scenario, with c 4.2k dpa distributed between: Milton Keynes: (30%) Luton (15%), Bedford (15%), Oxford (10%), Cambridge (10%), Northampton (10%), and Peterborough (10%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. | |
| | 24 | OxCam-2a-r | 'New Settlement' 30k dpa scenario, with c.11.2k dpa above Housing Plan distributed between Cherwell (20%), Aylesbury Vale (20%), Central Bedfordshire (40%), South Cambridgeshire (20%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. | |
| | 25 | OxCam-2b-r | 'Expansion' 30k dpa scenario, with c 11.2k dpa distributed between: Milton Keynes: (30%) Luton (15%), Bedford (15%), Oxford (10%), Cambridge (10%), Northampton (10%), and Peterborough (10%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. | |

3.18 To illustrate the impact of the 2018-based set of assumptions on growth outcomes, the 2014-based and 2016-based ONS projections are included in the VICUS scenario suite, for comparison.

- **ONS-14**
- **ONS-16**
- **ONS-18**

3.19 The inclusion of the 2014-based projection is important, as a considerable portion of the Local Plan evidence published by LPAs across England has been formulated using this growth scenario as a starting point in the housing need calculation.

3.20 Whilst the local variations in the relative contribution of international migration and natural change (births minus deaths) are influenced by the *national* assumptions applied, the *internal* migration variations have been influenced by a methodological change introduced in the 2018-based projections. ONS has implemented an improved process for recording student moves, post-graduation. As a result, internal migration profiles (particularly in local authorities with a University) have altered since 2016. The 2018-based 'Principal' projection has therefore used a two-year history (only) to calibrate its internal migration assumptions for each LPA, rather than the customary five-year history that has routinely been used in previous SNPP rounds.

3.21 To consider the effect of this methodological change upon population growth outcomes and to evaluate the potential for lower or higher assumptions on future growth through international migration, ONS has published four variant scenarios to accompany the ONS-18 Principal outcome. Given the uncertainty associated with international migration (in particular) in the post-Brexit and post-coronavirus world, each of these scenarios is presented for consideration within the VICUS suite:

- **ONS-18-Alt** (5-year internal migration history)
- **ONS-18-10Y** (10-year migration history)
- **ONS-18-High** (High international migration)
- **ONS-18-Low** (Low international migration)

3.22 At a national (England) level, the ONS-18-Alt and ONS-18-10Y scenarios have identical outcomes to the ONS-18 Principal scenario, they only differ in the impact of the different internal migration assumptions at local authority level. Comparison between the ONS-18 suite of output and the equivalent GLA scenarios, is presented below.

## GLA Population Projections

3.23 Alongside the ONS projections, the GLA also publishes its own suite of projections[10]. The latest round of scenarios is 2018-based and includes a 'Central' scenario, plus variants which consider both a short-term (5-year) and a long-term (15-year) history for the formulation of migration assumptions. Once again, a 'cohort-component' methodology underpins the formulation of the population projections.

[10] GLA Population and Household Projections

- **GLA-18-Central**
- **GLA-18-15Y**
- **GLA-18-5Y**

3.24 These scenarios include projections not only for the 33 London Boroughs (LB) but also for all other local authority areas. The GLA methodology differs from the ONS approach in a number of key areas.

3.25 In formulating its own demographic analysis, the GLA has made adjustments to the ONS mid-year estimates for London Boroughs, primarily to account for what it has identified as over-inflation of individual cohorts of children aged 0–14. This results in a base-year (2018) population that differs from the ONS total for all London Boroughs. The VICUS methodology has rebased all scenarios to a common (ONS) base population in 2018, to facilitate a consistent comparison of growth trajectories.

3.26 With regard to migration, the GLA uses a 5-, 10- (Central) and 15-year history from which to derive scenario assumptions, compared to 2- (Principal), 5- and 10-year histories for the ONS projections. The GLA also derives its own area-specific fertility and mortality assumptions, but these follow the ONS trend throughout the projection period.

## Housing-led Forecasts

3.27 Housing-led forecasts provide a different perspective on future population growth. Under these scenarios, the population impact of a pre-determined trajectory of housing growth is considered.

3.28 The starting point for a housing-led scenario is a trend projection, which is modified year-on-year to ensure reconciliation between population change and the capacity of the housing stock. The relationship between housing growth and population change is determined by the changing age-structure of the population, projected household representative rates (occupancy), a vacancy rate, plus the changing size of the population not-in-households.

3.29 In a housing-led forecast, if the demographic trend does not match the capacity of the housing stock, then the trend is altered, through higher or lower migration. If the capacity of the housing stock exceeds the population growth trend, then additional growth through migration will result. Likewise, if the capacity of the housing stock does not meet the requirements of the population growth trend, then growth is reduced through out-migration.

3.30 The VICUS framework incorporates a suite of housing-led forecasts, recognising the uncertainty associated with the future scale, distribution and phasing of growth across all English local authority areas. This suite of scenarios is designed to illustrate the likely population growth impact of different levels of housing growth and how these compare to the trend outcomes of the ONS and GLA scenarios.

3.31 A key component of any housing-led scenario is the average 'occupancy' associated with the changing housing stock. The general 'ageing' of the UK population results in a reduction in average household size, with the older population typically having smaller household sizes compared to the younger population. Since the financial crash of 2007/08, a counter trend brought about by both financial constraints and a mismatch between demand and supply of new homes, has seen a reduction in the speed at which young adults are able to form new households, resulting in a dampening of the rate of occupancy reduction. These factors are considered in the housing-led scenario analysis.

3.32 The simplest housing-led scenario is one in which past rates of housing growth are continued. Using MHCLG's published data tables, in combination with Council statistics, the Consilium database has compiled a history of housing growth for each individual local authority. From this information, two VICUS scenarios have been configured. The first, a housing-led scenario based on a continuation of the rate of growth recorded in each local authority's 18-year housing completions history (2001–2019); the second, a housing-led scenario based on a 5-year completions history (2014–2019).

- **Completions-18Y**
- **Completions-5Y**

3.33 Under each of these scenarios the average annual housing growth calculated from the completions histories continues for the full duration of the 2020–2050 forecast period.

3.34 WRMP guidance has mandated that water companies need to consider population and property forecasts derived from the Local Plans published by LPAs. Local Plan development encompasses a complex mix of processes, documents and data. Consilium collates evidence from all LPAs, enforcing a consistent classification on the derived data (Table 1), enabling the formulation of scenarios that consider housing need, housing requirement and planned delivery.

3.35 The Planning Advisory Service (PAS) defines housing need as *"total housing that would be provided… if land supply was not constrained by planning"*. The 'Objective Assessment of Need' (OAN) was the original process established to formulate each local authority's housing need. To simplify the planning process, MHCLG introduced a 'standard method' for calculating a minimum local housing need (LHN), based on the 2014-based household growth projections, with an adjustment to account for affordability. Modifications to the LHN methodology are due for publication in 2020.

3.36 A housing requirement is defined in the National Planning Policy Framework (NPPF) and Planning Policy Guidance (PPG) as a 'policy target' (what policy requires), as opposed to housing need (what people or the market requires). A housing requirement identifies the extent to which an identified need can be met over the designated plan period.

3.37 Planned delivery of housing is also defined in the NPPF. All LPAs are required to produce a trajectory of expected housing delivery over a plan period, with the anticipated rate of development for specific sites (where appropriate). Housing trajectories are often published as part of the Local Plan and are updated annually in monitoring/land supply reports. It can be the case that these trajectories are supply-based and may be similar to the housing land *supply* figures.

3.38 Whilst LHN is deemed to be a 'minimum' housing need, the general trend is for housing need to present higher housing growth than the requirement, which in turn is often higher than the planned delivery. These rules do not hold in all cases. Three housing-led scenarios are presented:

- **Housing-Need**
- **Housing-Req**
- **Housing-Plan**

3.39 Local Plan evidence on future housing growth is typically formulated for 10–15-year period, shorter than the 2020–2050 outlook required by the WRMP. Under each scenario, following the final year of plan data available, projected housing growth in non-London local authority areas returns to a long-term annual growth average by 2050. This annual growth average has been derived from a combination of the ONS-14 and ONS-16 scenarios. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050.

3.40 With all housing-led scenarios, household representative rates, drawn from the MHCLG's 2014-based household model, determine the relationship between the changing age structure of the population and the number of households. However, these rates are based on time-period when household formation amongst young adults (in particular) was subject to both financial and supply constraints.

3.41 A key objective of all Local Plans is to redress the imbalance in the demand and supply of new homes and thus lift the rate of household formation amongst affected groups. To model the potential for a return to higher rates of household growth amongst young adults, household representative rates for 25–44 year-olds have been returned to their 2001 levels by 2039, remaining fixed thereafter. Three additional scenarios have been formulated to test the sensitivity of the household representative rate adjustments:

- **Housing-Need-r**
- **Housing-Req-r**
- **Housing-Plan-r**

3.42 The GLA includes its own housing-led outcome in its suite of scenarios[11]. Its scenario is based on data from the 2016 Strategic Housing Land Availability Assessment (SHLAA) providing housing growth totals, with phasing, for each London Borough. Beyond 2041, housing growth is aligned to the 2035–2041 average.

- **GLA-Housing**

3.43 The GLA-Housing scenario adopts an alternative method for determining occupancy rates in the changing housing stock, setting upper and lower bounds for average household size in each local authority. Plus, whilst the housing-led approach is applied to each London Borough, the population projection for Greater London, in total, remains consistent with the GLA-18-Central scenario.

3.44 This scenario includes projections for London Boroughs only and is combined with the GLA-18-Central scenario for all other local authority areas when aggregated to WRZ geographies.

## OxCam Arc Scenarios

3.45 The OxCam 'Arc' covers 26 Local Authority Districts (Appendix E), extending between Oxford, Milton Keynes and Cambridge. It has been identified as an area of huge economic potential[12,13]. To support

[11] GLA Housing-led Population Projections
[12] Savills (2019) The Oxford-Cambridge Innovation Arc Savills
[13] MHCLG (2019) The Oxford-Cambridge Arc, Government ambition and joint declaration between Government and local partners OxCam Arc

the Arc's economic growth potential, a requirement for up to one million new homes has been estimated to 2050, together with improvements to the transport infrastructure of the region. However, with the UK's exit from the European Union and the unprecedented, short-term effects of the COVID-19 crisis, there is considerable uncertainty around the timing of infrastructure and housing delivery.

3.46 Councils within the Arc are already seeking to manage significant increases in the rate of house building to meet targets set out in current Local Plans. Achievement of one million homes by 2050 would present a further step-change in housing delivery requirements.

3.47 An accompanying report[14], presents housing-led scenarios for OxCam local authorities that are underpinned by current Local Plan evidence. In addition, the report examines the potential impact of higher housing growth across the OxCam Arc, achieving close to 1 million homes by 2050.

3.48 The OxCam *Housing & Population Growth* report focuses on the development of the Arc and identifies how different levels and distribution of new housing might impact upon population growth in both WRSE and WRE geographies.

## Employment-led Scenarios

3.49 Demographic and economic change are intertwined and whilst fertility, mortality, migration and household occupancy effects can be modelled very effectively over long-term horizons, forecasting economic growth is more problematic and typically such forecasts have a much shorter, 1–5-year outlook horizon.

3.50 Economic forecasting within the current political and social environment is particularly challenging. There are a multitude of organisations that are engaged in the derivation of forecasts of short-term economic change. HM Treasury publishes a regular review of forecasts for the UK economy, with the latest release in April 2020, in the midst of COVID-19 lockdown. Short-term forecasts of GDP growth (and other variables) are 'averaged' from up to 40 financial and economic institutions. The latest average indicates -5.8% decline in UK GDP in 2020, with a +5% recovery in 2021. In both years, there is a 5 percentage-point range around the average, indicating the very uncertain economic outlook within a very short-term horizon.

3.51 The Office for Budget Responsibility (OBR) is the UK's official financial watchdog, providing *"independent and authoritative analysis of the UK's public finances".* Biannually, the OBR publishes 5-year forecasts for the UK economy to inform spring and autumn Budget Statements, accompanied by the annual publication of its Economic and Fiscal Outlook (EFO). The March 2020 EFO estimated average GDP growth of 1.4% to 2024, with an annual average employment growth of 0.5% between 2019–2024, plus a 1.5% annual rise in the unemployment rate.

[14] Edge Analytics (2020) OxCam Housing & Population Growth, draft v1

3.52 The COVID-19 crisis has prompted the development of a coronavirus reference scenario, reflecting the HM Treasury evidence but with a sharper GDP decline and recovery in 2020/21, reverting to a 1.4% annual average, 2022–2024.

3.53 The current social and economic conditions have created an unprecedented but relatively short-term, interruption to normal life. Water resource planning needs to consider a much longer-term perspective on economic and demographic change. The GLA has previously published its own long-term projections of growth in employment across the 33 London Boroughs. The latest round of projections, published in 2017 estimated an average annual growth of 0.9% in workplace-based employment to 2030, declining to a 0.5% average to 2050.

3.54 In addition to its EFO output, the OBR also publishes its Fiscal Sustainability Report (FSR), providing a long-term outlook on economic change and its impact upon public debt[15]. Its long-term employment growth projections vary depending upon the degree to which international migration (and therefore the speed of population ageing) affects the UK economy. High migration outcomes estimate a 0.5% pa employment growth nationally to 2030, 0.4% to 2050. Under low-migration outcomes a 0.3% pa growth is projected across the UK to 2030, declining to 0.1% pa thereafter.

3.55 These forecasts of economic change are underpinned by a range of survey statistics which record historical change in employment, unemployment and business counts. These sources include: regional counts of workforce jobs by industry; Annual Population Survey (APS) workplace and labour force statistics; Business Register & Employment (BRES) survey; UK Business Count survey; and the 2011 Census. Achieving a consistent perspective on historical change from these datasets is challenging, particularly when drilling down to local areas, where sample surveys can produce large annual fluctuations.

3.56 Within the VICUS framework, the labour force model uses key assumptions on age-specific rates of economic activity, unemployment and commuting, to estimate the relationship between population change and employment. An employment-led scenario requires a trajectory of future employment growth, from which a population growth impact can be estimated.

3.57 Two employment-led scenarios have been derived for the WRSE region, using a combination of: historical evidence, to determine growth ratios between England, London, the South East and the East of England; GLA projections, to benchmark London growth rates; and OBR forecasts, to provide a high and low outcome to long-term growth:

- **Employment-1**
- **Employment-2**

3.58 Under the Employment-1 scenario, employment growth in each London borough grows at 1.0% per year to 2030, declining to 0.5% per year to 2050. At the same time, employment growth in all local authority districts outside London grows at a lower rate of 0.8% per year to 2030, reducing to 0.4% per year thereafter.

[15] OBR (2018) Fiscal Sustainability Report OBR July 2018

3.59 Lower growth is modelled under the Employment-2 scenario, with employment growth in each London borough growing at 0.5% per year to 2030, declining to 0.25% per year to 2050. At the same time, employment growth in all local authority districts outside London grows at a lower rate of 0.4% per year to 2030, reducing to 0.2% per year thereafter.

## Long-term Scenarios

3.60 For each of the 25 scenarios presented in Table 2, a long-term growth outlook is considered, extending the scenario horizon to 2100. Growth scenarios for the 2050–2100 period are aligned to the ONS 2018-based NPP, configuring a principal, low and high growth outcome (Table 3).

Table 3: VICUS – Scenario Definition, 2050–2100

| Scenario | Description |
|---|---|
| Principal ('-P') | The Principal long-term scenario incorporates the mortality and fertility assumptions of the ONS 2018-based NPP Principal scenario, plus its Principal net international migration assumption of +190k p.a. for the UK in total. |
| Low ('-L') | The Low long-term scenario incorporates the mortality and fertility assumptions of the ONS 2018-based NPP Principal scenario, plus a Low net international migration assumption of +90k p.a. for the UK in total. |
| High ('-H') | The High long-term scenario incorporates the mortality and fertility assumptions of the ONS 2018-based NPP Principal scenario, plus a High net international migration assumption of +290k p.a. for the UK in total. |

3.61 The key determinants of growth rates under these scenarios are assumptions relating to fertility, mortality and international migration. In each of the three long-term outcomes, fertility and mortality rates trends are consistent with the NPP Principal scenario. For international migration, the Principal scenario is based on an assumption of +190k annual net growth through international migration, with the High and Low variants assuming +290k and +90k per year respectively.

## Macro- and Micro-level Alignment

3.62 Where data on site level housing developments is available, the housing-led forecasting approach is able to utilise both a combined 'top-down' and 'bottom-up' methodology. This means that micro-level forecasts of population change can be directly linked to the location of planned housing growth and the phasing over time of that growth.

3.63 A 'top-down' forecast is produced providing an indication of population and property growth for an aggregate area (local authority district). This is used as a constraint for a 'bottom-up' forecast which takes account of micro-level housing intelligence. The Consilium data provides information on the extent of new housing growth and its likely spatial and temporal distribution.

3.64 Housing allocations typically have a location and a likely phasing over time combined with information on site area and density. Used in combination with estimates of new dwelling occupancy this allows the population forecasts to reflect, at a micro scale, the impact of new housing developments.

3.65 For new housing allocations where specific geographical location detail is not provided the model allocates these sites across aggregate areas in proportion to the existing property distribution.

3.66 The Consilium site data is used in conjunction with digital map data and existing micro-level housing stock data for the proportional assignment of micro-level forecasts to various water planning geographies. These proportions are modified over time to take account of the revised distribution of properties resulting from planned new development sites.

3.67 Typically, site level trajectories are provided for a relatively short-term period. When site level data is no longer available the modelling approach reverts to a 'top-down' approach.

# 4 Scenario Output

## Understanding Limitations

4.1 The UK is at a watershed moment in its political, economic and demographic history. The country's exit from the EU and the unprecedented global impact of the current pandemic, presents a significant challenge for predicting demographic futures for water resource planning. However, as the virus situation improves and the country returns to a new normal, the UK government will continue its objective of building up to 300,000 new homes per year. This will have important effects upon the growth and distribution of population in the WRSE communities.

4.2 The analysis detailed in this report and in accompanying data deliverables, has presented a *suite* of trend projections, housing-led and employment-led forecasts which estimate the potential scale and distribution of future demographic change. In the interpretation of these outputs, it is important to recognise some of the methodological and data differences that exist between scenarios and therefore the challenge of producing the consistency required for effective comparison.

4.3 In all trend projections and housing-led forecasts, the future population of an area is strongly influenced by its base population. Projections of the number of adults, particularly the older-age population, are usually more reliable than those for children because of the challenges associated with the estimation of future levels of fertility and working-age migration.

4.4 The WRMP scenario horizon stretches to 2100. As the process of population change is cumulative, the reliability of growth scenarios will reduce over time. Furthermore, growth scenarios for areas with small populations will generally be less reliable than those for areas with large populations, because the former will typically be affected more by migration.

4.5 The ONS and GLA *projections* provide an illustration of what will happen if a pre-determined combination of assumptions on fertility, mortality and migration are met. Projections are trend-based and are, therefore, not policy-based forecasts of what local or national government expects to happen. There are many economic, political and social factors that could influence population change, including policies adopted by both national and local government, or factors that are outside of any government's control (e.g. coronavirus).

4.6 Appendix C illustrates the UK's national population projection accuracy since 1950. Historically, the UK population has risen <u>more</u> than projected, due to one or other of: under-estimation of international migration; a failure to anticipate higher fertility rates; or a failure to anticipate continued improvements in life expectancy. More recently, successive projections have demonstrated greater convergence, compared to earlier years.

4.7 The effects of dampened fertility and mortality assumptions upon population change are very evident in the successively lower growth outcomes of the ONS-14, ONS-16 and ONS-18 projections (Appendix D (i)). A return to higher rates of fertility and/or an upturn in the rate of improvement in life expectancy, would reverse the trend towards lower growth suggested by the ONS-18 outcomes.

4.8 The size of migration flows (both internal and international) and the uncertainty of future trends, means that migration assumptions have a greater influence upon growth outcomes than fertility and mortality assumptions.

4.9 In the absence of a population register, the estimation of international migration (into and out of the UK) has long presented a real challenge to ONS[16]. Estimating *base-year* immigration and emigration effects, both nationally and locally, requires a complex mix of data inputs and assumptions, and is subject to estimation methodologies that are under constant review. This methodological uncertainty in the base data, coupled with the considerable uncertainty that now exists around future population exchanges with the EU and other countries, makes the international migration assumption the most sensitive in all trend scenarios.

4.10 The UK government had originally hinted at a +100k per year target for net international migration but this has never been established as policy. The +190k per year within the ONS-18 principal scenario, is a more reasonable assumption of future international migration to the UK, ensuring the necessary replenishment of its workforce to compensate for the accelerating process of demographic ageing in the resident population.

4.11 In relation to *internal* migration flows, the financial crash of 2007/08 resulted in constraints on movement due to lending restrictions, acute housing affordability issues and an under-supply of new homes. This had a particular impact upon the net outflow of migrants from London, a situation that has now begun to reverse itself with the renaissance in house building. This should mean that later trend projections are a more reliable indicator of future internal migration outcomes. However, the ONS-18 projections incorporate the effects of a methodological change to the estimation of internal migration, which makes comparison with other scenarios more difficult.

4.12 There are also methodological differences between the ONS and GLA trend projections presented here, which make a direct comparison of growth outcomes a challenge. The GLA has modified its base year populations, has calculated its own base fertility and mortality parameters (although following the long-term ONS trend) and its own migration assumptions.

4.13 To improve comparability, the VICUS framework has sought to align base year population and property totals to ensure consistency of growth comparison across scenarios. This alignment reveals that, despite the ONS and GLA each presenting a 2018-based scenario configuration, the GLA trend scenarios result in higher growth outcomes for the UK standard regions which overlap WRSE geographies (Appendix D (ii)).

4.14 Whilst projections provide an illustration of growth under a given set of fertility, mortality and migration assumptions, local planning policies can modify past trends. To illustrate how Local Plans

[16] ONS - Long-Term International Migration estimates methodology

have been formulated to meet particular local needs/requirements for new housing growth, the housing-led scenarios are presented as a direct contrast to the trend outcomes. But there is inevitable inconsistency and uncertainty with regard to the evidence which underpins these scenarios.

4.15 Local Plans are at different stages of development and completeness. There is limited consistency of timing or content of Council Local Plan publications and data. And whilst some areas have plan data for 5 years, others for up to 15 years, the majority of Local Plan housing growth is weighted more heavily towards the short-term horizon. It has been necessary to fill the data gaps required for the WRMP 2050 planning horizon, using trend scenario evidence to estimate housing growth for the period after which plan data expires. These factors are reflected in the shape of the growth curves associated with the Housing-Plan scenarios.

4.16 The use of household representative rates as a determinant of occupancy is a key component of the modelling approach, applied across all scenarios, trend, housing-led and employment-led. These rates, drawn from MHCLG's 2014-based household model are available to 2039 only, remaining constant thereafter. Modification of these rates ('r' scenarios in the analysis that follows) has enabled the estimation of population impacts resulting from higher rates of household formation amongst young adults, dampening the housing-led population growth in all cases. The 'r' scenario is an attempt to illustrate how lower average occupancy (and therefore lower population growth) might result from the higher Local Plan trajectories. This is achieved by allowing household representative rates for young adult age-groups to 'return' to their 2001 position (prior to the financial crash of 2008)[17].

4.17 In all cases, the housing-led growth outcomes detailed below are substantially *higher* than the latest, 2018-based trend projections published by the ONS. The amalgamated WRSE Local Plan evidence suggests an unprecedented level of housing growth to 2030. Some of this growth is to meet a 'backlog' from previous under-supply but the majority is designed to satisfy a housing 'need', meeting the requirements of future population growth.

4.18 The ONS 2014-based population projections (and accompanying household projections) have been a key input to MHCLG's housing need policies and the formulation of Local Plan housing requirements. For the WRSE in total, the population growth profile estimated by the ONS 2014-based projections, reveals an expectation of continued population growth through a mixture of natural change (higher births than deaths), internal migration and international migration. The housing-led scenarios, coupled with the 'r' assumption of higher rates of household formation amongst young adults, return an overall population growth that is higher, but not too dissimilar to, the ONS 2014-based outcome.

4.19 Contrast the ONS 2014-based outcome, to that of its 2018-based variant. With revised demographic inputs which assume falling fertility and lower life expectancies, natural change has a much smaller impact upon population change, quickly reverting to a population decline in parts of the WRSE. Whilst international migration is projected to remain at a higher level in the 2018-based projections, the dampened growth outcomes suggest a lower housing requirement over the WRMP horizon.

[17] Whilst using a similar approach, the GLA has applied borough-specific rules to the control of occupancy in its housing-led scenario and has constrained the overall population growth total in this scenario to its Central trend outcome for London

4.20 To aid consideration of the accelerated housing growth that is planned to 2030, a separate analysis has provided supplementary information on housing growth outlook, using a combination of (Consilium) Local Plan sources to produce a 'Delivery Performance Indicator' (DPI) for each local authority[18]. This DPI is designed to indicate those areas where current housing plans are more or less likely to be delivered, based upon: (i) historical delivery rates; (ii) planned completions; and (iii) available capacity. This DPI is of most use in the consideration of the higher housing growth evident in Local Plans to 2030 and its likelihood for delivery during this, short-term, WRMP horizon.

4.21 The development of employment-led forecasts is particularly challenging within the current political and social environment. And even within 'normal' conditions, economic forecasts typically have a have a much shorter, 1–5-year outlook horizon, compared to demographic scenarios. Nevertheless, two employment-led scenarios have been formulated, not as a definitive indication of likely economic trajectories, but to benchmark other demographic and housing-led scenarios against a higher and lower employment growth outcome.

4.22 The VICUS framework is able to configure employment-led scenarios, but it does so from a demographic perspective, balancing the relationship between employment growth and the size of the resident labour force using higher or lower migration. The methodology incorporates important projections of age-specific labour force participation rates, especially important for modelling higher female participation and the effects of state pension age (SPA) adjustments. However, it combines these with static measures of unemployment and commuting ratios, a necessary simplification of a complex modelling process.

## Outcomes 2020–2050

4.23 Despite the methodological and data challenges detailed above, the VICUS framework provides a rigorous and robust basis for the configuration and comparison of a suite of WRSE growth scenarios. Given the challenges of presenting a single, definitive outcome on future population and housing growth, the transparency of the VICUS approach is designed to encourage consideration of a 'range' of outcomes to support water resource planning.

4.24 A summary illustration of the suite of 2020–2050 growth scenarios is presented, for WRSE in aggregate (Figure 8) and for each water company (Figure 9 – Figure 14).

4.25 The accompanying VICUS-BI dashboard provides further detail for individual WRZs, plus scenario output for the extended 2020–2100 forecast period. An additional Microsoft Excel workbook provides full detail on the data outputs from each scenario.

4.26 The range of 2020–2050 growth outcomes for the WRSE, in total, suggests population growth in the range of 402,000 to 5.1 million, with accompanying dwelling growth of 31,700–99,500 dwellings per annum (dpa). This gives an average of approximately 3.3 million population growth (c. 17%) and 73,000 dpa over the 30-year plan period.

[18] The DPI analysis has been provided to WRSE members as an accompaniment to the main population and property forecast outputs.

4.27 This is a wide range of outcomes but at the lower end of the spectrum, the ONS-18-Low scenario presents an unrealistic growth projection. The ONS-18 *principal* projection presents an uncertain outcome itself, given the methodological differences in its approach to measuring internal migration. For this reason, a low variant on the principal outcome, which assumes a +90k per year international migration impact, should be disregarded.

4.28 In contrast, the ONS-14, Housing-Need and Housing-Plan scenarios present higher growth outcomes. The three are relatively consistent to 2030, deviating thereafter, with the Housing-Plan aligning more closely with ONS-14. The Housing-Need scenario with its continuation of an LPA's need assessment, albeit with a return to a trend value by 2050 and no modifications to account for higher household growth in young adults, produces a high growth outcome that is also likely to be unrealistic.

4.29 The inclusion of scenarios which consider future housing growth linked to past completion rates, provides a useful benchmark against the housing growth derived in the Housing-Plan trajectory. For the combined WRSE geography, the Housing-Plan dwelling growth total is approximately 23% higher than that associated with a continuation of the completion rate from the last five years of evidence and 45% higher than a continuation of the completion rate averaged over the extended 2001–2019 period.

4.30 The Housing-Plan scenario suggests high growth to 2030 (typically the limit of robust Local Plan evidence), reducing thereafter as the annual housing growth returns to a level derived from trend projections. The reduction in the household representative rates of young adults over the plan period (Housing-Plan-r), enforces a lower occupancy to the housing stock, reducing the population growth associated with the same level of housing growth. The requirement for higher housing growth in Local Plans is underpinned by a drive to make new homes more affordable and accessible to young adults, so the modification to household representative rates provides a legitimate dampening of the population growth, reducing housing stock average occupancies in the process.

4.31 The GLA scenarios project higher growth than the ONS-16 and ONS-18 outcomes, due to higher natural change and international migration, combined with a lower net outflow through internal migration. The Housing-Plan-r population growth aligns more closely with the GLA outcomes, albeit with a higher average dpa across the plan period, with the GLA assuming higher occupancies for the housing stock.

4.32 The employment-led scenarios estimate population growth of 8.4%–16.6%, with the higher growth of the Employment-1 scenario relatively consistent with the average over all scenarios. Dwelling growth associated with these scenarios is 48k–72k dpa to 2050, with a potential 20% uplift on the dpa if higher rates of household formation amongst young adults is considered.

4.33 The trends evident in the WRSE aggregate outcomes and the relationship between the different scenario outcomes, is generally replicated in the growth profiles presented for each of the water companies, with the Housing-Need and ONS-18-Low scenario sitting at the extremes of the growth spectrum.

4.34 For Affinity Water, an average population growth of approximately 605,000 (c. 17%) is estimated to 2050, coupled with a housing growth of 13,351 dpa. The Housing-Plan-r scenario aligns quite closely to the GLA population outcomes, albeit with a higher annual average housing growth estimated from the Local Plan evidence.

4.35 For Portsmouth Water an average population growth of approximately 110,000 (c. 15%) is combined with a 2,370 dpa housing growth to 2050. The short-term (2020–2030) impact of higher housing growth in the Local Plan evidence is noticeable, particularly when compared to the scenarios based upon past housing completion rates.

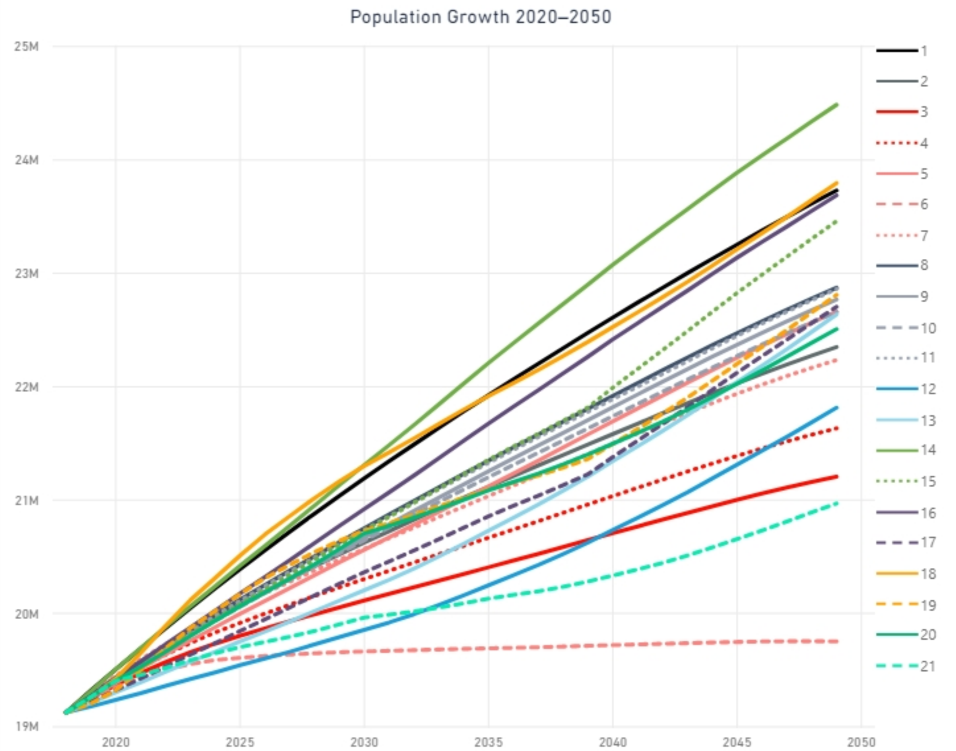
4.36 Of a similar size to Portsmouth Water, SES Water has an average population growth outcome of approximately 111,000 (c. 16%) to 2050, with a housing growth of 2,525 dpa. ONS-14 and Housing-Need scenarios are associated with particularly high population growth when compared to past completion rates and to the Housing-Plan growth trajectory.

4.37 For South East Water, an average 2020–2050 population growth of approximately 389,000 (18%) is associated with an average annual housing growth figure of 7,925 dpa. Large scale housing growth detailed in Local Plans is reflected in the Housing-Plan trajectories for the 2020–2030 plan period.

4.38 It is a similar case for Southern Water, with high Local Plan housing totals fuelling the 2020–2030 population growth of the Housing-Plan scenarios. Across all scenarios, an average population growth of approximately 413,000 (c. 16%) is estimated, coupled with an average annual housing growth of 8,602 dpa.

4.39 Thames Water covers the largest and most diverse geography, with the low growth trajectory of the Completions-18Y scenario being particularly noticeable reflecting a history of under-supply of homes relative to population growth. Across all scenarios, an average population growth of 1.63 million (c. 17%) to 2050 is estimated, in combination with an annual average housing growth of 38,011 dpa.

**WRSE**
Growth Forecasts




Population & Dwelling Growth 2020–2050

| ID | Scenario | Population 2020 | Population 2050 | Population Change | Population % Change | Dwellings (dpa) |
|---|---|---|---|---|---|---|
| 14 | Housing-Need | 19,507,619 | 24,628,751 | 5,121,133 | 26.3% | 99,488 |
| 18 | Housing-Plan | 19,426,171 | 23,945,684 | 4,519,513 | 23.3% | 90,809 |
| 16 | Housing-Req | 19,426,797 | 23,820,756 | 4,393,959 | 22.6% | 88,549 |
| 1 | ONS-14 | 19,507,637 | 23,844,343 | 4,336,706 | 22.2% | 88,440 |
| 15 | Housing-Need-r | 19,403,690 | 23,609,629 | 4,205,940 | 21.7% | 99,483 |
| 19 | Housing-Plan-r | 19,323,132 | 22,964,268 | 3,641,137 | 18.8% | 90,812 |
| 17 | Housing-Req-r | 19,323,795 | 22,844,116 | 3,520,321 | 18.2% | 88,547 |
| 8 | GLA-18-Central | 19,430,592 | 22,965,109 | 3,534,518 | 18.2% | 70,991 |
| 11 | GLA-18-Housing | 19,432,300 | 22,958,451 | 3,526,151 | 18.1% | 63,658 |
| 13 | Completions-5Y | 19,302,984 | 22,790,843 | 3,487,859 | 18.1% | 73,876 |
| 9 | GLA-18-15Y | 19,413,778 | 22,862,595 | 3,448,816 | 17.8% | 66,307 |
| 5 | ONS-18-High | 19,388,373 | 22,755,083 | 3,366,709 | 17.4% | 73,885 |
| 10 | GLA-18-5Y | 19,410,430 | 22,749,900 | 3,339,470 | 17.2% | 70,264 |
| 20 | Employment-1 | 19,406,059 | 22,621,049 | 3,214,990 | 16.6% | 71,674 |
| 2 | ONS-16 | 19,434,994 | 22,422,453 | 2,987,459 | 15.4% | 69,374 |
| 7 | ONS-18-10Y | 19,449,052 | 22,299,265 | 2,850,213 | 14.7% | 67,504 |
| 12 | Completions-18Y | 19,238,911 | 21,944,551 | 2,705,640 | 14.1% | 62,657 |
| 4 | ONS-18-Alt | 19,401,156 | 21,685,153 | 2,283,997 | 11.8% | 59,493 |
| 3 | ONS-18 | 19,367,853 | 21,251,483 | 1,883,629 | 9.7% | 52,782 |
| 21 | Employment-2 | 19,406,059 | 21,040,243 | 1,634,184 | 8.4% | 48,169 |
| 6 | ONS-18-Low | 19,347,329 | 19,749,373 | 402,044 | 2.1% | 31,702 |

| Summary 2020–2050 | Min | Max | Mean | Median |
|---|---|---|---|---|
| Population Growth | 402,044 | 5,121,133 | 3,257,352 | 3,448,816 |
| Dwellings (dpa) | 31,702 | 99,488 | 72,784 | 70,991 |

Company: 7. WRSE    Zone: All

Figure 8: VICUS-BI – Scenario Summary – WRSE


| ID | Scenario | Population 2020 | Population 2050 | Population Change | Population % Change | Dwellings (dpa) |
|---|---|---|---|---|---|---|
| 14 | Housing-Need | 3,669,614 | 4,756,450 | 1,086,836 | 29.6% | 20,268 |
| 15 | Housing-Need-r | 3,650,195 | 4,555,340 | 905,145 | 24.8% | 20,191 |
| 18 | Housing-Plan | 3,634,551 | 4,534,814 | 900,262 | 24.8% | 17,409 |
| 16 | Housing-Req | 3,638,529 | 4,510,792 | 872,262 | 24.0% | 17,119 |
| 1 | ONS-14 | 3,658,050 | 4,521,574 | 863,524 | 23.6% | 17,181 |
| 19 | Housing-Plan-r | 3,615,411 | 4,343,319 | 727,908 | 20.1% | 17,400 |
| 17 | Housing-Req-r | 3,619,536 | 4,325,241 | 705,706 | 19.5% | 17,047 |
| 8 | GLA-18-Central | 3,641,272 | 4,329,149 | 687,877 | 18.9% | 13,279 |
| 9 | GLA-18-15Y | 3,638,705 | 4,312,028 | 673,323 | 18.5% | 12,445 |
| 11 | GLA-18-Housing | 3,641,775 | 4,312,970 | 671,194 | 18.4% | 11,574 |
| 10 | GLA-18-5Y | 3,631,401 | 4,215,368 | 583,967 | 16.1% | 12,173 |
| 13 | Completions-5Y | 3,609,930 | 4,188,898 | 578,968 | 16.0% | 12,643 |
| 20 | Employment-1 | 3,629,941 | 4,202,661 | 572,720 | 15.8% | 12,766 |
| 2 | ONS-16 | 3,639,348 | 4,181,790 | 542,443 | 14.9% | 12,725 |
| 7 | ONS-18-10Y | 3,641,645 | 4,181,788 | 540,142 | 14.8% | 12,460 |
| 5 | ONS-18-High | 3,616,821 | 4,119,501 | 502,680 | 13.9% | 11,624 |
| 12 | Completions-18Y | 3,597,933 | 4,033,589 | 435,657 | 12.1% | 10,600 |
| 4 | ONS-18-Alt | 3,626,044 | 3,989,182 | 363,138 | 10.0% | 10,026 |
| 21 | Employment-2 | 3,629,941 | 3,913,676 | 283,735 | 7.8% | 8,665 |
| 3 | ONS-18 | 3,613,634 | 3,851,581 | 237,947 | 6.6% | 8,133 |
| 6 | ONS-18-Low | 3,610,446 | 3,583,967 | -26,479 | -0.7% | 4,646 |

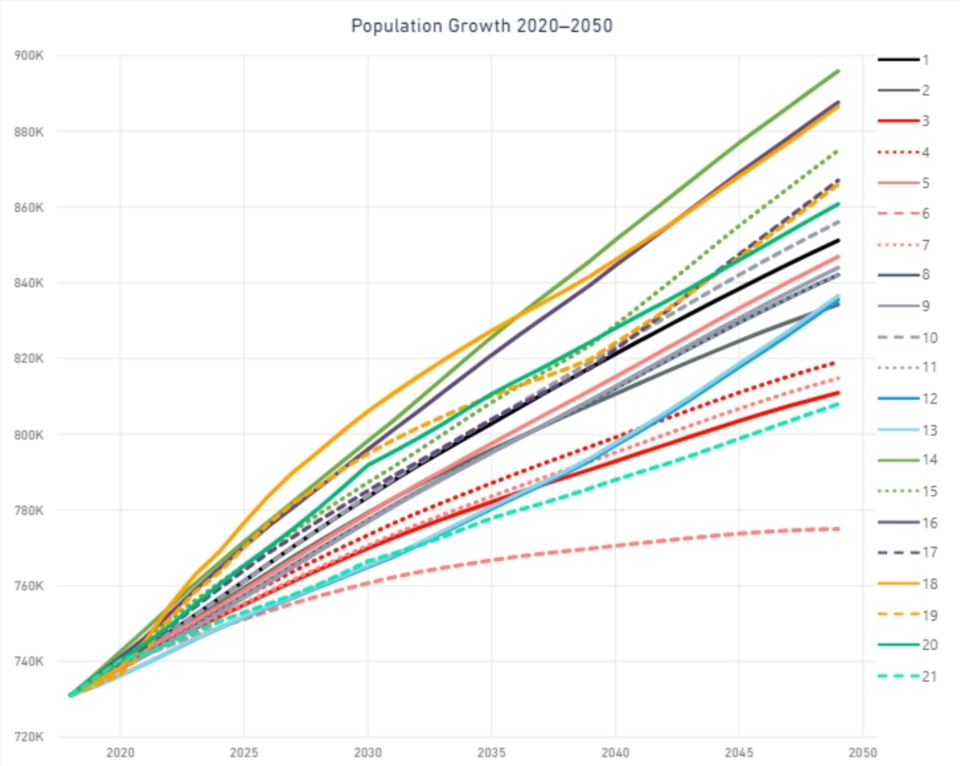
| Summary 2020–2050 | Min | Max | Mean | Median |
|---|---|---|---|---|
| Population Growth | -26,479 | 1,086,836 | 605,188 | 583,967 |
| Dwellings (dpa) | 4,646 | 20,268 | 13,351 | 12,643 |

Figure 9: VICUS-BI – Scenario Summary – Affinity Water

## Portsmouth Water - Portsmouth Water

Growth Forecasts

vicus BI




**Population & Dwelling Growth 2020–2050**

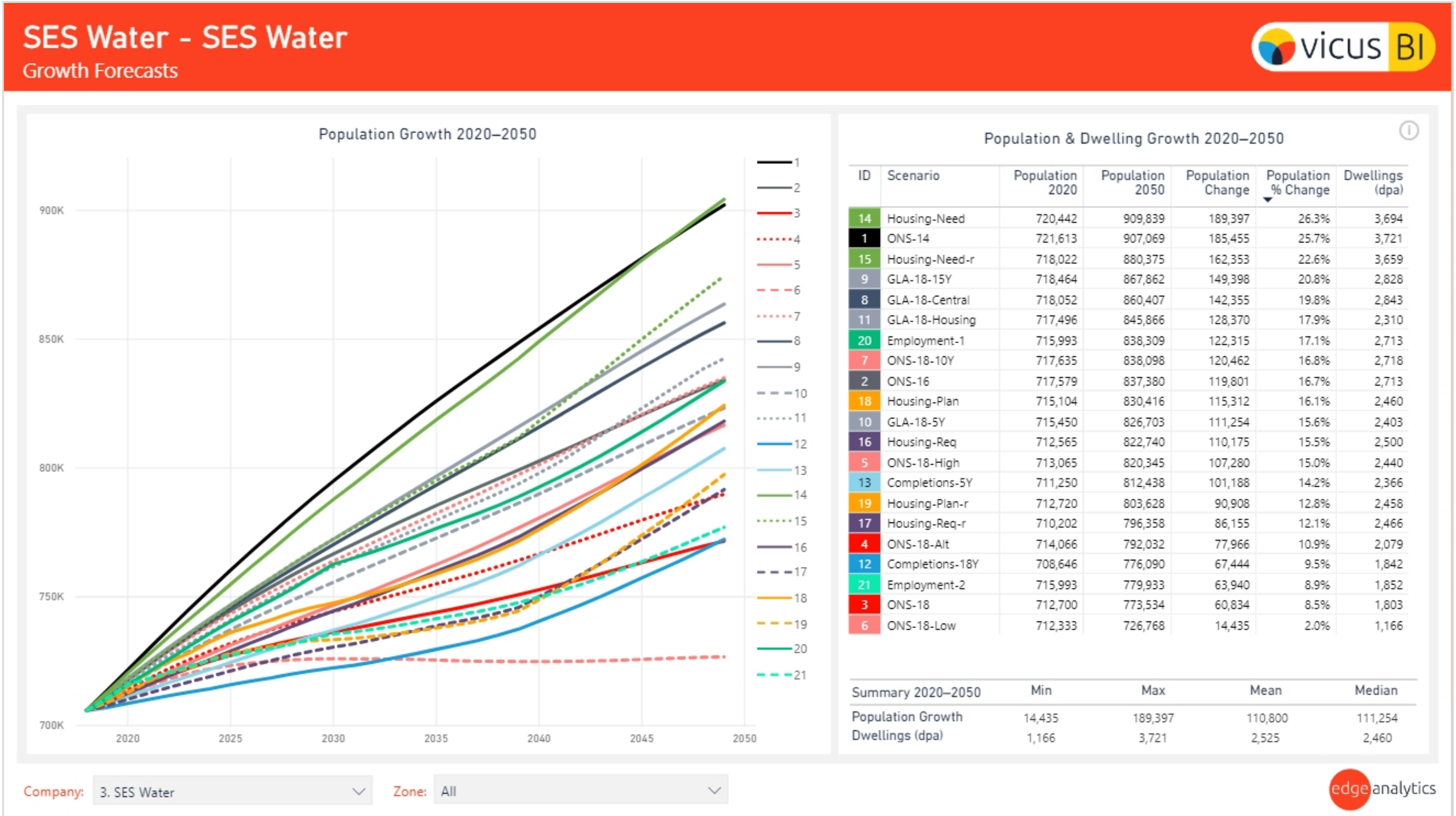
| ID | Scenario | Population 2020 | Population 2050 | Population Change | Population % Change | Dwellings (dpa) |
|---|---|---|---|---|---|---|
| 14 | Housing-Need | 742,586 | 900,486 | 157,900 | 21.3% | 3,077 |
| 18 | Housing-Plan | 738,466 | 891,292 | 152,826 | 20.7% | 3,037 |
| 16 | Housing-Req | 741,178 | 892,238 | 151,061 | 20.4% | 2,970 |
| 15 | Housing-Need-r | 740,810 | 879,720 | 138,911 | 18.8% | 3,078 |
| 19 | Housing-Plan-r | 736,705 | 870,827 | 134,122 | 18.2% | 3,037 |
| 17 | Housing-Req-r | 739,409 | 871,729 | 132,320 | 17.9% | 2,970 |
| 20 | Employment-1 | 740,325 | 864,176 | 123,851 | 16.7% | 2,558 |
| 10 | GLA-18-5Y | 739,396 | 859,243 | 119,847 | 16.2% | 2,343 |
| 1 | ONS-14 | 739,501 | 854,210 | 114,710 | 15.5% | 2,461 |
| 5 | ONS-18-High | 739,480 | 850,025 | 110,545 | 14.9% | 2,346 |
| 9 | GLA-18-15Y | 738,001 | 847,090 | 109,089 | 14.8% | 2,168 |
| 8 | GLA-18-Central | 738,245 | 845,040 | 106,795 | 14.5% | 2,151 |
| 11 | GLA-18-Housing | 738,245 | 845,040 | 106,795 | 14.5% | 2,151 |
| 13 | Completions-5Y | 736,416 | 841,243 | 104,827 | 14.2% | 2,246 |
| 12 | Completions-18Y | 736,391 | 840,135 | 103,743 | 14.1% | 2,218 |
| 2 | ONS-16 | 739,499 | 836,453 | 96,954 | 13.1% | 2,227 |
| 4 | ONS-18-Alt | 739,551 | 820,849 | 81,299 | 11.0% | 1,983 |
| 7 | ONS-18-10Y | 738,912 | 816,510 | 77,598 | 10.5% | 1,910 |
| 3 | ONS-18 | 739,094 | 812,532 | 73,439 | 9.9% | 1,816 |
| 21 | Employment-2 | 740,325 | 809,912 | 69,587 | 9.4% | 1,740 |
| 6 | ONS-18-Low | 738,707 | 775,022 | 36,316 | 4.9% | 1,287 |

| Summary 2020–2050 | Min | Max | Mean | Median |
|---|---|---|---|---|
| Population Growth | 36,316 | 157,900 | 109,644 | 109,089 |
| Dwellings (dpa) | 1,287 | 3,078 | 2,370 | 2,246 |

Company: 2. Portsmouth Water    Zone: All

edge analytics

Figure 10: VICUS-BI – Scenario Summary – Portsmouth Water




| ID | Scenario | Population 2020 | Population 2050 | Population Change | Population % Change | Dwellings (dpa) |
|---|---|---|---|---|---|---|
| 14 | Housing-Need | 720,442 | 909,839 | 189,397 | 26.3% | 3,694 |
| 1 | ONS-14 | 721,613 | 907,069 | 185,455 | 25.7% | 3,721 |
| 15 | Housing-Need-r | 718,022 | 880,375 | 162,353 | 22.6% | 3,659 |
| 9 | GLA-18-15Y | 718,464 | 867,862 | 149,398 | 20.8% | 2,828 |
| 8 | GLA-18-Central | 718,052 | 860,407 | 142,355 | 19.8% | 2,843 |
| 11 | GLA-18-Housing | 717,496 | 845,866 | 128,370 | 17.9% | 2,310 |
| 20 | Employment-1 | 715,993 | 838,309 | 122,315 | 17.1% | 2,713 |
| 7 | ONS-18-10Y | 717,635 | 838,098 | 120,462 | 16.8% | 2,718 |
| 2 | ONS-16 | 717,579 | 837,380 | 119,801 | 16.7% | 2,713 |
| 18 | Housing-Plan | 715,104 | 830,416 | 115,312 | 16.1% | 2,460 |
| 10 | GLA-18-5Y | 715,450 | 826,703 | 111,254 | 15.6% | 2,403 |
| 16 | Housing-Req | 712,565 | 822,740 | 110,175 | 15.5% | 2,500 |
| 5 | ONS-18-High | 713,065 | 820,345 | 107,280 | 15.0% | 2,440 |
| 13 | Completions-5Y | 711,250 | 812,438 | 101,188 | 14.2% | 2,366 |
| 19 | Housing-Plan-r | 712,720 | 803,628 | 90,908 | 12.8% | 2,458 |
| 17 | Housing-Req-r | 710,202 | 796,358 | 86,155 | 12.1% | 2,466 |
| 4 | ONS-18-Alt | 714,066 | 792,032 | 77,966 | 10.9% | 2,079 |
| 12 | Completions-18Y | 708,646 | 776,090 | 67,444 | 9.5% | 1,842 |
| 21 | Employment-2 | 715,993 | 779,933 | 63,940 | 8.9% | 1,852 |
| 3 | ONS-18 | 712,700 | 773,534 | 60,834 | 8.5% | 1,803 |
| 6 | ONS-18-Low | 712,333 | 726,768 | 14,435 | 2.0% | 1,166 |

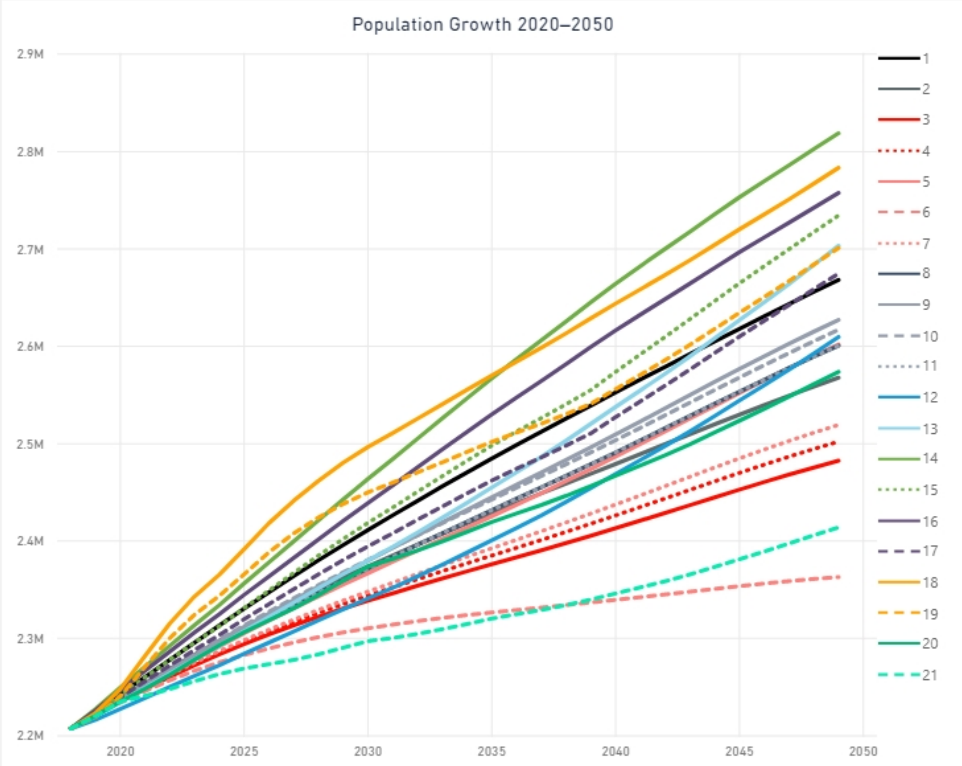
| Summary 2020–2050 | Min | Max | Mean | Median |
|---|---|---|---|---|
| Population Growth | 14,435 | 189,397 | 110,800 | 111,254 |
| Dwellings (dpa) | 1,166 | 3,721 | 2,525 | 2,460 |

Figure 11: VICUS-BI – Scenario Summary – SES Water

## South East Water

Growth Forecasts

vicus BI




**Population & Dwelling Growth 2020–2050**

| ID | Scenario | Population 2020 | Population 2050 | Population Change | Population % Change | Dwellings (dpa) |
|---|---|---|---|---|---|---|
| 14 | Housing-Need | 2,249,529 | 2,834,703 | 585,174 | 26.0% | 10,741 |
| 18 | Housing-Plan | 2,247,978 | 2,799,709 | 551,732 | 24.5% | 10,353 |
| 16 | Housing-Req | 2,246,887 | 2,772,459 | 525,573 | 23.4% | 9,792 |
| 15 | Housing-Need-r | 2,241,988 | 2,751,003 | 509,015 | 22.7% | 10,746 |
| 13 | Completions-5Y | 2,234,762 | 2,723,101 | 488,338 | 21.9% | 9,087 |
| 19 | Housing-Plan-r | 2,240,409 | 2,717,828 | 477,419 | 21.3% | 10,356 |
| 17 | Housing-Req-r | 2,239,363 | 2,690,379 | 451,016 | 20.1% | 9,799 |
| 1 | ONS-14 | 2,242,632 | 2,680,307 | 437,675 | 19.5% | 8,747 |
| 9 | GLA-18-15Y | 2,237,839 | 2,639,007 | 401,168 | 17.9% | 7,300 |
| 12 | Completions-18Y | 2,227,723 | 2,626,694 | 398,971 | 17.9% | 7,851 |
| 10 | GLA-18-5Y | 2,238,921 | 2,628,671 | 389,750 | 17.4% | 7,234 |
| 5 | ONS-18-High | 2,236,193 | 2,613,706 | 377,513 | 16.9% | 7,624 |
| 8 | GLA-18-Central | 2,236,882 | 2,611,741 | 374,859 | 16.8% | 7,034 |
| 11 | GLA-18-Housing | 2,236,882 | 2,611,741 | 374,859 | 16.8% | 7,034 |
| 20 | Employment-1 | 2,235,049 | 2,585,205 | 350,156 | 15.7% | 7,296 |
| 2 | ONS-16 | 2,238,543 | 2,576,633 | 338,090 | 15.1% | 7,354 |
| 7 | ONS-18-10Y | 2,236,127 | 2,527,004 | 290,877 | 13.0% | 6,592 |
| 4 | ONS-18-Alt | 2,235,981 | 2,509,301 | 273,320 | 12.2% | 6,320 |
| 3 | ONS-18 | 2,235,112 | 2,489,172 | 254,060 | 11.4% | 5,958 |
| 21 | Employment-2 | 2,235,049 | 2,421,214 | 186,165 | 8.3% | 4,905 |
| 6 | ONS-18-Low | 2,234,030 | 2,364,644 | 130,614 | 5.8% | 4,292 |

| Summary 2020–2050 | Min | Max | Mean | Median |
|---|---|---|---|---|
| Population Growth | 130,614 | 585,174 | 388,874 | 389,750 |
| Dwellings (dpa) | 4,292 | 10,746 | 7,925 | 7,354 |

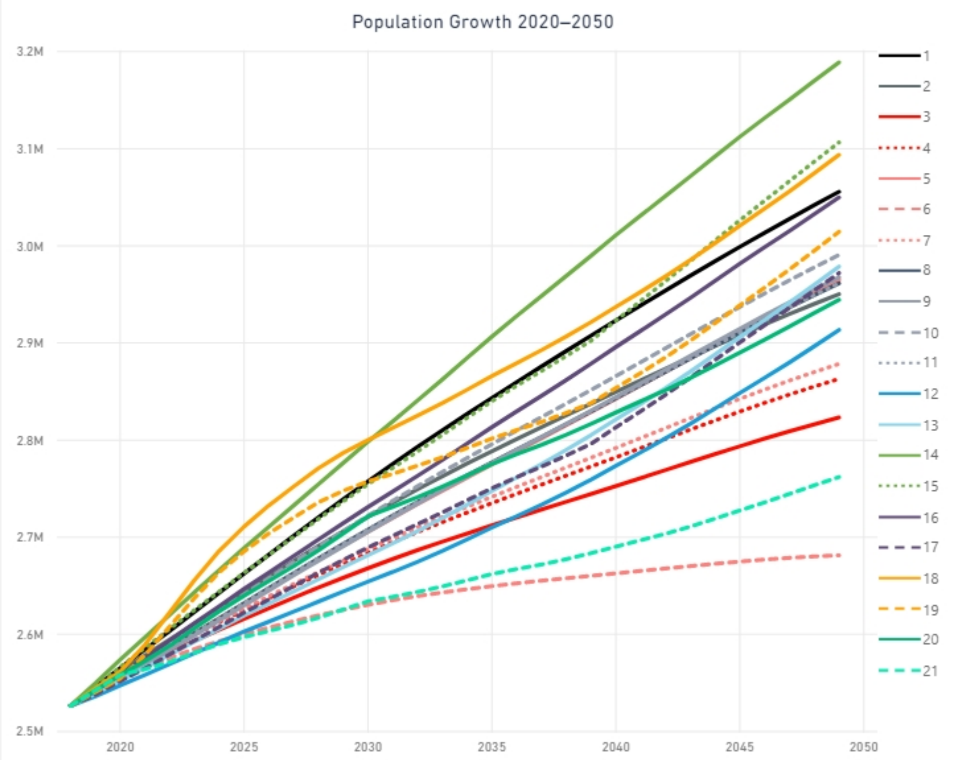
Company: 4. South East Water    Zone: All

edge analytics

Figure 12: VICUS-BI – Scenario Summary – South East Water

## Southern Water

Growth Forecasts




Population & Dwelling Growth 2020–2050

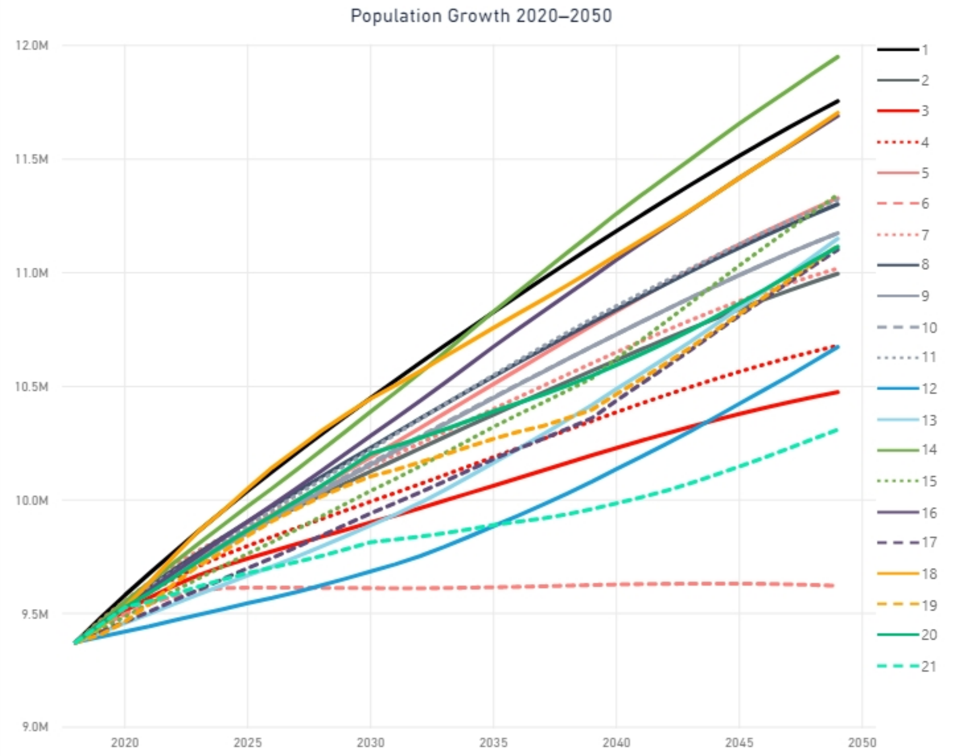
| ID | Scenario | Population 2020 | Population 2050 | Population Change | Population % Change | Dwellings (dpa) |
|---|---|---|---|---|---|---|
| 14 | Housing-Need | 2,573,681 | 3,207,317 | 633,636 | 24.6% | 11,874 |
| 15 | Housing-Need-r | 2,566,309 | 3,125,638 | 559,329 | 21.8% | 11,873 |
| 18 | Housing-Plan | 2,561,810 | 3,112,693 | 550,883 | 21.5% | 10,592 |
| 16 | Housing-Req | 2,559,087 | 3,066,825 | 507,738 | 19.8% | 9,913 |
| 1 | ONS-14 | 2,565,276 | 3,069,261 | 503,985 | 19.6% | 10,074 |
| 19 | Housing-Plan-r | 2,554,492 | 3,033,955 | 479,462 | 18.8% | 10,592 |
| 13 | Completions-5Y | 2,552,529 | 2,997,406 | 444,877 | 17.4% | 8,799 |
| 10 | GLA-18-5Y | 2,559,088 | 3,003,320 | 444,231 | 17.4% | 8,282 |
| 17 | Housing-Req-r | 2,551,796 | 2,989,574 | 437,779 | 17.2% | 9,911 |
| 9 | GLA-18-15Y | 2,554,692 | 2,980,184 | 425,491 | 16.7% | 8,000 |
| 5 | ONS-18-High | 2,557,508 | 2,977,408 | 419,900 | 16.4% | 8,663 |
| 8 | GLA-18-Central | 2,555,842 | 2,973,313 | 417,471 | 16.3% | 7,936 |
| 11 | GLA-18-Housing | 2,555,842 | 2,973,313 | 417,471 | 16.3% | 7,936 |
| 20 | Employment-1 | 2,558,072 | 2,956,937 | 398,865 | 15.6% | 8,401 |
| 2 | ONS-16 | 2,561,498 | 2,959,981 | 398,483 | 15.6% | 8,577 |
| 12 | Completions-18Y | 2,547,500 | 2,930,221 | 382,721 | 15.0% | 7,937 |
| 7 | ONS-18-10Y | 2,558,139 | 2,886,428 | 328,289 | 12.8% | 7,502 |
| 4 | ONS-18-Alt | 2,558,417 | 2,870,461 | 312,044 | 12.2% | 7,223 |
| 3 | ONS-18 | 2,555,874 | 2,829,776 | 273,902 | 10.7% | 6,548 |
| 21 | Employment-2 | 2,558,072 | 2,769,629 | 211,557 | 8.3% | 5,567 |
| 6 | ONS-18-Low | 2,554,239 | 2,682,139 | 127,899 | 5.0% | 4,433 |

| Summary 2020–2050 | Min | Max | Mean | Median |
|---|---|---|---|---|
| Population Growth | 127,899 | 633,636 | 413,143 | 419,900 |
| Dwellings (dpa) | 4,433 | 11,874 | 8,602 | 8,401 |

Company: 5. Southern Water    Zone: All

Figure 13: VICUS-BI – Scenario Summary – Southern Water

**Thames Water**
Growth Forecasts




Population & Dwelling Growth 2020–2050

| ID | Scenario | Population 2020 | Population 2050 | Population Change | Population % Change | Dwellings (dpa) |
|---|---|---|---|---|---|---|
| 14 | Housing-Need | 9,551,766 | 12,019,956 | 2,468,190 | 25.8% | 49,834 |
| 18 | Housing-Plan | 9,528,261 | 11,776,760 | 2,248,499 | 23.6% | 46,957 |
| 16 | Housing-Req | 9,528,552 | 11,755,702 | 2,227,150 | 23.4% | 46,256 |
| 1 | ONS-14 | 9,580,566 | 11,811,923 | 2,231,357 | 23.3% | 46,256 |
| 15 | Housing-Need-r | 9,486,366 | 11,417,553 | 1,931,187 | 20.4% | 49,935 |
| 5 | ONS-18-High | 9,525,306 | 11,374,097 | 1,848,791 | 19.4% | 41,189 |
| 11 | GLA-18-Housing | 9,542,060 | 11,369,523 | 1,827,463 | 19.2% | 32,652 |
| 8 | GLA-18-Central | 9,540,299 | 11,345,460 | 1,805,162 | 18.9% | 37,747 |
| 13 | Completions-5Y | 9,458,096 | 11,227,757 | 1,769,661 | 18.7% | 38,735 |
| 19 | Housing-Plan-r | 9,463,396 | 11,194,713 | 1,731,317 | 18.3% | 46,969 |
| 17 | Housing-Req-r | 9,463,490 | 11,170,835 | 1,707,345 | 18.0% | 46,354 |
| 10 | GLA-18-5Y | 9,526,173 | 11,216,595 | 1,690,421 | 17.7% | 37,829 |
| 9 | GLA-18-15Y | 9,526,078 | 11,216,425 | 1,690,347 | 17.7% | 33,565 |
| 20 | Employment-1 | 9,526,678 | 11,173,762 | 1,647,084 | 17.3% | 37,940 |
| 2 | ONS-16 | 9,538,527 | 11,030,215 | 1,491,688 | 15.6% | 35,777 |
| 7 | ONS-18-10Y | 9,556,593 | 11,049,437 | 1,492,844 | 15.6% | 36,322 |
| 12 | Completions-18Y | 9,420,718 | 10,737,822 | 1,317,104 | 14.0% | 32,209 |
| 4 | ONS-18-Alt | 9,527,098 | 10,703,329 | 1,176,231 | 12.3% | 31,862 |
| 3 | ONS-18 | 9,511,440 | 10,494,887 | 983,448 | 10.3% | 28,524 |
| 21 | Employment-2 | 9,526,678 | 10,345,878 | 819,200 | 8.6% | 25,440 |
| 6 | ONS-18-Low | 9,497,574 | 9,616,833 | 119,259 | 1.3% | 15,877 |

| Summary 2020–2050 | Min | Max | Mean | Median |
|---|---|---|---|---|
| Population Growth | 119,259 | 2,468,190 | 1,629,702 | 1,707,345 |
| Dwellings (dpa) | 15,877 | 49,935 | 38,011 | 37,829 |

Company: 6. Thames Water    Zone: All

Figure 14: VICUS-BI – Scenario Summary – Thames Water

# Outcomes 2020–2100

4.40 To support the requirement for a long-term outlook for water resource planning across the WRSE region, the WRMP scenario horizon stretches to 2100. The accompanying VICUS-BI dashboard and Microsoft Excel workbook provide a full illustration and data detail on the range of growth outcomes for this extended outlook.

4.41 Inevitably, as the process of population change is cumulative, the reliability of growth scenarios will reduce over time. The long-term horizon, stretching from 2050–2100 is the period with greatest uncertainty. It is a period during which the large birth cohorts of the 1950s and 1960s will leave the population. Without a significant and continuing input from international migration, the UK's population and that of its local communities would quickly decline.

4.42 However, the 2020–2100 scenarios have been configured to first take account of the range of outcomes for the 2020–2050 plan period and then to consider longer-term growth aligned to ONS national population projections. For each of the scenarios presented for 2020–2050, a long-term growth outlook is considered, extending the scenario horizon to 2100, in alignment with the ONS 2018-based national population projection for the UK.

4.43 Three long-term trajectories are presented for each of the 2020–2050 scenarios: a principal, low and high growth outcome. The high and low variants of the long-term scenarios illustrate the potential extremes of growth under different assumptions of fertility, mortality and international migration.

4.44 In each of the three long-term outcomes, fertility and mortality rates trends are consistent with the NPP principal scenario. For international migration, the principal scenario assumes a +190k annual net growth through international migration, with the High and Low variants assuming +290k and +90k per year respectively. Whilst the robust prediction of likely growth through international migration post-2050 presents a significant challenge, the principal scenario is presented as the most prudent outlook for consideration in the long-term water resource planning process.

4.45 For the WRSE region in total, the 17% average growth in population 2020–2050, is accompanied by a 13% average growth for 2050–2100 under the principal long-term outcome. This is equivalent to an average population growth of approximately 32% over the 2020–2100 plan period, an additional 6.2 million people on the base year total. The Low and High population growth averages for the full 2020–2100 horizon, range from 21–42%.

4.46 In terms of estimated housing growth, the average annual growth under the suite of Principal scenarios for the long-term horizon is approximately 51,432 dpa, ranging from 38,194 dpa to 63,403 dpa under the Low and High scenarios respectively.

4.47 Similar long-term outcomes for each water company and each WRZ are contained within the accompanying VICUS-BI and Microsoft Excel output.

# Appendix A Glossary of Terms

| | |
|---|---|
| APS | Annual Population Survey |
| ASFR | Age-specific fertility rate |
| ASMR | Age-specific mortality rate |
| BRES | Business Register & Employment survey |
| Defra | Department for Environment, Food and Rural Affairs |
| DWMP | Drainage and Wastewater Management Plan |
| DWP | Department for Works and Pensions |
| EA | Environment Agency |
| EFO | Economic and Fiscal Outlook |
| EU | European Union |
| GDP | Gross Domestic Product |
| GLA | Greater London Authority |
| H&T | Hidden and transient |
| LHN | Local Housing Need |
| LPA | Local Planning Authority |
| MHCLG | Ministry for Housing, Communities and Local Government |
| MYE | Mid-year population estimate |
| NPP | National Population Projection |
| NPPF | National Planning Policy Framework |
| OAN | Objective Assessment of Need |
| OBR | Office for Budget Responsibility |
| ONS | Office for National Statistics |
| OxCam | Oxford Cambridge Arc |
| PAF | Postcode Address File |
| PAS | Planning Advisory Service |
| PPG | Planning Policy Guidance |
| SHLAA | Strategic Housing Land Availability Assessment |
| SNPP | Sub-national Population Projection |
| SPA | State Pension Age |
| SRRP | Statement of Regional Resource Position |
| UK | United Kingdom |
| WG | Welsh Government |
| WRE | Water Resources East |
| WRMP | Water Resources Management Plan |
| WRN | Water Resources North |
| WRSE | Water Resources South East |
| WRSW | Water Resources South West |
| WRW | Water Resources West |
| WRZ | Water Resource Zone |

# Appendix B Local Authority Status Log

B.1 The activity log indicates the date at which Local Plan evidence was last accessed from each LPA and added to the Consilium database.

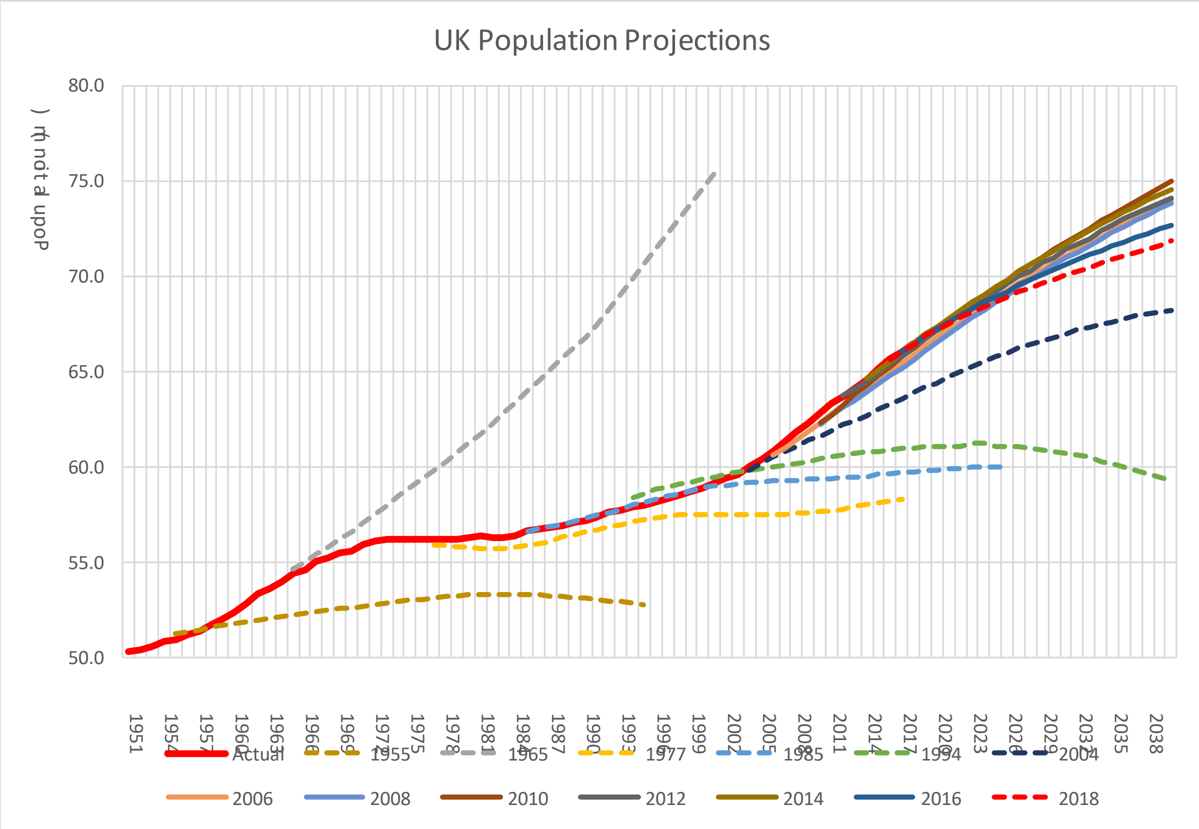
| Area Name | Area Code | Region | WRSE | OxCam | Last Updated |
|---|---|---|---|---|---|
| Adur | E07000223 | South East | WRSE | | 02/04/2020 |
| Arun | E07000224 | South East | WRSE | | 02/04/2020 |
| Ashford | E07000105 | South East | WRSE | | 17/03/2020 |
| Aylesbury Vale | E07000004 | South East | WRSE | OxCam | 17/03/2020 |
| Barnet | E09000003 | London | WRSE | | 30/03/2020 |
| Basingstoke and Deane | E07000084 | South East | WRSE | | 02/04/2020 |
| Bedford | E06000055 | East of England | | OxCam | 26/03/2020 |
| Bexley | E09000004 | London | WRSE | | 31/03/2020 |
| Bracknell Forest | E06000036 | South East | WRSE | | 02/04/2020 |
| Brent | E09000005 | London | WRSE | | 31/03/2020 |
| Brentwood | E07000068 | East of England | WRSE | | 25/03/2020 |
| Brighton and Hove | E06000043 | South East | WRSE | | 02/04/2020 |
| Bromley | E09000006 | London | WRSE | | 30/03/2020 |
| Broxbourne | E07000095 | East of England | WRSE | | 27/03/2020 |
| Cambridge | E07000008 | East of England | | OxCam | 27/03/2020 |
| Camden | E09000007 | London | WRSE | | 30/03/2020 |
| Canterbury | E07000106 | South East | WRSE | | 17/03/2020 |
| Central Bedfordshire | E06000056 | East of England | WRSE | OxCam | 27/03/2020 |
| Cherwell | E07000177 | South East | WRSE | OxCam | 16/03/2020 |
| Chichester | E07000225 | South East | WRSE | | 16/03/2020 |
| Chiltern | E07000005 | South East | WRSE | OxCam | 18/03/2020 |
| City of London | E09000001 | London | WRSE | | 30/03/2020 |
| Corby | E07000150 | East Midlands | | OxCam | 29/03/2020 |
| Cotswold | E07000079 | South West | WRSE | | 18/03/2020 |
| Crawley | E07000226 | South East | WRSE | | 02/04/2020 |
| Croydon | E09000008 | London | WRSE | | 30/03/2020 |
| Dacorum | E07000096 | East of England | WRSE | | 27/03/2020 |
| Dartford | E07000107 | South East | WRSE | | 17/03/2020 |
| Daventry | E07000151 | East Midlands | | OxCam | 29/03/2020 |
| Dover | E07000108 | South East | WRSE | | 18/03/2020 |
| Ealing | E09000009 | London | WRSE | | 31/03/2020 |
| East Cambridgeshire | E07000009 | East of England | | OxCam | 27/03/2020 |
| East Hampshire | E07000085 | South East | WRSE | | 18/03/2020 |
| East Hertfordshire | E07000242 | East of England | WRSE | | 27/03/2020 |
| East Northamptonshire | E07000152 | East Midlands | | OxCam | 30/03/2020 |
| Eastbourne | E07000061 | South East | WRSE | | 18/03/2020 |
| Eastleigh | E07000086 | South East | WRSE | | 18/03/2020 |
| Elmbridge | E07000207 | South East | WRSE | | 18/03/2020 |
| Enfield | E09000010 | London | WRSE | | 31/03/2020 |
| Epping Forest | E07000072 | East of England | WRSE | | 29/03/2020 |
| Epsom and Ewell | E07000208 | South East | WRSE | | 18/03/2020 |
| Fareham | E07000087 | South East | WRSE | | 02/04/2020 |
| Fenland | E07000010 | East of England | | OxCam | 26/03/2020 |
| Folkestone and Hythe | E07000112 | South East | WRSE | | 19/03/2020 |

| Area Name | Area Code | Region | WRSE | OxCam | Last Updated |
|---|---|---|---|---|---|
| Gosport | E07000088 | South East | WRSE | | 29/03/2020 |
| Gravesham | E07000109 | South East | WRSE | | 17/03/2020 |
| Greenwich | E09000011 | London | WRSE | | 31/03/2020 |
| Guildford | E07000209 | South East | WRSE | | 20/03/2020 |
| Hackney | E09000012 | London | WRSE | | 30/03/2020 |
| Hammersmith and Fulham | E09000013 | London | WRSE | | 30/03/2020 |
| Haringey | E09000014 | London | WRSE | | 31/03/2020 |
| Harlow | E07000073 | East of England | WRSE | | 27/03/2020 |
| Harrow | E09000015 | London | WRSE | | 31/03/2020 |
| Hart | E07000089 | South East | WRSE | | 20/03/2020 |
| Hastings | E07000062 | South East | WRSE | | 20/03/2020 |
| Havant | E07000090 | South East | WRSE | | 20/03/2020 |
| Hertsmere | E07000098 | East of England | WRSE | | 27/03/2020 |
| Hillingdon | E09000017 | London | WRSE | | 31/03/2020 |
| Horsham | E07000227 | South East | WRSE | | 20/03/2020 |
| Hounslow | E09000018 | London | WRSE | | 31/03/2020 |
| Huntingdonshire | E07000011 | East of England | | OxCam | 27/03/2020 |
| Isle of Wight | E06000046 | South East | WRSE | | 23/03/2020 |
| Islington | E09000019 | London | WRSE | | 30/03/2020 |
| Kensington and Chelsea | E09000020 | London | WRSE | | 30/03/2020 |
| Kettering | E07000153 | East Midlands | | OxCam | 30/03/2020 |
| Kingston upon Thames | E09000021 | London | WRSE | | 30/03/2020 |
| Lambeth | E09000022 | London | WRSE | | 30/03/2020 |
| Lewes | E07000063 | South East | WRSE | | 23/03/2020 |
| Lewisham | E09000023 | London | WRSE | | 29/03/2020 |
| Luton | E06000032 | East of England | WRSE | OxCam | 26/03/2020 |
| Maidstone | E07000110 | South East | WRSE | | 23/03/2020 |
| Medway | E06000035 | South East | WRSE | | 23/03/2020 |
| Merton | E09000024 | London | WRSE | | 28/03/2020 |
| Mid Sussex | E07000228 | South East | WRSE | | 23/03/2020 |
| Milton Keynes | E06000042 | South East | | OxCam | 23/03/2020 |
| Mole Valley | E07000210 | South East | WRSE | | 18/03/2020 |
| New Forest | E07000091 | South East | WRSE | | 23/03/2020 |
| New Forest National Park | E26000009 | National Park | WRSE | | 30/03/2020 |
| Newham | E09000025 | London | WRSE | | 28/03/2020 |
| North Hertfordshire | E07000099 | East of England | WRSE | | 29/03/2020 |
| Northampton | E07000154 | East Midlands | | OxCam | 18/03/2020 |
| Oxford | E07000178 | South East | WRSE | OxCam | 16/03/2020 |
| Peterborough | E06000031 | East of England | | OxCam | 29/03/2020 |
| Portsmouth | E06000044 | South East | WRSE | | 23/03/2020 |
| Reading | E06000038 | South East | WRSE | | 23/03/2020 |
| Redbridge | E09000026 | London | WRSE | | 27/03/2020 |
| Reigate and Banstead | E07000211 | South East | WRSE | | 23/03/2020 |
| Richmond upon Thames | E09000027 | London | WRSE | | 27/03/2020 |
| Rother | E07000064 | South East | WRSE | | 25/03/2020 |
| Runnymede | E07000212 | South East | WRSE | | 25/03/2020 |
| Rushmoor | E07000092 | South East | WRSE | | 25/03/2020 |
| Sevenoaks | E07000111 | South East | WRSE | | 25/03/2020 |

| Area Name | Area Code | Region | WRSE | OxCam | Last Updated |
|---|---|---|---|---|---|
| Slough | E06000039 | South East | WRSE | | 25/03/2020 |
| South Bucks | E07000006 | South East | WRSE | OxCam | 25/03/2020 |
| South Cambridgeshire | E07000012 | East of England | | OxCam | 27/03/2020 |
| South Downs National Park | E26000010 | National Park | WRSE | | 02/04/2020 |
| South Northamptonshire | E07000155 | East Midlands | WRSE | OxCam | 18/03/2020 |
| South Oxfordshire | E07000179 | South East | WRSE | OxCam | 29/03/2020 |
| Southampton | E06000045 | South East | WRSE | | 25/03/2020 |
| Southwark | E09000028 | London | WRSE | | 27/03/2020 |
| Spelthorne | E07000213 | South East | WRSE | | 26/03/2020 |
| St Albans | E07000240 | East of England | WRSE | | 27/03/2020 |
| Stevenage | E07000243 | East of England | WRSE | | 23/03/2020 |
| Stratford-on-Avon | E07000221 | West Midlands | WRSE | | 12/03/2020 |
| Surrey Heath | E07000214 | South East | WRSE | | 27/03/2020 |
| Sutton | E09000029 | London | WRSE | | 24/03/2020 |
| Swale | E07000113 | South East | WRSE | | 27/03/2020 |
| Swindon | E06000030 | South West | WRSE | | 18/03/2020 |
| Tandridge | E07000215 | South East | WRSE | | 27/03/2020 |
| Test Valley | E07000093 | South East | WRSE | | 27/03/2020 |
| Tewkesbury | E07000083 | South West | WRSE | | 18/03/2020 |
| Thanet | E07000114 | South East | WRSE | | 27/03/2020 |
| Three Rivers | E07000102 | East of England | WRSE | | 23/03/2020 |
| Tonbridge and Malling | E07000115 | South East | WRSE | | 27/03/2020 |
| Tower Hamlets | E09000030 | London | WRSE | | 24/03/2020 |
| Tunbridge Wells | E07000116 | South East | WRSE | | 27/03/2020 |
| Uttlesford | E07000077 | East of England | WRSE | | 23/03/2020 |
| Vale of White Horse | E07000180 | South East | WRSE | OxCam | 16/03/2020 |
| Waltham Forest | E09000031 | London | WRSE | | 23/03/2020 |
| Wandsworth | E09000032 | London | WRSE | | 23/03/2020 |
| Watford | E07000103 | East of England | WRSE | | 23/03/2020 |
| Waverley | E07000216 | South East | WRSE | | 27/03/2020 |
| Wealden | E07000065 | South East | WRSE | | 27/03/2020 |
| Wellingborough | E07000156 | East Midlands | | OxCam | 18/03/2020 |
| Welwyn Hatfield | E07000241 | East of England | WRSE | | 20/03/2020 |
| West Berkshire | E06000037 | South East | WRSE | | 28/03/2020 |
| West Oxfordshire | E07000181 | South East | WRSE | OxCam | 16/03/2020 |
| Westminster | E09000033 | London | WRSE | | 23/03/2020 |
| Wiltshire | E06000054 | South West | WRSE | | 18/03/2020 |
| Winchester | E07000094 | South East | WRSE | | 28/03/2020 |
| Windsor and Maidenhead | E06000040 | South East | WRSE | | 29/03/2020 |
| Woking | E07000217 | South East | WRSE | | 29/03/2020 |
| Wokingham | E06000041 | South East | WRSE | | 29/03/2020 |
| Worthing | E07000229 | South East | WRSE | | 16/03/2020 |
| Wychavon | E07000238 | West Midlands | WRSE | | 12/03/2020 |
| Wycombe | E07000007 | South East | WRSE | OxCam | 29/03/2020 |

# Appendix C Projection Accuracy

C.1 The illustration below provides a summary of official UK population projections and their relationship to the actual trajectory of population change.




*Source: ONS, OBR*

C.2 Historically, the UK population has risen more than projected, with one exception. The 1965-based population growth trajectory was based upon the continuation of the high fertility rates experienced in the early 1960s, which peaked in 1964, falling to a record low in 1977.

C.3 In subsequent years, projections have typically under-estimated future population growth due to one or more of three factors: (i) the allocation of insufficient growth through international migration; (ii) a failure to anticipate a return to higher fertility rates; and (iii) a failure to anticipate the continued improvements in life expectancy (longevity).

C.4 More recently, projections have demonstrated greater convergence, with lower international migration, plus reduced assumptions on long-term fertility rates and improvements in life expectancy, having a dampening effect upon population growth outcomes.

# Appendix D ONS & GLA Projections

## (i) ONS National Projections

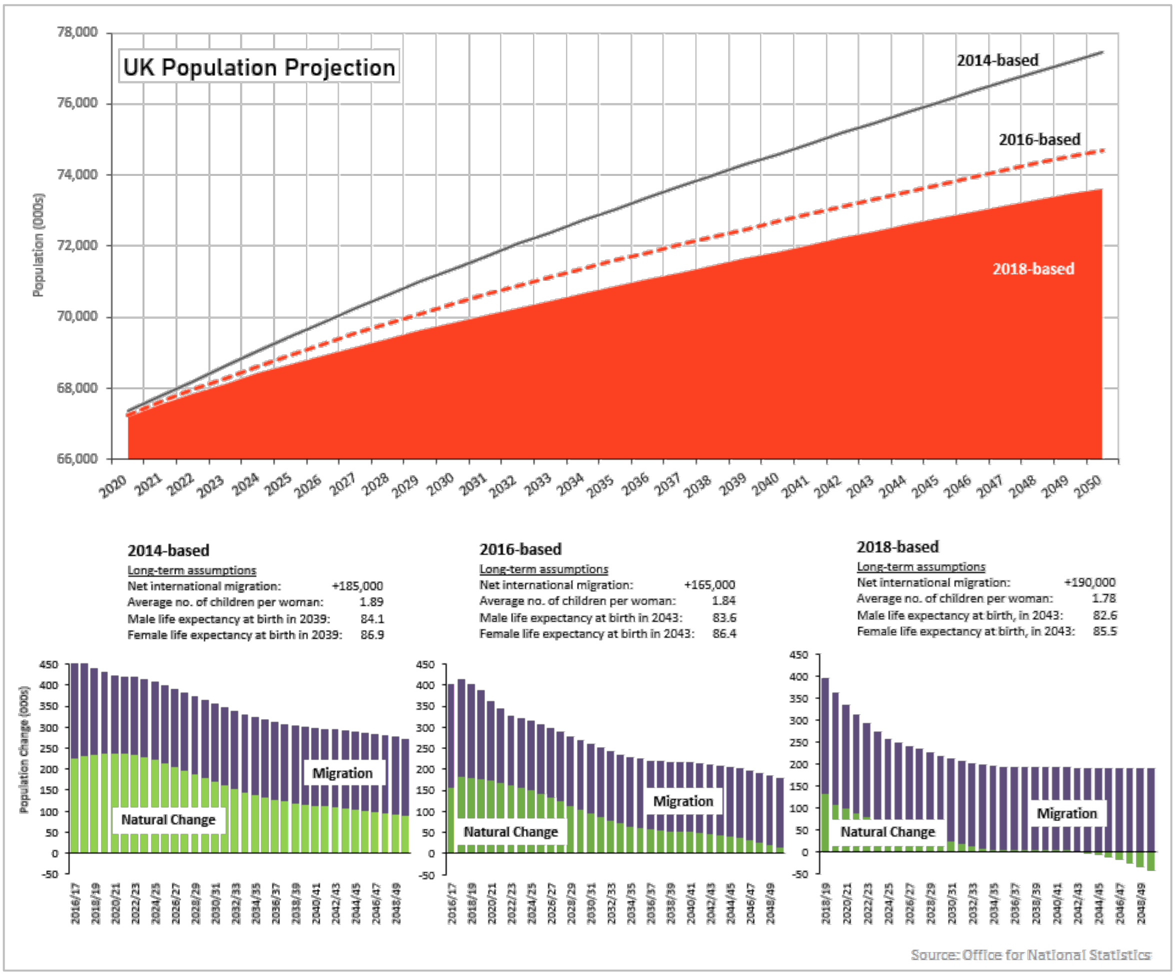
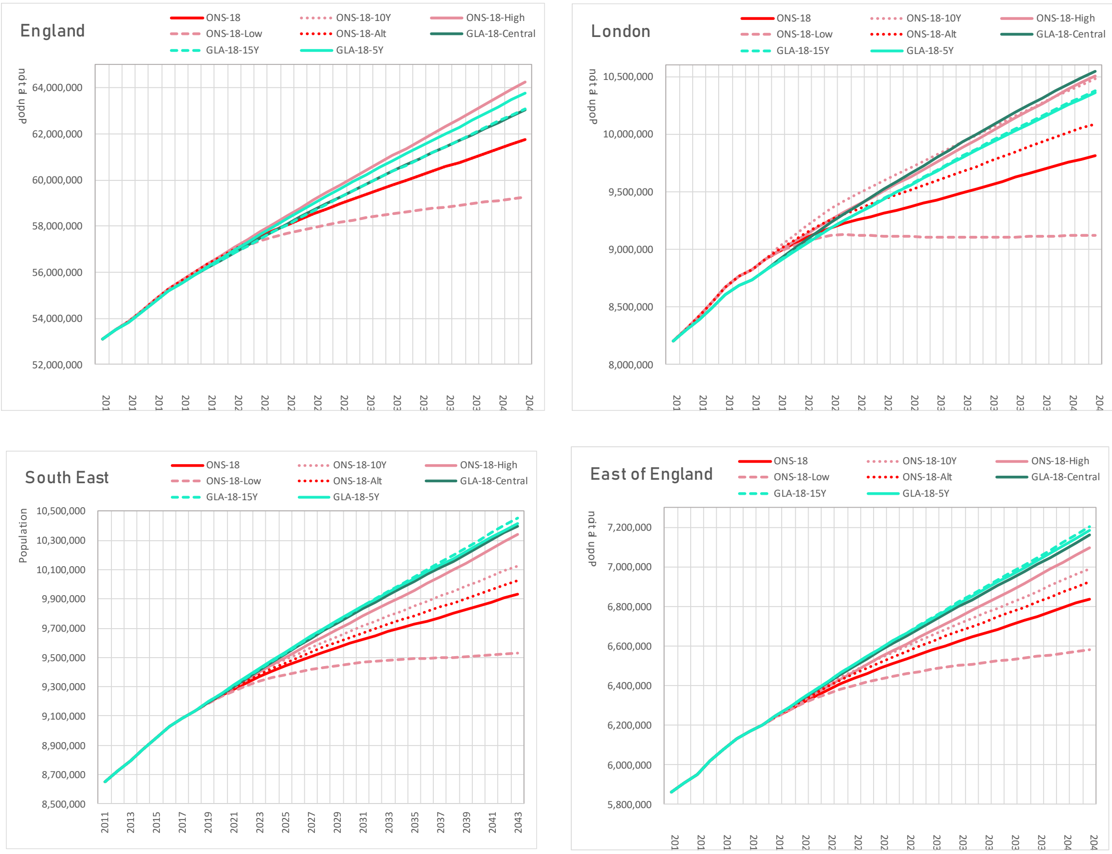



Figure 15: UK Population Projections

# (ii) ONS vs GLA Projections Compared




Source: ONS, GLA

Figure 16: ONS & GLA 2018-based Projections Compared

# Appendix E OxCam Geography

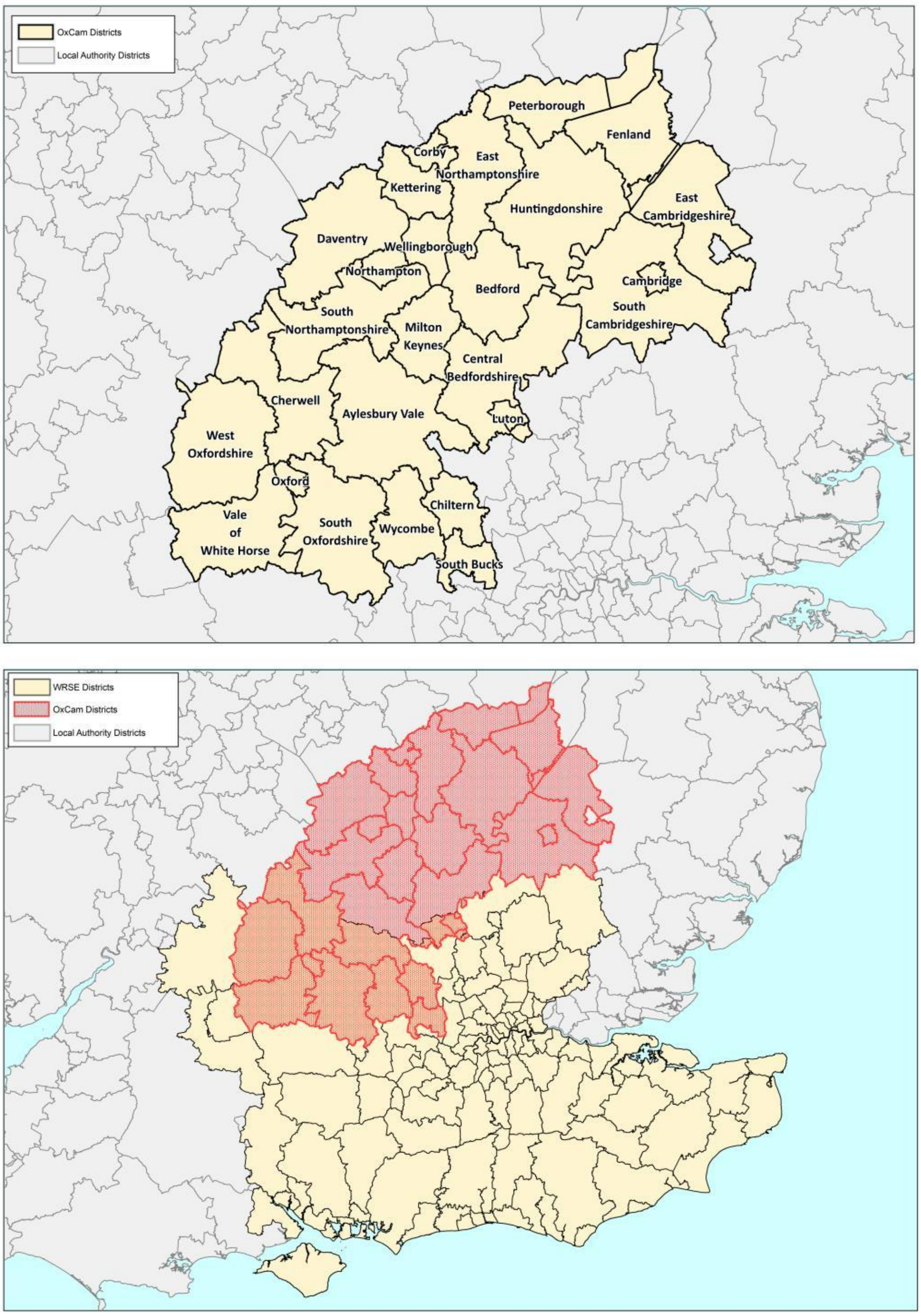



Figure 17: OxCam Area Definition

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Nexus | Discovery Way | University of Leeds | Leeds | LS2 3AA
www.edgeanalytics.co.uk

# 2. Annex 7b: Growth Forecast Update

# WRSE

## FORECAST COMPARISON

June 2023

EDGE ANALYTICS

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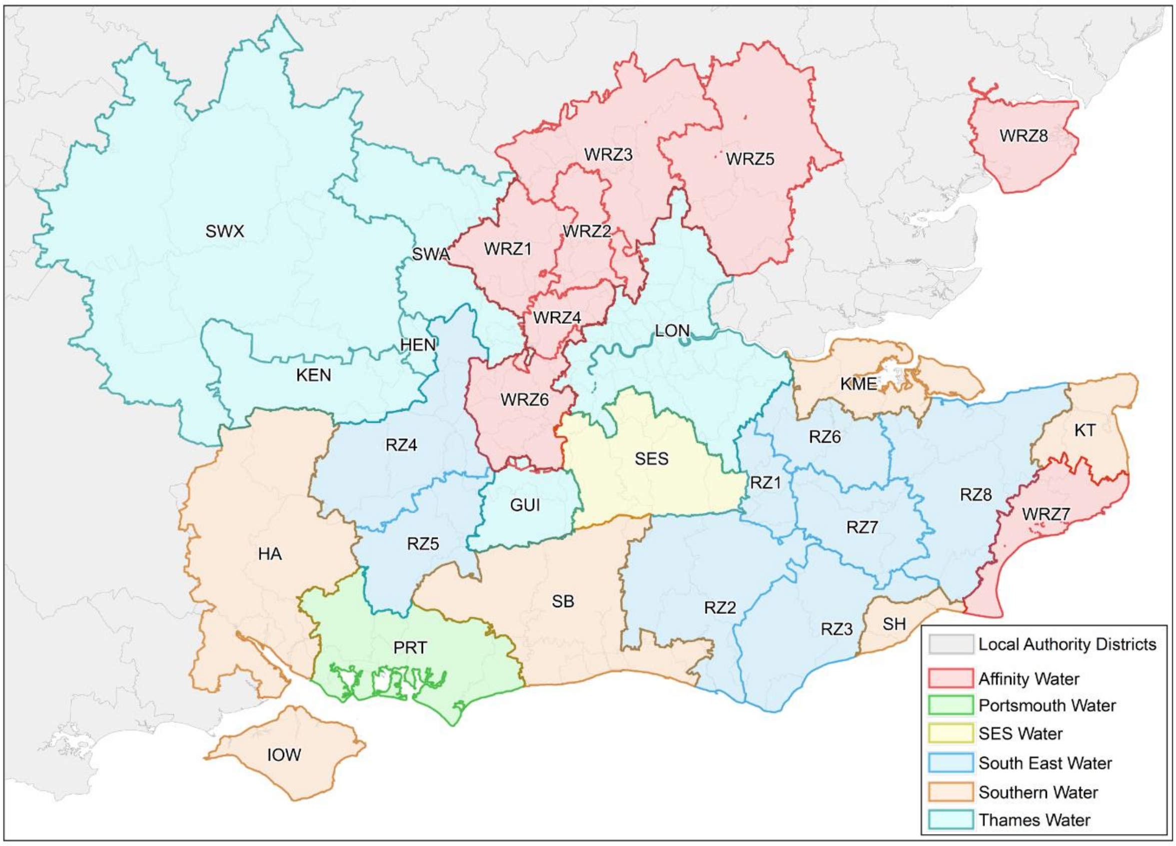
# ACKNOWLEDGEMENTS

Demographic statistics used in this report have been derived from data from the Office for National Statistics licensed under the Open Government Licence v.3.0.

# CONTENTS

# 1 INTRODUCTION

1.1 The Water Resources South East (WRSE) group is an alliance of the six water companies that cover the South East region of England: Affinity Water, Portsmouth Water, SES Water, South East Water, Southern Water, and Thames Water.




Contains OS Data © Crown Copyright and database rights 2023.

Figure 1: WRSE Area Definition

1.2 In spring and summer 2020, Edge Analytics delivered a suite of demographic and housing evidence to WRSE to inform the development of their Water Resource Management Plans (WRMP). The deliverables included (amongst other items):

- Local Plan Housing Growth information, from the Edge Analytics Consilium database
- Population and housing forecasts generated using Edge Analytics' VICUS forecasting technology (for a forecast period 2020–2100 and a range of trend-based, housing-led and employment-led scenarios)[1].

[1] *For the full list of scenarios refer to Appendix A.*

1.3 Since the 2020 delivery, there have been a number of important data releases (e.g., Census 2021 results, more up-to-date Local Plan Housing Growth information), which highlighted the need to revisit the forecasts and update them in light of this new information.

1.4 In February 2023, WRSE commissioned Edge Analytics to produce updated population and property forecasts, taking account of the latest demographic and housing statistics[2]. The outputs were produced for a **2021–2101** forecast period and for a sub-set of the 2020 scenarios, including:

- ONS-18-Rebased-P
- ONS-18-Rebased-L
- Housing-Plan-P
- Housing-Need-H
- OxCam-1a-r-P.

1.5 An additional scenario was also produced, which was not included in the 2020 forecasts:

- OxCam-1a-P.

1.6 A detailed description of each of the scenarios is provided in Section 3 of this document.

1.7 This concise report aims to help in understanding how the 2023 forecasts compare to those produced in 2020, summarising the key differences in terms of methods, data inputs and assumptions (Section 2). A side-by-side comparison of the forecast outcomes is also presented at regional and company level in Section 3. Section 4 of the document provides a timeline of expected future data releases which will provide additional intelligence which can feed into future updated population and housing forecasts.

[2] Note that the latest Local Plan Housing Growth data was used to inform the scenario forecast development in February 2023, but it did not form part of the 2023 deliverable to WRSE.

# 2 METHODS, DATA INPUTS & ASSUMPTIONS

2.1 The overall approach for the development of the 2023 forecasts remains the same as in 2020. A detailed description of the forecasting framework can be found in the earlier Edge Analytics' report: VICUS - Methodology - Final - 31.07.2020.

2.2 This section focuses on the key changes to the methods, data inputs and assumptions that were required for the 2023 update.

2.3 The main drivers of the differences between the 2020 and 2023 forecasts are different **base years** and changes to the **housing growth evidence** informing the Housing-Need and Housing-Plan scenarios. Other methodological/data changes have also had an impact on the forecast outcomes but to a lesser extent. All are discussed in more detail below.

## Base Year

2.4 In the 2020 forecasts, the **2018** mid-year population estimates (MYE) provided the forecast base year. In the 2023 forecasts, the base year was updated to the **2021** MYEs, which were published by the Office for National Statistics (ONS) in December 2022. Importantly, the 2021 MYEs are the first MYEs to be underpinned by the Census 2021.

2.5 In the years in between the decennial Census, the population is estimated via an annual ONS MYE. This estimate takes account of registered births and deaths and estimates of domestic and international migration.

2.6 The output from the Census 2021 and the subsequent 2021 MYEs derived from it have shown differences in both the *population total* and the underlying *structure of the population* (its composition by age and sex) when compared to the MYEs that preceded it.

## Local Plan Housing Growth Data

2.7 Local Plan Housing Growth data provides the housing growth trajectories that drive population growth under the Housing-Need and Housing-Plan scenarios. In addition, it is the source of the housing development site information that further enhances the Housing-Plan scenario, ensuring that the growth forecasts are distributed in line with the location and phasing of future housing developments.

2.8 In both sets of the forecasts (2020 and 2023), the 'Need' and 'Plan' housing trajectories were drawn from the Edge Analytics Consilium Local Plan Housing Growth database. However, the information used in the 2020 forecasts was last updated in **March–April 2020**, whereas in the 2023 forecasts this data was last updated in **January–February 2023**.

## Other Changes

2.9 A number of other methodological/data changes were required for the 2023 update, including:

- Coercion of historical demographic inputs (population, households, population not-in-households, etc.) to a Census 2021 Output Area (OA21) geography.
- Alignment of the Census 2021 population, households and population not-in-households at district and small area level.
- Use of the Census/2021 MYE data to devise population by single year of age and sex constraints at OA21 level (not available from official releases).
- Modelling of population not-in-households data by age groups and sex from available partial Census 2021 data, aligning it with 2021 MYE.
- Updating/estimating other model inputs, such as household, vacancy, and properties to an OA21 basis, utilising Census 2021 where available.
- Rescaling Sub-National Population Projection (SNPP) trajectories to a 2021 MYE starting point and extending them to 2050.
- Rescaling of household headship rates to a rebased Census 2021 value.
- Reformulation of all models to accept the new Census/2021 MYE data.

# 3 SCENARIO OUTCOMES

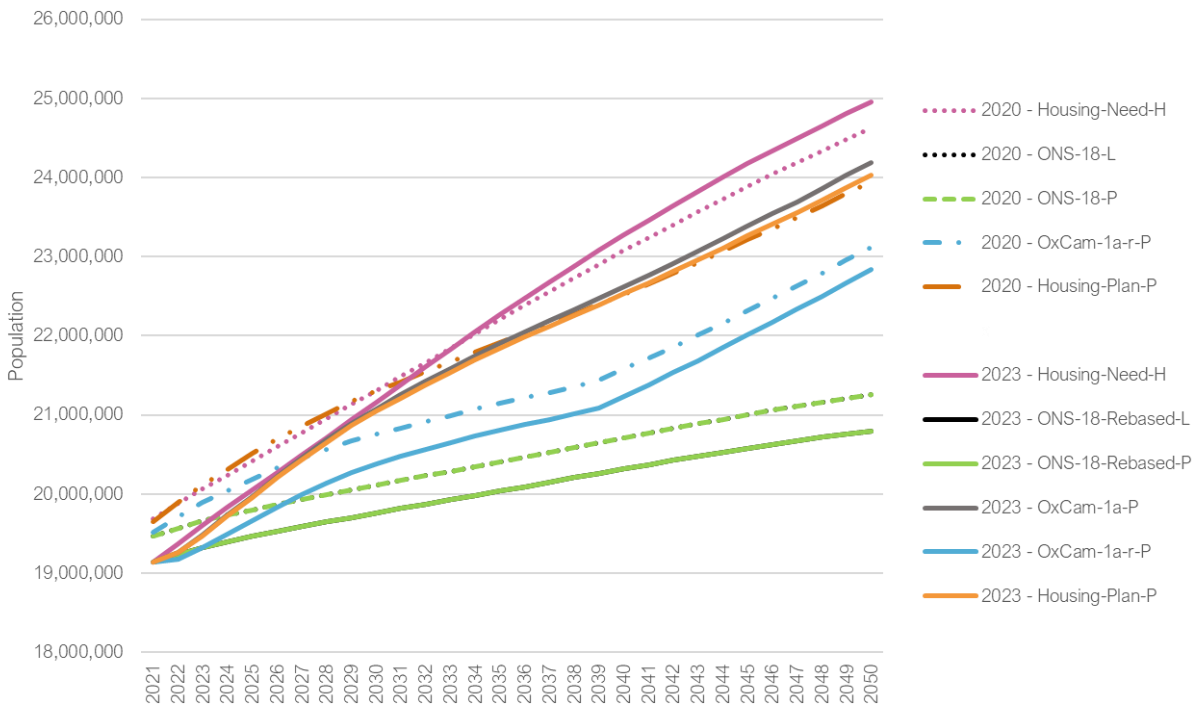
3.1 The 2023 forecasts were produced for the following scenarios:

| ID | SCENARIO | DESCRIPTION |
|---|---|---|
| 1a | ONS-18-Rebased-P | ONS 2018-based *Principal* sub-national population projection (SNPP), using a five-year history (2013–2018) to derive local fertility & mortality assumptions and a long-term UK net international migration assumption of +190k. Unlike earlier rounds of SNPP, the 2018-based Principal projection uses a two-year history (2016–2018) of internal migration assumptions, following recent changes to the methodology used for its estimation, which have only covered the latest 2 years. **This scenario has been rebased to the 2021 MYE.**<br>From 2050 to 2101, growth under this scenario is trended in line with the *Principal* (-P) 2018-based national population projection (NPP) from ONS. |
| 1b | ONS-18-Rebased-L | ONS 2018-based *Principal* SNPP using a five-year history (2013–2018) to derive local fertility & mortality assumptions and a long-term UK net international migration assumption of +190k. Unlike earlier rounds of SNPP, the 2018-based Principal projection uses a two-year history (2016–2018) of internal migration assumptions, following recent changes to the methodology used for its estimation, which have only covered the latest 2 years. **This scenario has been rebased to the 2021 MYE.**<br>From 2050 to 2101, growth under this scenario is trended in line with the *Low migration* (-L) variant of the ONS 2018-based NPP. |
| 2 | Housing-Need-H | A Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's Local Housing Need (LHN) or Objectively Assessed Housing Need (OAHN). Following the final year of data, projected housing growth in non-London areas returns to the average of ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050.<br>From 2050 to 2101, growth under this scenario is trended in line with the *High migration* (-H) variant of the ONS 2018-based NPP. |
| 3 | Housing-Plan-P | A Housing-led scenario, with population growth underpinned by each local authority's Local Plan housing growth trajectory. Following the final year of data, projected housing growth in non-London areas returns to the average of ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050.<br>From 2050 to 2101, growth under this scenario is trended in line with the *Principal* (-P) 2018-based NPP from ONS. |
| 4 | OxCam-1a-P | 'New Settlement' 23k dpa scenario, with c.3.8k dpa above Housing-Plan distributed between Cherwell (20%), Aylesbury Vale (20%), Central Bedfordshire (40%), South Cambridgeshire (20%).<br>From 2050 to 2101, growth under this scenario is trended in line with the *Principal* (-P) 2018-based NPP from ONS. |
| 5 | OxCam-1a-r-P | A Housing-led scenario, consistent with the OxCam-1a scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter.<br>From 2050 to 2101, growth under this scenario is trended in line with the *Principal* (-P) 2018-based NPP from ONS. |

3.2 Scenario outcomes for these scenarios, compared to the equivalent scenarios from the 2020 forecasts, are presented below. Note that an additional OxCam scenario was included in the 2023 projections (OxCam-1a-P) that was not delivered as part of the 2020 scenarios.

3.3 For WRSE in total and each constituent water company, the summaries include a chart showing population growth between 2021 and 2050 and two tables contrasting population change and average dwellings per annum for the medium- (2021–2050) and long-term (2021–2100) forecast periods.

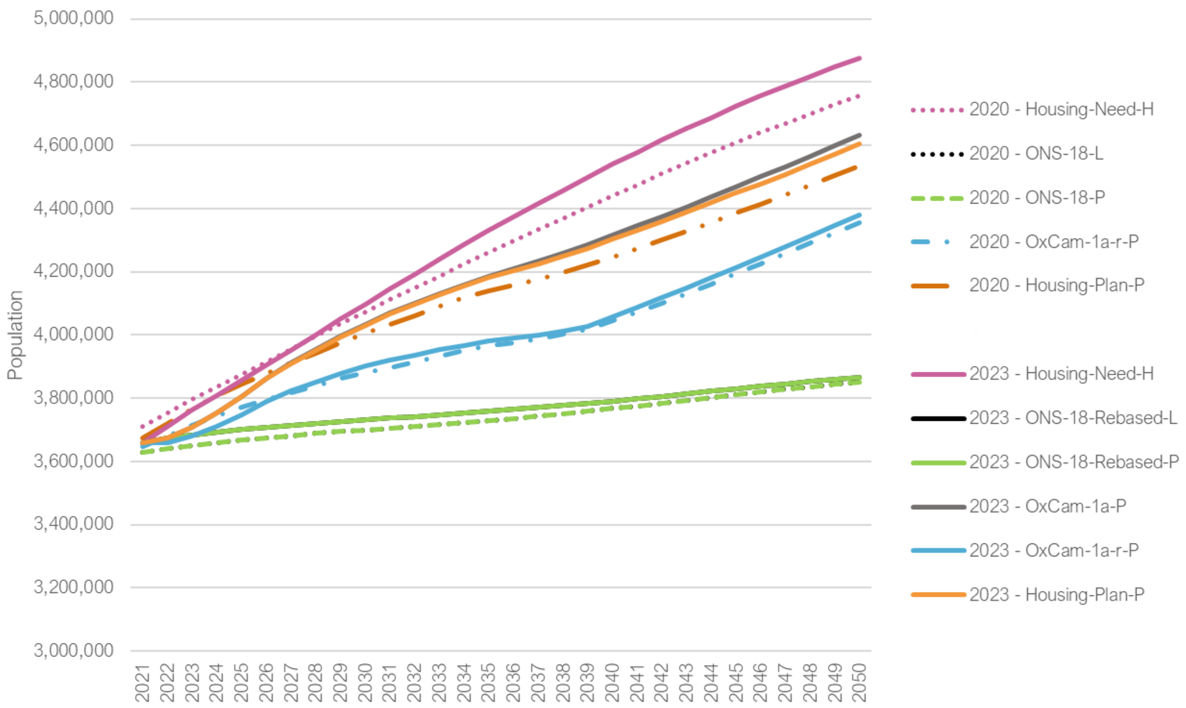
# WRSE




| 2020 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 19,692,433 | 24,628,751 | 4,936,318 | 25.1% | 99,131 | 19,692,433 | 29,805,795 | 10,113,361 | 51.4% | 75,819 |
| Housing-Plan-P | 19,648,395 | 23,945,684 | 4,297,290 | 21.9% | 89,688 | 19,648,395 | 27,011,856 | 7,363,461 | 37.5% | 58,558 |
| ONS-18-L | 19,473,684 | 21,251,483 | 1,777,798 | 9.1% | 51,770 | 19,473,684 | 22,074,570 | 2,600,886 | 13.4% | 29,409 |
| ONS-18-P | 19,473,684 | 21,251,483 | 1,777,798 | 9.1% | 51,770 | 19,473,684 | 24,031,005 | 4,557,320 | 23.4% | 42,021 |
| OxCam-1a-r-P | 19,514,665 | 23,117,138 | 3,602,473 | 18.5% | 91,761 | 19,514,665 | 26,092,542 | 6,577,877 | 33.7% | 59,484 |

| 2023 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 19,136,248 | 24,959,131 | 5,822,883 | 30.4% | 105,433 | 19,136,248 | 29,243,867 | 10,107,619 | 52.8% | 69,438 |
| Housing-Plan-P | 19,136,298 | 24,028,276 | 4,891,978 | 25.6% | 91,840 | 19,136,298 | 25,884,596 | 6,748,298 | 35.3% | 49,432 |
| ONS-18-Rebased-L | 19,136,248 | 20,799,731 | 1,663,482 | 8.7% | 46,074 | 19,136,248 | 20,231,861 | 1,095,613 | 5.7% | 17,364 |
| ONS-18-Rebased-P | 19,136,248 | 20,799,731 | 1,663,482 | 8.7% | 46,074 | 19,136,248 | 22,442,699 | 3,306,451 | 17.3% | 30,832 |
| OxCam-1a-P | 19,136,248 | 24,193,687 | 5,057,439 | 26.4% | 94,542 | 19,136,248 | 26,060,611 | 6,924,363 | 36.2% | 50,562 |
| OxCam-1a-r-P | 19,136,248 | 22,842,472 | 3,706,224 | 19.4% | 94,469 | 19,136,248 | 24,629,081 | 5,492,833 | 28.7% | 50,533 |

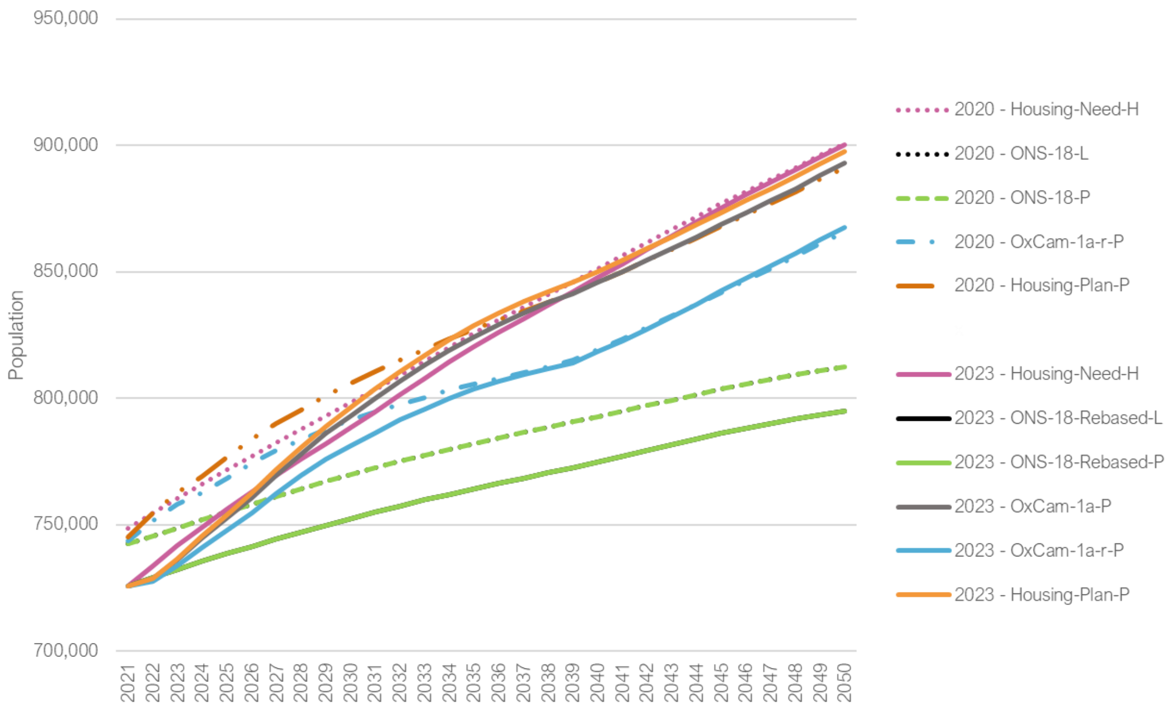
# Affinity Water (WRZ 1–7)




| 2020 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 3,712,322 | 4,756,450 | 1,044,128 | 28.1% | 20,185 | 3,712,322 | 5,757,125 | 2,044,803 | 55.1% | 14,996 |
| Housing-Plan-P | 3,675,735 | 4,534,814 | 859,079 | 23.4% | 21,776 | 3,675,735 | 5,108,527 | 1,432,793 | 39.0% | 13,576 |
| ONS-18-L | 3,627,846 | 3,851,581 | 223,735 | 6.2% | 7,979 | 3,627,846 | 3,988,751 | 360,905 | 9.9% | 4,814 |
| ONS-18-P | 3,627,846 | 3,851,581 | 223,735 | 6.2% | 7,979 | 3,627,846 | 4,352,547 | 724,701 | 20.0% | 7,087 |
| OxCam-1a-r-P | 3,645,711 | 4,356,258 | 710,547 | 19.5% | 17,418 | 3,645,711 | 4,912,389 | 1,266,677 | 34.7% | 11,232 |

| 2023 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 3,659,990 | 4,876,354 | 1,216,364 | 33.2% | 21,484 | 3,659,990 | 5,675,305 | 2,015,315 | 55.1% | 13,517 |
| Housing-Plan-P | 3,659,509 | 4,603,991 | 944,483 | 25.8% | 17,540 | 3,659,509 | 4,923,200 | 1,263,692 | 34.5% | 9,113 |
| ONS-18-Rebased-L | 3,659,990 | 3,867,145 | 207,156 | 5.7% | 7,115 | 3,659,990 | 3,730,791 | 70,801 | 1.9% | 2,478 |
| ONS-18-Rebased-P | 3,659,990 | 3,867,145 | 207,156 | 5.7% | 7,115 | 3,659,990 | 4,140,910 | 480,920 | 13.1% | 4,914 |
| OxCam-1a-P | 3,659,990 | 4,633,982 | 973,992 | 26.6% | 18,169 | 3,659,990 | 4,955,098 | 1,295,109 | 35.4% | 9,389 |
| OxCam-1a-r-P | 3,659,990 | 4,381,606 | 721,617 | 19.7% | 18,108 | 3,659,990 | 4,689,747 | 1,029,757 | 28.1% | 9,365 |

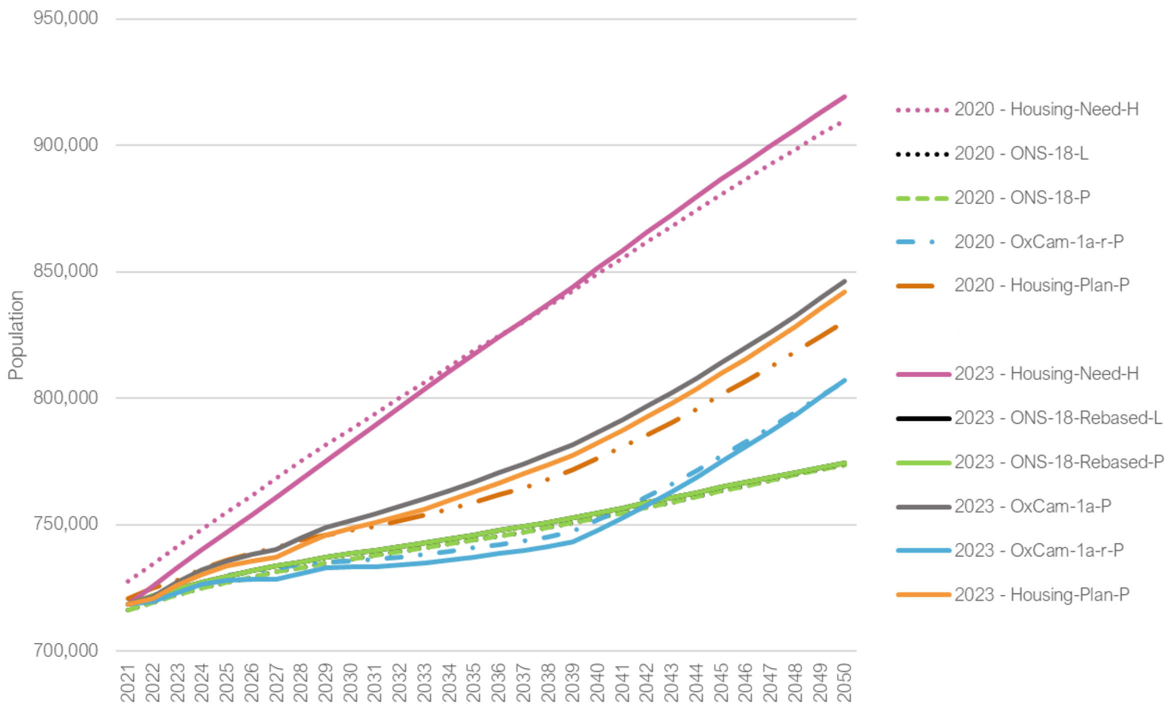
# Portsmouth Water




| 2020 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 748,387 | 900,486 | 152,099 | 20.3% | 3,066 | 748,387 | 1,085,645 | 337,258 | 45.1% | 2,532 |
| Housing-Plan-P | 745,237 | 891,292 | 146,055 | 19.6% | 3,880 | 745,237 | 1,008,361 | 263,124 | 35.3% | 2,721 |
| ONS-18-L | 742,427 | 812,532 | 70,105 | 9.4% | 1,794 | 742,427 | 853,492 | 111,065 | 15.0% | 1,111 |
| ONS-18-P | 742,427 | 812,532 | 70,105 | 9.4% | 1,794 | 742,427 | 920,393 | 177,966 | 24.0% | 1,542 |
| OxCam-1a-r-P | 743,456 | 865,817 | 122,361 | 16.5% | 2,881 | 743,456 | 979,714 | 236,258 | 31.8% | 2,014 |

| 2023 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 725,553 | 900,343 | 174,789 | 24.1% | 3,127 | 725,553 | 1,075,251 | 349,698 | 48.2% | 2,406 |
| Housing-Plan-P | 725,539 | 897,778 | 172,239 | 23.7% | 3,140 | 725,539 | 985,527 | 259,988 | 35.8% | 1,872 |
| ONS-18-Rebased-L | 725,553 | 795,045 | 69,492 | 9.6% | 1,704 | 725,553 | 790,037 | 64,484 | 8.9% | 752 |
| ONS-18-Rebased-P | 725,553 | 795,045 | 69,492 | 9.6% | 1,704 | 725,553 | 874,172 | 148,619 | 20.5% | 1,276 |
| OxCam-1a-P | 725,553 | 892,887 | 167,333 | 23.1% | 3,022 | 725,553 | 980,087 | 254,533 | 35.1% | 1,824 |
| OxCam-1a-r-P | 725,553 | 867,562 | 142,009 | 19.6% | 3,023 | 725,553 | 952,748 | 227,194 | 31.3% | 1,825 |

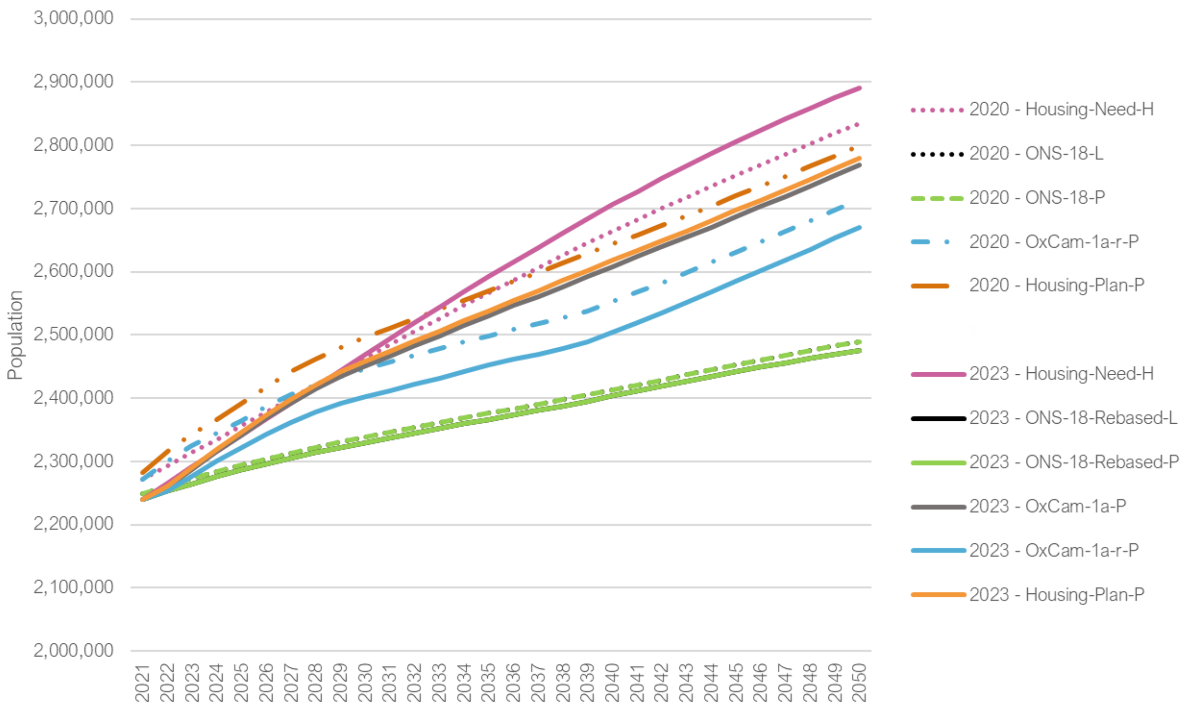
# SES Water




| 2020 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 727,523 | 909,839 | 182,316 | 25.1% | 3,682 | 727,523 | 1,113,103 | 385,581 | 53.0% | 2,872 |
| Housing-Plan-P | 720,607 | 830,416 | 109,809 | 15.2% | 2,432 | 720,607 | 943,989 | 223,382 | 31.0% | 1,797 |
| ONS-18-L | 716,189 | 773,534 | 57,344 | 8.0% | 1,772 | 716,189 | 805,858 | 89,669 | 12.5% | 1,052 |
| ONS-18-P | 716,189 | 773,534 | 57,344 | 8.0% | 1,772 | 716,189 | 880,331 | 164,142 | 22.9% | 1,520 |
| OxCam-1a-r-P | 718,493 | 806,816 | 88,323 | 12.3% | 2,564 | 718,493 | 917,366 | 198,873 | 27.7% | 1,875 |

| 2023 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 718,414 | 919,290 | 200,876 | 28.0% | 3,822 | 718,414 | 1,082,268 | 363,854 | 50.6% | 2,569 |
| Housing-Plan-P | 718,411 | 841,948 | 123,537 | 17.2% | 2,561 | 718,411 | 908,215 | 189,804 | 26.4% | 1,490 |
| ONS-18-Rebased-L | 718,414 | 774,239 | 55,825 | 7.8% | 1,647 | 718,414 | 750,752 | 32,338 | 4.5% | 615 |
| ONS-18-Rebased-P | 718,414 | 774,239 | 55,825 | 7.8% | 1,647 | 718,414 | 835,422 | 117,008 | 16.3% | 1,122 |
| OxCam-1a-P | 718,414 | 846,313 | 127,899 | 17.8% | 2,766 | 718,414 | 912,751 | 194,337 | 27.1% | 1,582 |
| OxCam-1a-r-P | 718,414 | 807,012 | 88,598 | 12.3% | 2,726 | 718,414 | 870,926 | 152,512 | 21.2% | 1,566 |

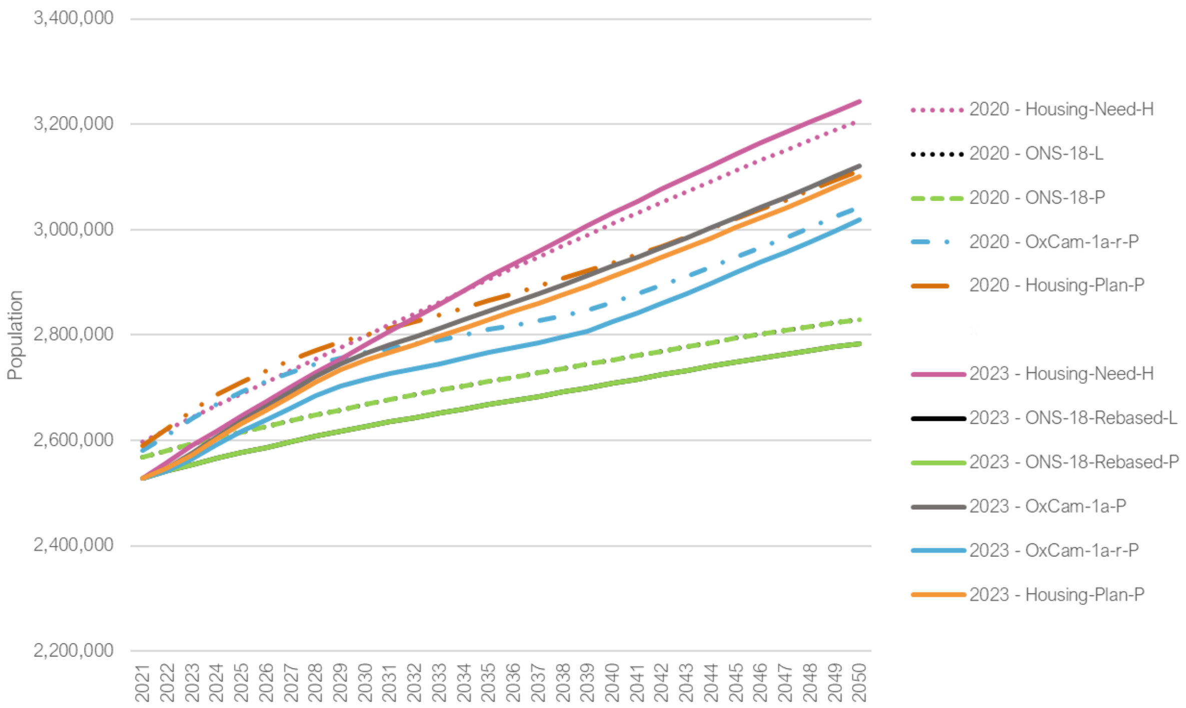
# South East Water




| 2020 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 2,271,042 | 2,834,703 | 563,661 | 24.8% | 10,703 | 2,271,042 | 3,456,943 | 1,185,901 | 52.2% | 8,592 |
| Housing-Plan-P | 2,282,131 | 2,799,709 | 517,578 | 22.7% | 9,479 | 2,282,131 | 3,192,214 | 910,083 | 39.9% | 6,473 |
| ONS-18-L | 2,248,224 | 2,489,172 | 240,948 | 10.7% | 5,863 | 2,248,224 | 2,629,952 | 381,728 | 17.0% | 3,730 |
| ONS-18-P | 2,248,224 | 2,489,172 | 240,948 | 10.7% | 5,863 | 2,248,224 | 2,845,650 | 597,426 | 26.6% | 5,064 |
| OxCam-1a-r-P | 2,271,558 | 2,714,652 | 443,094 | 19.5% | 10,041 | 2,271,558 | 3,097,239 | 825,681 | 36.3% | 6,915 |

| 2023 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 2,239,920 | 2,891,603 | 651,683 | 29.1% | 11,689 | 2,239,920 | 3,436,782 | 1,196,862 | 53.4% | 8,237 |
| Housing-Plan-P | 2,239,978 | 2,779,534 | 539,556 | 24.1% | 10,040 | 2,239,978 | 3,034,274 | 794,296 | 35.5% | 5,846 |
| ONS-18-Rebased-L | 2,239,920 | 2,475,501 | 235,580 | 10.5% | 5,573 | 2,239,920 | 2,444,097 | 204,177 | 9.1% | 2,429 |
| ONS-18-Rebased-P | 2,239,920 | 2,475,501 | 235,580 | 10.5% | 5,573 | 2,239,920 | 2,706,523 | 466,603 | 20.8% | 4,002 |
| OxCam-1a-P | 2,239,920 | 2,769,517 | 529,597 | 23.6% | 9,852 | 2,239,920 | 3,023,315 | 783,394 | 35.0% | 5,771 |
| OxCam-1a-r-P | 2,239,920 | 2,670,687 | 430,767 | 19.2% | 9,858 | 2,239,920 | 2,917,194 | 677,274 | 30.2% | 5,773 |

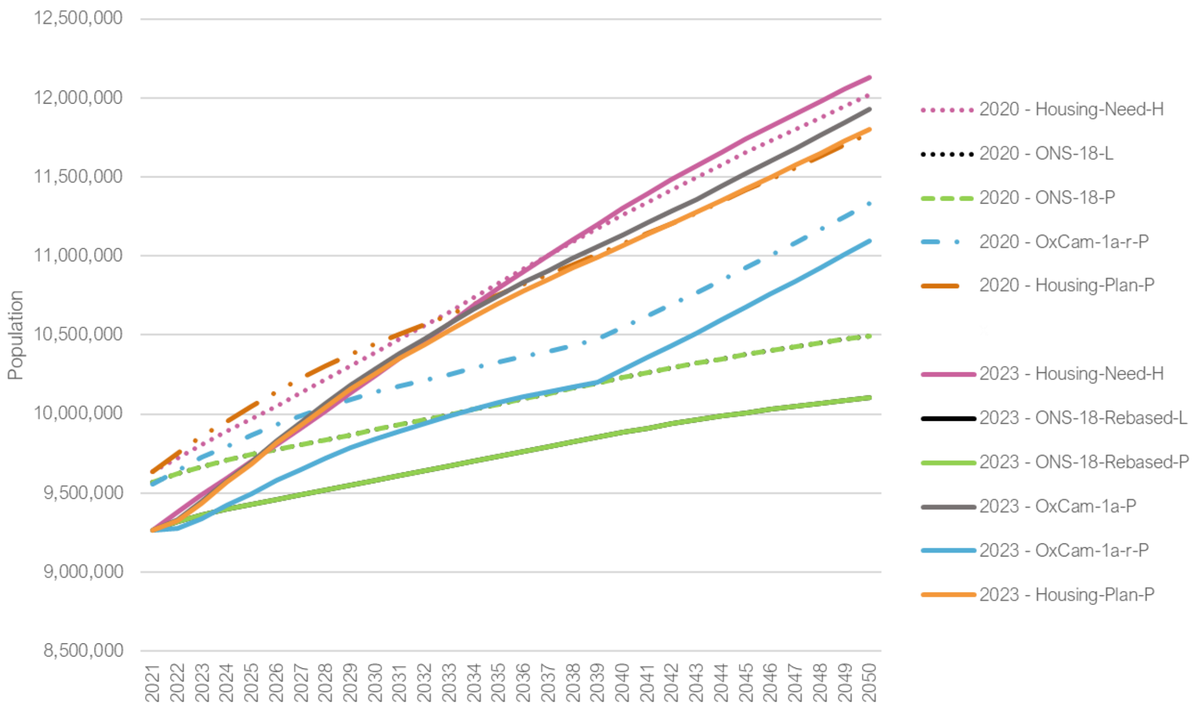
# Southern Water




| 2020 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 2,596,809 | 3,207,317 | 610,509 | 23.5% | 11,837 | 2,596,809 | 3,934,210 | 1,337,401 | 51.5% | 9,825 |
| Housing-Plan-P | 2,589,291 | 3,112,693 | 523,402 | 20.2% | 10,330 | 2,589,291 | 3,578,632 | 989,341 | 38.2% | 7,477 |
| ONS-18-L | 2,568,914 | 2,829,776 | 260,862 | 10.2% | 6,459 | 2,568,914 | 3,014,022 | 445,108 | 17.3% | 4,265 |
| ONS-18-P | 2,568,914 | 2,829,776 | 260,862 | 10.2% | 6,459 | 2,568,914 | 3,256,305 | 687,392 | 26.8% | 5,817 |
| OxCam-1a-r-P | 2,580,275 | 3,043,213 | 462,938 | 17.9% | 10,648 | 2,580,275 | 3,499,841 | 919,565 | 35.6% | 7,699 |

| 2023 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 2,528,359 | 3,243,223 | 714,864 | 28.3% | 12,541 | 2,528,359 | 3,851,253 | 1,322,894 | 52.3% | 8,952 |
| Housing-Plan-P | 2,528,327 | 3,100,327 | 572,000 | 22.6% | 10,358 | 2,528,327 | 3,385,798 | 857,471 | 33.9% | 6,147 |
| ONS-18-Rebased-L | 2,528,359 | 2,783,869 | 255,511 | 10.1% | 6,170 | 2,528,359 | 2,748,969 | 220,610 | 8.7% | 2,588 |
| ONS-18-Rebased-P | 2,528,359 | 2,783,869 | 255,511 | 10.1% | 6,170 | 2,528,359 | 3,044,246 | 515,888 | 20.4% | 4,411 |
| OxCam-1a-P | 2,528,359 | 3,120,341 | 591,983 | 23.4% | 10,746 | 2,528,359 | 3,407,774 | 879,416 | 34.8% | 6,306 |
| OxCam-1a-r-P | 2,528,359 | 3,018,091 | 489,732 | 19.4% | 10,741 | 2,528,359 | 3,298,060 | 769,701 | 30.4% | 6,305 |

# Thames Water




| 2020 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 9,636,351 | 12,019,956 | 2,383,605 | 24.7% | 49,658 | 9,636,351 | 14,458,769 | 4,822,417 | 50.0% | 37,003 |
| Housing-Plan-P | 9,635,394 | 11,776,760 | 2,141,366 | 22.2% | 41,790 | 9,635,394 | 13,180,132 | 3,544,738 | 36.8% | 26,513 |
| ONS-18-L | 9,570,084 | 10,494,887 | 924,804 | 9.7% | 27,903 | 9,570,084 | 10,782,495 | 1,212,411 | 12.7% | 14,437 |
| ONS-18-P | 9,570,084 | 10,494,887 | 924,804 | 9.7% | 27,903 | 9,570,084 | 11,775,778 | 2,205,694 | 23.0% | 20,991 |
| OxCam-1a-r-P | 9,555,172 | 11,330,382 | 1,775,210 | 18.6% | 48,209 | 9,555,172 | 12,685,994 | 3,130,822 | 32.8% | 29,749 |

| 2023 Scenarios | Population | | Population Change | Population Change % | Dwellings p.a. | Population | | Population Change | Population Change % | Dwellings p.a. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2050 | | | | 2021 | 2100 | | | |
| Housing-Need-H | 9,264,012 | 12,128,318 | 2,864,306 | 30.9% | 52,770 | 9,264,012 | 14,123,008 | 4,858,996 | 52.5% | 33,757 |
| Housing-Plan-P | 9,264,534 | 11,804,698 | 2,540,164 | 27.4% | 48,201 | 9,264,534 | 12,647,581 | 3,383,048 | 36.5% | 24,964 |
| ONS-18-Rebased-L | 9,264,012 | 10,103,932 | 839,920 | 9.1% | 23,865 | 9,264,012 | 9,767,215 | 503,203 | 5.4% | 8,502 |
| ONS-18-Rebased-P | 9,264,012 | 10,103,932 | 839,920 | 9.1% | 23,865 | 9,264,012 | 10,841,426 | 1,577,414 | 17.0% | 15,107 |
| OxCam-1a-P | 9,264,012 | 11,930,647 | 2,666,635 | 28.8% | 49,987 | 9,264,012 | 12,781,586 | 3,517,574 | 38.0% | 25,689 |
| OxCam-1a-r-P | 9,264,012 | 11,097,513 | 1,833,500 | 19.8% | 50,012 | 9,264,012 | 11,900,407 | 2,636,395 | 28.5% | 25,699 |

# 4 FUTURE DATA RELEASES

4.1 All forecasts are dependent on the data inputs and assumptions used in their configuration, so it is important to monitor future data releases to understand when it may be needed to revisit and update the forecasts in the light of more up-to-date evidence.

4.2 The following table details the key forthcoming data from ONS which will provide additional intelligence to inform future forecasts:

| Data release | Release date |
|---|---|
| Revised official 2021 MYE for the UK, its constituent countries and local authority districts. | September 2023 (provisional) |
| Rebasing of MYEs following Census 2021, England and Wales<br>This release contains the rebased MYEs for the period 2012 to 2020 to align with Census 2021 results. | September 2023 (provisional) |
| Population estimates for England and Wales: mid-2022<br>National and sub-national mid-year population estimates for England and Wales by administrative area, age and sex. | September 2023 (provisional) |
| National population projections: 2021-based | December 2023 (provisional) |
| Sub-national population projections: 2021-based | Will follow on from 2021-based national population projections in 2024, but release timescale unknown |
| Household projections: 2021-based | Unknown |

4.3 Due to uncertainty around the 2021 Census estimates and the intercensal MYEs, it is recommended that, once the updated MYEs are released in September 2023, a refresh of the scenario evidence is considered.

# Appendix A
# SCENARIO DEFINITION 2020

A.1 The table below provides a list of all 2020–2050 scenarios that were delivered to WRSE in 2020:

| ID | SCENARIO | DESCRIPTION |
|---|---|---|
| 1 | ONS-14 | ONS 2014-based sub-national population projection (SNPP), using a six-year history (2008–2014) to derive local fertility, mortality and internal migration assumptions, with a long-term UK net international migration assumption of +185k p.a. |
| 2 | ONS-16 | ONS 2016-based Principal sub-national population projection (SNPP), using a five-year history (2011–2016) to derive local fertility, mortality and internal migration assumptions, and a long-term UK net international migration assumption of +165k. In line with the ONS 2016-based national population projection (NPP), this round of projections includes a reduced UK fertility outlook compared to ONS-14 and a dampened rate of improvement in life expectancy compared to ONS-14. |
| 3 | ONS-18 | ONS 2018-based Principal sub-national population projection (SNPP), using a five-year history (2013–2018) to derive local fertility & mortality assumptions and a long-term UK net international migration assumption of +190k. Unlike earlier rounds of SNPP, the 2018-based Principal projection uses a two-year history (2016–2018) of internal migration assumptions, following recent changes to the methodology used for its estimation, which have only covered the latest 2 years. In line with the ONS 2018-based national population projection (NPP), this round of projections includes a reduced UK fertility outlook compared to ONS-16 and a dampened rate of improvement in life expectancy compared to ONS-16. |
| 4 | ONS-18-Alt | ONS 2018-based Alternative Internal Migration sub-national population projection (SNPP), produced by ONS as a comparison with the Principal projection. It uses a five-year average of internal migration (2013–2018), combining 3 years of data based on the old methodology and 2 years based on the new methodology. All other assumptions are consistent with ONS-18. |
| 5 | ONS-18-High | ONS 2018-based High International Migration sub-national population projection (SNPP), incorporating a High long-term UK net international migration assumption of +290k p.a., with all other assumptions consistent with ONS-18. |
| 6 | ONS-18-Low | ONS 2018-based Low International Migration sub-national population projection (SNPP), incorporating a Low long-term UK net international migration assumption of +90k p.a., with all other assumptions consistent with ONS-18. |
| 7 | ONS-18-10Y | ONS 2016-based 10yr Migration (all types) sub-national population projection, using a ten-year history (2008–2018) to derive internal migration assumptions, with all other assumptions consistent with ONS-18. |
| 8 | GLA-18-Central | Greater London Authority (GLA) 2018-based Central population projection, incorporating: GLA's own adjustments to the mid-year population estimates of London Boroughs; local fertility and mortality assumptions, trended in line with the ONS 2018-based NPP assumptions; internal and international migration assumptions derived from a 10-year history (2008–2018). This scenario includes projections for London Boroughs and for all other local authority areas. |
| 9 | GLA-18-15Y | GLA 2018-based long-term trend projection, incorporating internal and international migration assumptions derived from a 15-year history (2003–2018), with all other assumptions consistent with the Central scenario. This scenario includes projections for London Boroughs and for all other local authority areas. |
| 10 | GLA-18-5Y | GLA 2018-based short-term trend projection, incorporating internal and international migration assumptions derived from a 5-year history (2013–2018), with all other assumptions consistent with the Central scenario. This scenario includes projections for London Boroughs and for all other local authority areas. |

| ID | SCENARIO | DESCRIPTION |
|---|---|---|
| 11 | GLA-Housing | GLA 2018-based Housing-led projection, based on data from the 2016 Strategic Housing Land Availability Assessment (SHLAA). Beyond 2041, housing growth is aligned to the 2035–2041 average. Whilst the housing-led approach is applied to each London Borough, the population projection for Greater London, in total, remains consistent with the Central scenario. This scenario includes projections for London Boroughs only and is combined with the Central scenario for all other local authority areas when aggregated to WRZ geographies. |
| 12 | Completions-18Y | A Housing-led scenario, with population growth underpinned by a continuation of the rate of housing growth recorded in each local authority's 18-year completions history (2001–2019). |
| 13 | Completions-5Y | A Housing-led scenario, with population growth underpinned by a continuation of the rate of housing growth recorded in each local authority's 5-year completions history (2014–2019). |
| 14 | Housing-Need | A Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's Local Housing Need (LHN) or Objectively Assessed Housing Need (OAHN). Following the final year of data, projected housing growth in non-London areas returns to the ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050. |
| 15 | Housing-Need-r | A Housing-led scenario, consistent with the Housing-Need scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. |
| 16 | Housing-Req | A Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's housing Requirement. Following the final year of data, projected housing growth in non-London areas returns to the ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050. |
| 17 | Housing-Req-r | A Housing-led scenario, consistent with the Housing-Req scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. |
| 18 | Housing-Plan | A Housing-led scenario, with population growth underpinned by each local authority's Local Plan housing growth trajectory. Following the final year of data, projected housing growth in non-London areas returns to the ONS-14 & ONS-16 long-term annual growth average by 2050. For London Boroughs, housing growth returns to the GLA Central scenario long-term annual average by 2050. |
| 19 | Housing-Plan-r | A Housing-led scenario, consistent with the Housing-Plan scenario, but with household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. |
| 20 | Employment-1 | An Employment-led scenario with 1.0% pa growth in London to 2030 and 0.5% pa thereafter; 0.8% pa growth in the South East and East of England to 2030, 0.4% thereafter. |
| 21 | Employment-2 | An Employment-led scenario with 0.5% pa growth in London to 2030 and 0.25% pa thereafter; 0.4% pa growth in the South East and East of England to 2030, 0.2% thereafter. |
| 22 | OxCam-1a-r | 'New Settlement' 23k dpa scenario, with c.4.2k dpa above Housing Plan distributed between Cherwell (20%), Aylesbury Vale (20%), Central Bedfordshire (40%), South Cambridgeshire (20%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. |
| 23 | OxCam-1b-r | 'Expansion' 23k dpa scenario, with c 4.2k dpa distributed between: Milton Keynes: (30%) Luton (15%), Bedford (15%), Oxford (10%), Cambridge (10%), Northampton (10%), and Peterborough (10%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. |
| 24 | OxCam-2a-r | 'New Settlement' 30k dpa scenario, with c.11.2k dpa above Housing Plan distributed between Cherwell (20%), Aylesbury Vale (20%), Central Bedfordshire (40%), South Cambridgeshire (20%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. |

| ID | SCENARIO | DESCRIPTION |
|---|---|---|
| 25 | OxCam-2b-r | 'Expansion' 30k dpa scenario, with c 11.2k dpa distributed between: Milton Keynes: (30%) Luton (15%), Bedford (15%), Oxford (10%), Cambridge (10%), Northampton (10%), and Peterborough (10%). Household representative rates for young adults returning to (higher) 2001 levels by 2039, remaining fixed thereafter. |

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Part of the LDC Group.

# 3. Annex 7c: Demand Forecast Methodology

CONFIDENTIAL

08 January 2021

# Household demand forecast 2020

Southern Water Services

J1941\GD013\02
Version: 2

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# Revision History

| Version | Date | Description |
| --- | --- | --- |
| 1 | 24 December 2020 | First issue |
| 2 | 08 January 2021 | Minor updates and clarifications, addition of detailed WRZ level results |

| Author | Reviewer 1 | Reviewer 2 | Reviewer 3 | Approver |
| --- | --- | --- | --- | --- |
| Alan Cunningham | | | | |
| | Julian Rickard | Chang Xu | | Alan Cunningham |

# Contents

# 1 Introduction

Ovarro DA Ltd ("Ovarro"), has been asked by Southern Water Services Ltd (SWS) to provide a proposal to produce a household demand forecast to support the Water Resources in the South East (WRSE) regional plan scheduled for publication in 2023 and the 2024 Water Resources Management Plan (WRMP24).

This document details the work undertaken. The following associated spreadsheets implementing the forecast have been provided to SWS:

- J1941_GD016_04_HH_demand_forecast_dWRMP24.xlsm
- J1941_GD020a_01_MicroComponent_model_2020_HA.xlsx through to J1941_GD020n_01_MicroComponent_model_2020_SW.xlsx

The following spreadsheets extracting results for WRSE reporting have also been provided:

- J1941_GD017_04_DLP input template for Demand Forecasts Outage Losses v4 SWS.xlsx
- J1941_GD018_04_Demand_Reduction_Template.xlsx

The intended audience for this document is Faisal Butt and colleagues at SWS in the area of water resources.

# 2 Overview of demand forecast

## 2.1 Requirements

The SWS region comprises 14 Water Resource Zones (WRZs) as follows:

- Hampshire Andover (HA)
- Hampshire Kingsclere (HK)
- Hampshire Winchester (HW)
- Hampshire Rural (HR)
- Hampshire Southampton East (HSE)
- Hampshire Southampton West (HSW)
- Isle of Wight (IOW)
- Sussex North (SN)
- Sussex Worthing (SW)
- Sussex Brighton (SB)
- Kent Medway East (KME)
- Kent Medway West (KMW)
- Kent Thanet (KT)
- Sussex Hastings (SH)

In order to support the regional plan and WRMP24, SWS are required to generate forecasts of annual Distribution Input (DI) for each of the following planning scenarios for each WRZ:

- Normal Year Annual Average (NYAA)
- Dry Year Annual Average (DYAA)
- Dry Year Critical Period (DYCP)
- Dry Year Minimum Deployable Output (DYMDO)
- Critical Period during a 1 in 200 years summer (1:200)
- Critical Period during a 1 in 500 years summer (1:500)

In order to support the regional plan, SWS are considering a number of different scenarios under which DI is being derived as follows:

- 6 growth scenarios
- 3 water efficiency scenarios
- 3 non-household demand scenarios
- 4 leakage scenarios
- 3 climate change scenarios

## 2.2 Outline approach

The demand forecast comprises a number of constituent parts detailed in the following sections:

- A micro-component forecast to determine the likely changes in demand as a result of appliance efficiency and societal trends
- Derivation of base year household demand for each planning scenario
- Derivation of impacts of climate change and water efficiency scenarios on household demand
- Incorporation of forecasts of other components of demand (non-household demand, leakage and minor components)
- Forecasting of DI under each of the scenarios being considered
- Population of WRMP forecasting tables

# 3 Micro-component forecast

The standard Ownership, Frequency and Volume (OFV) micro-component forecasting approach as previously used by SWS and described in UKWIR research[1] has been applied.

Detailed assumptions for the micro-component modelling are discussed in the following sections. These are based upon previous work carried out by SWS for WRMP19 with reference to published industry research, notably the 2018 Energy Saving Trust (EST) report on water labelling options[2].

1 Customer Behaviour and Water Use, UKWIR Report ref: 12/CU/02/11

2 Independent review of the costs and benefits of water labelling options in the UK: EXTENSION PROJECT: Technical Report - FINAL

Three categories of property type are considered within each of the measured and unmeasured customer bases as previously used by SWS. These are as follows:

- Group 1: Detached
- Group 2: Semi-detached or Terraced
- Group 3: Flat or Bungalow

The micro-component modelling is focused on deriving baseline changes in water consumption associated with appliance efficiency and societal trends. Details of the assumptions made are provided in Appendix A.

The modelling is implemented in the associated spreadsheets J1941_GD020a_01_MicroComponent_model_2020_HA.xlsx through to J1941_GD020n_01_MicroComponent_model_2020_SW.xlsx. Separate sheets for each WRZ use specific occupancy assumptions for each WRZ and adjust the frequency factors across the model to align the Per Capita Consumption (PCC) with the base year.

The results of the micro-component modelling are subsequently adjusted to align with the forecast PCC under the scenario being considered as discussed in section 8.1.

# 4 Base year demand by planning scenario

Consumption for 2019-20 is taken as the base year NYAA. The summer was warmer than average, but wetter than average[3] and hence there is no clear reason to adjust this in either direction.

The following peak factors are applied to NYAA household consumption as advised by SWS for deriving household consumption under other planning scenarios:

**Table 1: Peak factors for each planning scenario**

| WRZ | NYAA | DYAA | DYCP | DYMDO | 1:200 | 1:500 |
|---|---|---|---|---|---|---|
| HA | 1.00 | 1.06 | 1.36 | 1.02 | 1.33 | 1.33 |
| HK | 1.00 | 1.13 | 1.56 | 1.11 | 1.56 | 1.56 |
| HW | 1.00 | 1.14 | 1.35 | 1.11 | 1.39 | 1.39 |
| HR | 1.00 | 1.14 | 1.35 | 1.11 | 1.39 | 1.39 |
| HSE | 1.00 | 1.14 | 1.35 | 1.11 | 1.39 | 1.39 |
| HSW | 1.00 | 1.14 | 1.35 | 1.11 | 1.39 | 1.39 |
| IOW | 1.00 | 1.13 | 1.46 | 1.07 | 1.53 | 1.53 |
| SN | 1.00 | 1.07 | 1.34 | 1.05 | 1.35 | 1.35 |
| SW | 1.00 | 1.19 | 1.40 | 1.15 | 1.41 | 1.41 |
| SB | 1.00 | 1.00 | 1.19 | 0.98 | 1.22 | 1.22 |
| KME | 1.00 | 1.07 | 1.27 | 1.04 | 1.32 | 1.32 |
| KMW | 1.00 | 1.07 | 1.27 | 1.04 | 1.32 | 1.32 |

[3] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/summaries/uk_monthly_climate_summary_summer_2019.pdf

| **WRZ** | **NYAA** | **DYAA** | **DYCP** | **DYMDO** | **1:200** | **1:500** |
|---|---|---|---|---|---|---|
| KT | 1.00 | 1.09 | 1.41 | 1.03 | 1.34 | 1.34 |
| SH | 1.00 | 1.02 | 1.24 | 1.01 | 1.29 | 1.29 |

# 5 Scenario impacts

## 5.1 Climate change

As requested by SWS, 3 scenarios regarding climate change have been developed based upon UKWIR research[4]:

- No impact: No adjustment to consumption is made as a result of climate change
- Low impact: Based upon the 50th percentile results in the UKWIR analysis
- High impact: Based upon the 90th percentile results in the UKWIR analysis

The UKWIR report contains two models that forecast the climate change impact on household demand over a 28-year period for the different planning scenarios. Using the average of the two models gives the following climate change scenario impacts for a 28-year period:

**Table 2: Climate change scenario impacts**

| | **No climate change impact scenario** | **Low climate change impact scenario** | **High climate change impact scenario** |
|---|---|---|---|
| NYAA impact after 28 years | 0.00% | 0.74% | 1.45% |
| DYAA impact after 28 years | 0.00% | 0.74% | 1.45% |
| DYCP impact after 28 years | 0.00% | 2.08% | 4.09% |
| DYMDO impact after 28 years | 0.00% | 1.43% | 2.79% |

The percentage increase is applied linearly and extrapolated to the end of the forecast period.

## 5.2 Water efficiency

As requested by SWS, the water efficiency targets for AMP7 are assumed to be met under all scenarios in line with the draft Water Resources Planning Guidance (WRPG)[5], with PCC being reduced to a three-year average of 123.5 l/head/d. 4 scenarios regarding water efficiency post AMP7 have been developed:

- High water efficiency scenario: The average PCC across the SWS region is reduced to 100 l/head/d by 2040 and further reduced to 85 l/head/d by 2050; remaining constant thereafter

4 Impact of Climate Change on Water Demand, UKWIR report ref: 13/CL/04/12

5 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/903694/Water_resources_planning_guideline.pdf

- Medium water efficiency scenario: The average PCC across the SWS region is reduced to 100 litres/head/day by 2040 and remains constant thereafter
- Low water efficiency scenario: The average PCC across the SWS region is reduced to 110 litres/head/day by 2040 and further reduced to 100 litres/head/day by 2050; remaining constant thereafter
- Baseline scenario: Changes in PCC after AMP7 are driven directly by the micro-component analysis with no interventions by SWS to promote water efficiency

## 5.3 Growth

A total of 54 initial scenarios were developed for WRSE regarding population and property growth, with forecast numbers provided to SWS. The method statement published by WRSE on demand forecasting requires 6 growth scenarios to be incorporated into demand forecasts as detailed in Table 3. The ability to apply any of the growth modelling scenarios has been included in the spreadsheet.

**Table 3: Growth modelling scenarios list**

| WRZ | Baseline scenario reference | Max growth scenario reference | Min growth scenario reference | Median growth scenario reference | Trend based scenario reference | Housing need scenario reference |
|---|---|---|---|---|---|---|
| HA | Housing-Plan-P | Completions-5Y-H | ONS-18-Low-L | ONS-14-P | Completions-5Y-H | Housing-Need-H |
| HK | Housing-Plan-P | Housing-Req-H | ONS-18-Low-L | ONS-18-Alt-H | Completions-5Y-H | Housing-Need-H |
| HW | Housing-Plan-P | Housing-Need-H | ONS-18-Low-L | GLA-18-15Y-P | Completions-5Y-H | Housing-Need-H |
| HR | Housing-Plan-P | Completions-5Y-H | ONS-18-Low-L | Completions-18Y-L | Completions-5Y-H | Housing-Need-H |
| HSE | Housing-Plan-P | Completions-5Y-H | ONS-18-Low-L | Completions-5Y-L | Completions-5Y-H | Housing-Need-H |
| HSW | Housing-Plan-P | Housing-Req-H | ONS-18-Low-L | GLA-18-5Y-P | Completions-5Y-H | Housing-Need-H |
| IOW | Housing-Plan-P | Housing-Need-H | ONS-18-Low-L | Housing-Req-P | Completions-5Y-H | Housing-Need-H |
| SN | Housing-Plan-P | Completions-5Y-H | ONS-18-Low-L | GLA-18-15Y-P | Completions-5Y-H | Housing-Need-H |
| SW | Housing-Plan-P | Housing-Need-H | ONS-18-Low-L | GLA-18-Central-P | Completions-5Y-H | Housing-Need-H |
| SB | Housing-Plan-P | Housing-Need-H | ONS-18-Low-L | GLA-18-15Y-P | Completions-5Y-H | Housing-Need-H |
| KME | Housing-Plan-P | Housing-Need-H | ONS-18-Low-L | Housing-Need-L | Completions-5Y-H | Housing-Need-H |
| KMW | Housing-Plan-P | Housing-Need-H | ONS-18-Low-L | Housing-Plan-L | Completions-5Y-H | Housing-Need-H |
| KT | Housing-Plan-P | Housing-Req-H | ONS-18-Low-L | GLA-18-15Y-P | Completions-5Y-H | Housing-Need-H |
| SH | Housing-Plan-P | ONS-14-H | ONS-18-Low-L | ONS-18-High-P | Completions-5Y-H | Housing-Need-H |

The growth scenarios were provided by SWS.

# 6 Other components of demand

## 6.1 Non-household demand

Assumed demand under each of the 3 non-household scenarios being considered has been provided by SWS.

No uplift for alternative planning scenarios has been applied to non-household demand. This is consistent with the approach used by SWS in developing demand forecasts with the previous WRMPs.

No adjustment in respect of climate change has been applied to non-household demand.

No adjustment in respect of water efficiency has been applied to non-household demand.

## 6.2 Leakage

Assumed leakage levels under each of the 4 leakage scenarios being considered has been provided by SWS.

No uplift for alternative planning scenarios has been applied to leakage.

No adjustment in respect of climate change has been applied to leakage.

No adjustment in respect of water efficiency has been applied to leakage.

This is consistent with the approach used by SWS in developing demand forecasts with the previous WRMPs.

## 6.3 Minor components

The assumptions for the minor components are based upon the 2019-20 water balance:

- Water Taken Illegally Unbilled (WTIU)
- Water Taken Legally Unbilled (WTLU)
- Distribution System Operational Use (DSOU)

No adjustments to any of these values has been applied in respect of different scenarios. This is consistent with the approach used by SWS in developing demand forecasts with the previous WRMPs.

# 7 Forecasting future Distribution Input

## 7.1 Properties and population

The total household population and property counts are taken from the selected growth scenario.

All new households are assumed to be measured with meters installed externally.

A small proportion of previously unmeasured households are assumed to switch annually, despite the completion of the universal metering programme. These properties are assumed to be metered internally, on the basis that if an external meter could be readily installed, they would have been included as part of the universal metering programme. However, it is assumed that there will always be a small number of properties that cannot be metered. The threshold is set at 95% meter penetration and above this no further properties are assumed to switch to metered billing.

It is assumed that the switching households will have the same occupancy as the average occupancy of the unmeasured customer base.

The total measured household population is calculated as the total population minus the remaining unmeasured household population once switching properties are accounted for.

## 7.2 Household consumption

It is assumed that switching to measured status will lead to a 15% reduction in PCC - in line with the reduction seen upon implementation of the universal metering programme which was reviewed by Southampton University[6] - regardless of the PCC prior to switching. This amount is subtracted from the unmeasured consumption from the previous year and added to the measured consumption.

It is assumed that new properties will be built to defined PCC standards. The PCC figure for new builds is held constant over the AMP7 period and assumed to decline over successive AMP periods until it reaches 90 litres/head/day. If the defined PCC standard for a given year is higher than the PCC of the existing housing stock, then the PCC of existing housing stock is applied to new builds. Occupancy is assumed to be the same as the average for measured properties. The total consumption associated with these properties is added to the measured consumption total.

The results of the micro-component analysis are used to calculate proportional annual changes in consumption for unmeasured and measured households associated with appliance efficiency and societal trends that are not linked to any water efficiency activity. This adjustment is applied to the unmeasured and measured consumption from the previous year.

A percentage uplift for climate change is applied to the resulting consumption based upon the scenario being applied.

A reduction due to water efficiency is then applied to align the overall PCC with the scenario being considered. If the overall PCC is already below that specified for the given water efficiency scenario, no adjustment is made. Note that the water efficiency scenario applies irrespective of the climate change scenario chosen; for example, if a climate change scenario is applied then additional water efficiency is assumed to take place to meet the selected water efficiency scenario.

## 7.3 Non-household consumption

The non-household consumption in each year is taken directly from the chosen scenario.

## 7.4 Leakage

The leakage in each year is taken directly from the chosen scenario, including the disaggregation into distribution losses and supply pipe leakage. The supply pipe leakage is apportioned between the different property types based upon the property counts and relative levels of supply pipe leakage assumed in the base year.

## 7.5 Minor components

WTIU is estimated by assuming 35% of void households are occupied and consuming the same as an average unmeasured household. This is consistent with the assumption made by SWS in its annual water balance calculations.

Other minor components are assumed to remain unchanged.

## 7.6 Total Distribution Input

The total DI for the NYAA planning scenario is calculated as the total of the above components.

[6] https://www.southampton.ac.uk/economics/research/discussion_papers/area/aplied_economics/1801-the-effects-of-the-universal-metering-programme-on-water-consumption.page

The total DI for each of the other planning scenarios is calculated by applying the relevant uplift factors to household demand.

# 8 Outputs

## 8.1 Comparison sheets

A macro within the spreadsheet may be used to population comparison sheets that list DI, overall PCC, measured PCC and unmeasured PCC at company level for each planning scenario under all combinations of the other scenarios.

## 8.2 Populating planning tables

The population, property and demand estimates are used to populate the relevant planning tables for the chosen growth, water efficiency, leakage, non-household and climate change scenarios for each WRZ and planning scenario.

The micro-component estimates for each year are scaled to align with the unmeasured and measured consumption for the NYAA planning scenario. Uplifts for other planning scenarios are assigned 75% to garden watering and 25% to personal washing.

Results from specific combinations of scenarios as required for WRSE reporting have been extracted into the template spreadsheets provided by SWS.

## 8.3 Results

Taking account of all growth, water efficiency, non-household demand, leakage and climate change scenarios results in 864 DI scenarios for each WRZ for each planning scenario. The maximum, minimum, median, 25$^{th}$ percentile and 50$^{th}$ percentile DI scenarios for each of the four planning scenarios at the company level are shown in Figures 1-4. The associated PCC forecasts are shown in Figures 5-8. Forecasts at the WRZ level can be found in Appendix B.

Figure 1: Range of NYAA Distribution Input results

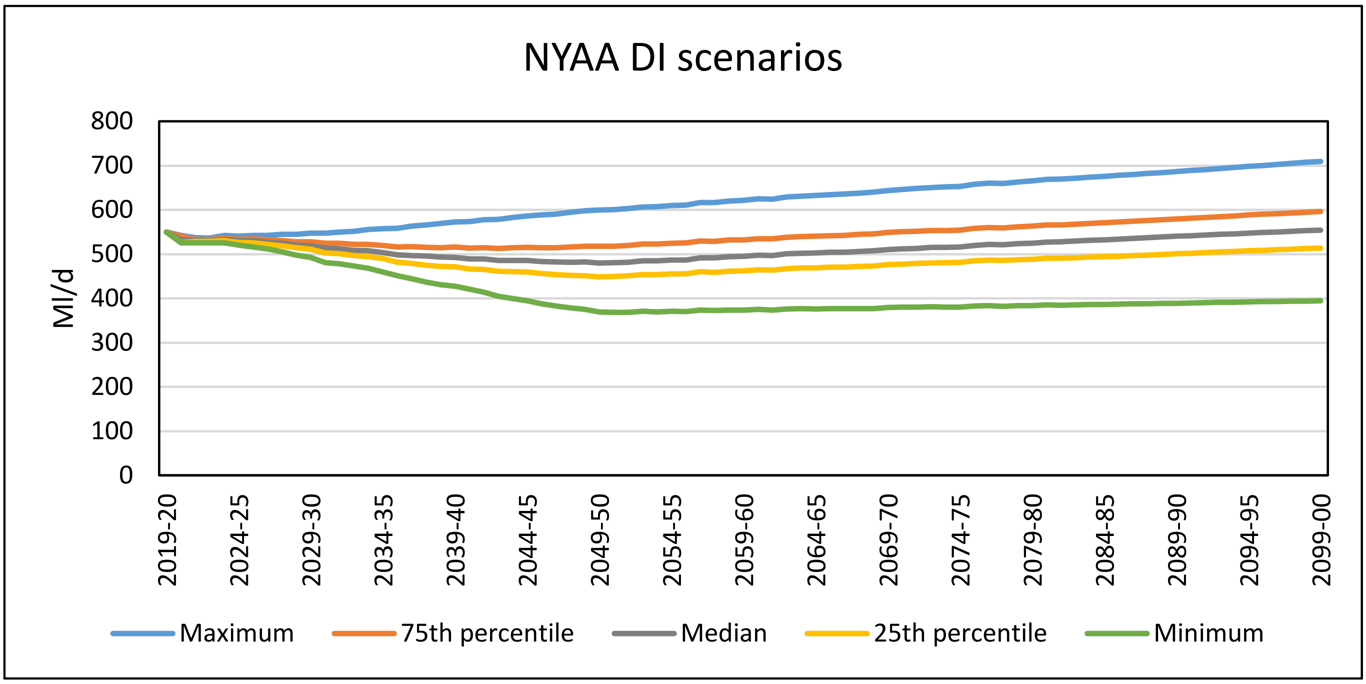



Figure 2: Range of DYAA Distribution Input results

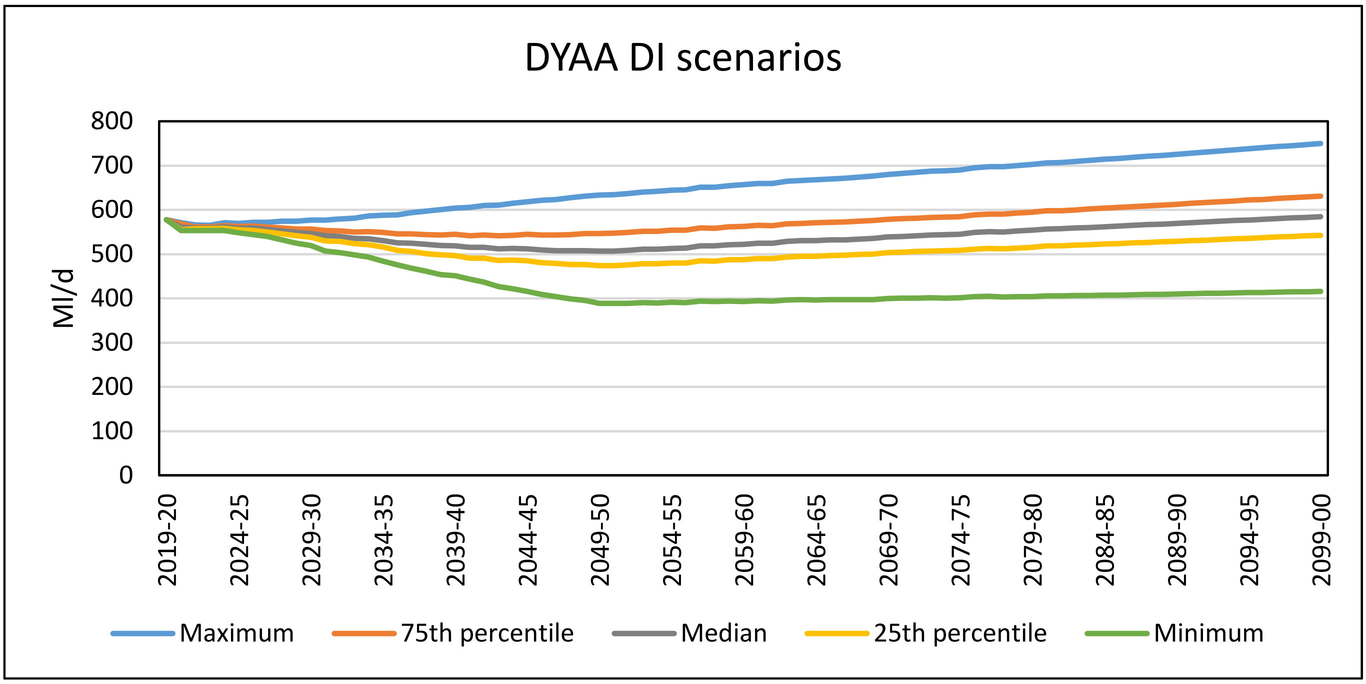


Figure 3: Range of DYCP Distribution Input results

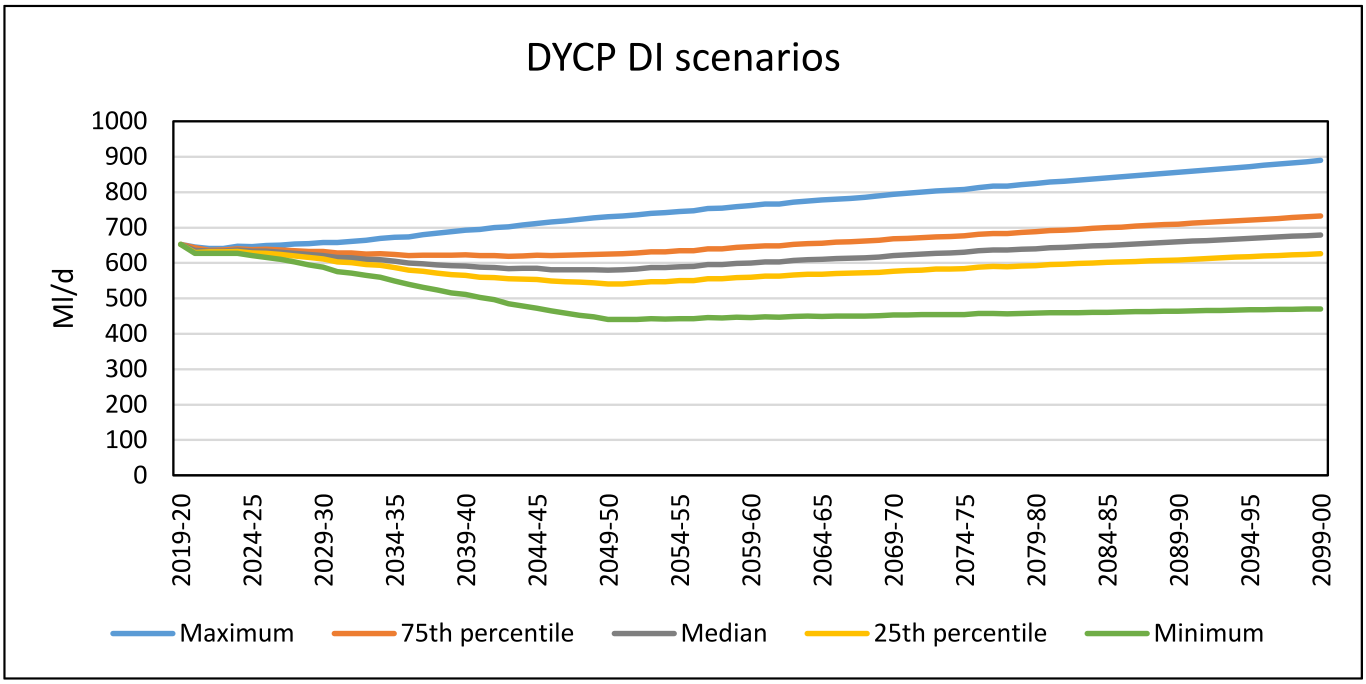



Figure 4: Range of DYMDO Distribution Input results

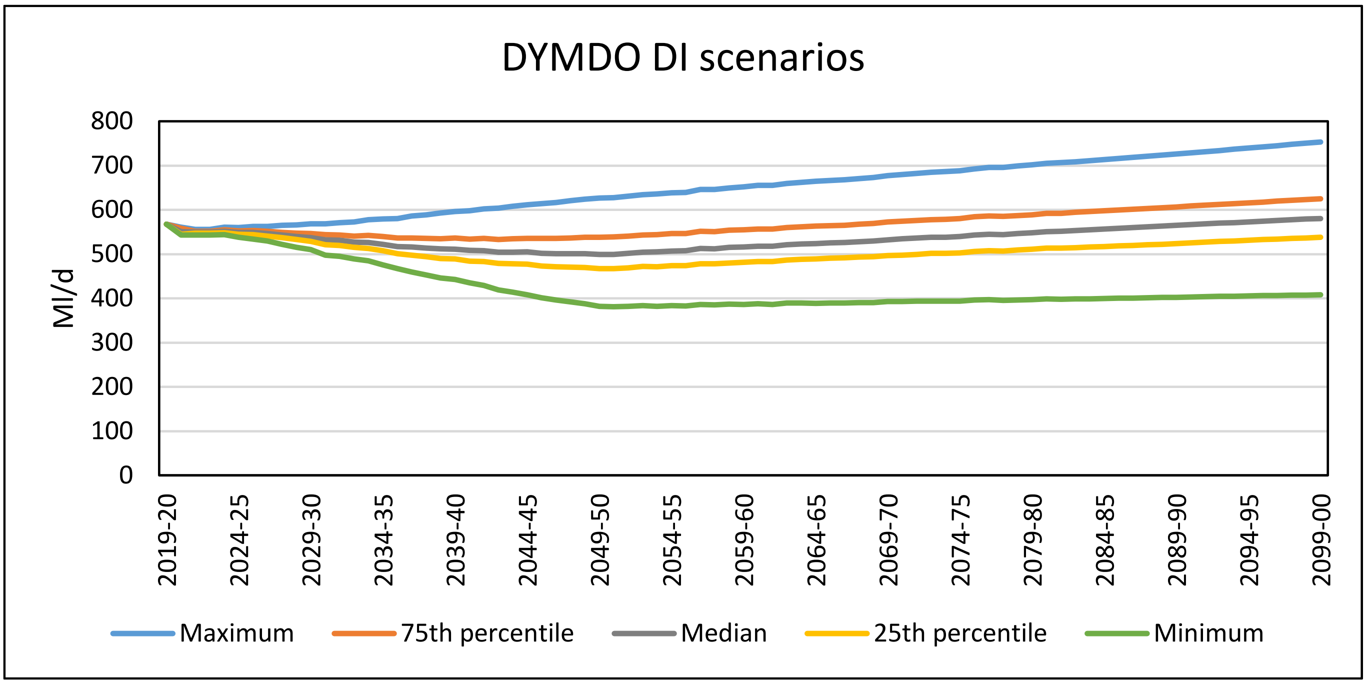


Figure 5: Range of NYAA PCC results

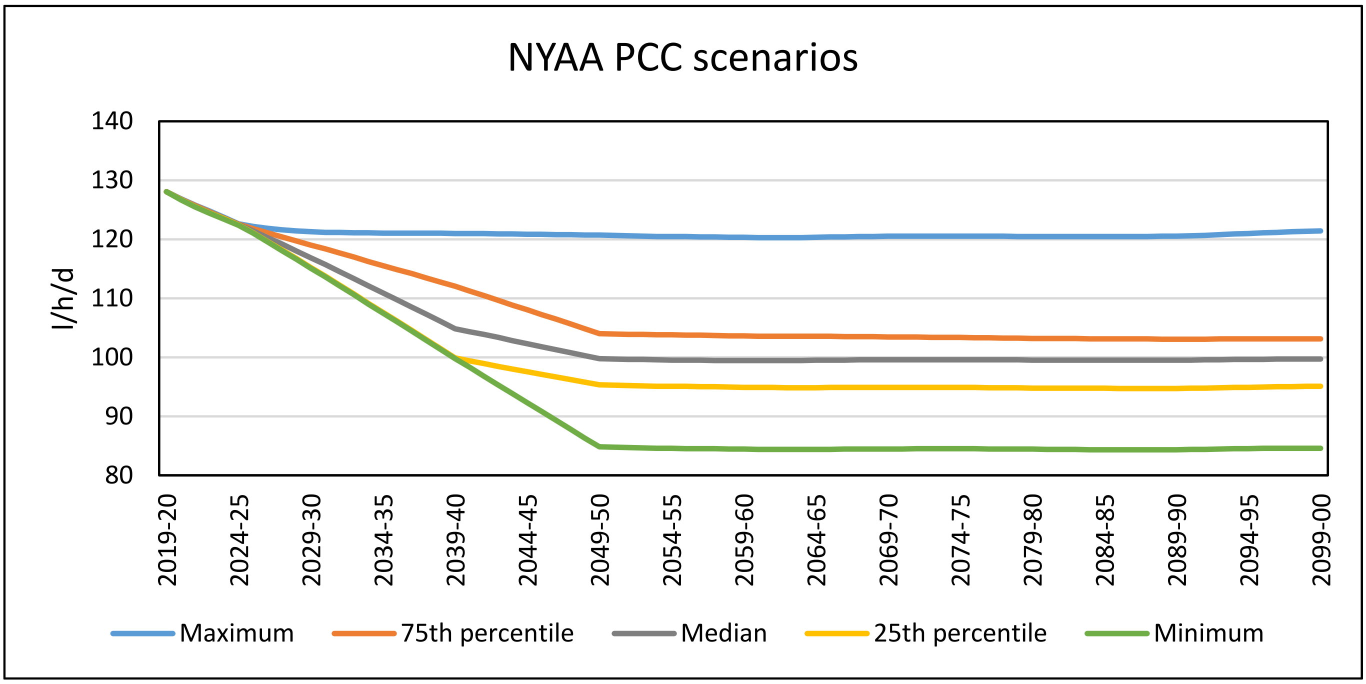



Figure 6: Range of DYAA PCC results

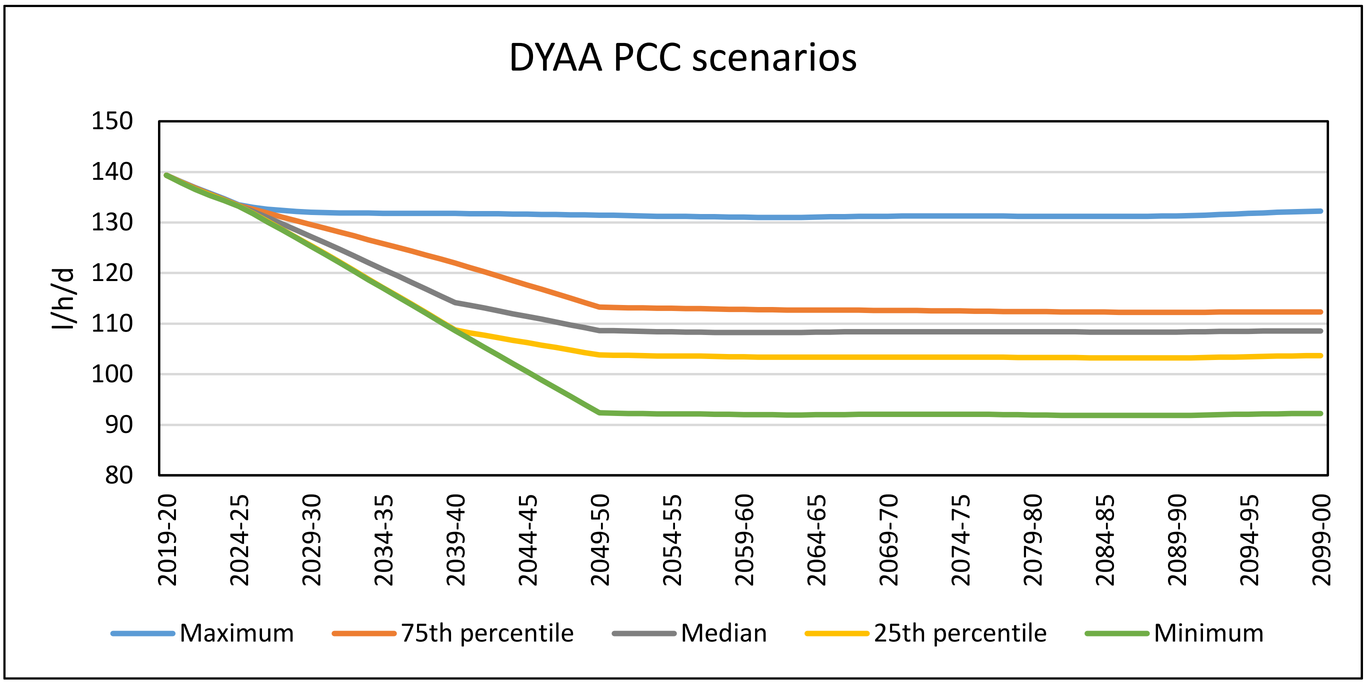


Figure 7: Range of DYCP PCC results

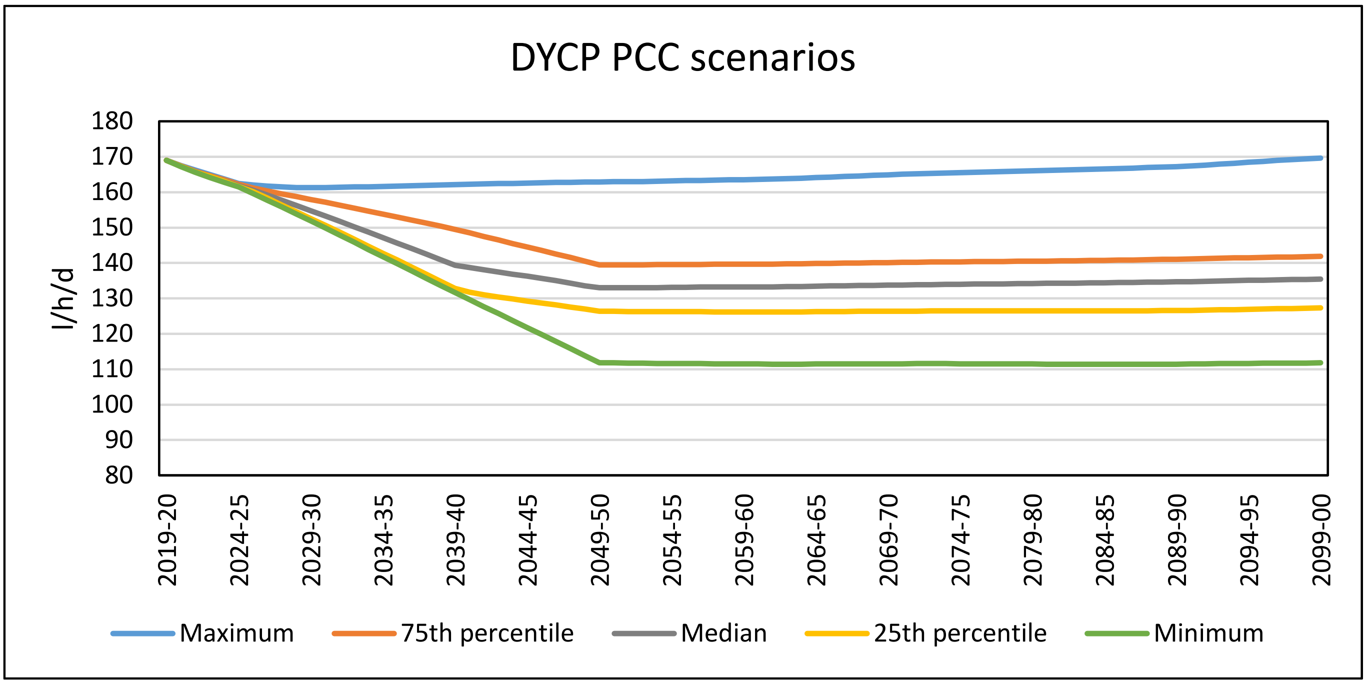
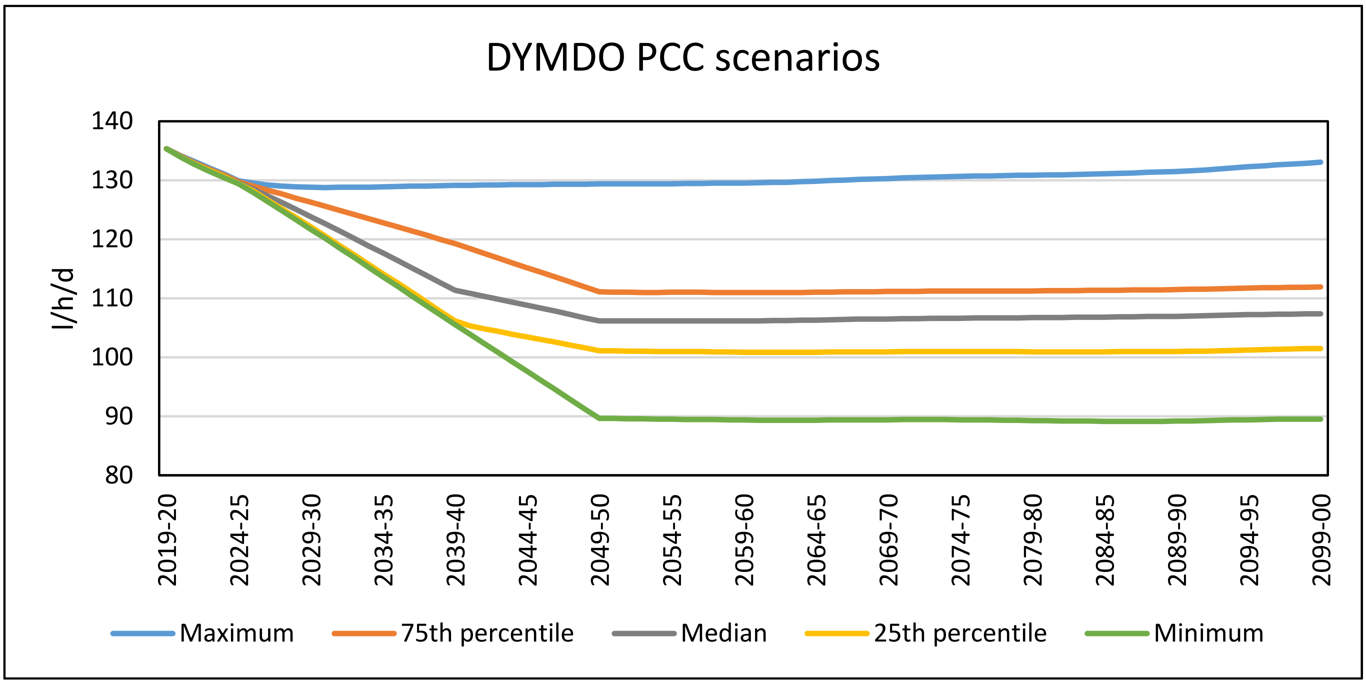



Figure 8: Range of DYMDO PCC results



# 9 Endpoint

It is expected that the outputs of the analysis will be incorporated within the WRSE and WRMP24 submissions.

# Appendices

# A. Detailed micro-component analysis

The following sections discuss the detailed assumptions made in the micro-component analysis.

## A.1. Occupancy

Occupancy assumptions are required to convert several of the micro-components from the household level to a per-capita basis.

The following occupancies have been assumed in the micro-component analysis, based upon survey data provided by SWS:

**Table 4: Occupancy assumptions**

| WRZ | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| HA | 2.80 | 2.74 | 1.71 | 2.80 | 2.74 | 1.71 |
| HK | 3.21 | 2.90 | 1.62 | 3.21 | 2.90 | 1.62 |
| HR | 2.61 | 2.49 | 1.73 | 2.61 | 2.49 | 1.73 |
| HSE | 2.97 | 2.72 | 1.68 | 2.97 | 2.72 | 1.68 |
| HSW | 2.41 | 2.37 | 1.67 | 2.41 | 2.37 | 1.67 |
| HW | 2.79 | 2.68 | 1.76 | 2.79 | 2.68 | 1.76 |
| IOW | 2.70 | 2.68 | 2.05 | 2.70 | 2.68 | 2.05 |
| KME | 2.97 | 2.85 | 1.71 | 2.97 | 2.85 | 1.71 |
| KMW | 2.86 | 2.95 | 1.86 | 2.86 | 2.95 | 1.86 |
| KT | 2.77 | 2.68 | 1.86 | 2.77 | 2.68 | 1.86 |
| SB | 2.98 | 2.71 | 1.83 | 2.98 | 2.71 | 1.83 |
| SH | 2.49 | 2.36 | 1.75 | 2.49 | 2.36 | 1.75 |
| SN | 2.48 | 2.81 | 1.71 | 2.48 | 2.81 | 1.71 |
| SW | 2.62 | 2.76 | 1.80 | 2.62 | 2.76 | 1.80 |

The survey data provided did not include any customers identified as being charged on an unmeasured basis. Following the completion of the universal metering programme, occupancy levels for unmeasured and measured households are very similar as seen in the annual returns data for 2019/20 provided by SWS. The same occupancy assumptions have therefore been used as for measured customers.

# A.2. Toilet flushing

## A.2.1. Ownership

All households are assumed to own at least one toilet. Multiple toilet ownership is not assumed to impact on frequency of use.

## A.2.2. Frequency

A flushing frequency in the range 4.8-5.6 flushes per person per day has previously been used by SWS. This is relatively consistent with the EST report that assumes 4.71 flushes per person per day in household consumption modelling and suggests total correct toilet use of 1 large flush per day and 5.2 small flushes per day based upon medical research. The total number of flushes is assumed to be an overestimate for households as it will include toilet use in non-households.

For simplicity, in the context of limited evidence to support variation, a constant value of 5 flushes per day has been used. It is reasonable to assume that there is no difference in flushing frequency between measured and unmeasured properties.

It is assumed that there will be no change in flushing frequency across the different planning scenarios.

There are some references in the literature to increased frequency of toilet use in the future due to an ageing population and trends towards working from home. Previous UKWIR research[7] suggested that the evidence is inconclusive and may also be counterbalanced by increased environmental awareness and consequent reduced flushing. It is therefore assumed that there will be no change in flushing frequency in the future.

## A.2.3. Volume

Since 2001, a maximum flush volume of 6 litres has been mandated by legislation. Between 1993 and 2001, the maximum flush volume was 7.5 litres. Prior to that flush volumes were higher and could be up to 13 litres in the 1960s. However, these volumes assumed that the toilets work correctly with no need for double flushing.

SWS previously considered 3 generations of toilets:

- Generation 1: 12 litres/ flush
- Generation 2: 9 litres/ flush
- Generation 3: 6 litres/ flush

Given the limitations on evidence regarding ownership, it has not been considered necessary to create a specific generation to handle the 1993-2001 period. The generations have been retained with the following assumed proportions, based upon the previous SWS analysis:

**Table 5: WC Ownership by Generation**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Generation 1 (% devices) | 16% | 24% | 21% | 15% | 20% | 19% |

7 Customer Behaviour and Water Use, UKWIR Report ref: 12/CU/02/11

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Generation 2 (% devices) | 36% | 22% | 27% | 34% | 26% | 26% |
| Generation 3 (% devices) | 48% | 54% | 52% | 51% | 54% | 55% |

The EST report quotes an assumed toilet lifetime of 15 years, which implies an overall replacement rate of 6.7%. This is considered relatively consistent with the existing SWS assumptions of 5% on Generation 2 toilets and 15% on older Generation 1 toilets. The SWS assumptions have been retained on the basis that replacement of older toilets is more likely than replacement of newer toilets.

## A.3. Personal washing

### A.3.1. Ownership

It is assumed that all households have some form of shower available, with bath attachments and electric showers included within the scope of standard showers. Power showers with an internal pump to increase flow rate are considered separately.

The assumed split between standard showers and power showers based on the previous SWS analysis is as follows:

**Table 6: Shower Ownership by Type**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Standard showers (% devices) | 56% | 67% | 72% | 50% | 64% | 66% |
| Power showers (% devices) | 44% | 33% | 28% | 50% | 36% | 34% |

It is assumed that the following proportions of properties have a bath that is routinely used based upon the previous SWS analysis (baths that are never or rarely used are excluded):

**Table 7: Bath Ownership**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Bath ownership (in use devices) | 54% | 55% | 57% | 55% | 52% | 44% |

It is assumed that trends in reduced bath use will continue over the period, even in the absence of specific water efficiency activity. A 15% reduction over 50 years has been assumed based upon the previous SWS analysis.

The split between power showers and standard showers has been assumed to remain unchanged.

### A.3.2. Frequency

The assumed frequency of baths and showers, based upon the previous SWS analysis, is as follows:

**Table 8: Personal washing frequency by Type**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Showers (per week) | 5.78 | 5.64 | 5.95 | 5.08 | 4.95 | 4.61 |
| Baths (per week; if applicable) | 2.28 | 2.35 | 2.58 | 1.29 | 1.10 | 0.99 |
| Overall total accounting for bath ownership | 7.03 | 6.98 | 7.39 | 5.79 | 5.52 | 5.04 |

The higher values noted in the recent EST report are noted, but the overall frequencies of approximately one bath or shower per day in unmeasured properties and slightly less in measured properties are considered reasonable.

It is assumed that the frequencies for both baths and showers will remain unchanged in that absence of specific activity to promote water-efficiency.

### A.3.3. Volume

The bath volume of 75 litres previously used by SWS has been retained. This is reasonably consistent with the 72.2 litres used in the EST report.

The flow rates for normal and power showers are retained from those previously used by SWS as 6 l/min and 12 l/min, respectively.

The current durations of showers previously assumed by SWS have been retained. These are 8 minutes for unmeasured households (irrespective of shower type), 7 minutes for measured households using a standard shower and 6.5 minutes for measured households using a power shower. Unlike in the previous analysis, these have been assumed to remain constant in the absence of specific activity to promote water efficiency.

## A.4. Clothes washing

### A.4.1. Ownership

Ownership of washing machines is very high and customer surveys indicate that a significant number of households do some washing by hand. Overall assumed ownership of washing machines, based upon the previous SWS analysis, is as follows:

**Table 9: Clothes washing Ownership**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Washing machine ownership (% properties) | 97% | 95% | 90% | 98% | 97% | 94% |
| Routine hand-washing (% properties) | 32% | 28% | 26% | 33% | 31% | 26% |

The lower washing machine ownership assumption of 0.82 quoted in the EST research is noted but considered infeasible given that the results of surveys previously carried out by SWS and others[8] consistently report ownership of above 90%.

Given the already high ownership figures, overall ownership of washing machines is assumed to remain unchanged over time.

### A.4.2. Frequency

The following frequencies of washing machine and hand clothes-washing use are assumed, based upon the previous SWS analysis:

**Table 10: Clothes washing frequency**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Washing machine (per household, per week; if applicable) | 5.69 | 5.73 | 5.88 | 5.26 | 4.91 | 4.26 |
| Hand clothes washing (per household, per week; if applicable) | 1.31 | 1.34 | 1.42 | 1.09 | 1.05 | 1.06 |

The EST analysis appears to use the frequency of 220 uses per year (4.22 per week) quoted in Building Regulations Part G. Given that this is based upon a generic specification rather than a specific study, it is not considered a reason to adjust the washing machine frequency assumptions to better align with this.

### A.4.3. Volume

We have retained the four generations of washing machines previously used by SWS:

- Generation 1: 100 litres/ wash

[8] https://www.statista.com/statistics/289017/washing-machine-ownership-in-the-uk/

- Generation 2: 80 litres/ wash
- Generation 3: 55 litres/ wash
- Generation 4: 50 litres/ wash

The EST report notes that water-efficient washing machines with volumes of 8.33 l/kg or even 6.70 l/kg (42 l or 34 l for a typical 5 kg load) exist. However, 50 litres/ wash is considered reasonable for a modern washing machine in the absence of specific activity to drive water efficiency of devices and hence it has not been considered appropriate to modify the assumed volume of a modern washing machine as a result.

The generations have been retained with the following assumed proportions, based upon the previous SWS analysis:

**Table 11: Washing machine Ownership by Generation**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Generation 1 (% devices) | 9% | 7% | 4% | 10% | 12% | 12% |
| Generation 2 (% devices) | 20% | 19% | 20% | 20% | 21% | 20% |
| Generation 3 (% devices) | 33% | 41% | 36% | 39% | 34% | 37% |
| Generation 4 (% devices) | 38% | 33% | 40% | 31% | 33% | 31% |

The EST report does not appear to quote an assumed washing machine lifetime. Previous consumer research indicates an expected lifetime of typically 6-7 years[9]. The existing SWS assumptions (8% for Generation 3, 10% for Generation 2 and 20% for Generation 1) are considered reasonable in this context and have been retained.

It is assumed that when a washing machine is replaced, a Generation 4 washing machine is installed.

Volume used in hand washing of clothes is retained at 30 litres/wash. This is equivalent to a typical basin tap flow rate of 6 l/min running for 5 minutes.

## A.5. Dishwashing

### A.5.1. Ownership

Overall assumed ownership of dishwashers, based upon the previous SWS analysis, is as follows:

9 www.wrap.org.uk/sites/files/wrap/WRAP%20longer%20product%20lifetimes.pdf

**Table 12: Dishwasher Ownership**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Dishwasher ownership (% properties) | 77% | 47% | 23% | 75% | 50% | 31% |

The ownership assumption of 0.41 quoted in the EST research is noted but the previous SWS analysis is considered to be more representative of the region.

As in the previous SWS analysis, all households are assumed to do some dishwashing by hand, irrespective of whether or not they own a dishwasher.

It is assumed that trends in increased dishwasher ownership will continue over the period, even in the absence of specific water efficiency activity. A 50% increase over 50 years has been assumed based upon the previous SWS analysis. A maximum ownership of 90% in any one category has been assumed.

### A.5.2. Frequency

The following frequency of dish washing is assumed, based upon the previous SWS analysis:

**Table 13: Dishwashing frequency**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Dishwasher use (per household, per week; if applicable) | 5.87 | 5.99 | 6.31 | 5.56 | 5.14 | 4.51 |
| Hand dish-washing (per household, per week; owning dishwasher) | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 | 1.40 |
| Hand dish-washing (per household, per week; no dishwasher) | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 | 7.00 |

The EST research is based upon the Building Regulations water efficiency calculator which quotes an assumption of 280 uses per year (5.4 uses per week), which is relatively consistent with the previous SWS assumptions.

Daily dishwashing by hand in the absence of a dishwasher is considered reasonable, as is the assumption that hand dishwashing is 20% of this where a dishwasher exists.

Frequencies are assumed to remain unchanged in the absence of specific water-efficiency activity.

### A.5.3. Volume

We have retained the four generations of dishwashers previously used by SWS:

- Generation 1: 55 litres/ use
- Generation 2: 40 litres/ use
- Generation 3: 15 litres/ use
- Generation 4: 11 litres/ use

The EST report notes that water-efficient dishwashers with volumes of 0.78 l/place-setting or even 0.5 l/place-setting (9.4 l or 6 l for a typical 12 place-setting load respectively) exist. However, 11 litres/ use is considered reasonable for a modern washing machine in the absence of specific activity to drive water efficiency of devices and hence it has not been considered appropriate to modify the assumed volume of a modern washing machine as a result.

The generations have been retained with the following assumed proportions, based upon the previous SWS analysis:

**Table 14: Dishwasher Ownership by Generation**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Generation 1 (% devices) | 8% | 8% | 10% | 12% | 8% | 14% |
| Generation 2 (% devices) | 26% | 22% | 18% | 23% | 24% | 21% |
| Generation 3 (% devices) | 38% | 36% | 33% | 34% | 32% | 28% |
| Generation 4 (% devices) | 28% | 34% | 39% | 31% | 36% | 37% |

The EST report does not appear to quote an assumed dishwasher lifetime, but surveys of consumers and manufacturers indicate an expected lifespan of approximately 10 years[10]. The previous SWS assumptions for replacement rates (12% for Generation 3, 6% for Generation 2 and 3% for Generation 1) are considered too low in this context. The following higher replacement rates have been used instead:

- Generation 1: 20%
- Generation 2: 10%
- Generation 3: 8%

It is assumed that when a dishwasher is replaced, a Generation 4 dishwasher is installed.

The previous SWS volume estimates for dishwashing by hand were 10 l for measured households and 12.5 l for unmeasured households. These look low in comparison to research suggesting that manual dishwashing by UK consumers of a full dishwasher load typically uses 49 litres[11]. It is considered reasonable to assume that measured customers would use less Volume estimates of 45 l and 50 l for measured and unmeasured customers have therefore been used instead.

[10] https://www.consumerreports.org/dishwashers/how-to-make-your-dishwasher-last-longer/

[11] Berkholz, Petra & Stamminger, Rainer & Wnuk, Gabi & Owens, Jeremy & Bernarde, Simone. (2010). Manual dishwashing habits: An empirical analysis of UK consumers. International Journal of Consumer Studies. 34. 235 - 242. 10.1111/j.1470-6431.2009.00840.x.

## A.6. Miscellaneous internal use

The previous SWS analysis assumed miscellaneous internal use ranging from 2.8-7.5 litres/head/day.

For this analysis, miscellaneous internal use has been assumed at 5 litres/head/day given the limited evidence to support the variation assumed for WRMP19.

## A.7. External use

### A.7.1. Ownership

The previous SWS analysis referred four modes of garden watering: hosepipes, sprinklers, watering cans and 'other'. Ownership for the 'other' category was reported as 0%, so it has not been used in this analysis. For the identified devices, the following ownership has been assumed, based upon the previous SWS analysis:

**Table 15: Garden watering device Ownership**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Hosepipe (% properties) | 28% | 28% | 33% | 27% | 23% | 14% |
| Sprinkler (% properties) | 6% | 4% | 1% | 5% | 2% | 1% |
| Watering can (% properties) | 30% | 32% | 31% | 32% | 34% | 39% |

### A.7.2. Frequency

The following frequencies of use, averaged throughout the entire year, have been assumed based upon the previous SWS analysis:

**Table 16: Garden watering device Frequency**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Hosepipe (per property, per week; where applicable) | 0.85 | 0.82 | 0.68 | 0.57 | 0.38 | 0.25 |
| Sprinkler (per property, per week; where applicable) | 0.85 | 0.82 | 0.68 | 0.57 | 0.38 | 0.25 |

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Watering can (per property, per week; where applicable) | 0.85 | 0.82 | 0.68 | 0.57 | 0.38 | 0.25 |

### A.7.3. Volume

The volumes associated with hosepipes and sprinklers are calculated as the product of flow rate and duration. The previously assumed flow rates of 12 litres/minute for hosepipe use and 6 litres/minute for sprinkler use have been retained.

The EST analysis quotes values of 11 litres per use and 7179 litres per year for hose attachments. It is assumed that this actually means a flow rate of 11 l/min with an implied 10.8 hour total duration of use throughout the year.

The following durations have been assumed, based upon the previous SWS analysis:

**Table 17: Garden watering device durations**

| | Unmeasured Group 1 | Unmeasured Group 2 | Unmeasured Group 3 | Measured Group 1 | Measured Group 2 | Measured Group 3 |
|---|---|---|---|---|---|---|
| Hosepipe use duration (minutes) | 44 | 33 | 32 | 34 | 26 | 24 |
| Sprinkler use duration (minutes) | 45 | 45 | 45 | 45 | 45 | 45 |

The volume of water used by watering cans has been retained as 5 litres.

### A.7.4. Miscellaneous external use

Miscellaneous outdoor use (in respect of car washing, cleaning garden furniture, etc) of 1 litre/head/day has been assumed in addition to the devices calculated on the OFV basis. This is similar to the assumption made in the previous analysis.

# B. Detailed WRZ level results

## B.1. Hampshire Andover (HA)

**Figure 9: Range of NYAA Distribution Input results**

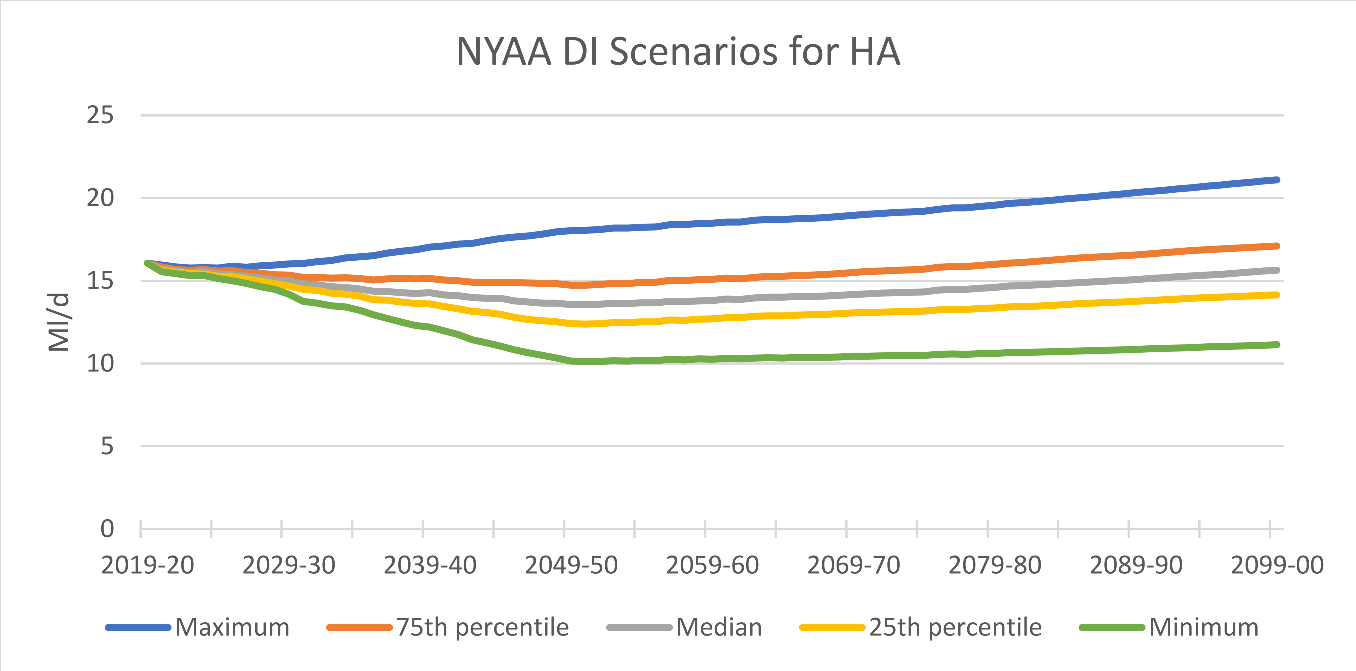


**Figure 10: Range of DYAA Distribution Input results**

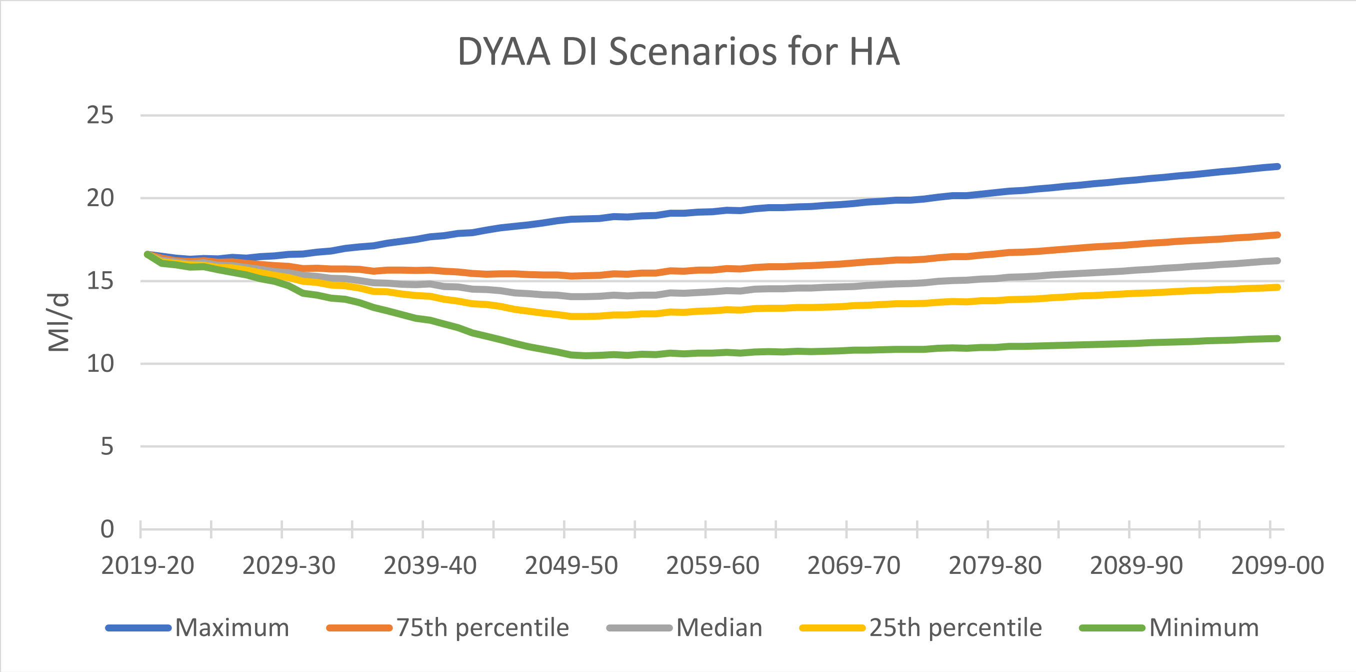



**Figure 11: Range of DYCP Distribution Input results**

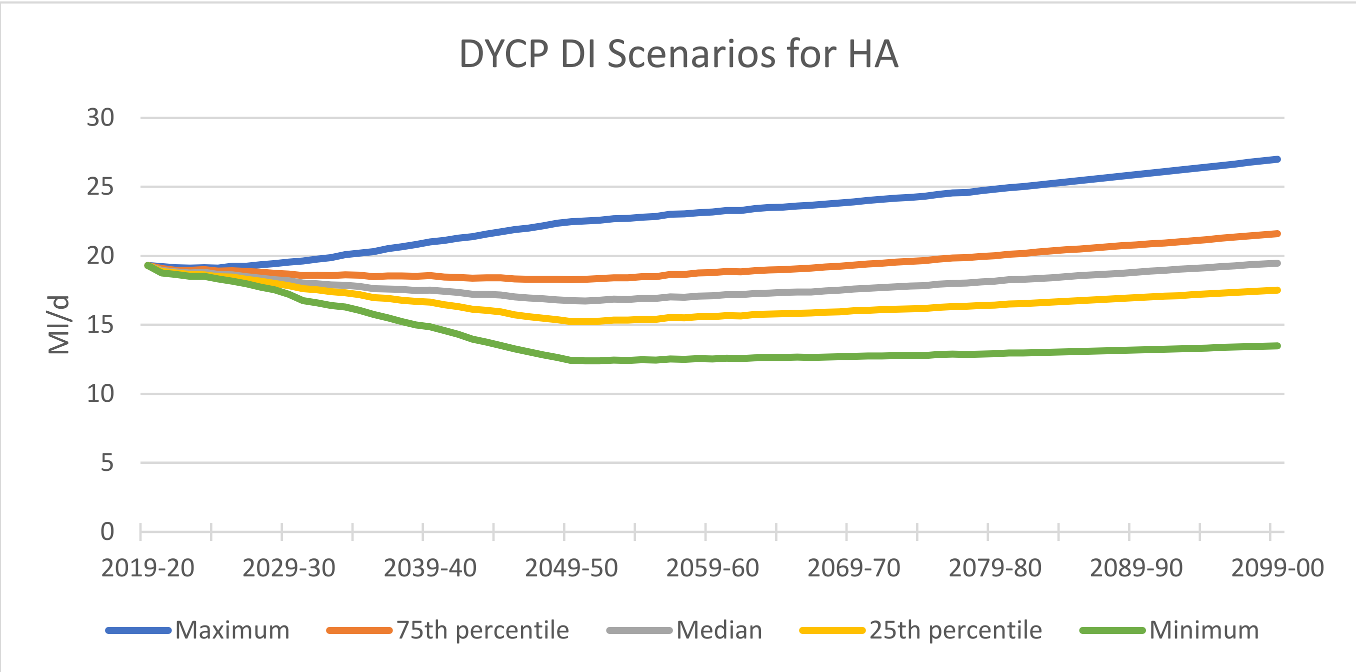


**Figure 12: Range of DYMDO Distribution Input results**

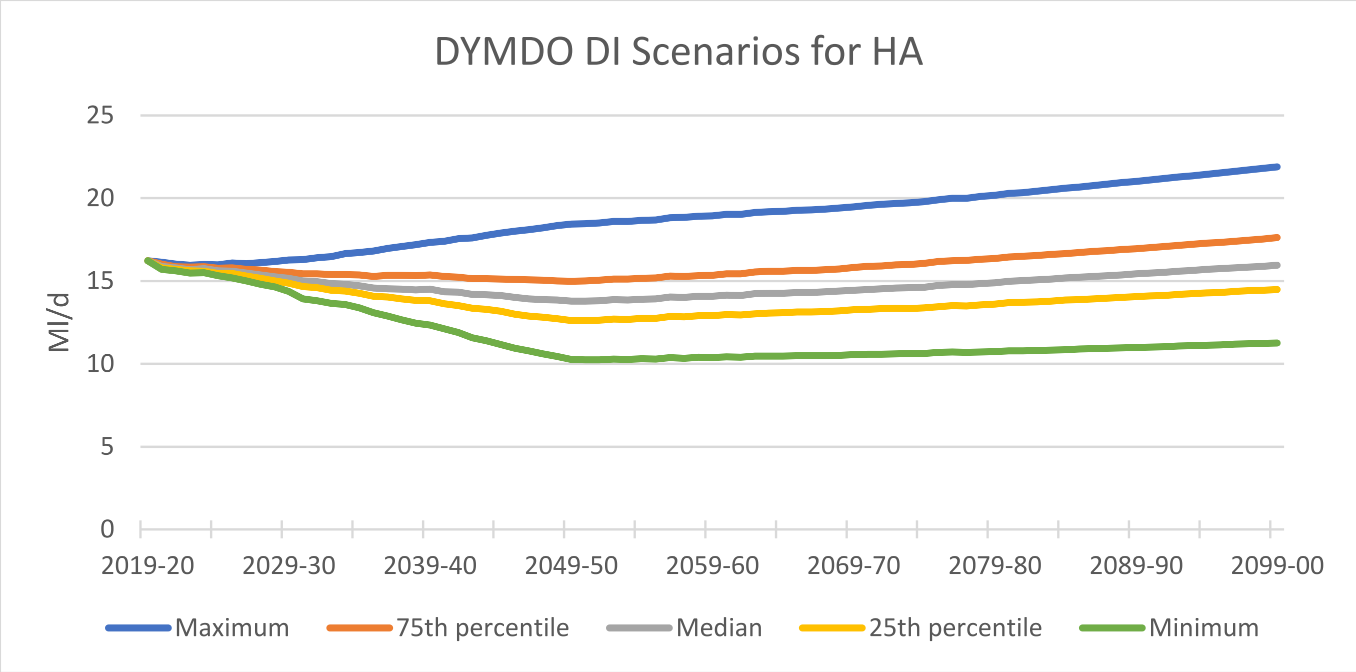



**Figure 13: Range of NYAA PCC results**

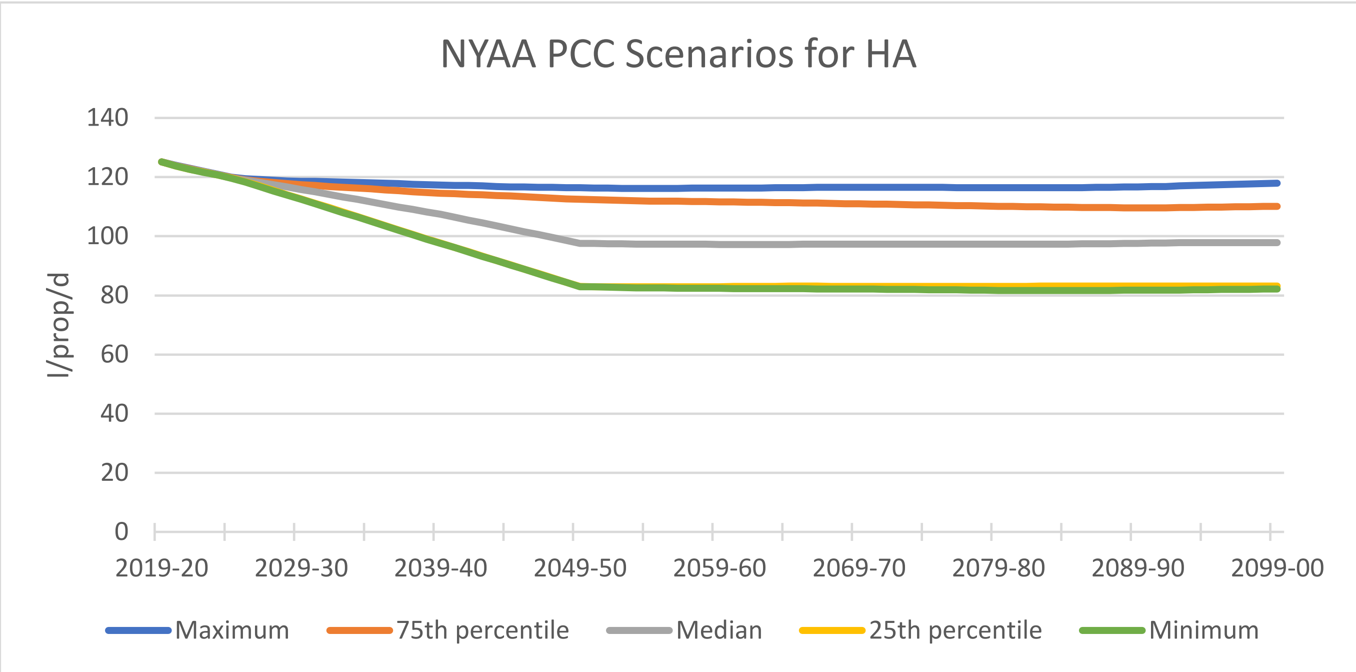


**Figure 14: Range of DYAA PCC results**

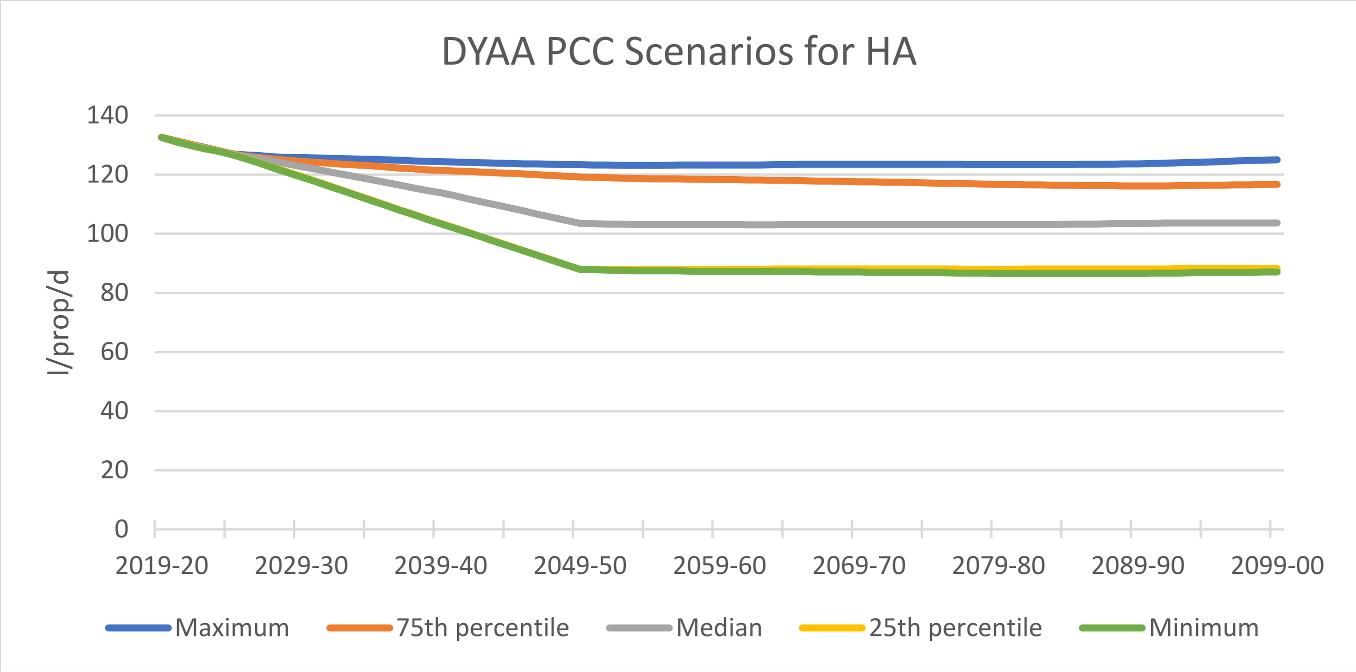



**Figure 15: Range of DYCP PCC results**

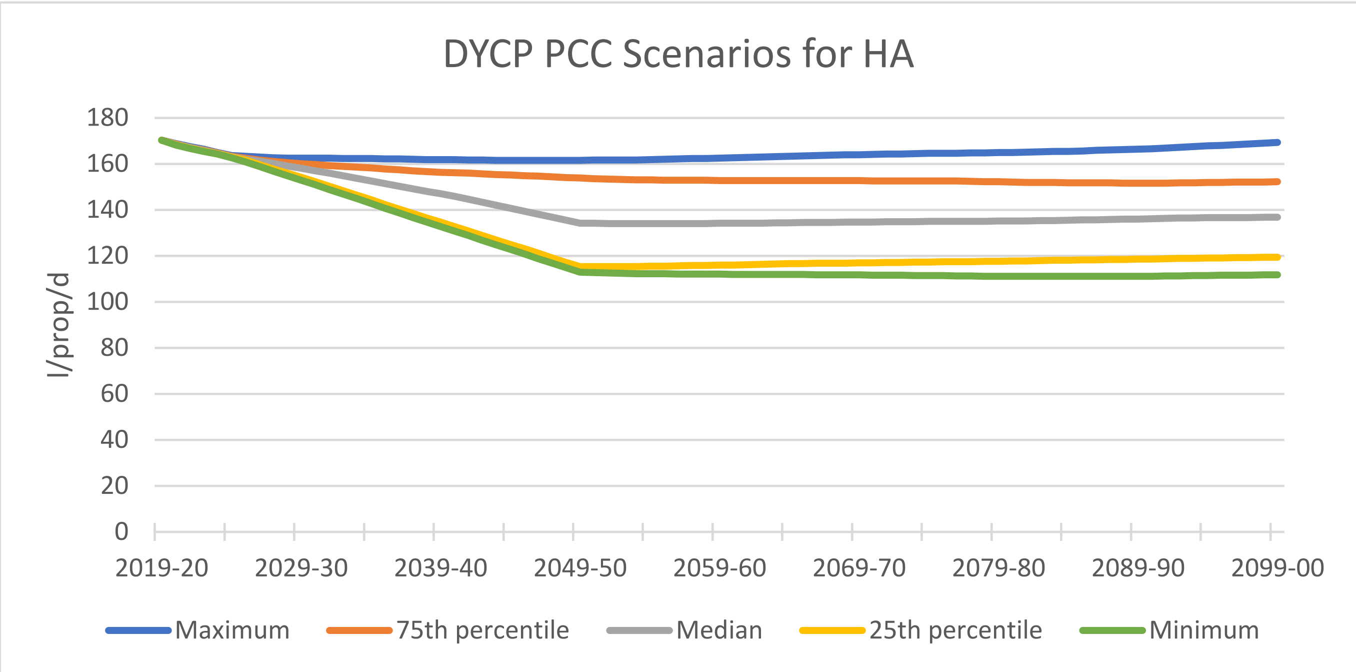
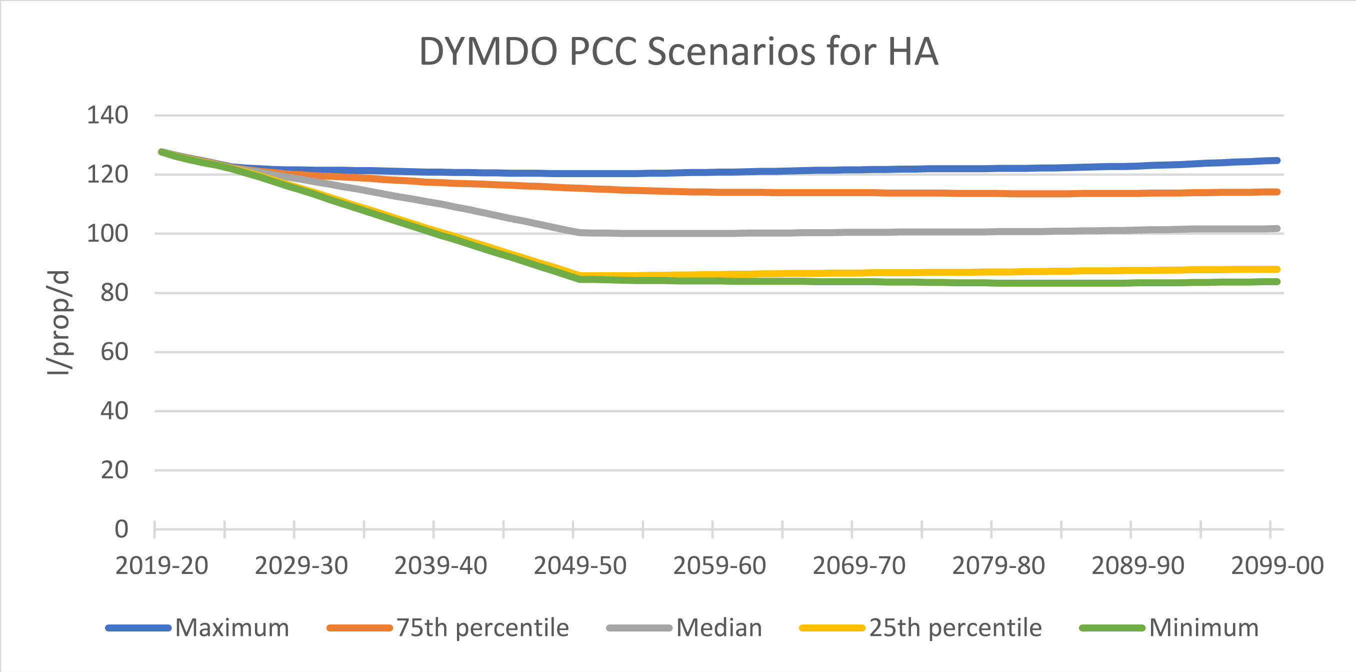


**Figure 16: Range of DYMDO PCC results**




## B.2. Hampshire Kingsclere (HK)

**Figure 17: Range of NYAA Distribution Input results**

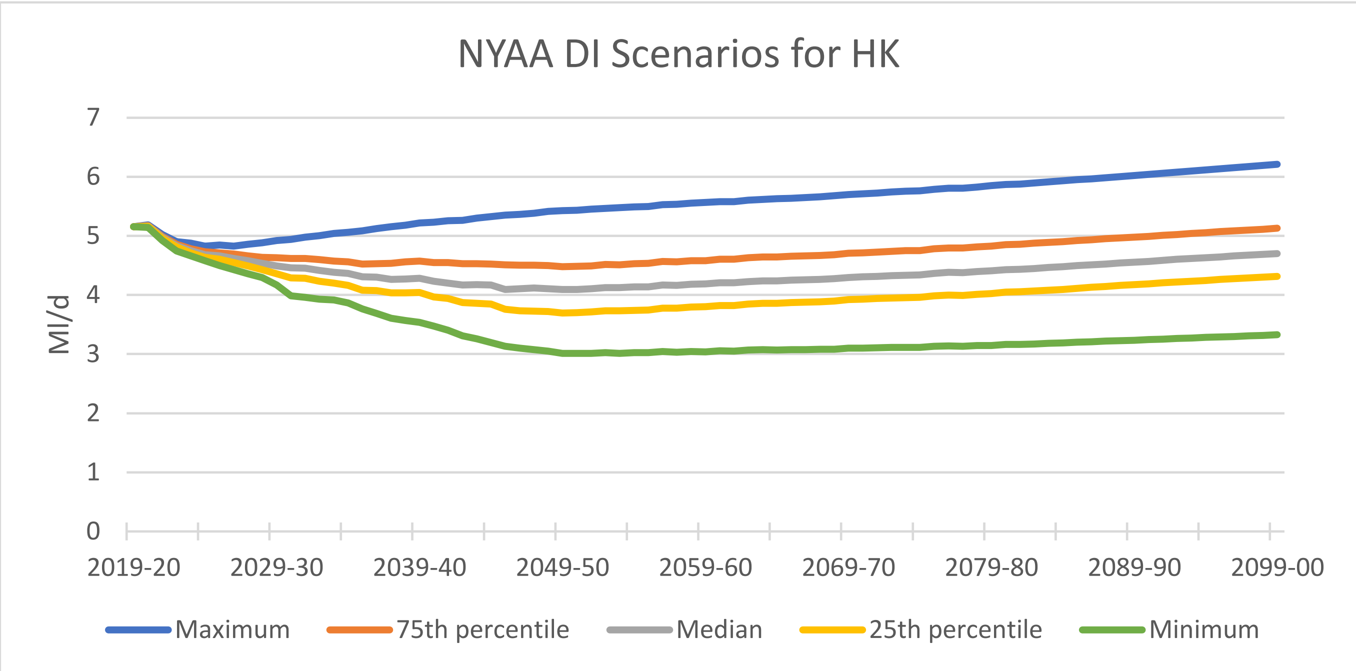


Figure 18: Range of DYAA Distribution Input results

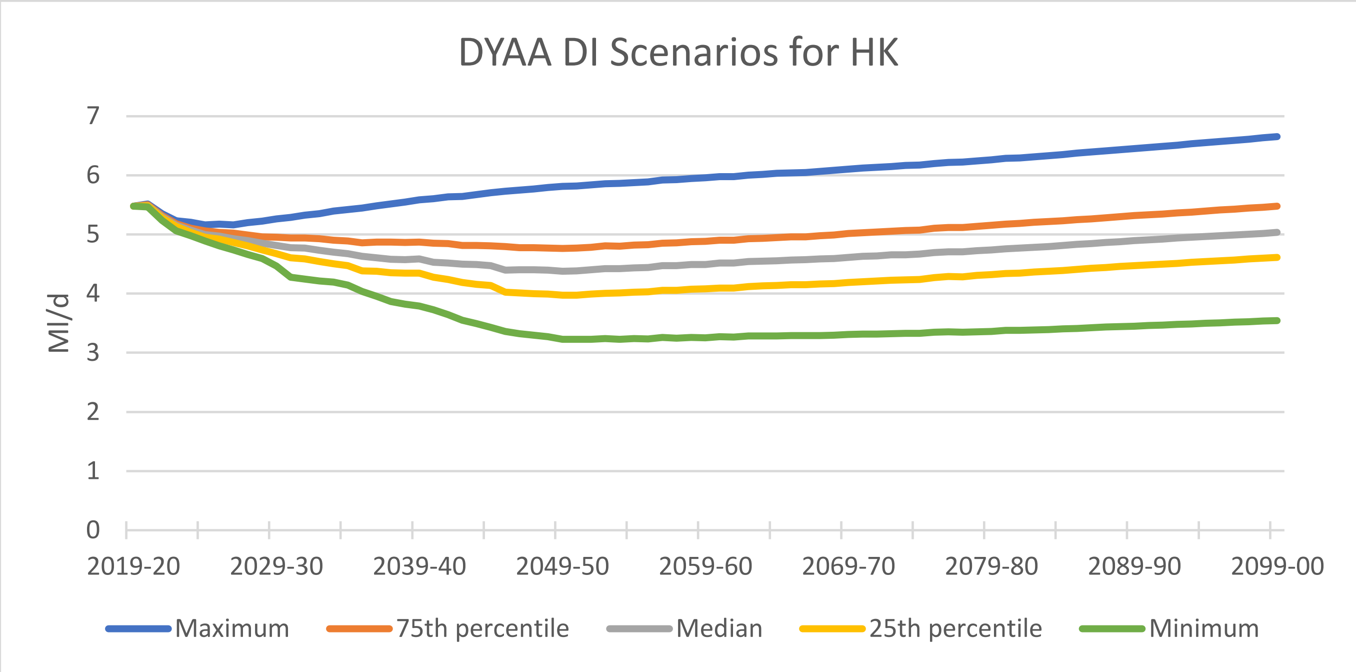



Figure 19: Range of DYCP Distribution Input results

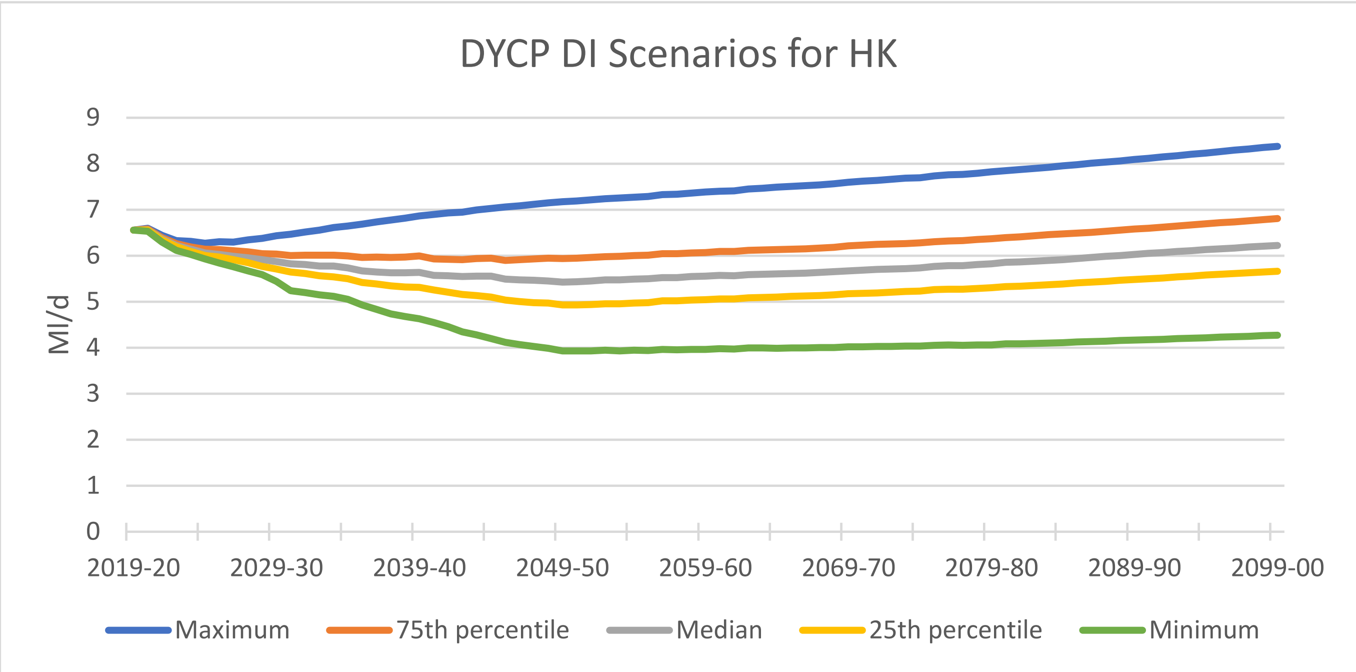


**Figure 20: Range of DYMDO Distribution Input results**

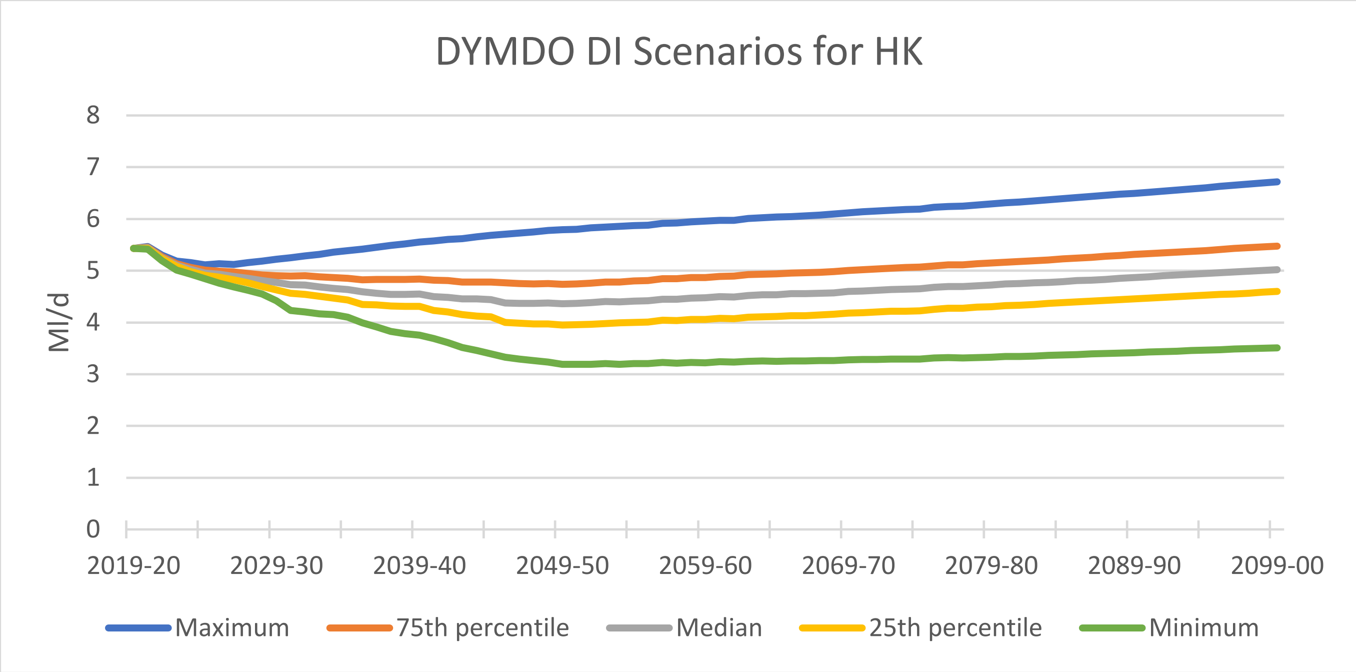



**Figure 21: Range of NYAA PCC results**

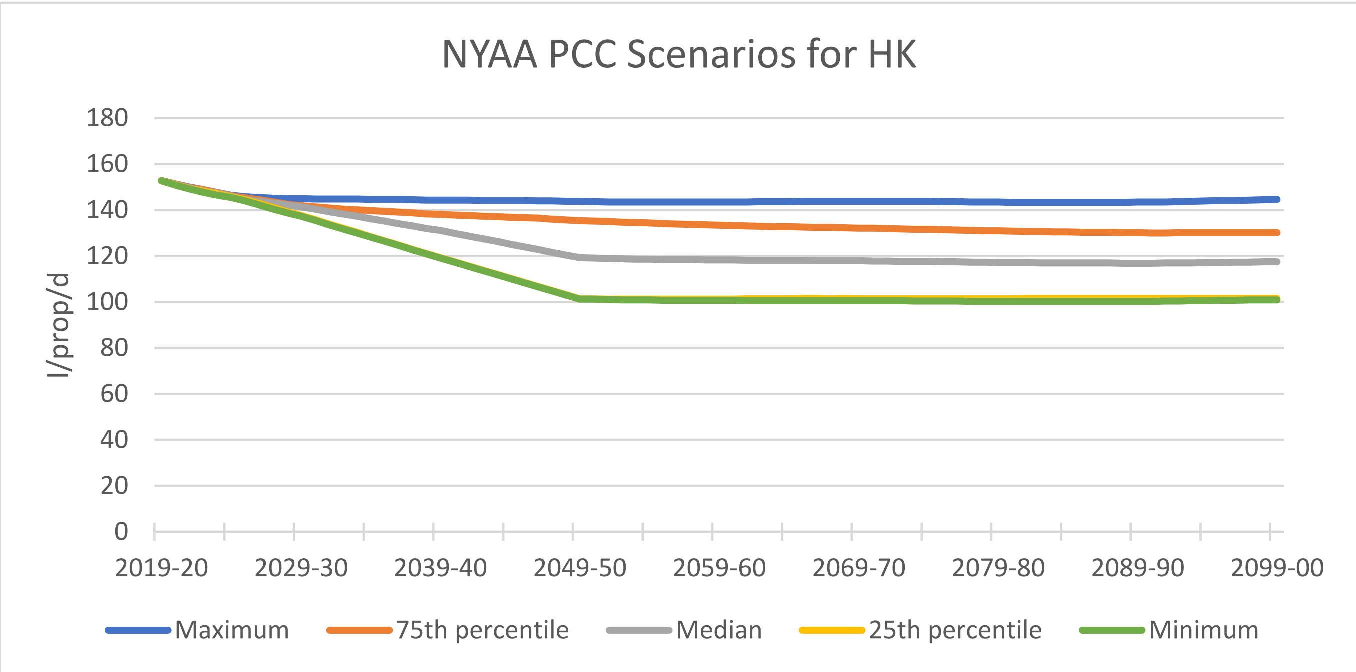


**Figure 22: Range of DYAA PCC results**

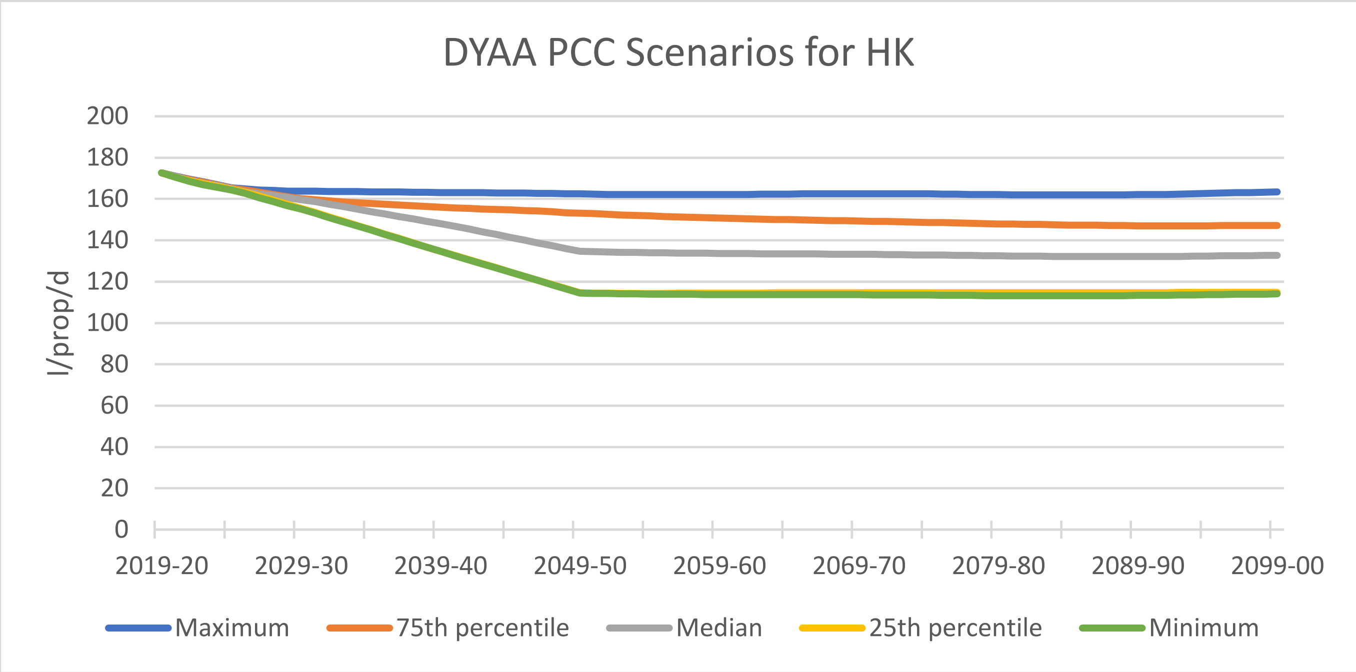



**Figure 23: Range of DYCP PCC results**

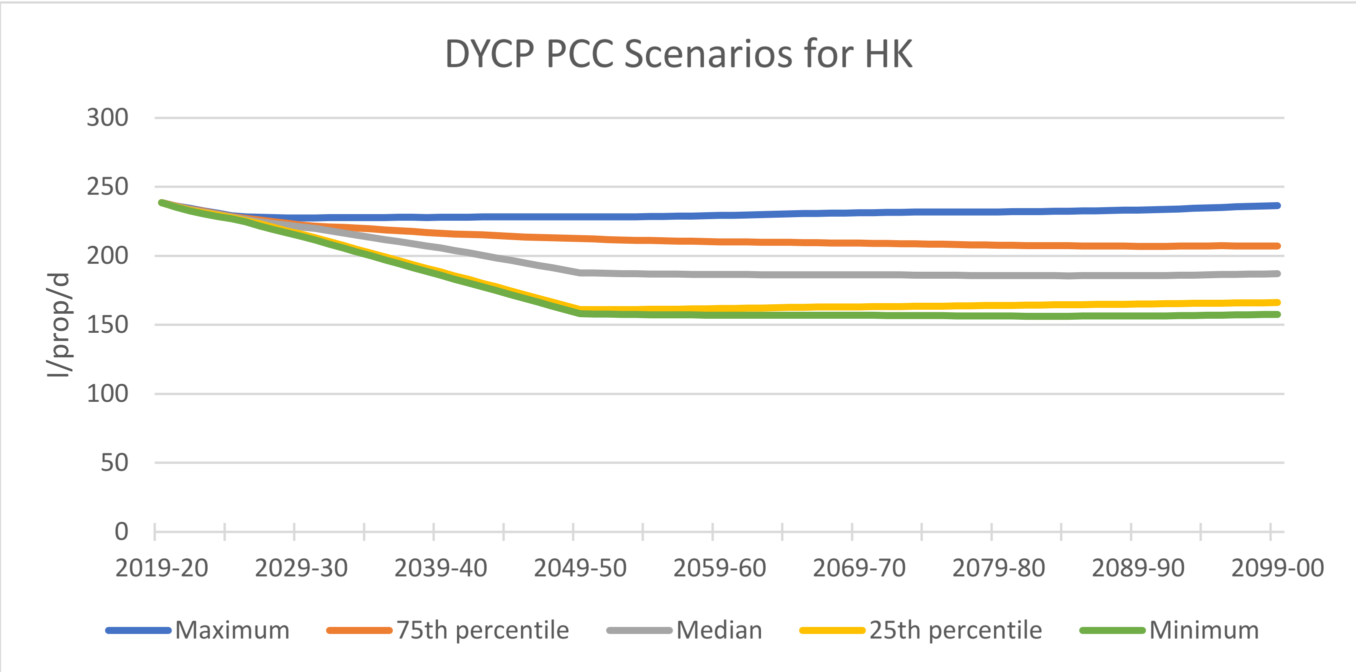
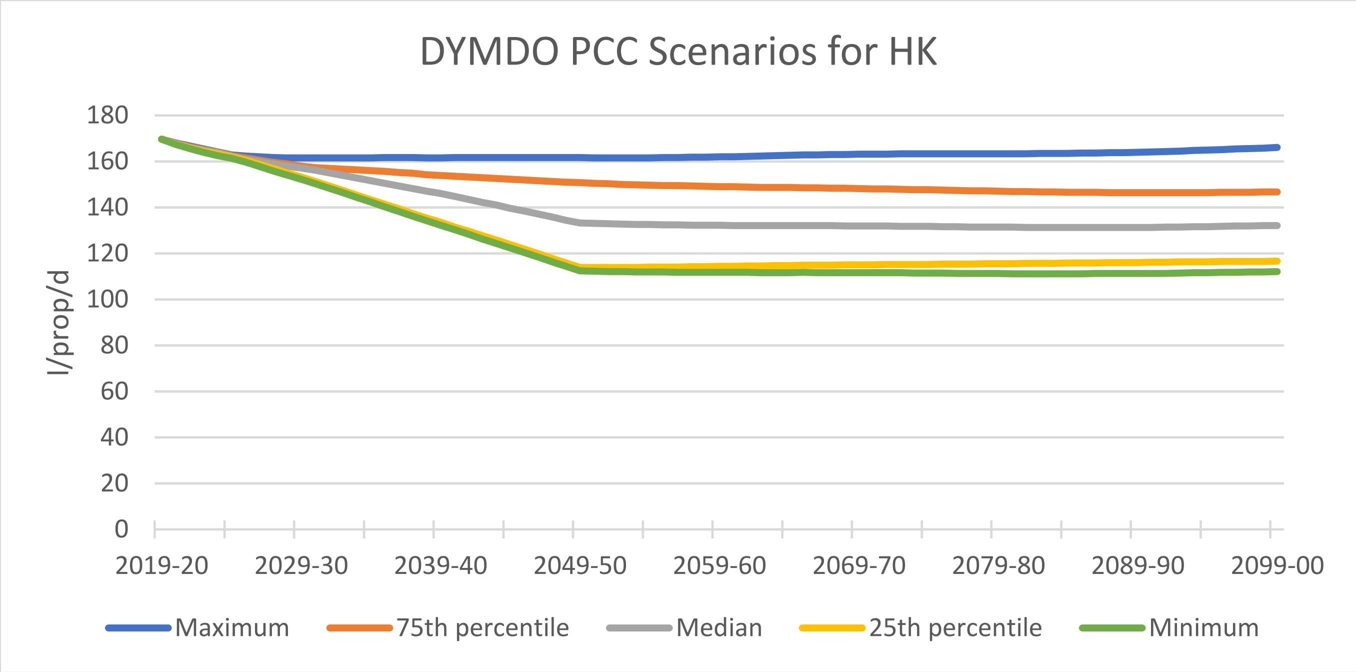


**Figure 24: Range of DYMDO PCC results**




## B.3. Hampshire Winchester (HW)

**Figure 25: Range of NYAA Distribution Input results**

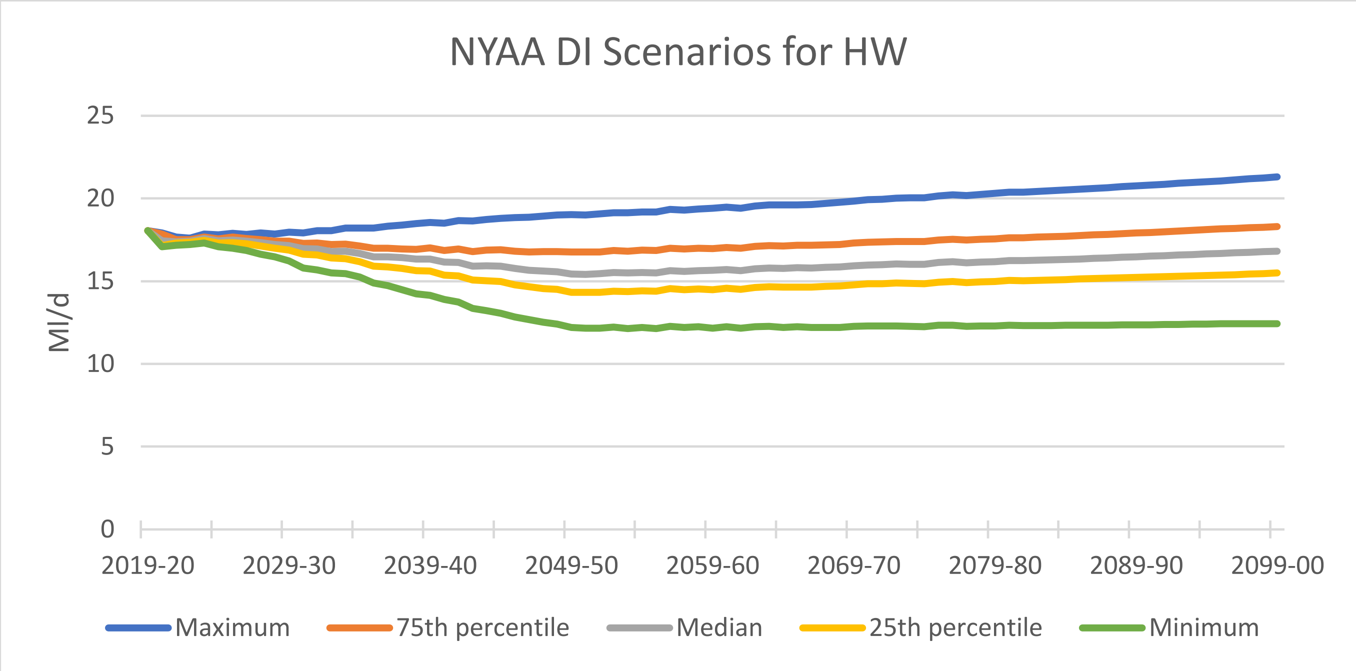


**Figure 26: Range of DYAA Distribution Input results**

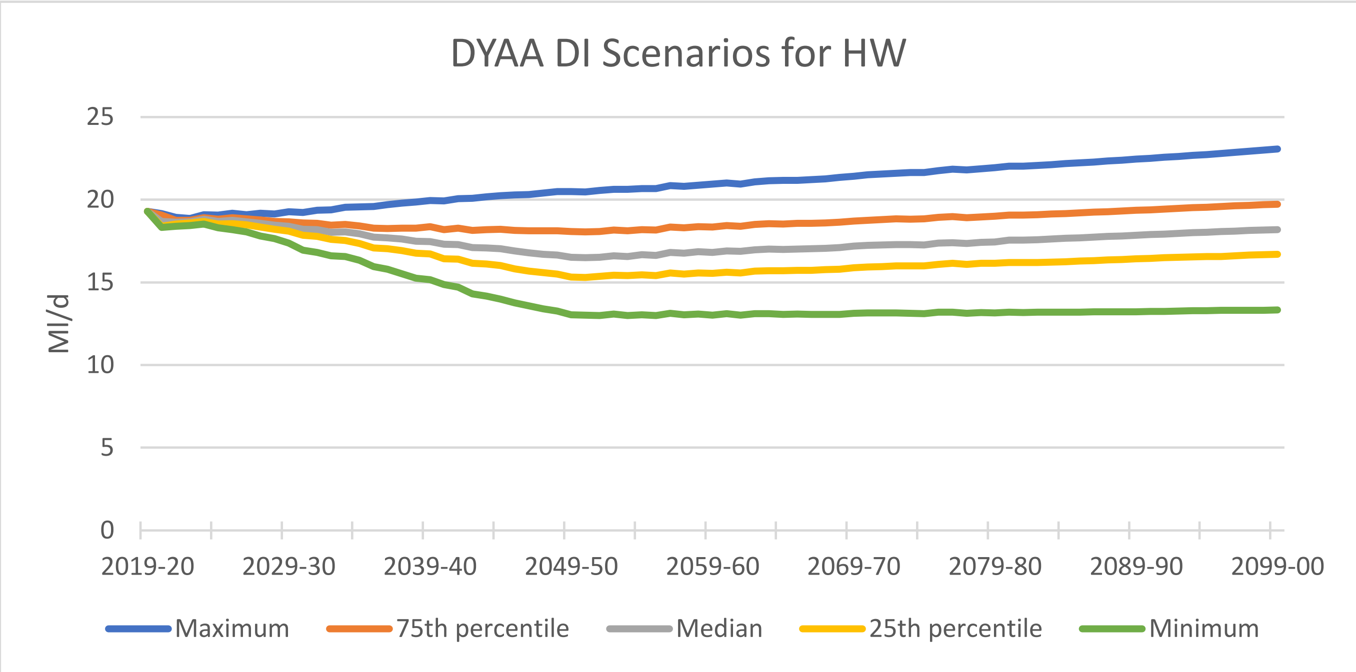



**Figure 27: Range of DYCP Distribution Input results**

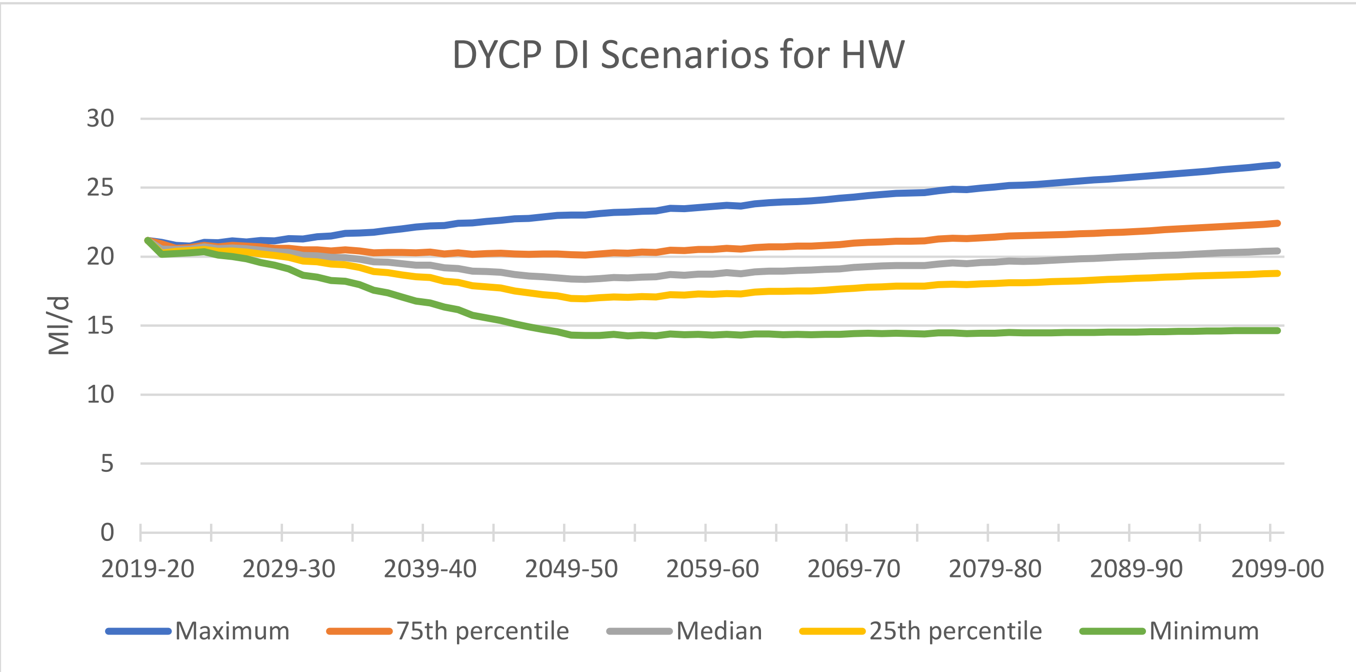


Figure 28: Range of DYMDO Distribution Input results

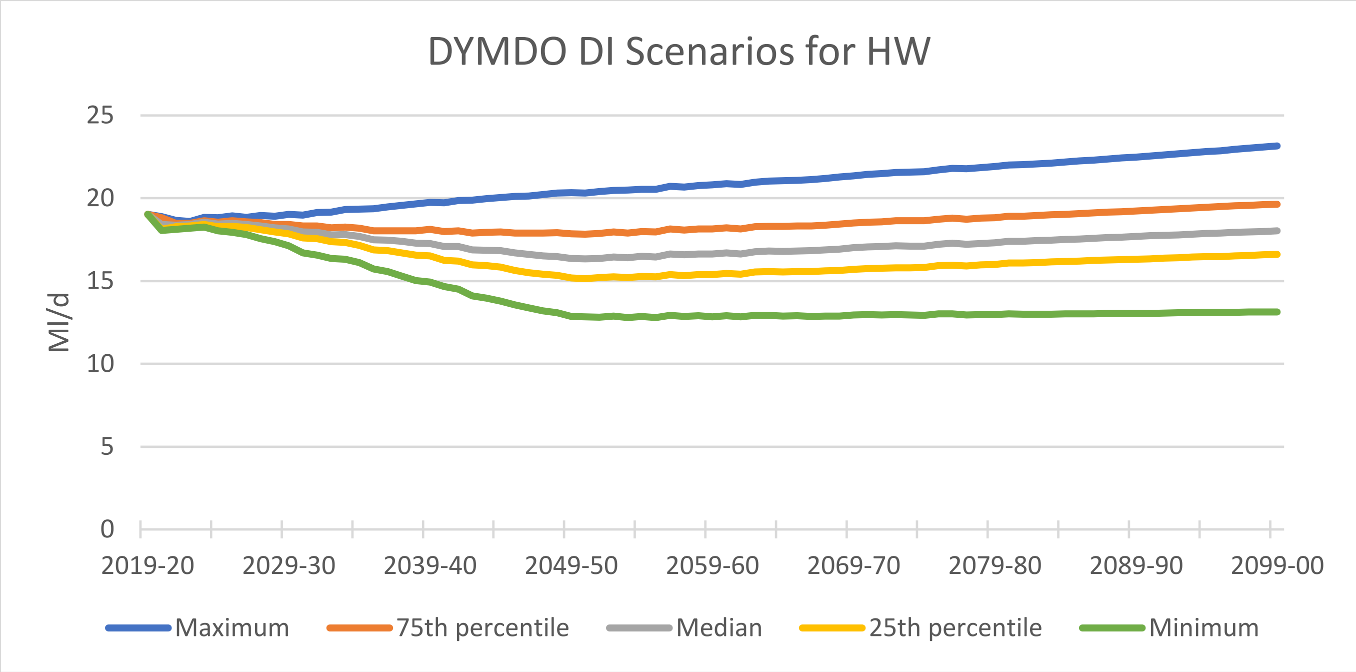



Figure 29: Range of NYAA PCC results

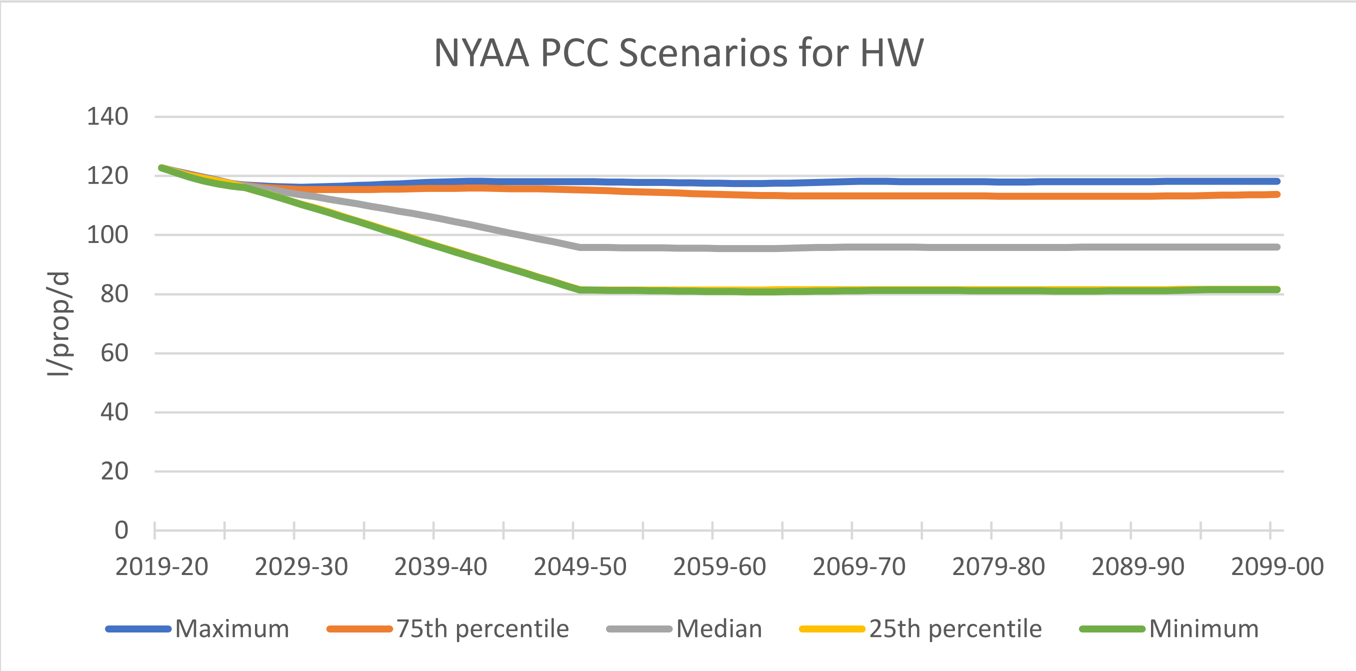


**Figure 30: Range of DYAA PCC results**

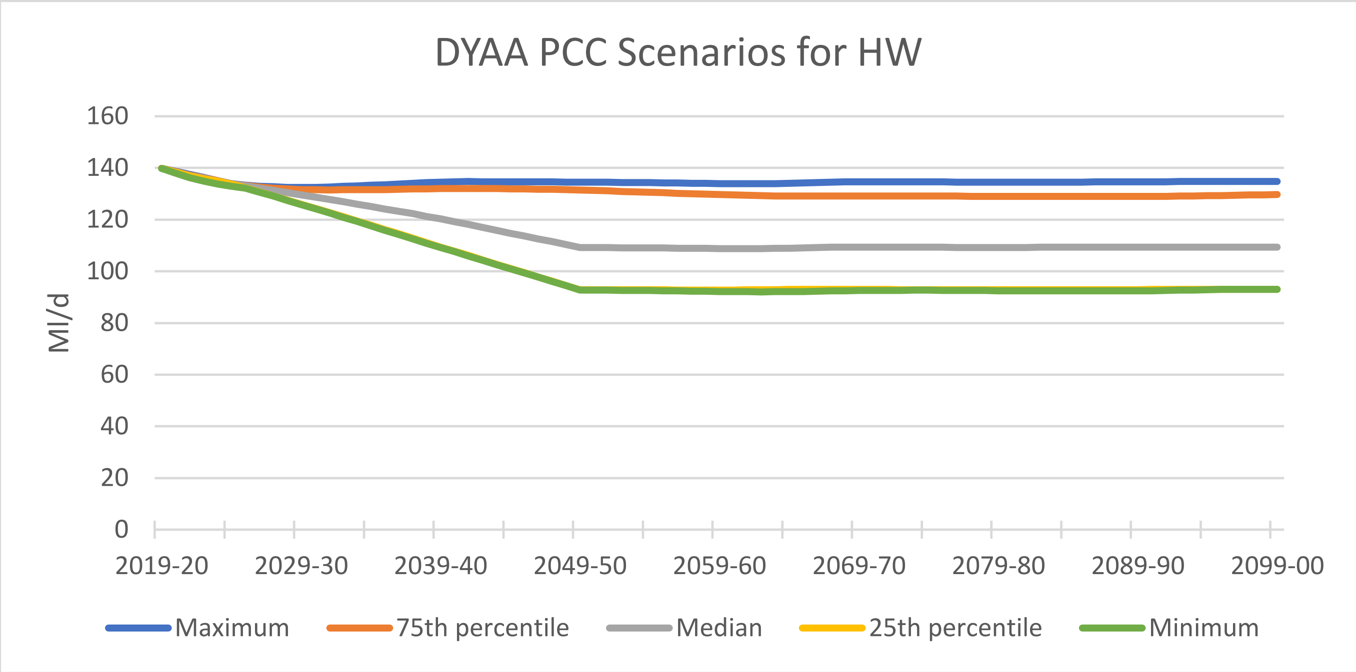



**Figure 31: Range of DYCP PCC results**

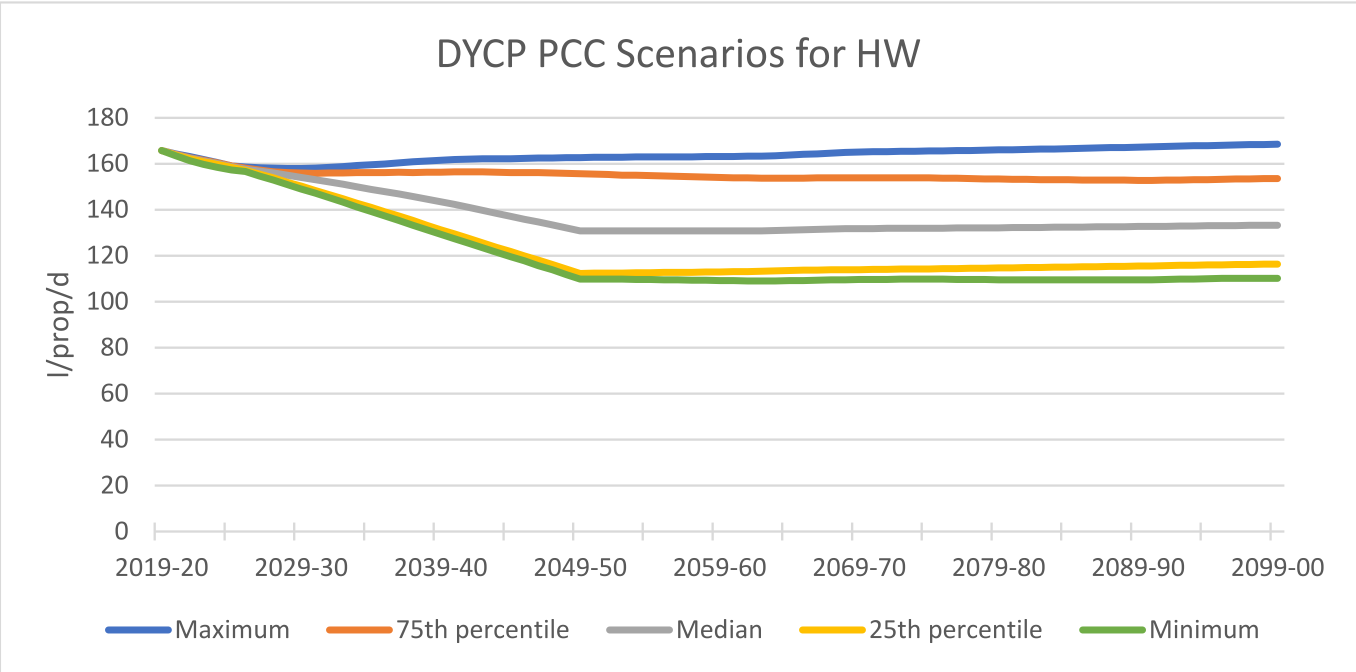
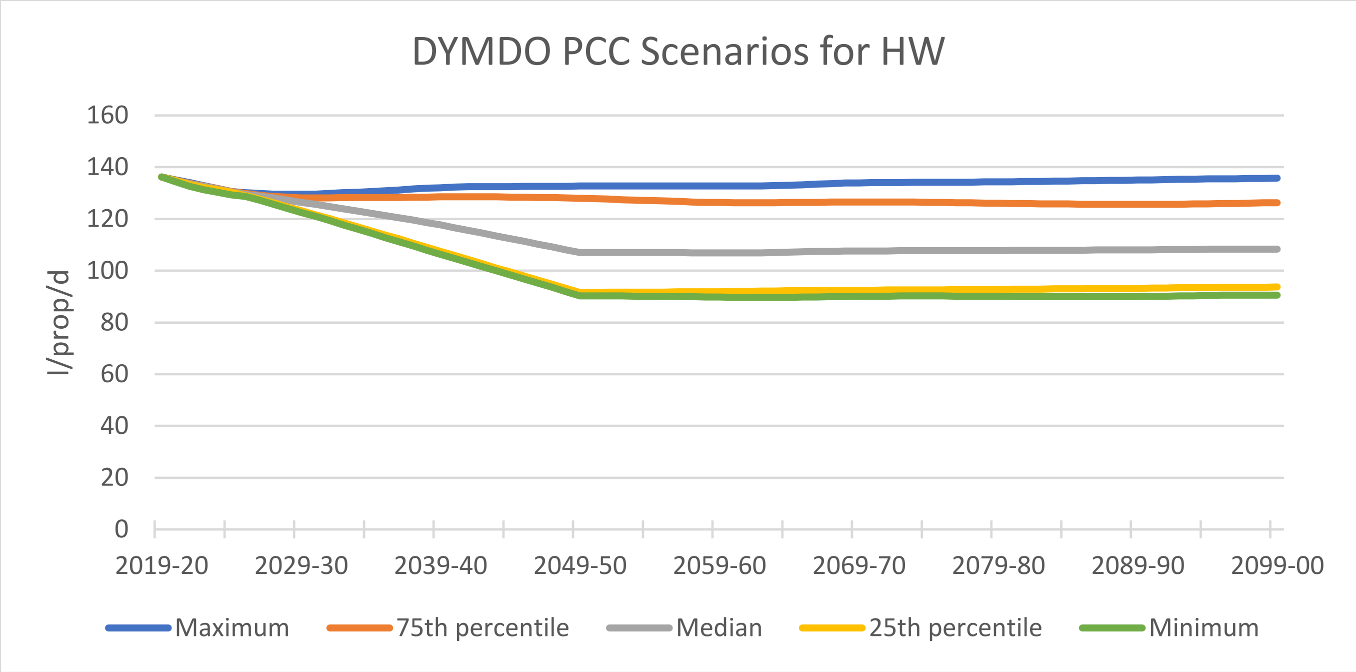


Figure 32: Range of DYMDO PCC results




## B.4. Hampshire Rural (HR)

Figure 33: Range of NYAA Distribution Input results

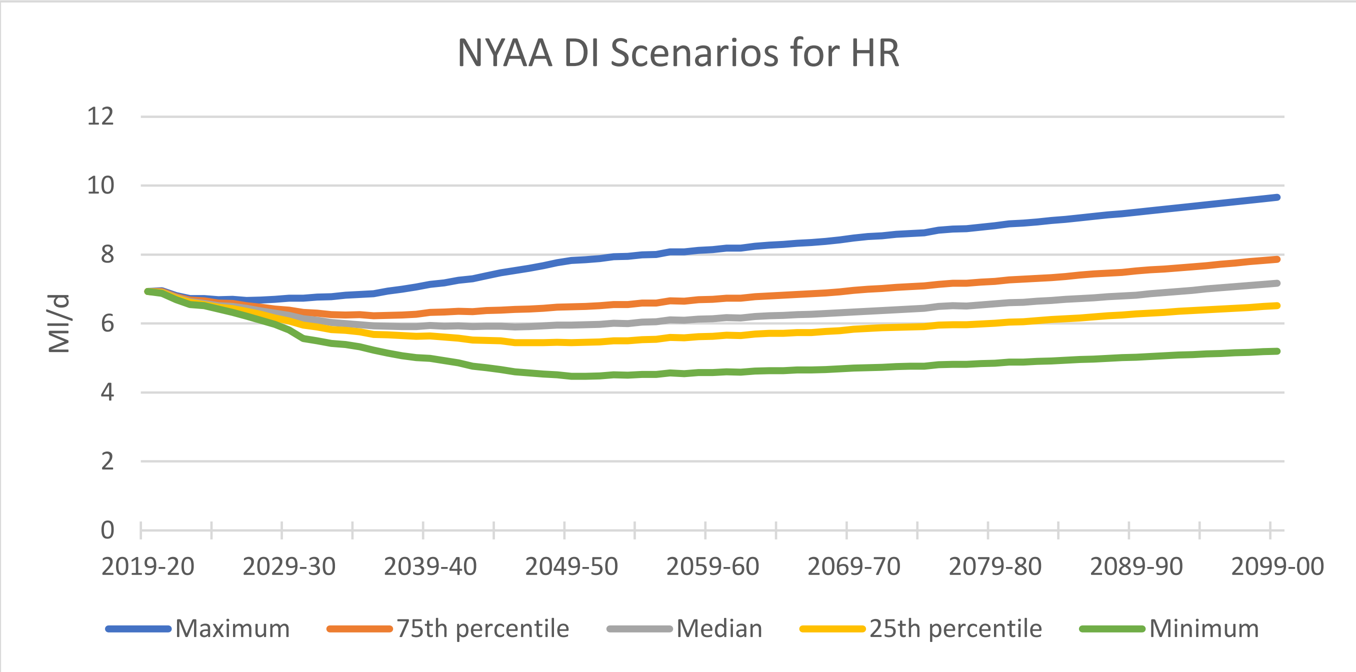


Figure 34: Range of DYAA Distribution Input results

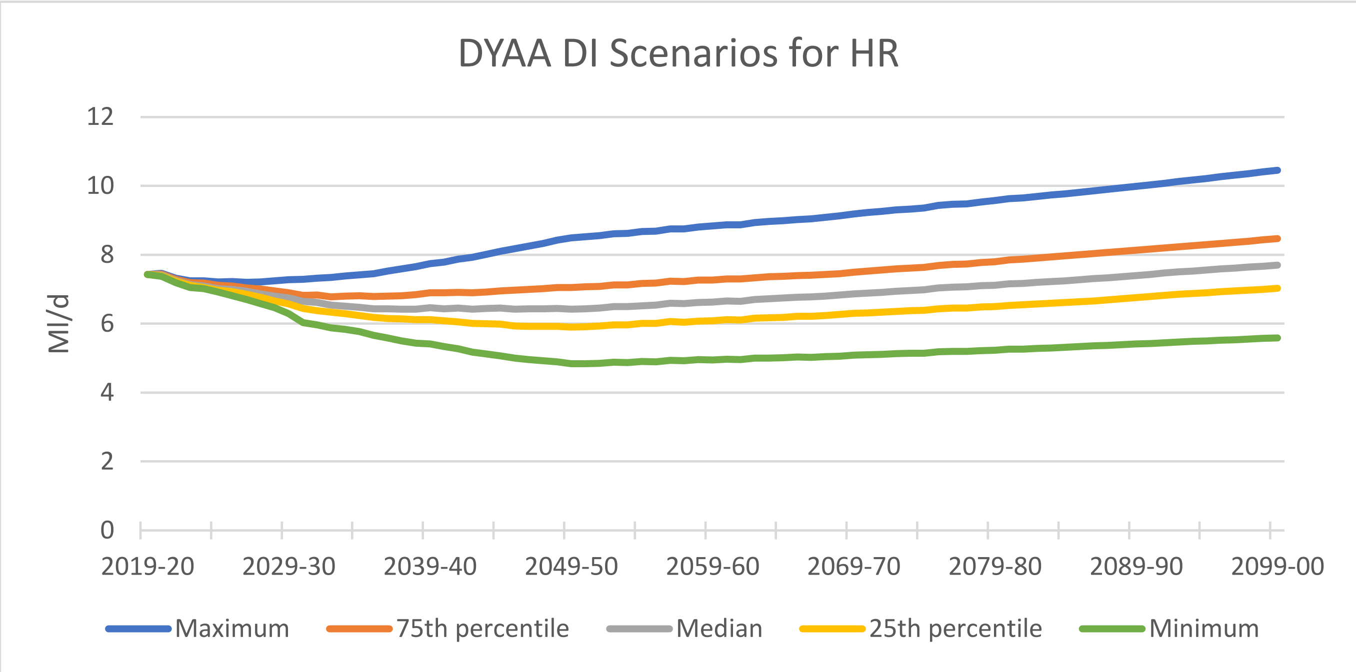



Figure 35: Range of DYCP Distribution Input results

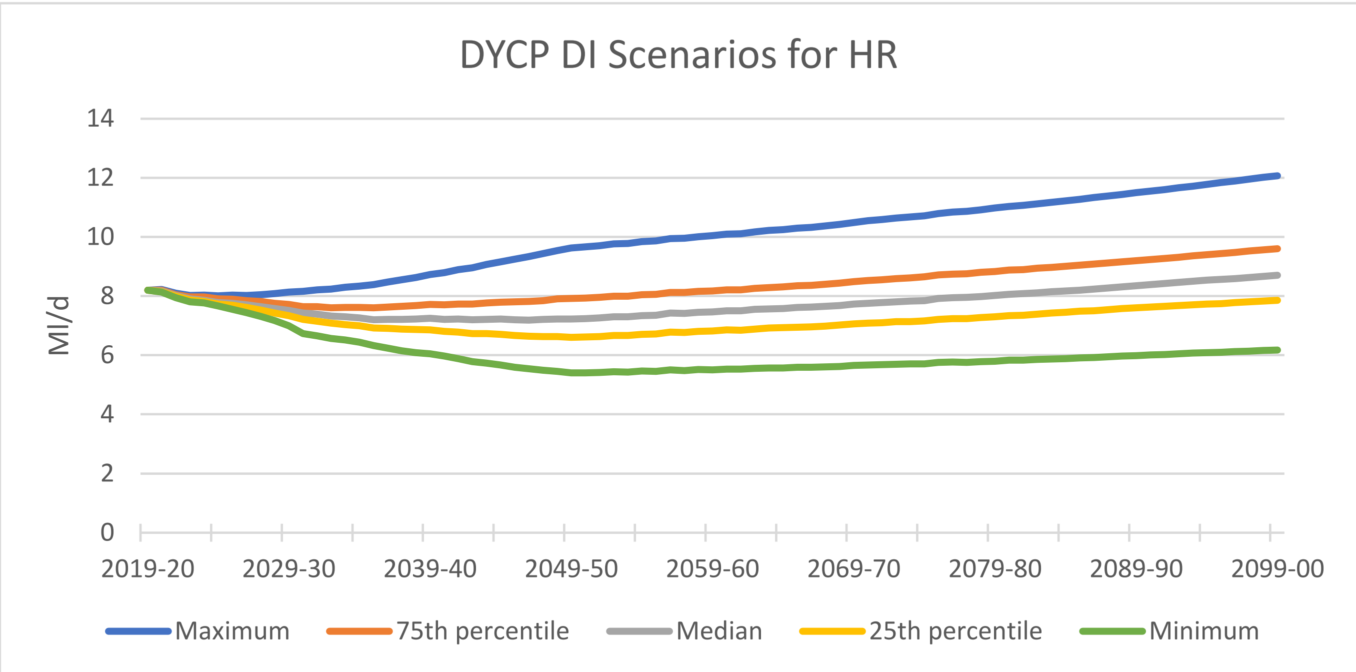


**Figure 36: Range of DYMDO Distribution Input results**

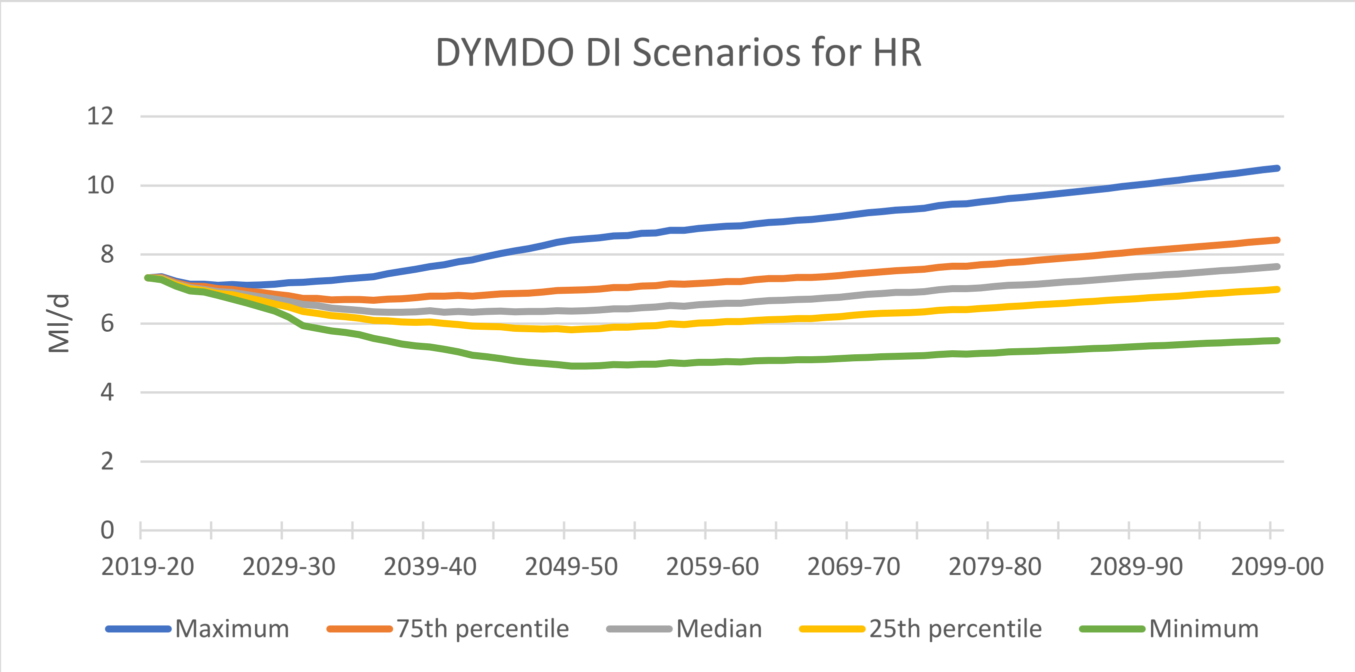



**Figure 37: Range of NYAA PCC results**

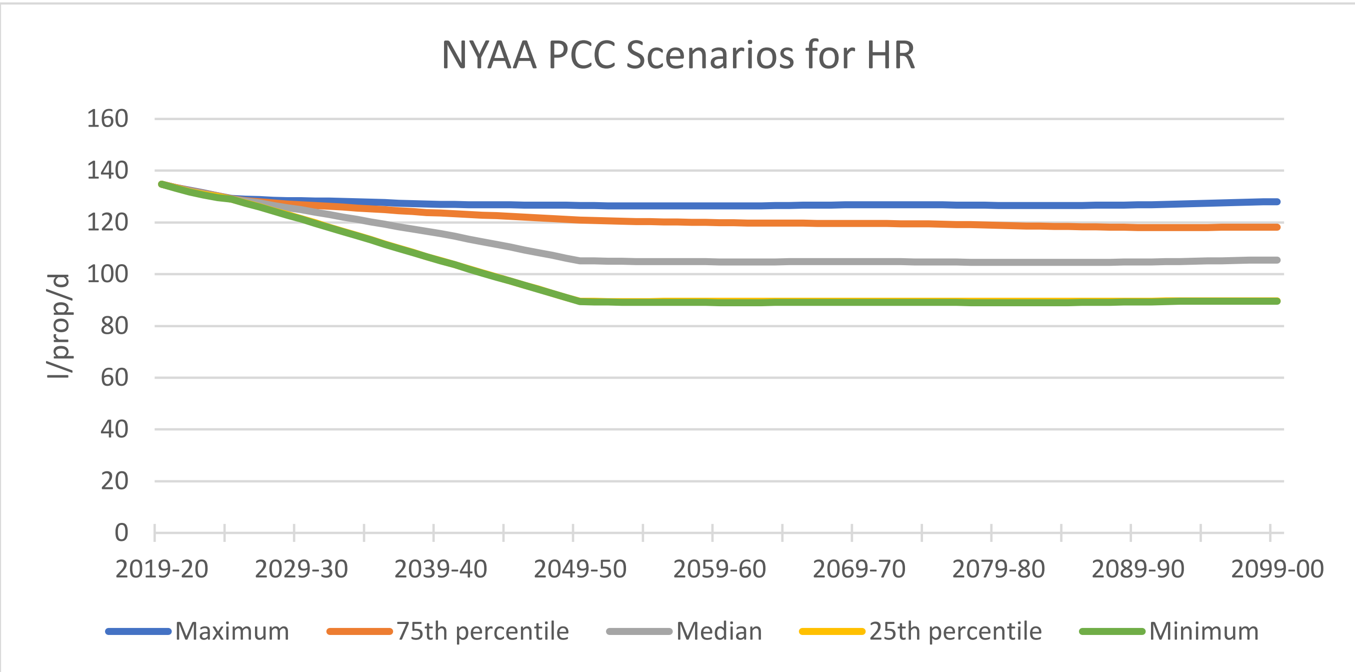


**Figure 38: Range of DYAA PCC results**

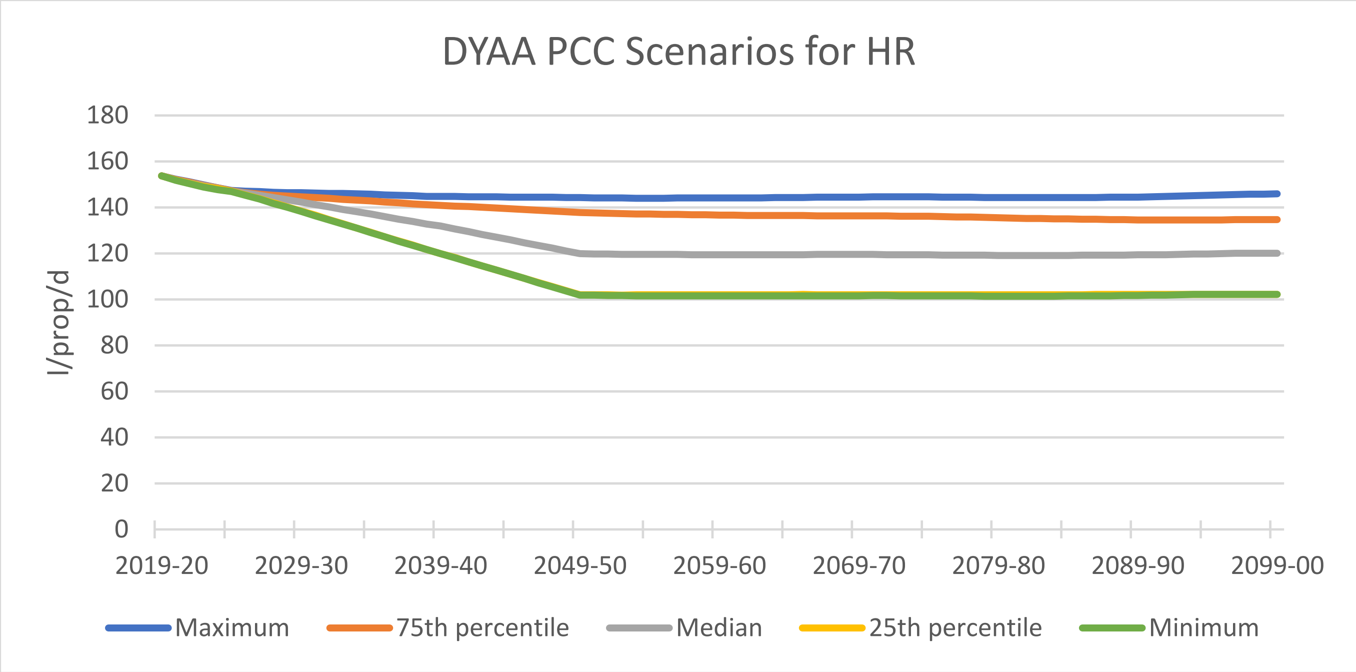



**Figure 39: Range of DYCP PCC results**

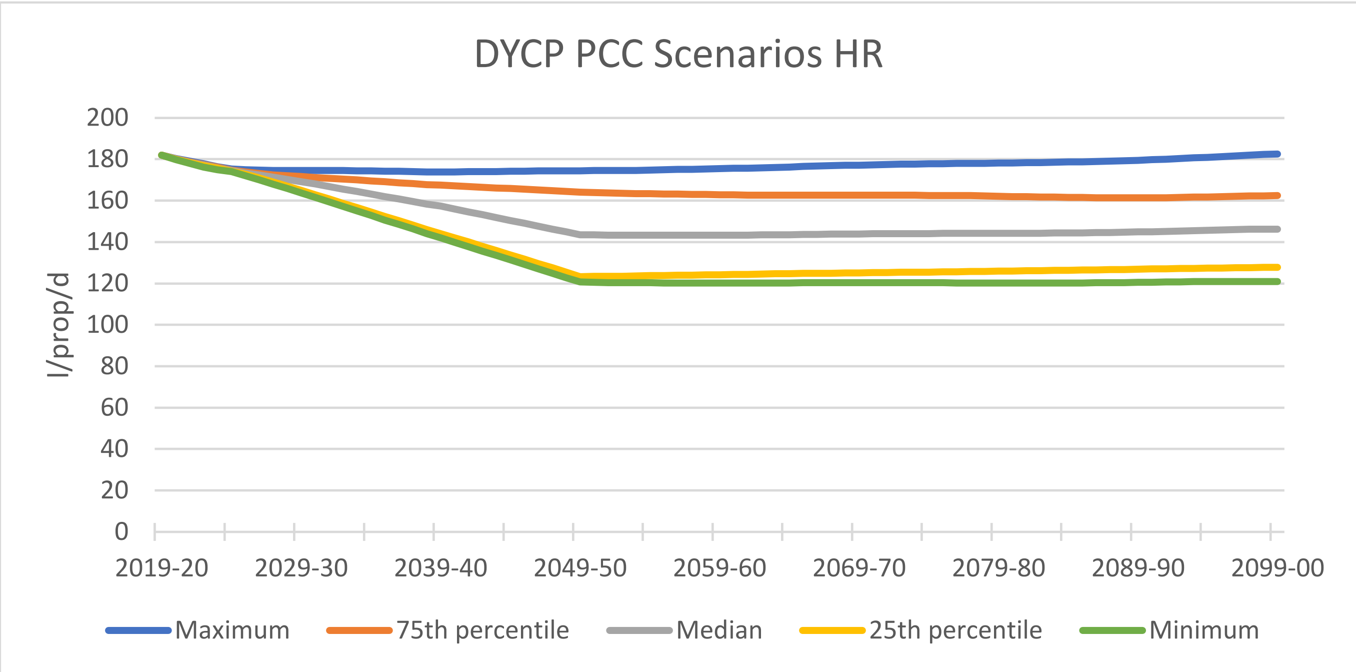
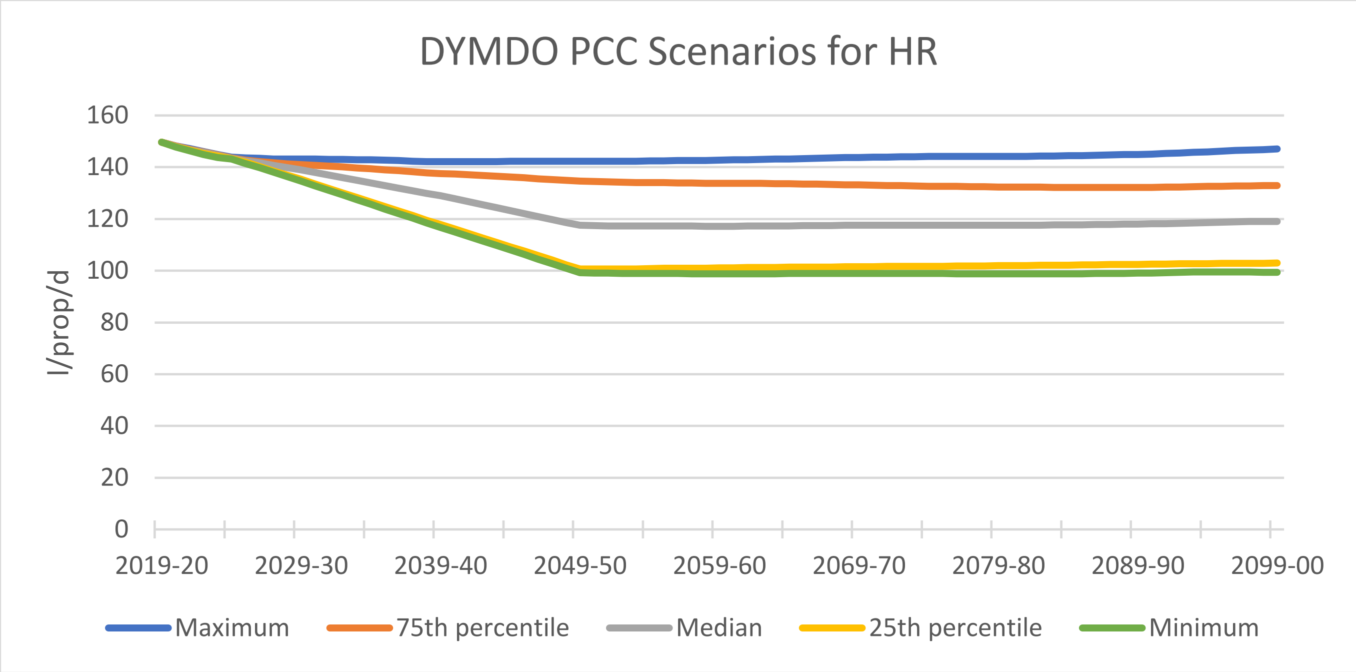


**Figure 40: Range of DYMDO PCC results**




## B.5. Hampshire Southampton East (HSE)

**Figure 41: Range of NYAA Distribution Input results**

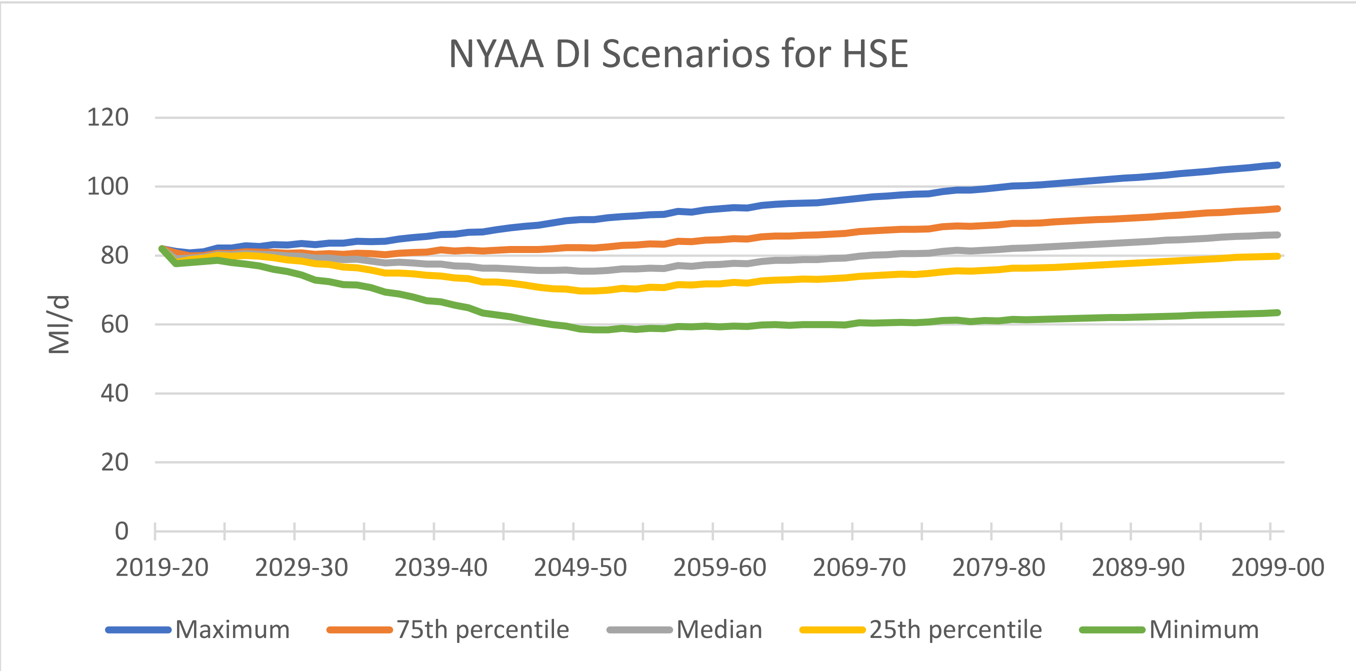


**Figure 42: Range of DYAA Distribution Input results**

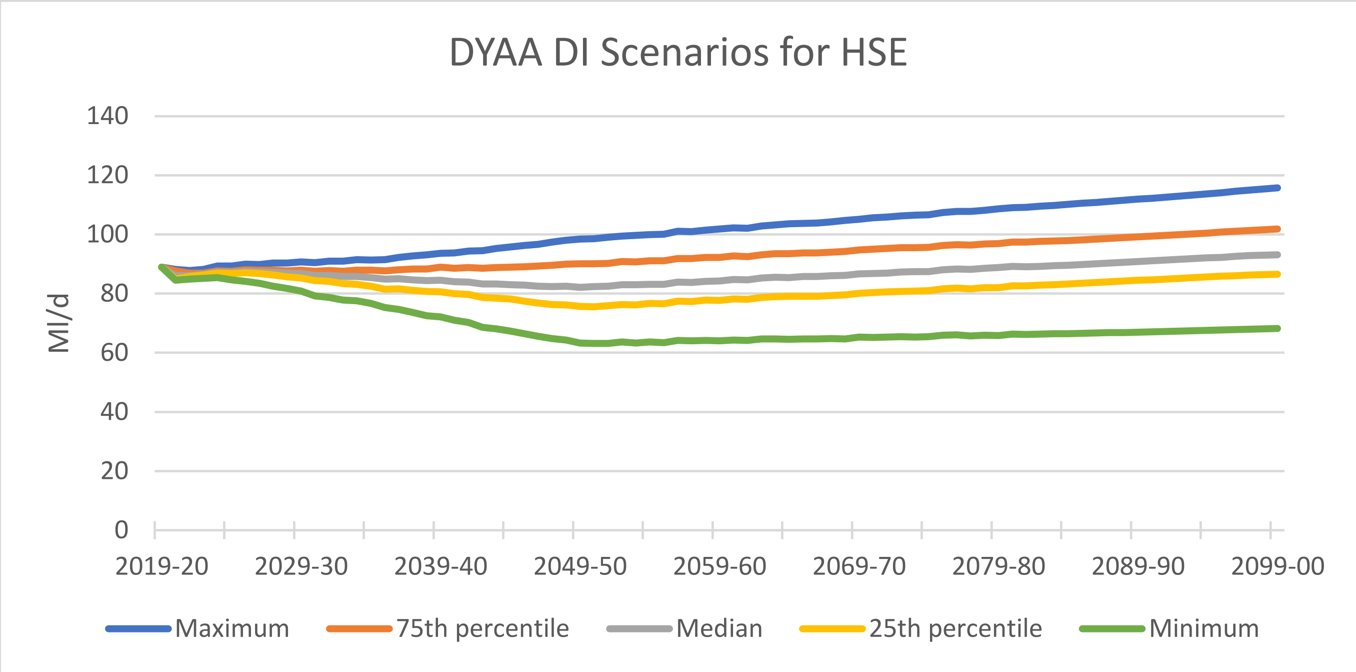



**Figure 43: Range of DYCP Distribution Input results**

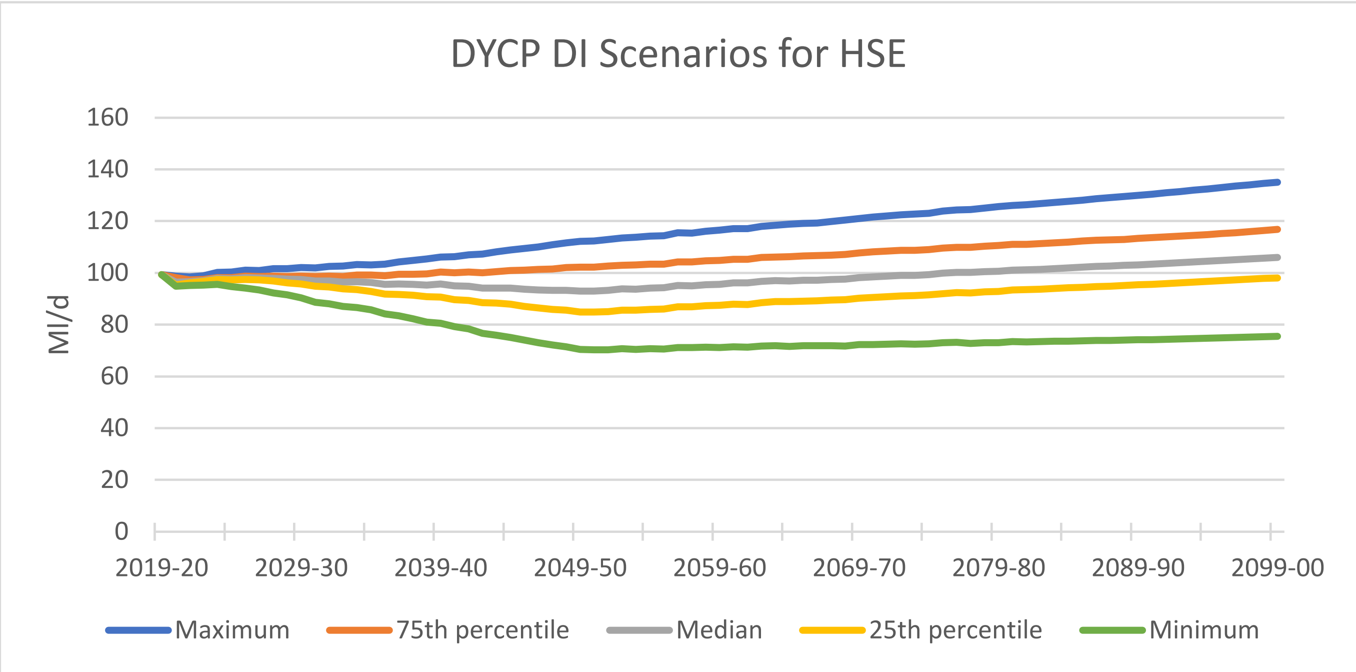


**Figure 44: Range of DYMDO Distribution Input results**

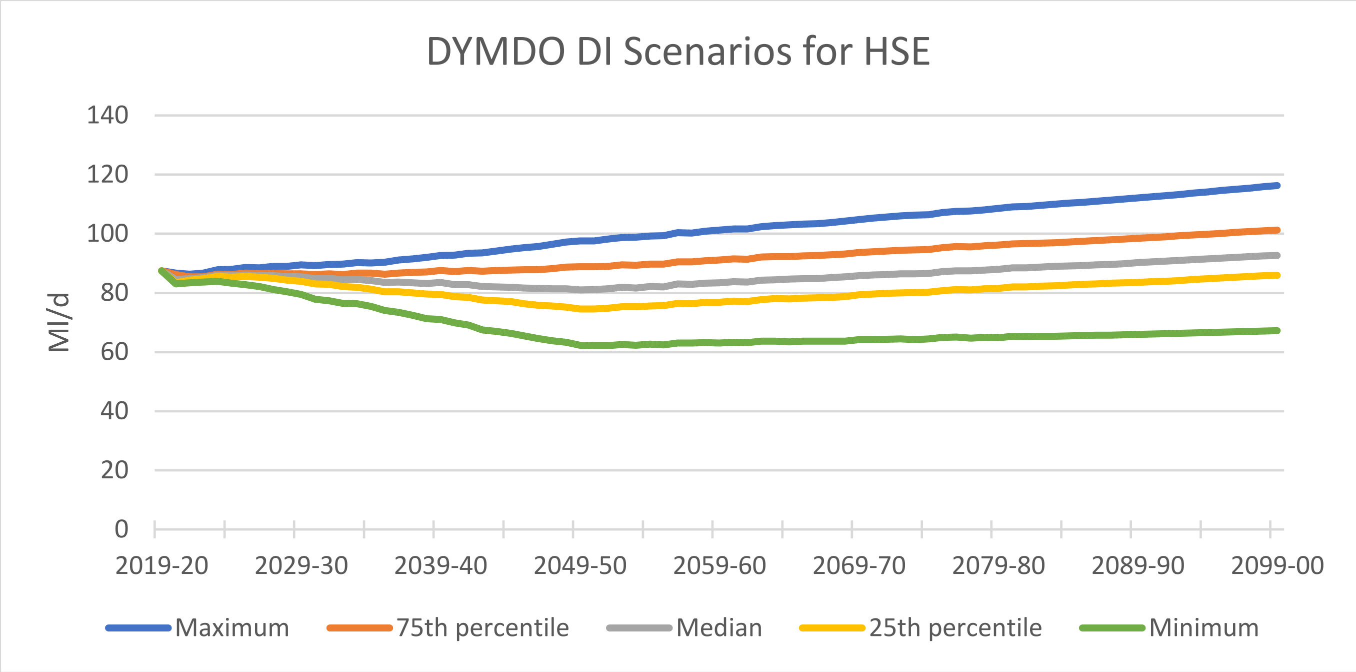



**Figure 45: Range of NYAA PCC results**

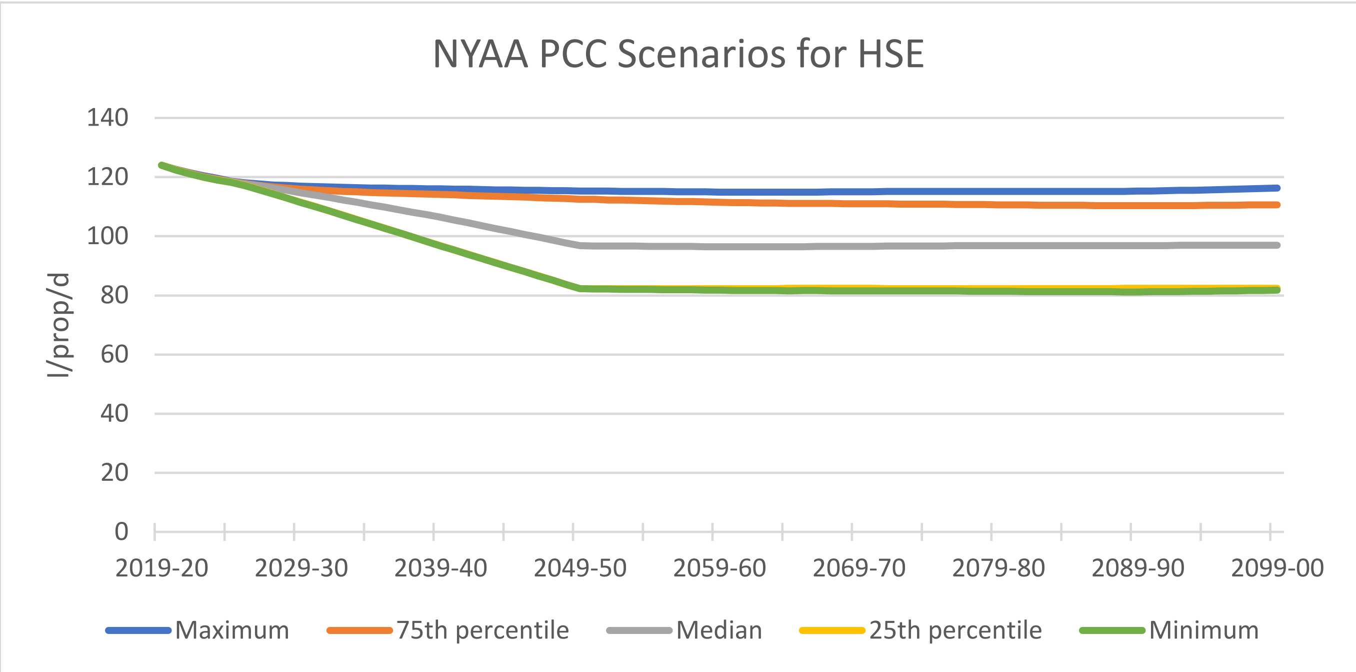


**Figure 46: Range of DYAA PCC results**

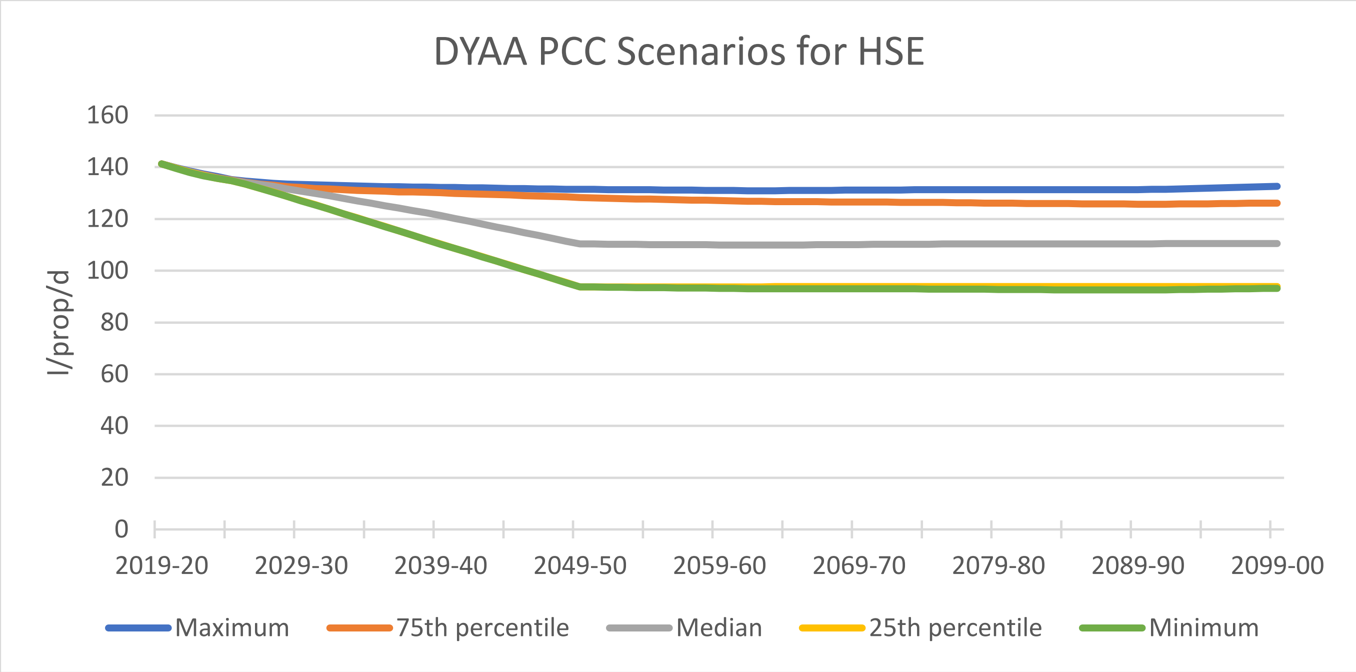



**Figure 47: Range of DYCP PCC results**

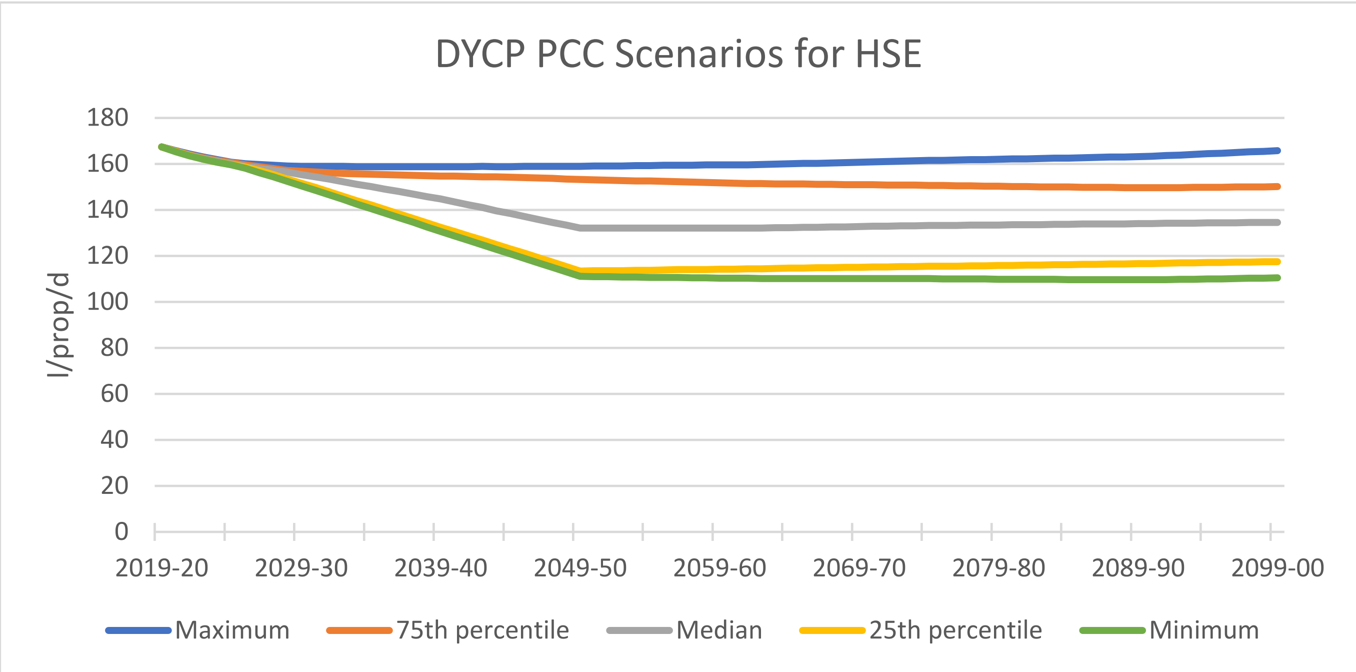
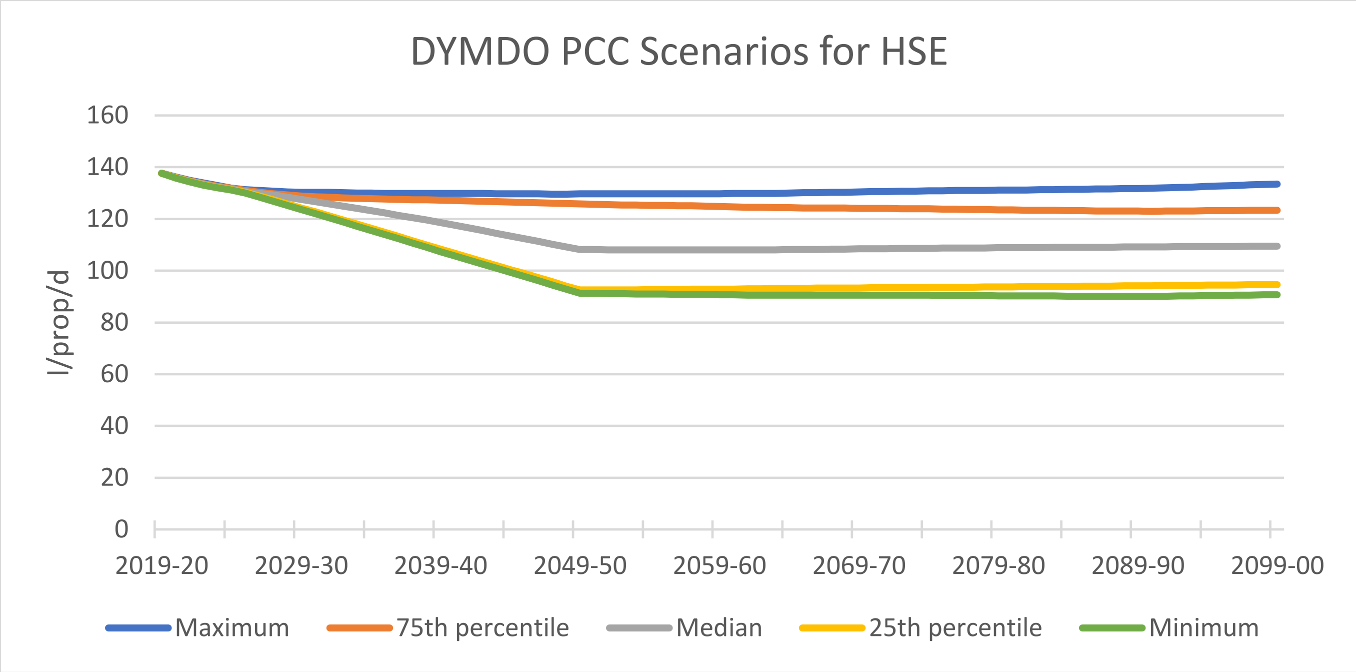


Figure 48: Range of DYMDO PCC results




## B.6. Hampshire Southampton West (HSW)

Figure 49: Range of NYAA Distribution Input results

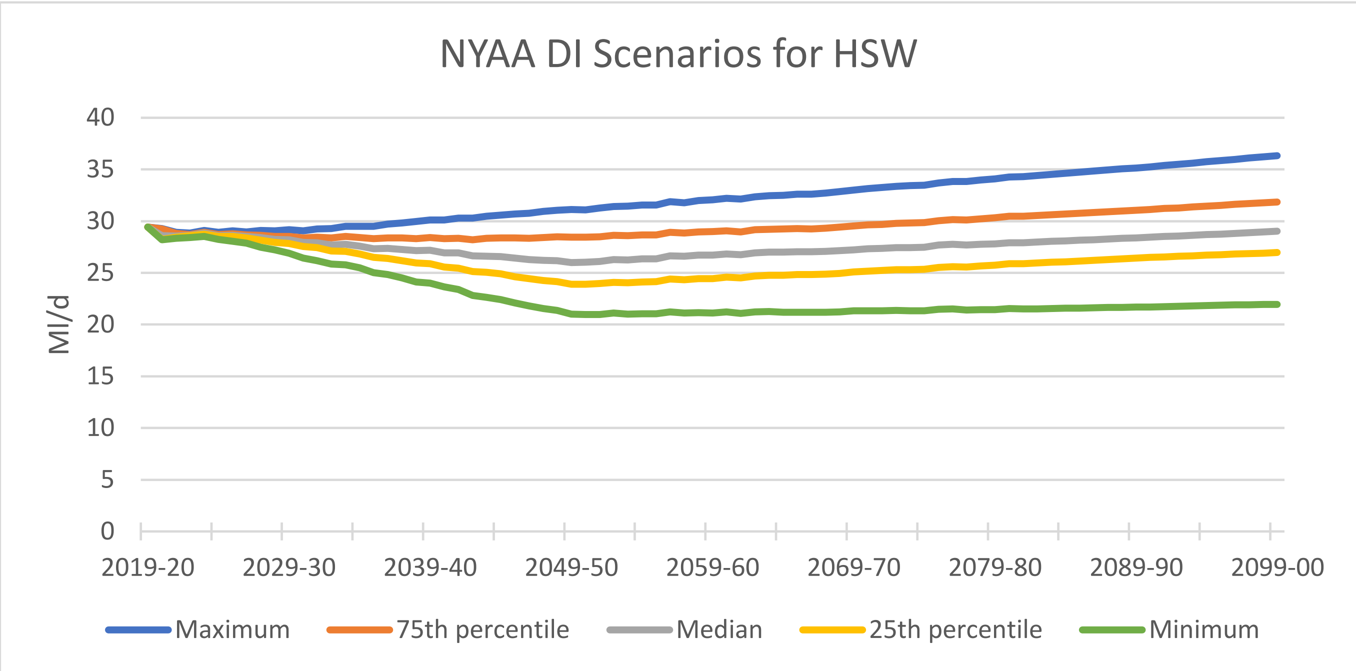


**Figure 50: Range of DYAA Distribution Input results**

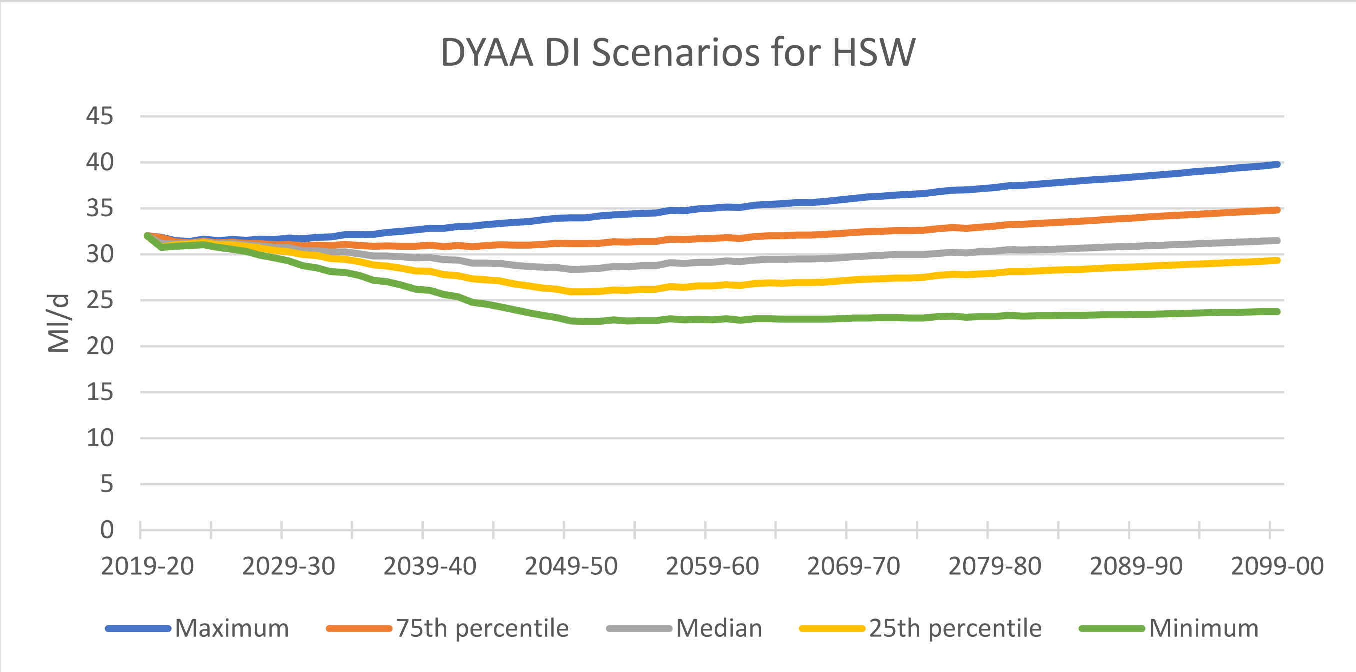



**Figure 51: Range of DYCP Distribution Input results**

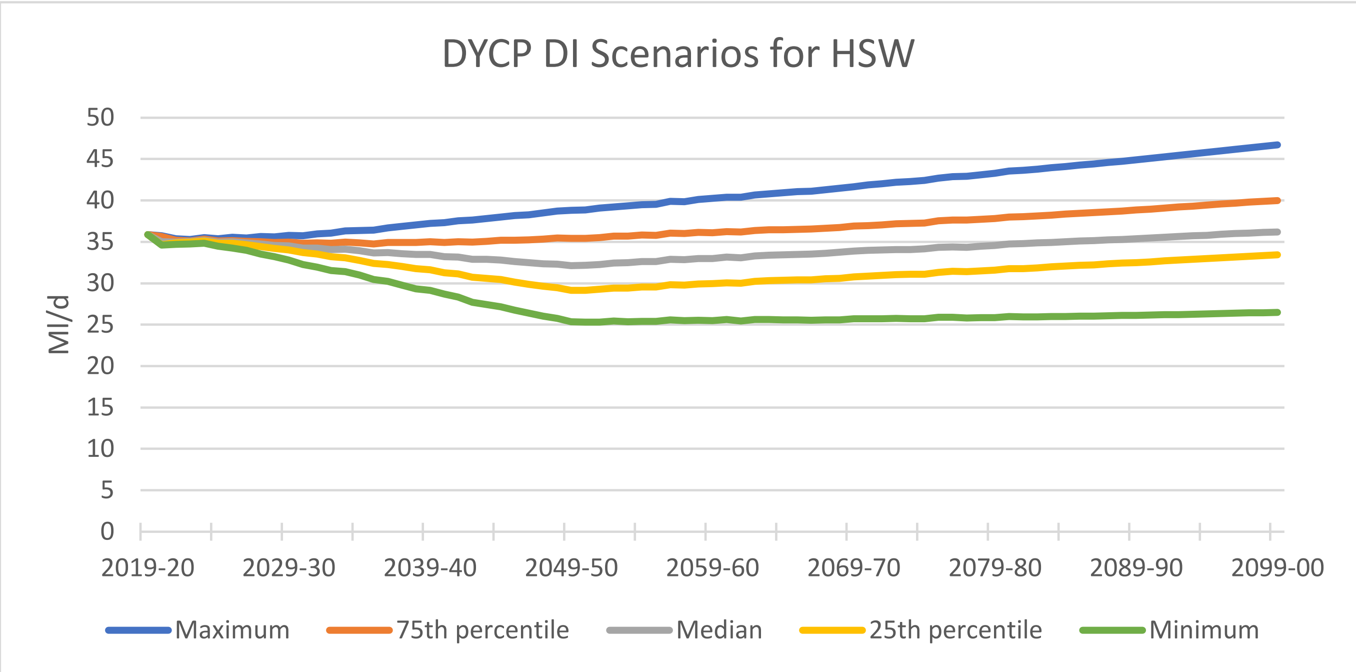


**Figure 52: Range of DYMDO Distribution Input results**

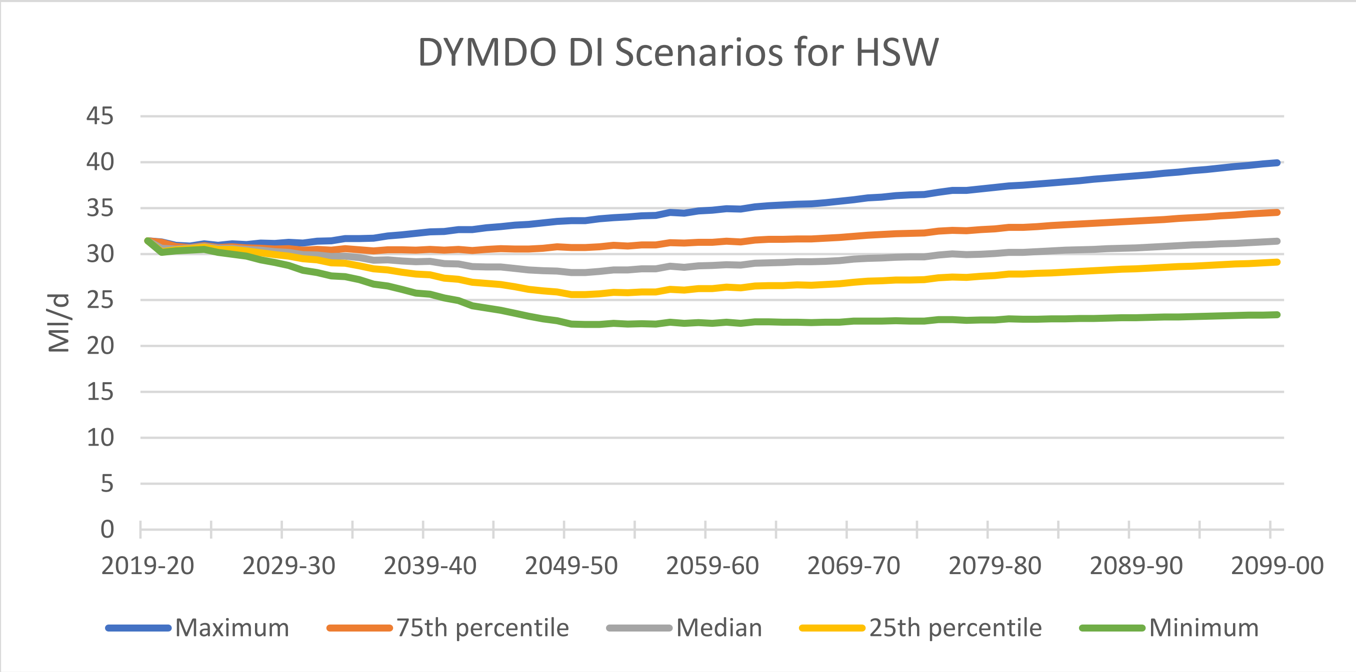



**Figure 53: Range of NYAA PCC results**

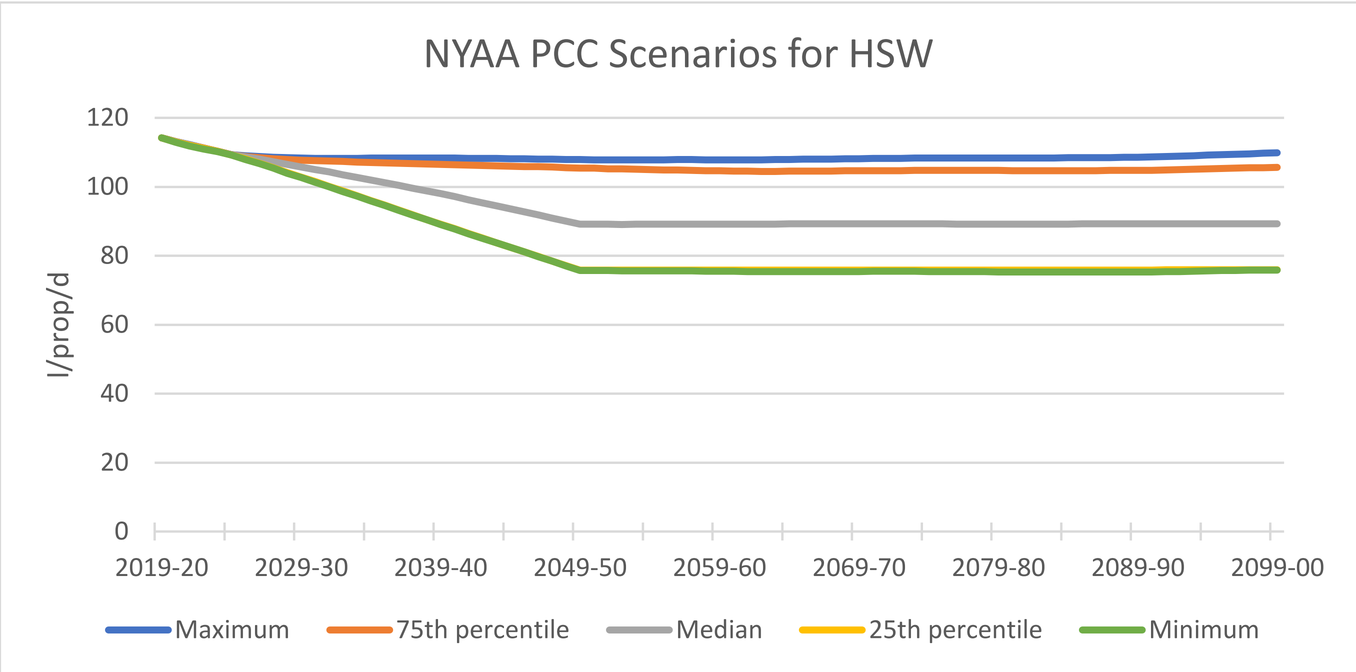


Figure 54: Range of DYAA PCC results

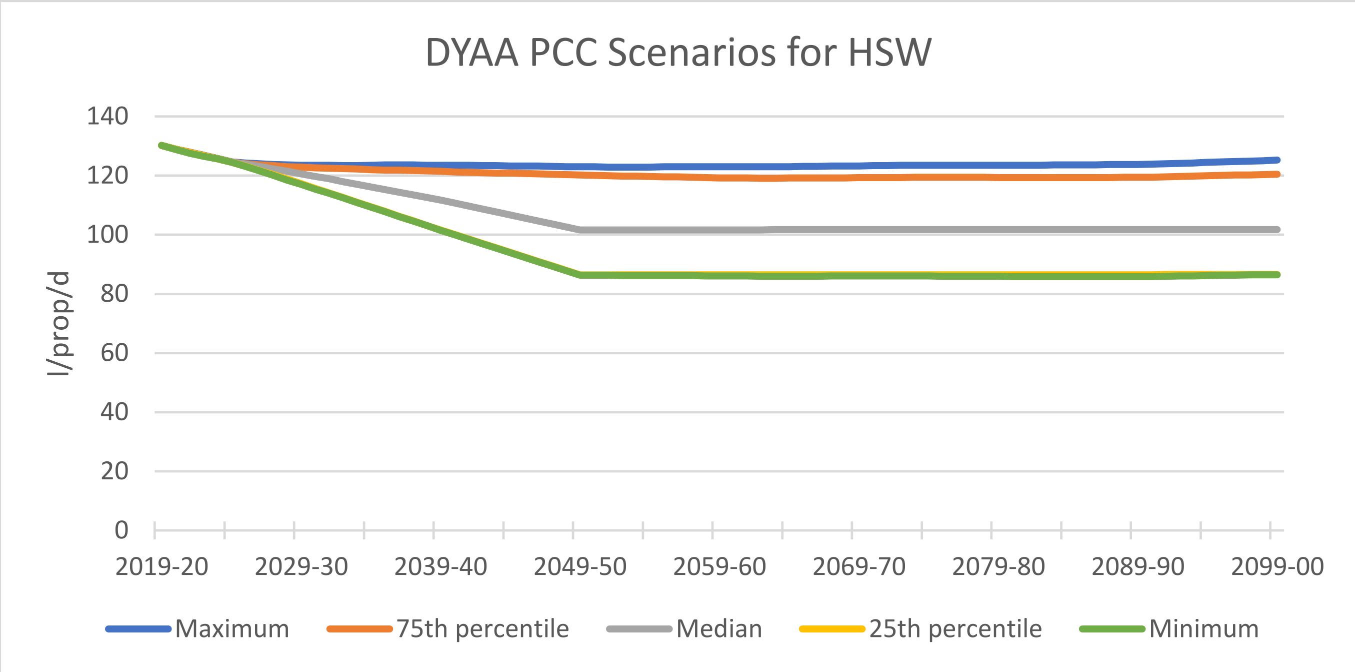



Figure 55: Range of DYCP PCC results

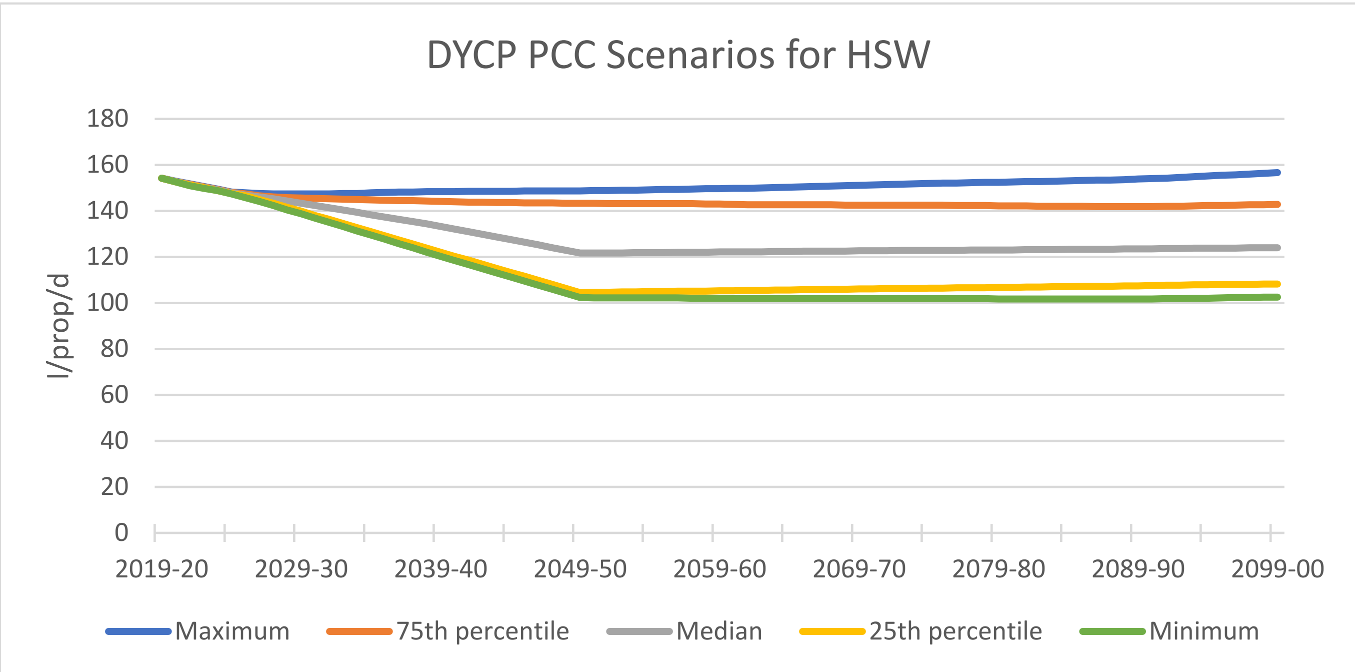
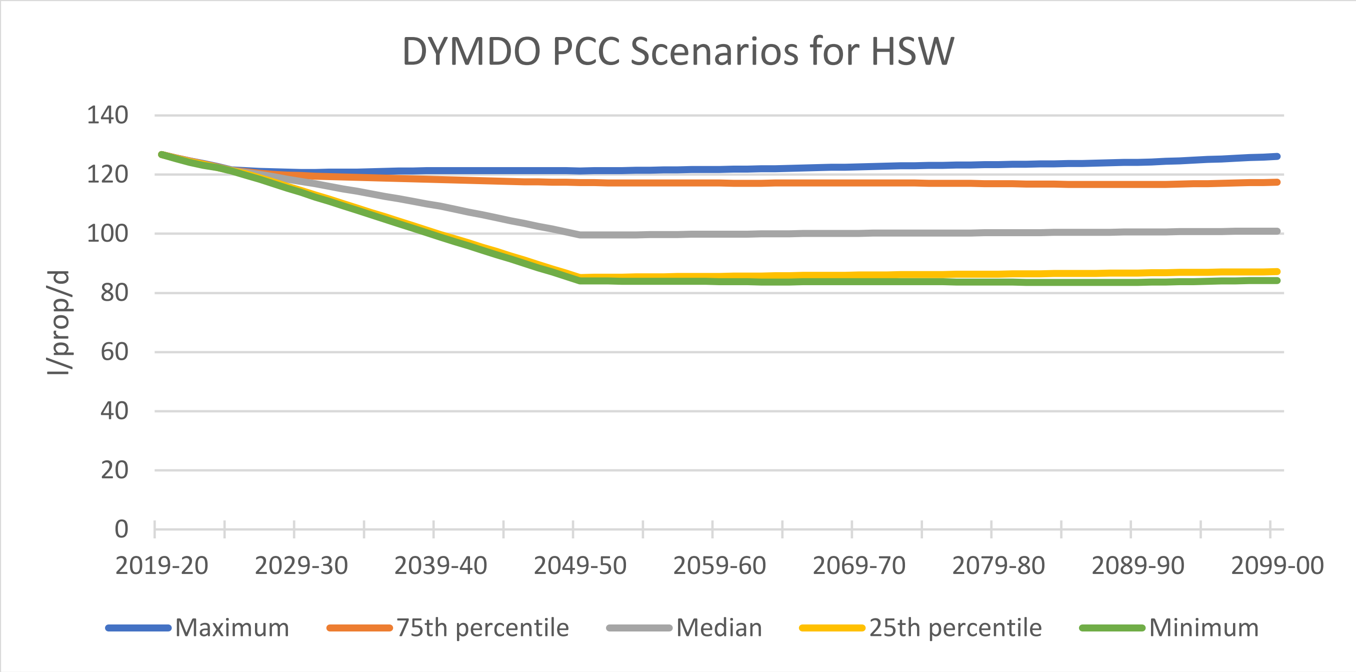


Figure 56: Range of DYMDO PCC results




## B.7. Isle of Wight (IOW)

Figure 57: Range of NYAA Distribution Input results

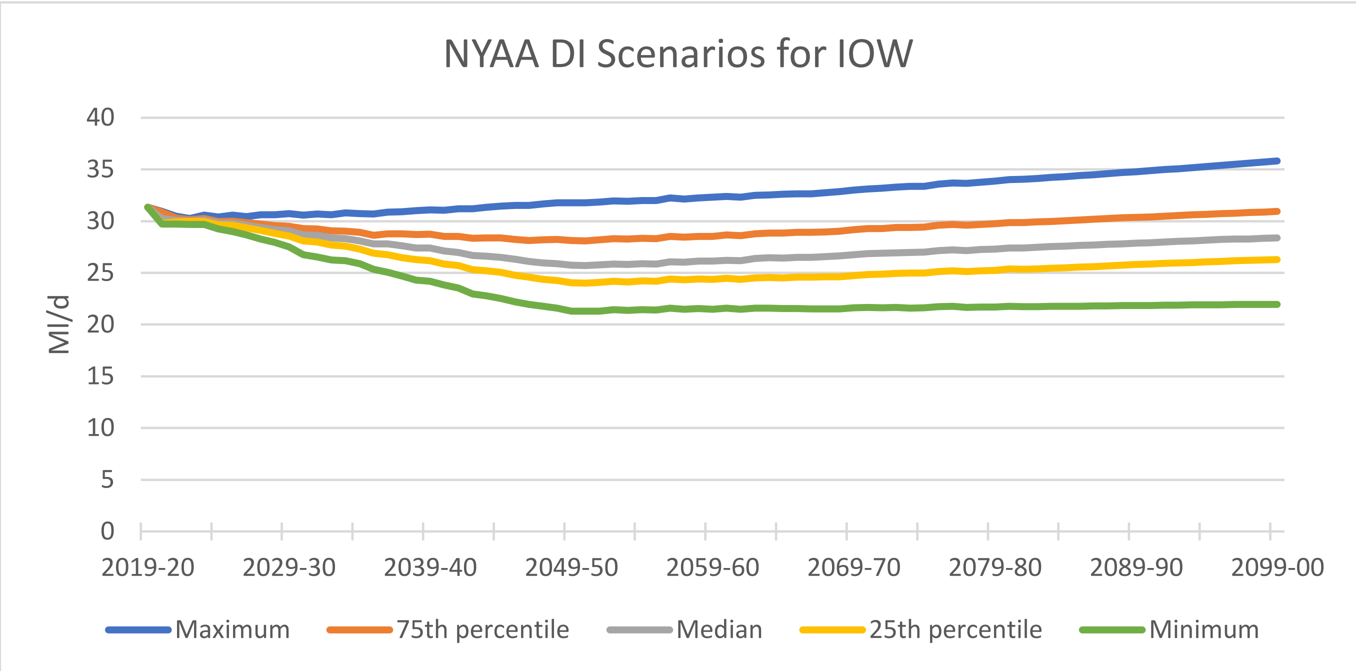


**Figure 58: Range of DYAA Distribution Input results**

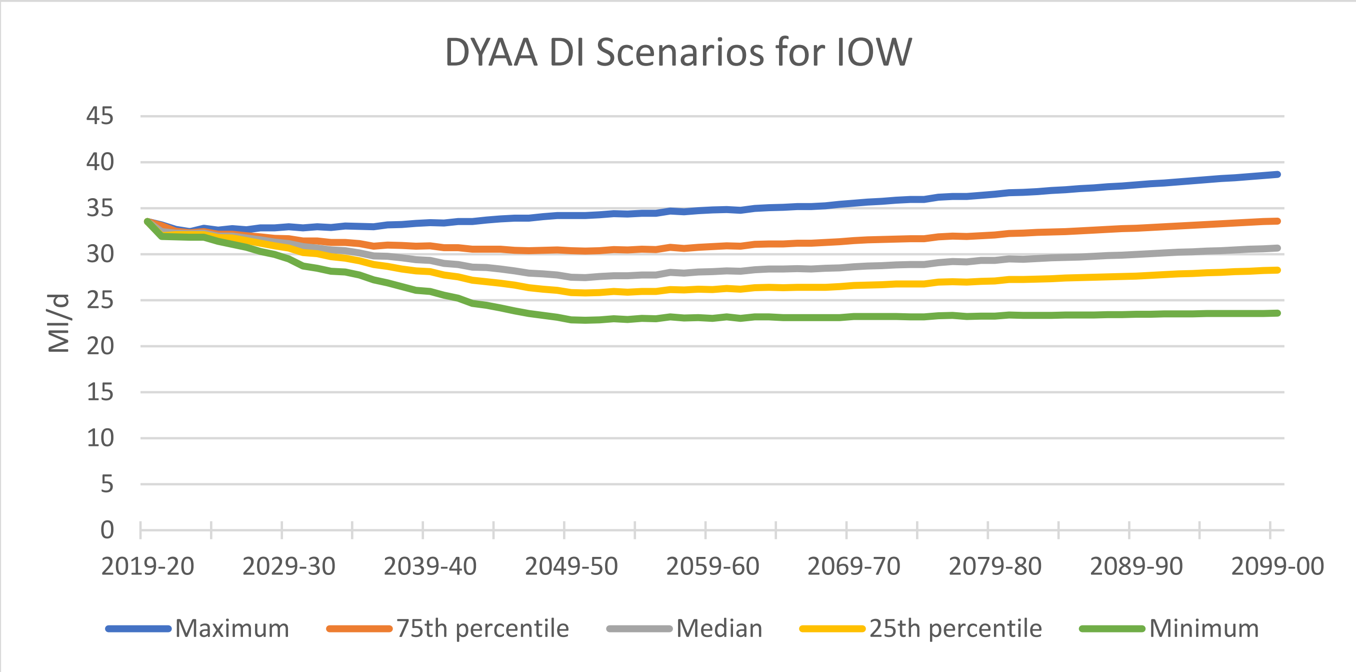



**Figure 59: Range of DYCP Distribution Input results**

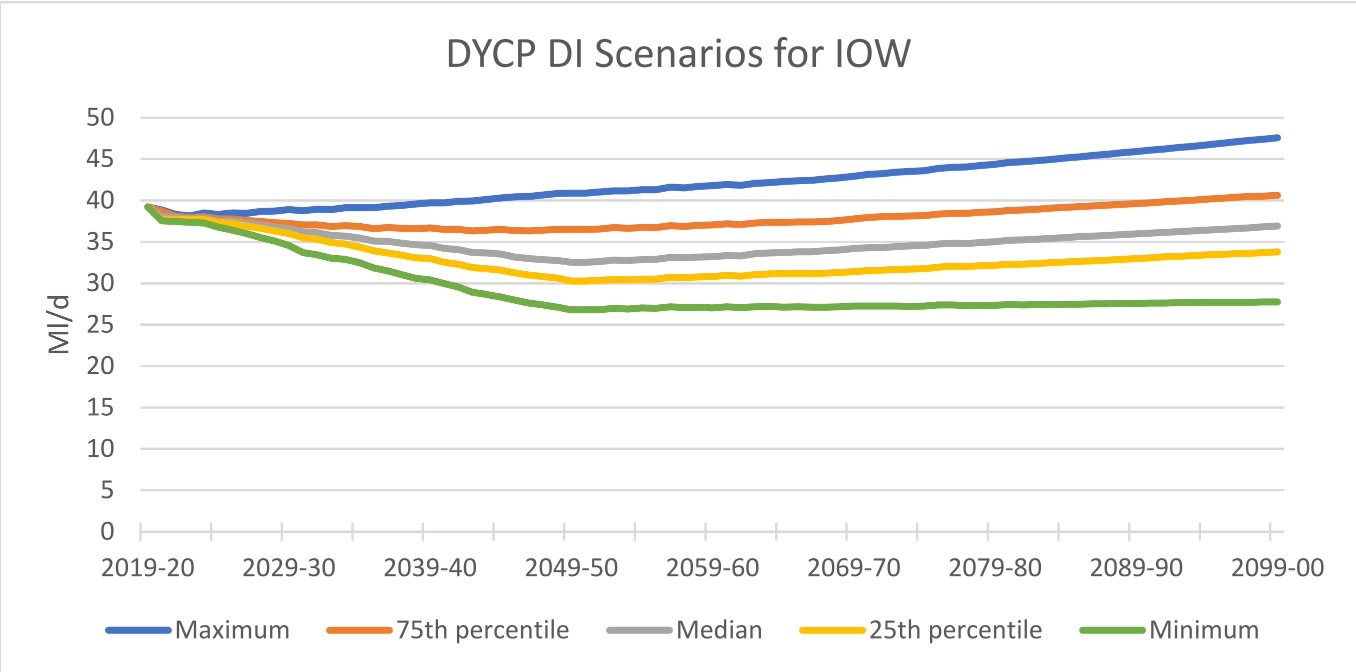


**Figure 60: Range of DYMDO Distribution Input results**

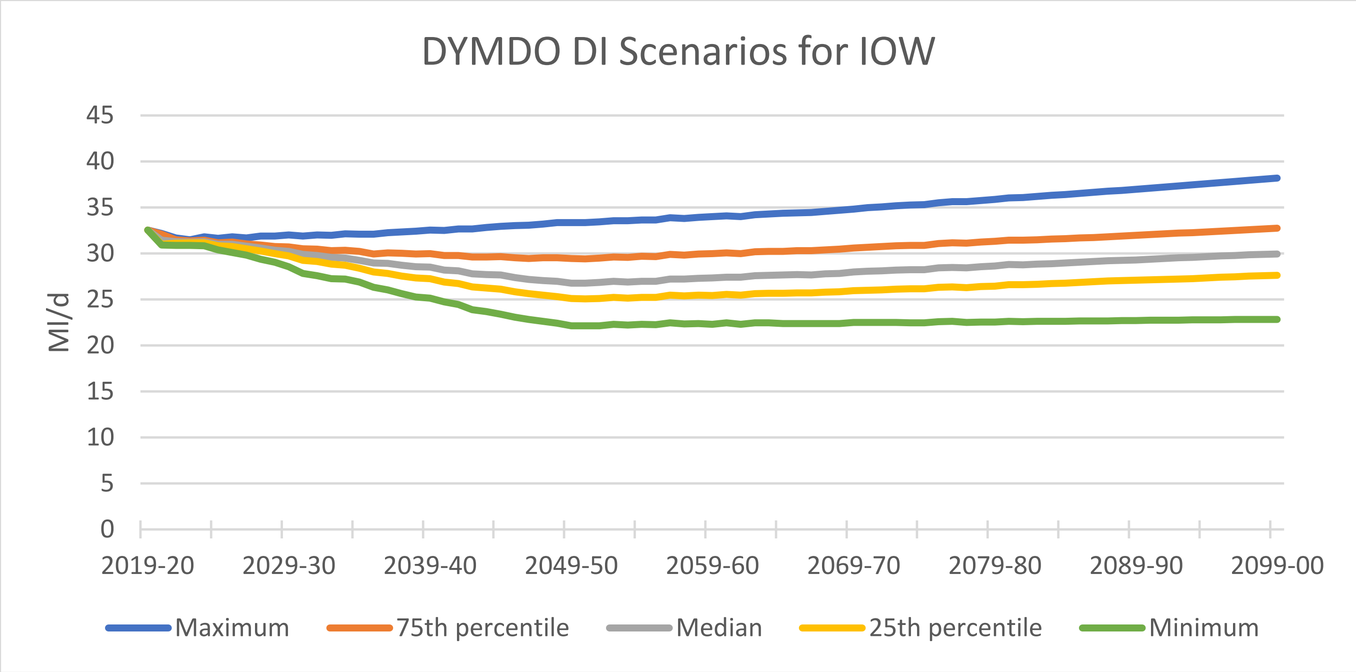



**Figure 61: Range of NYAA PCC results**

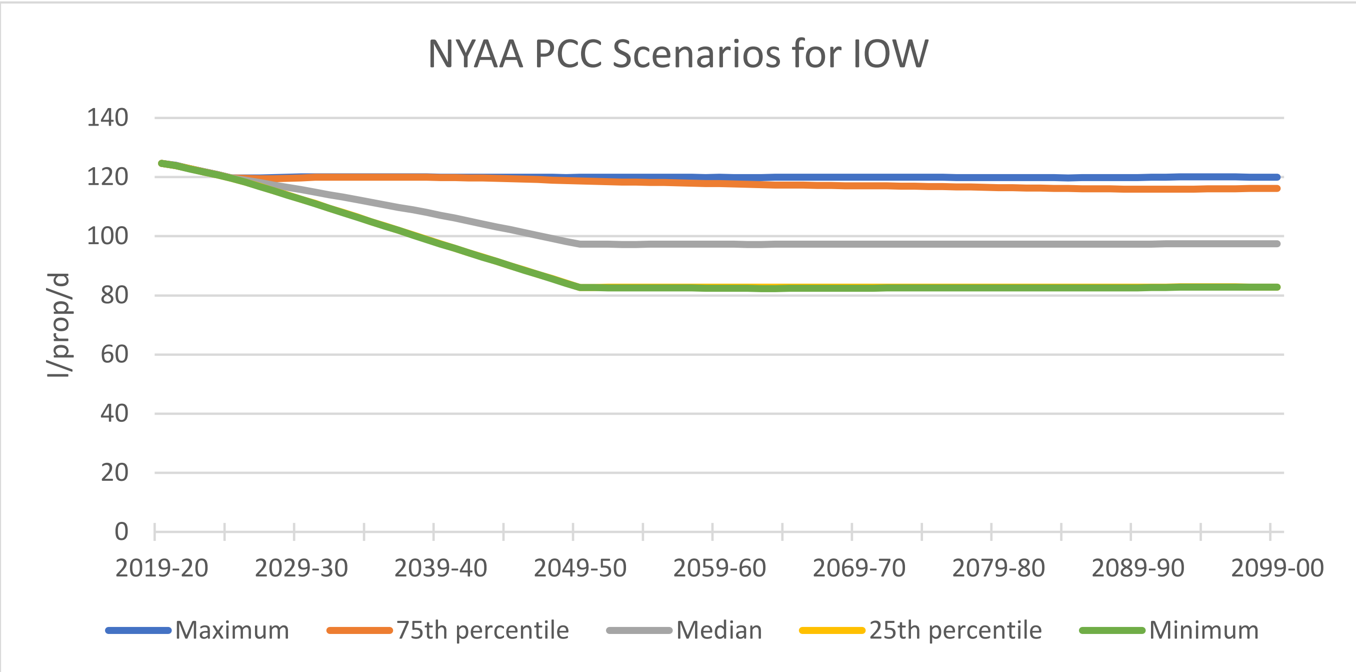


**Figure 62: Range of DYAA PCC results**

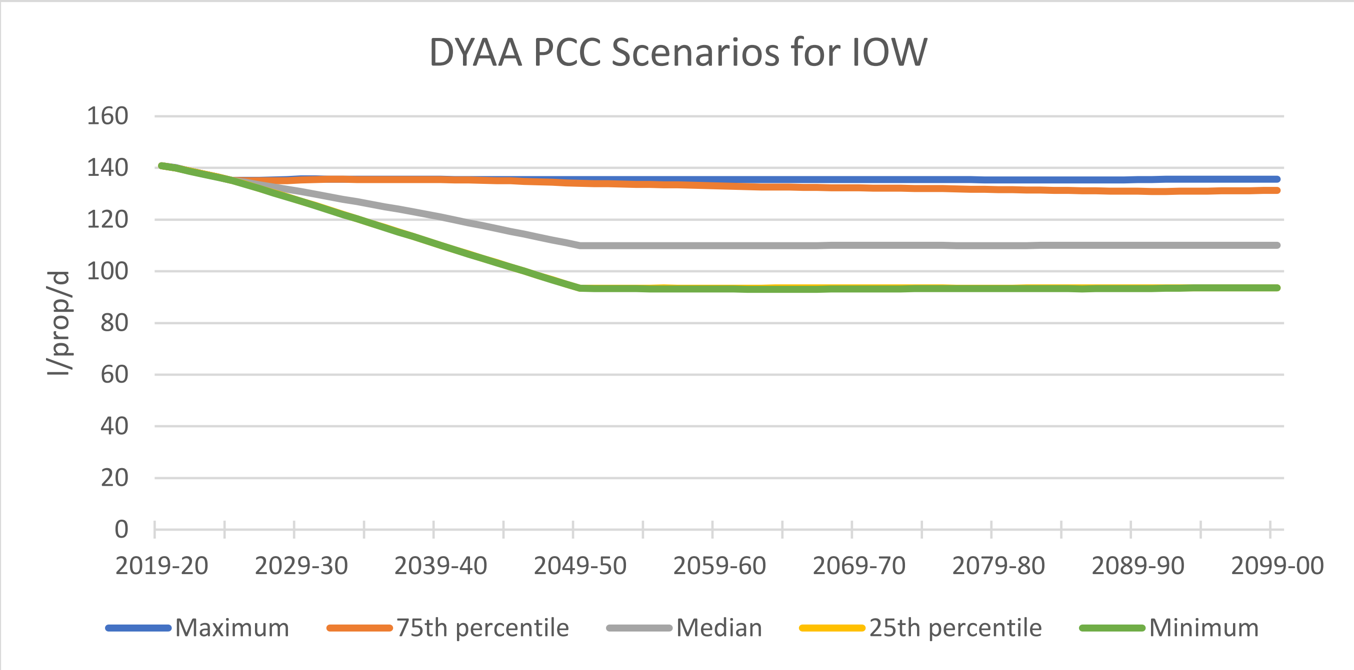



**Figure 63: Range of DYCP PCC results**

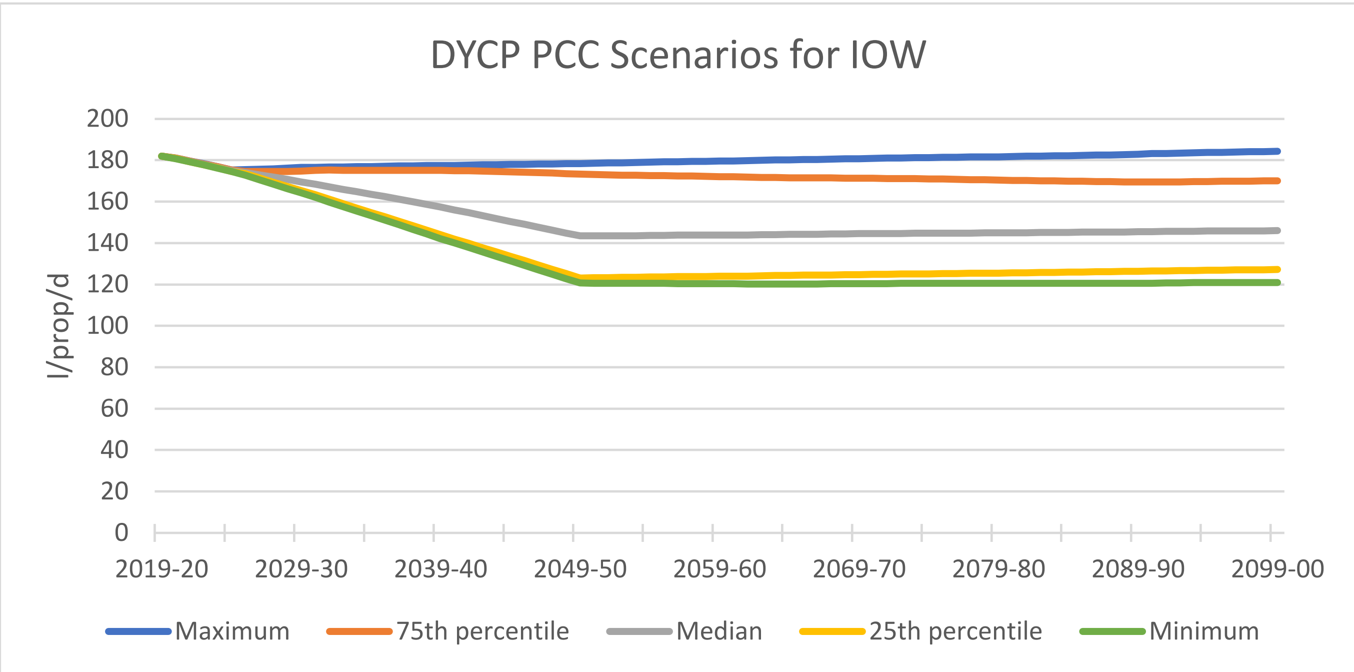
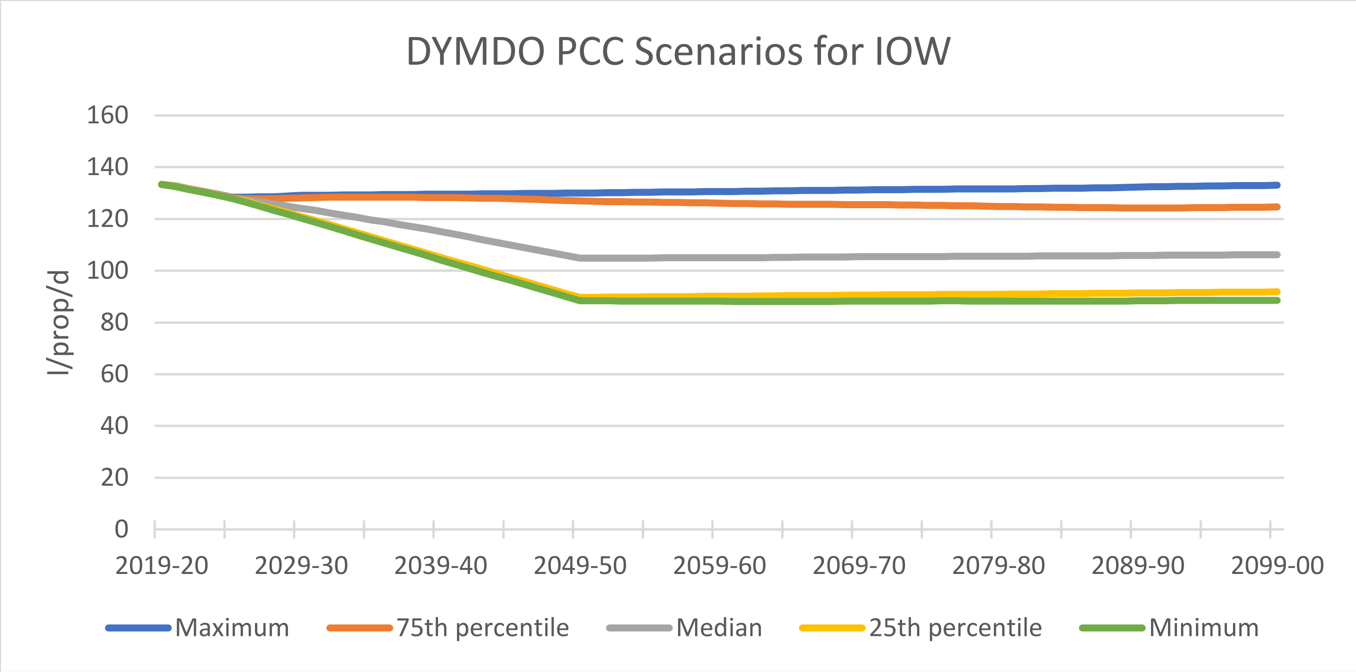


**Figure 64: Range of DYMDO PCC results**




## B.8. Sussex North (SN)

**Figure 65: Range of NYAA Distribution Input results**

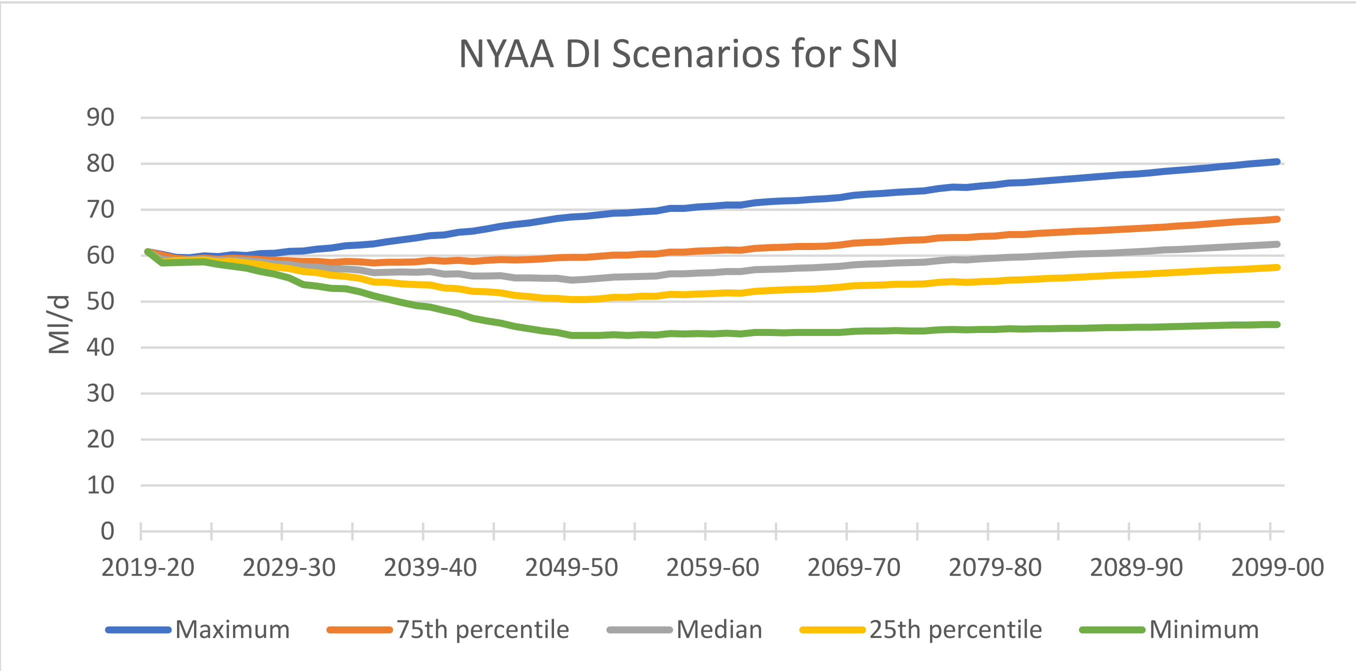


**Figure 66: Range of DYAA Distribution Input results**

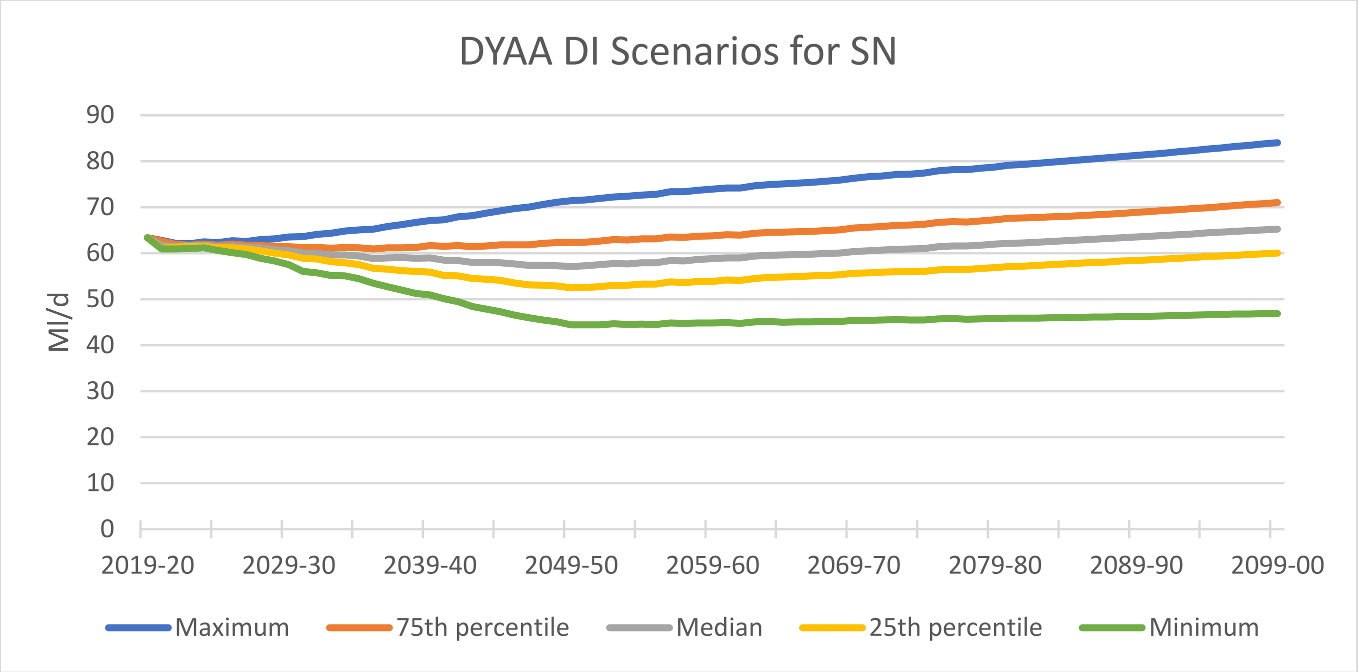



**Figure 67: Range of DYCP Distribution Input results**

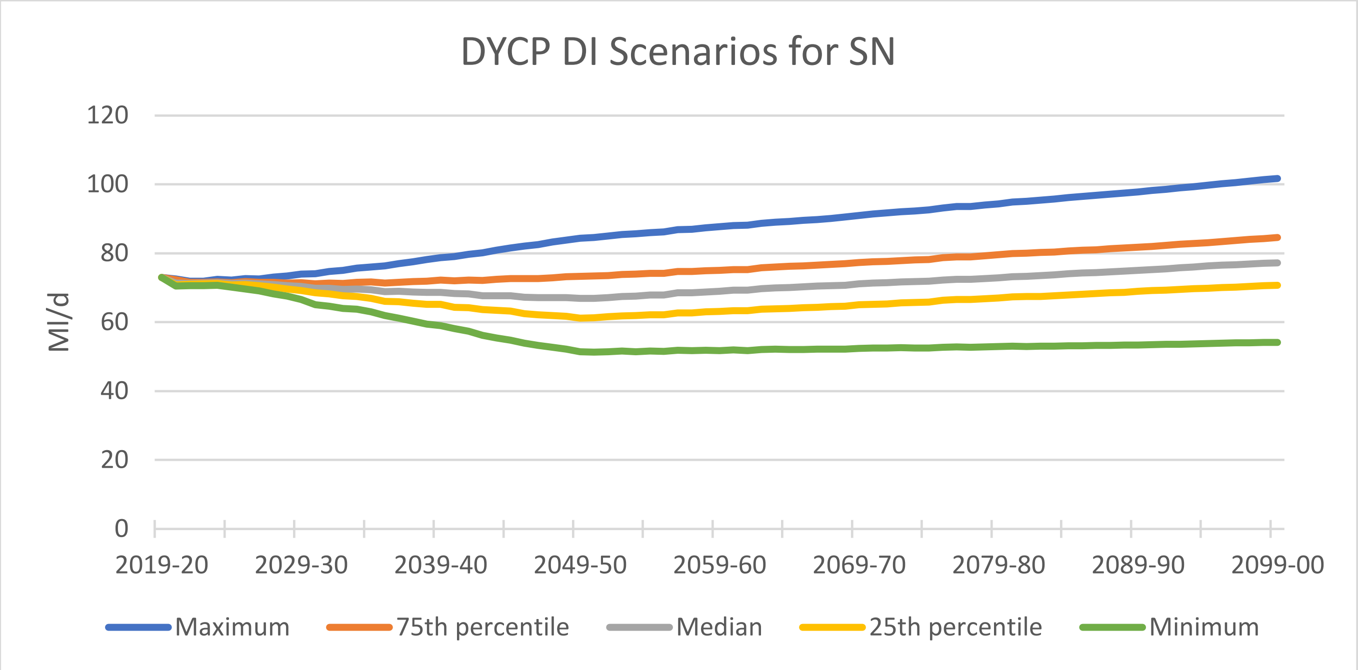


Figure 68: Range of DYMDO Distribution Input results

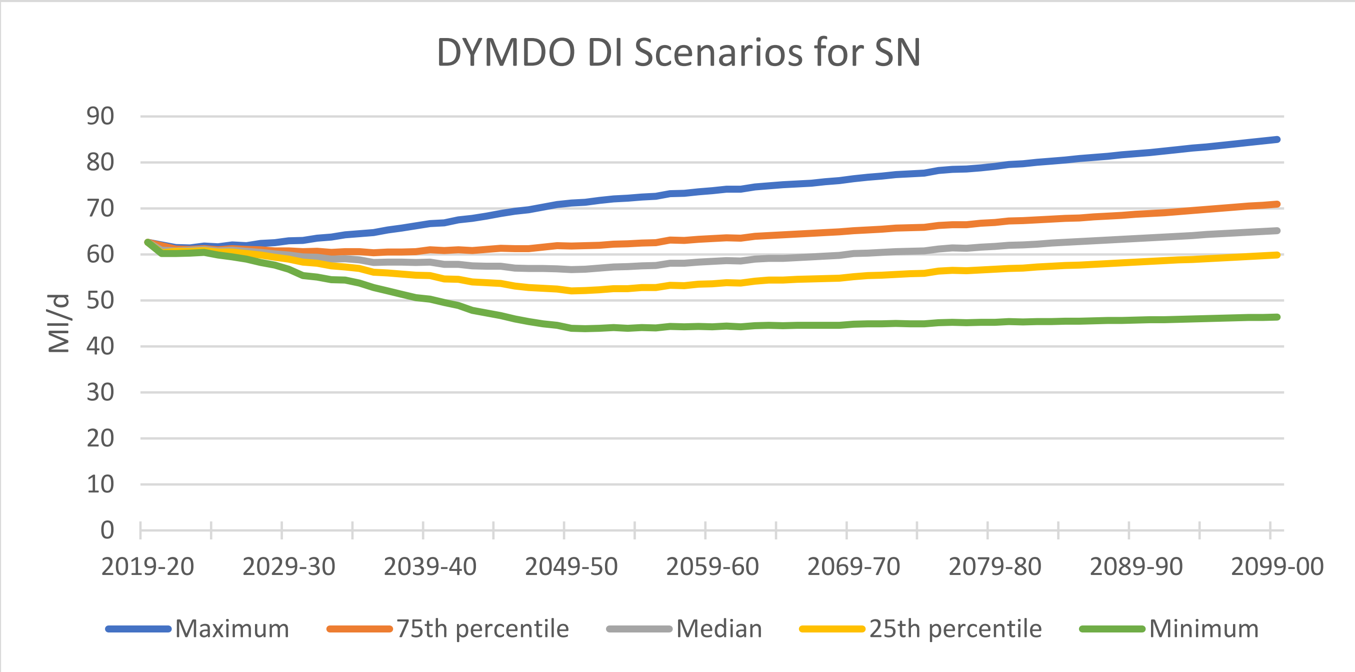



Figure 69: Range of NYAA PCC results

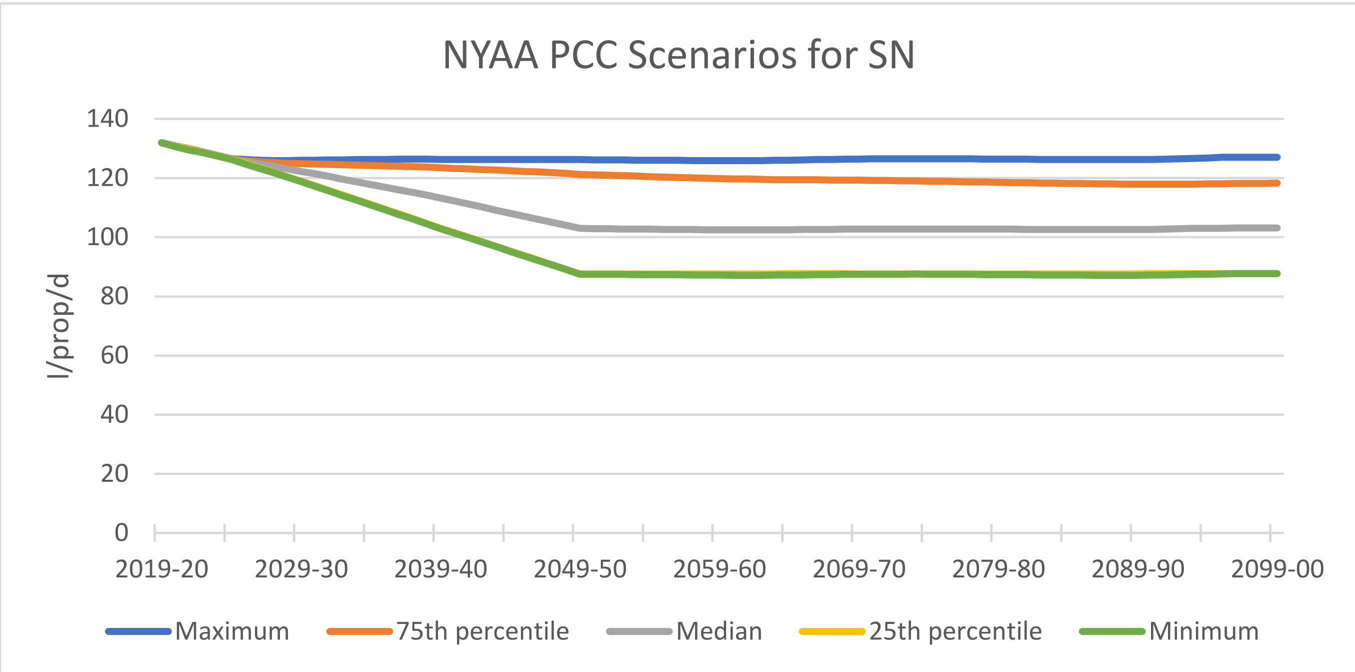


**Figure 70: Range of DYAA PCC results**

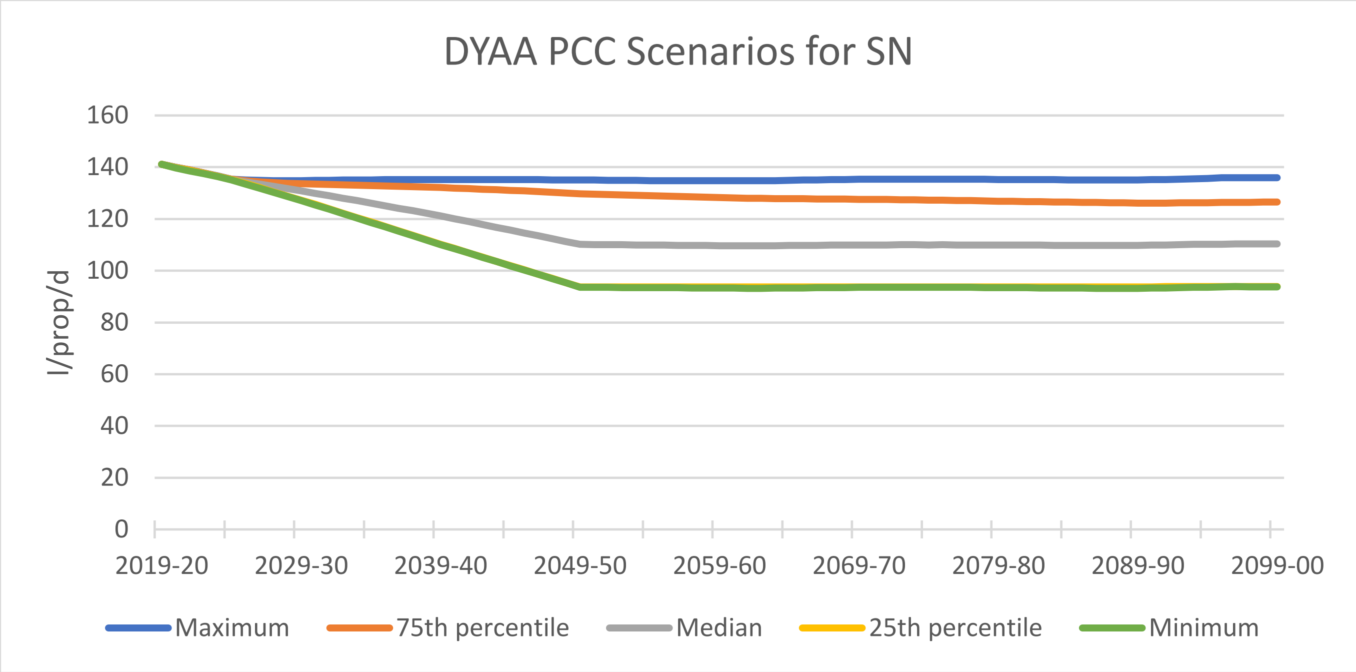



**Figure 71: Range of DYCP PCC results**

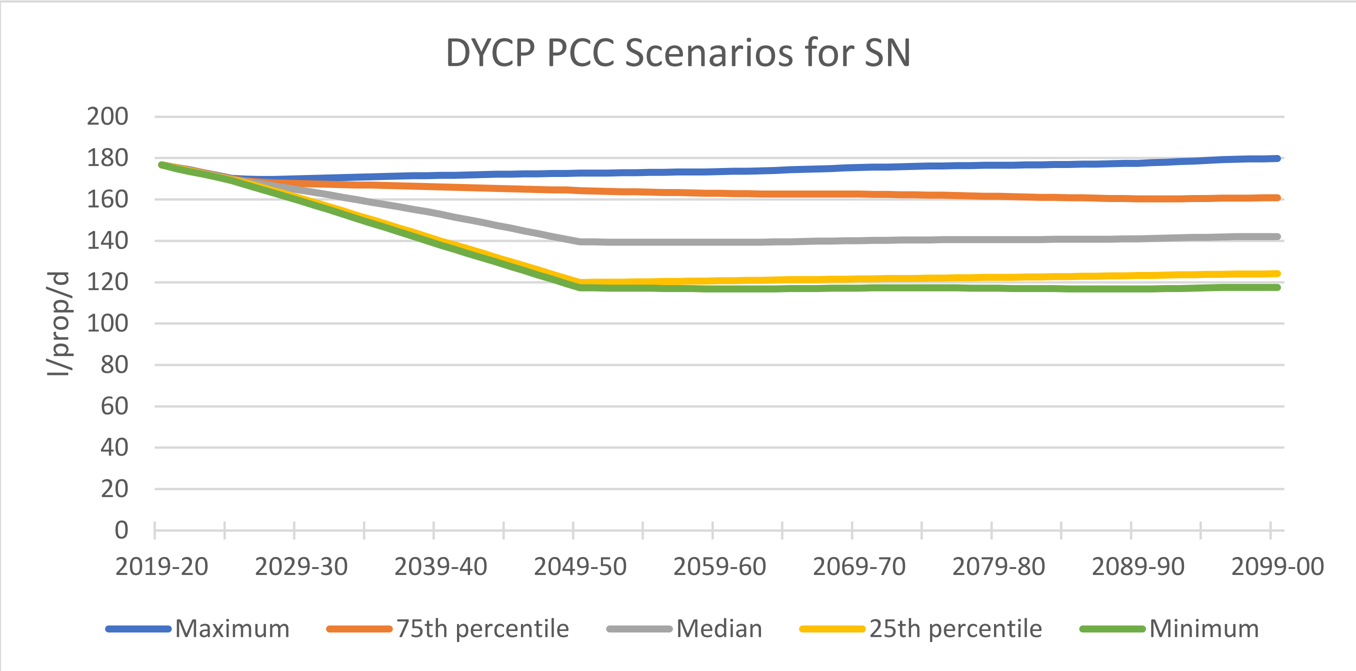
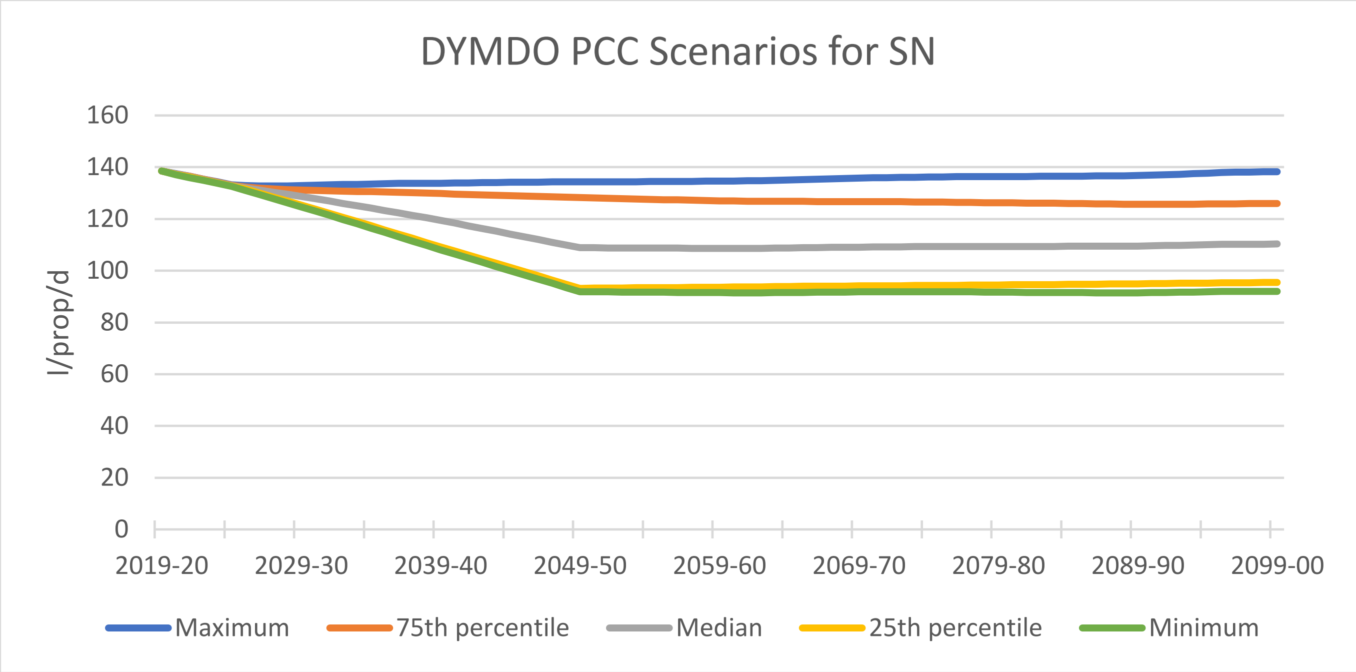


**Figure 72: Range of DYMDO PCC results**




## B.9. Sussex Worthing (SW)

**Figure 73: Range of NYAA Distribution Input results**

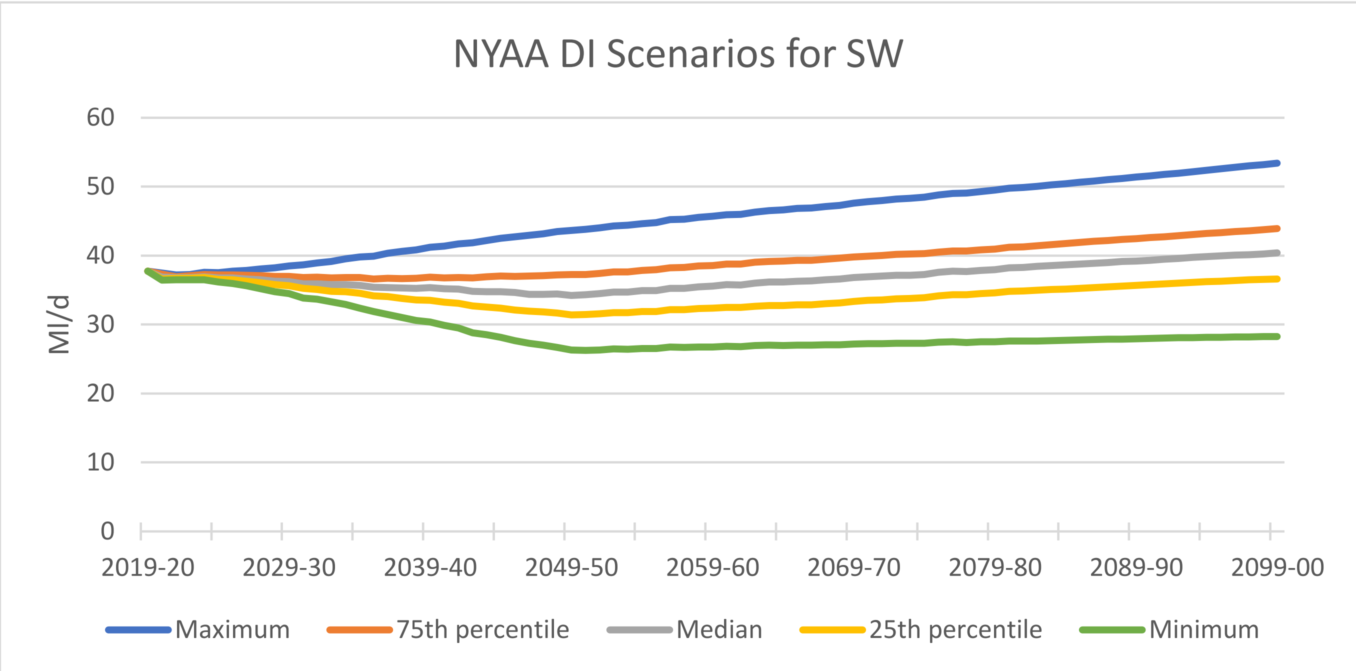


**Figure 74: Range of DYAA Distribution Input results**

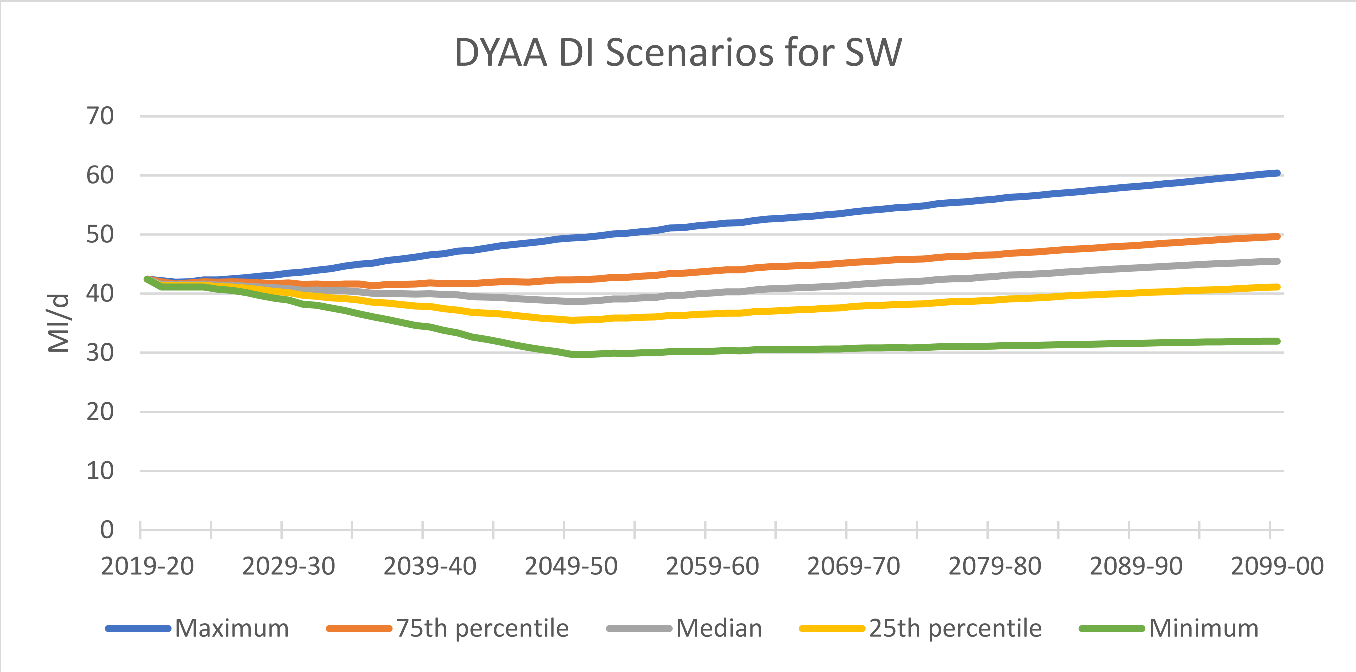



**Figure 75: Range of DYCP Distribution Input results**

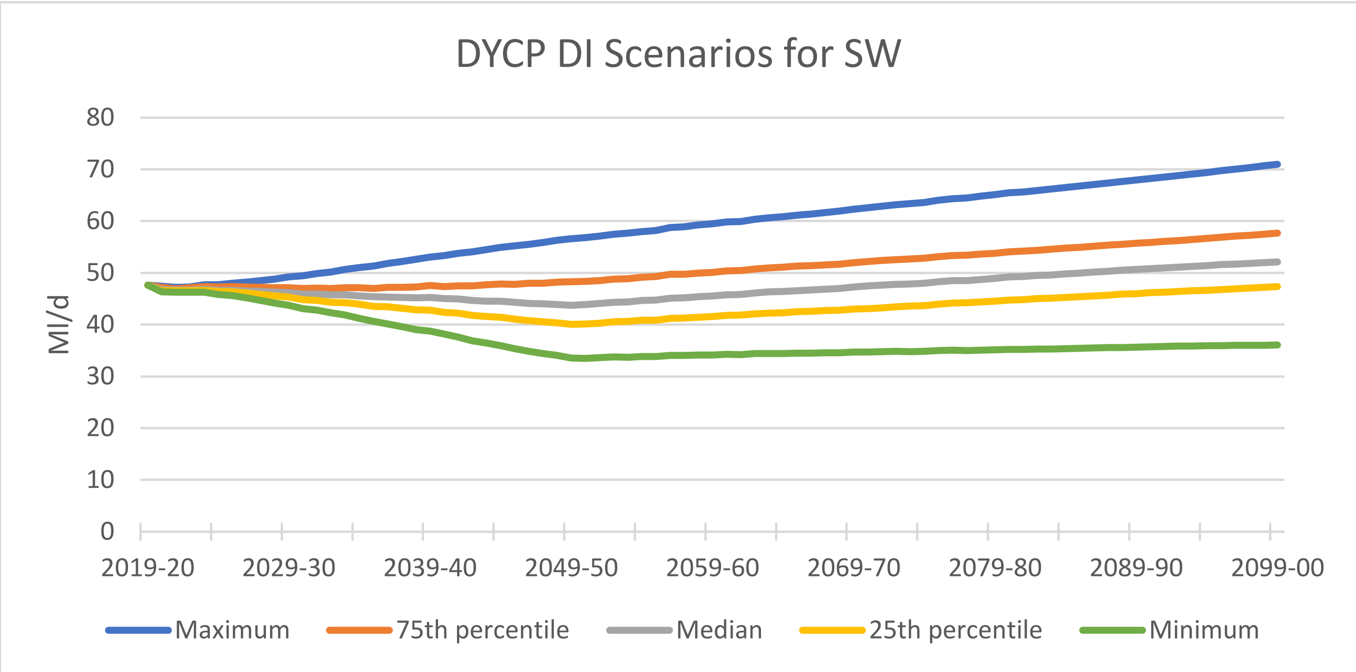


**Figure 76: Range of DYMDO Distribution Input results**

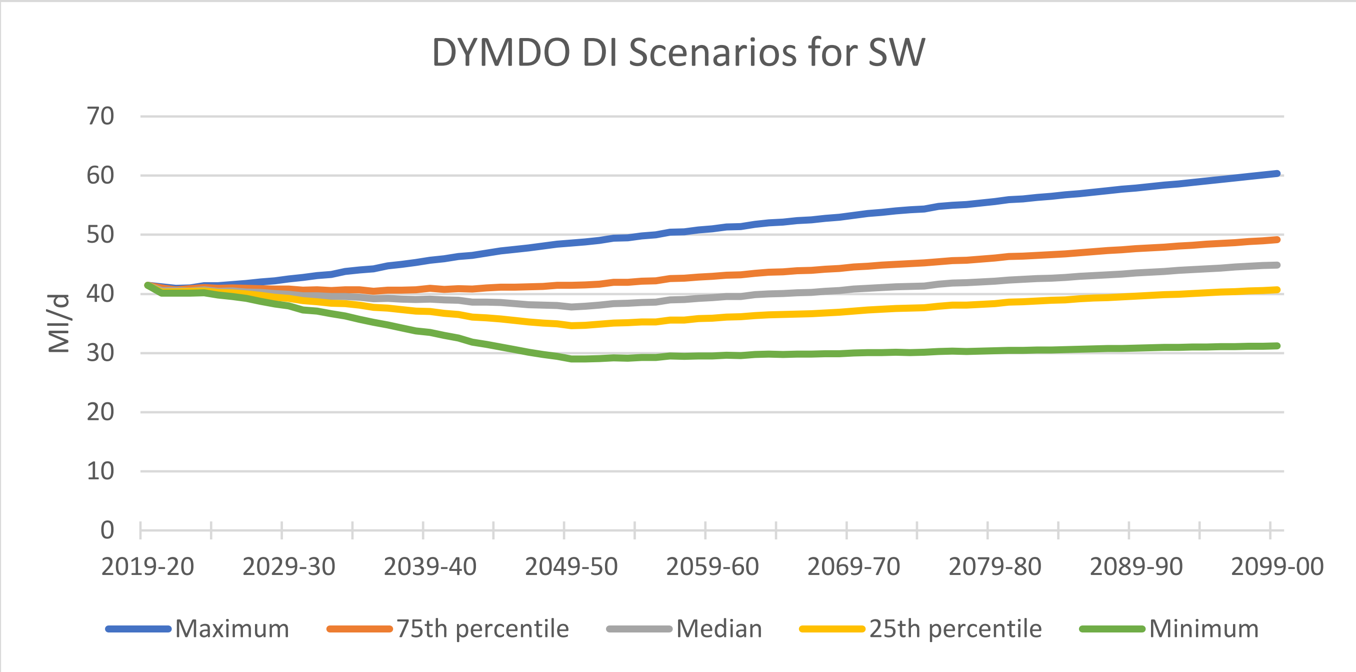



**Figure 77: Range of NYAA PCC results**

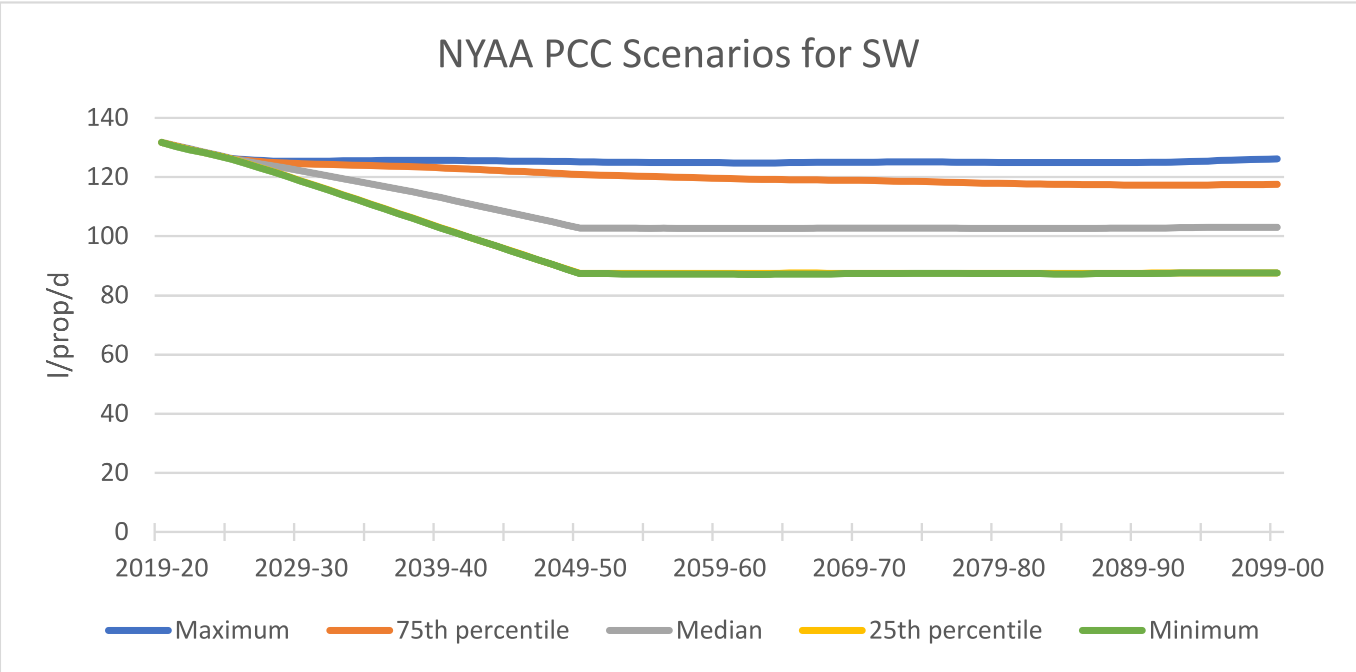


Figure 78: Range of DYAA PCC results

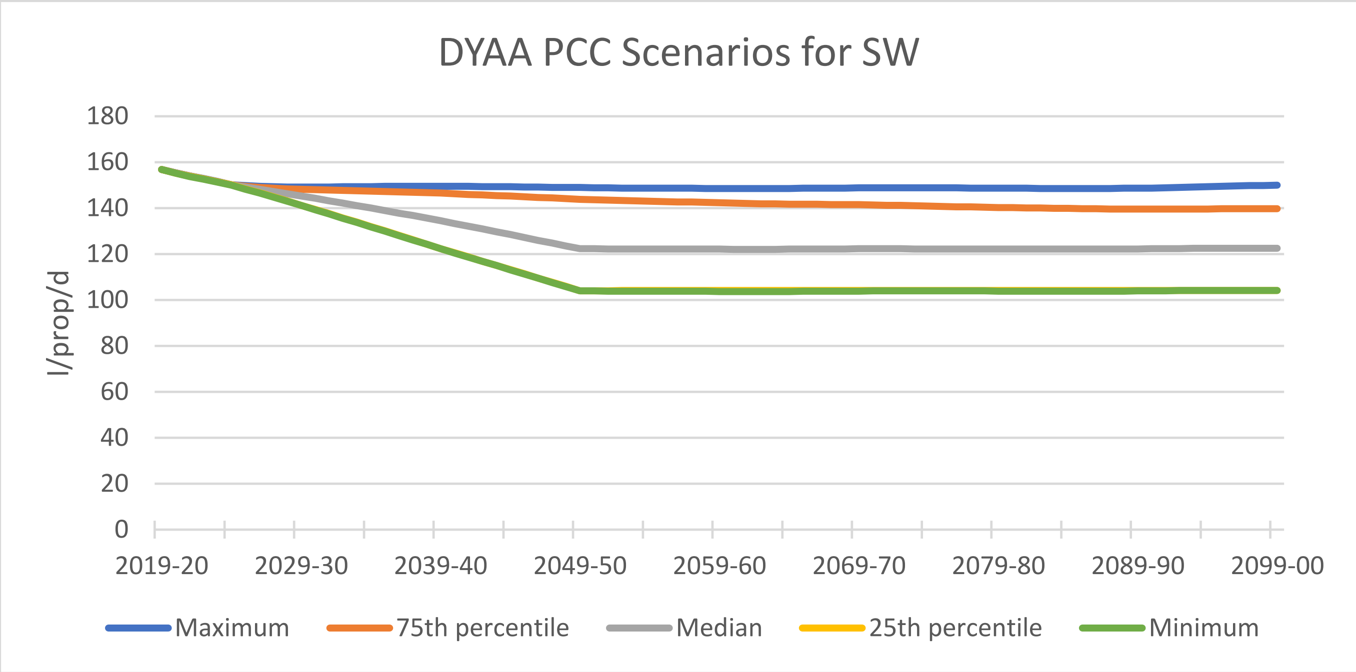



Figure 79: Range of DYCP PCC results

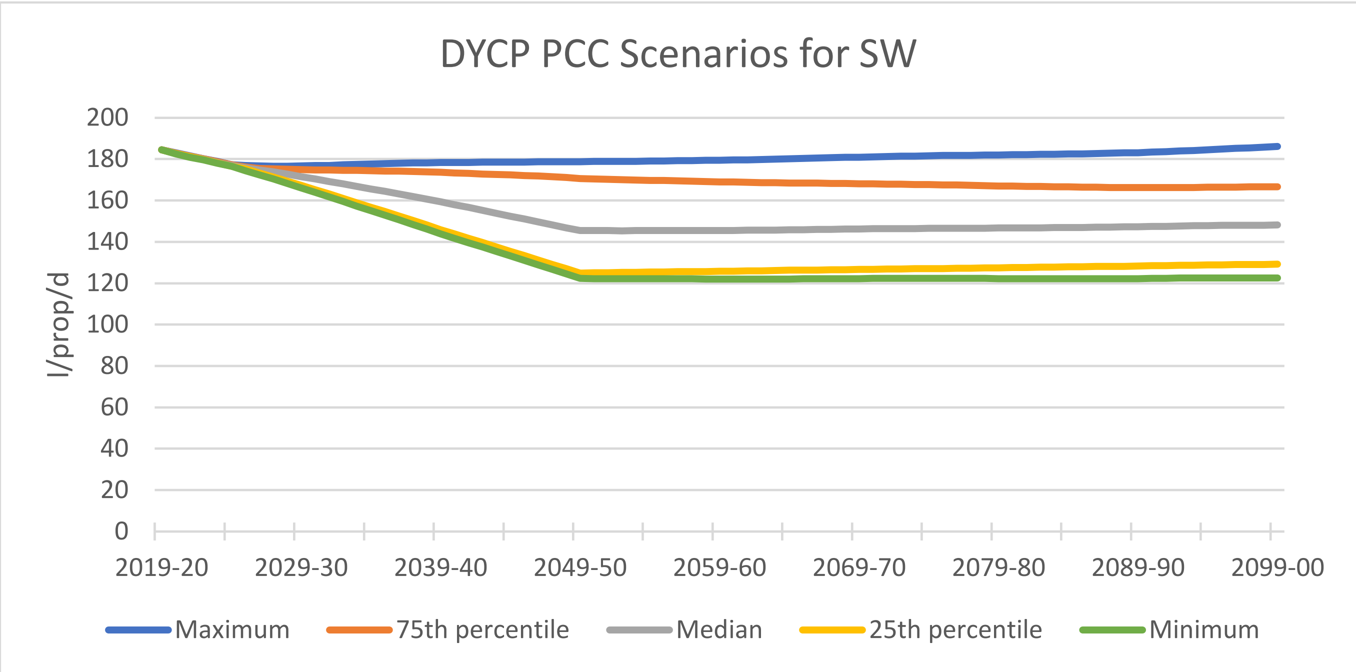
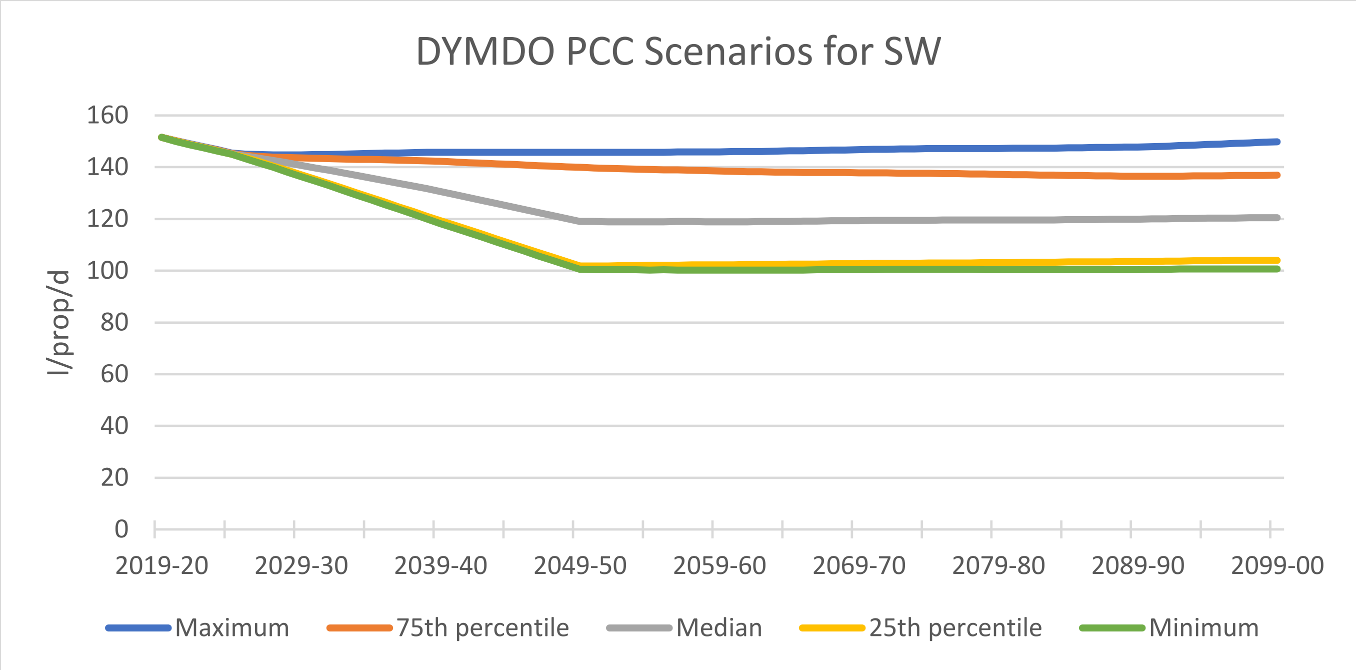


**Figure 80: Range of DYMDO PCC results**




## B.10. Sussex Brighton (SB)

**Figure 81: Range of NYAA Distribution Input results**

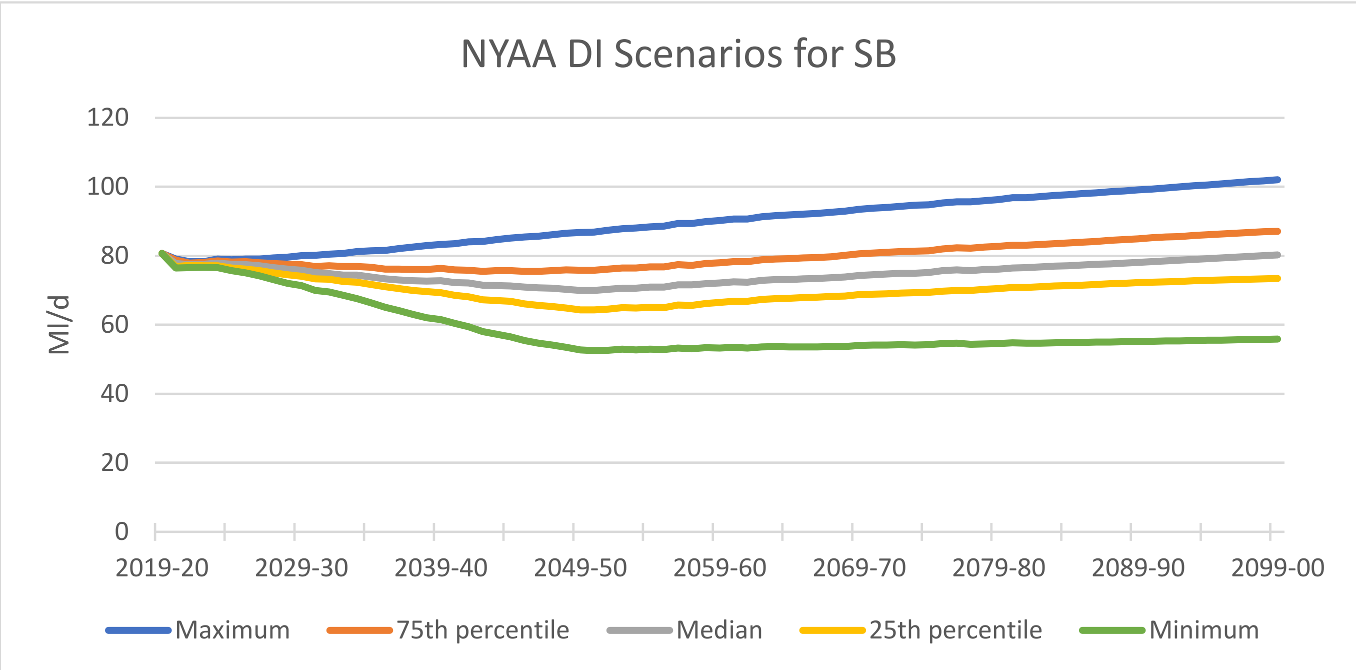


**Figure 82: Range of DYAA Distribution Input results**

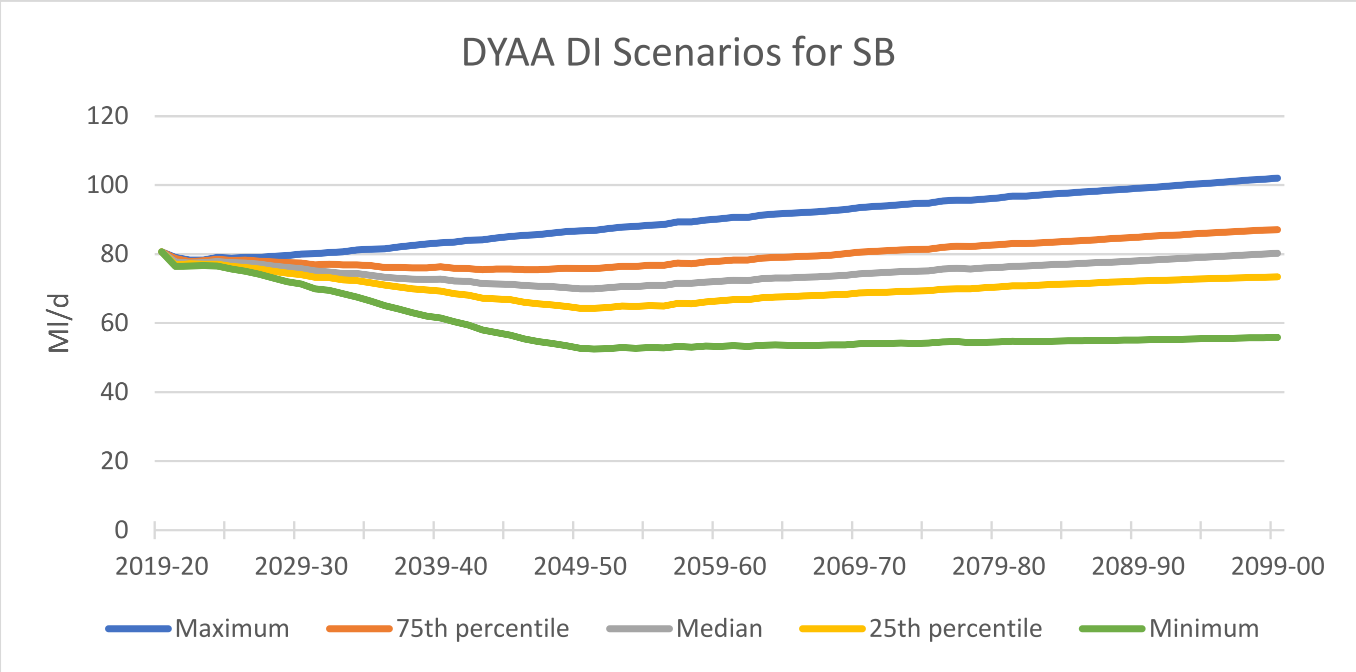



**Figure 83: Range of DYCP Distribution Input results**

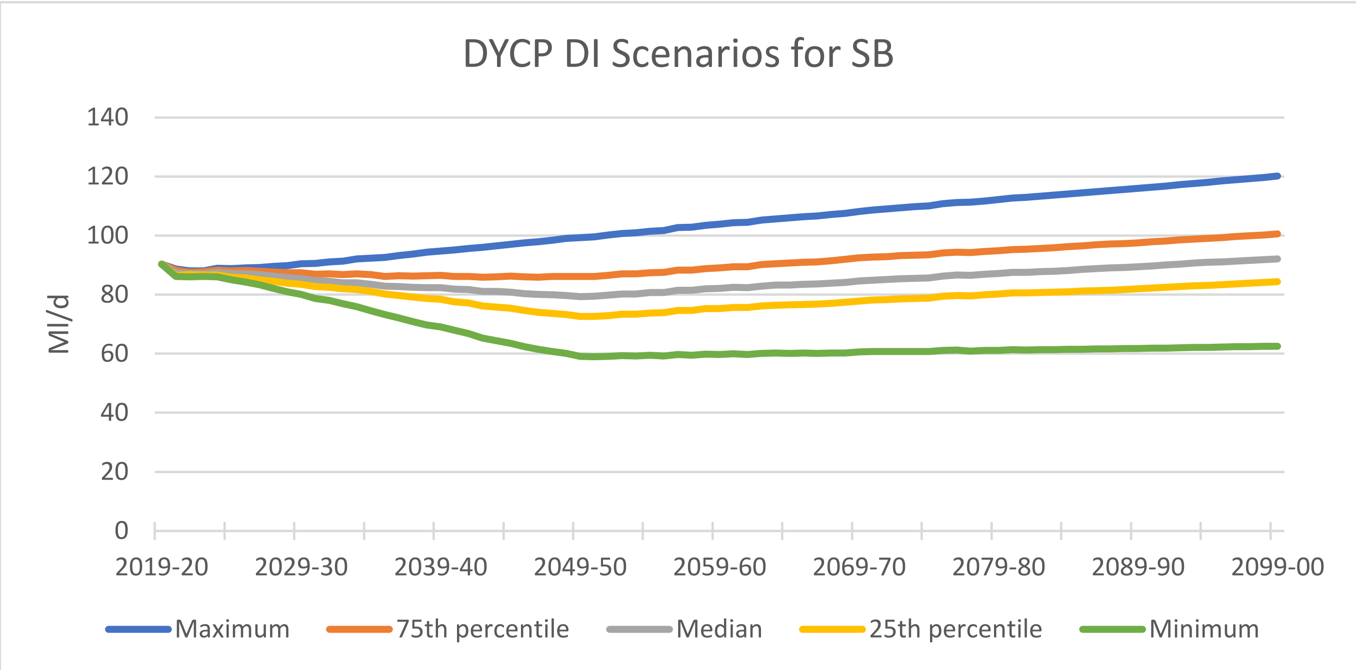


**Figure 84: Range of DYMDO Distribution Input results**

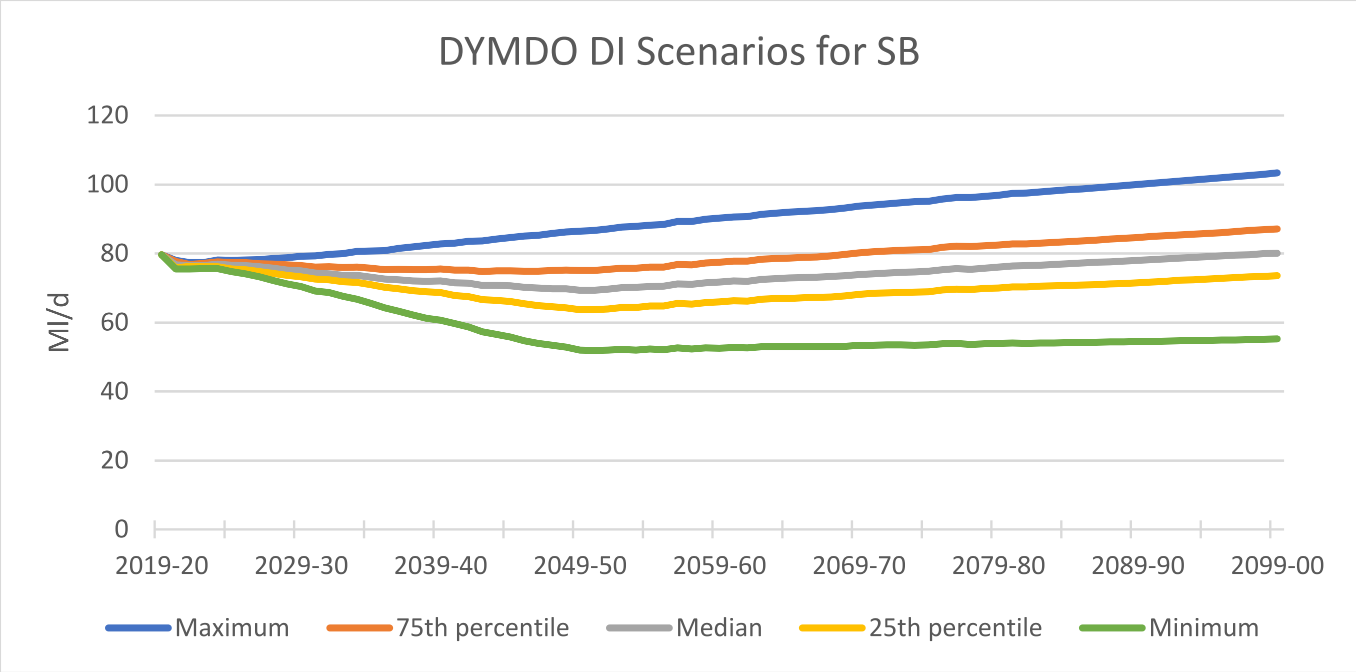



**Figure 85: Range of NYAA PCC results**

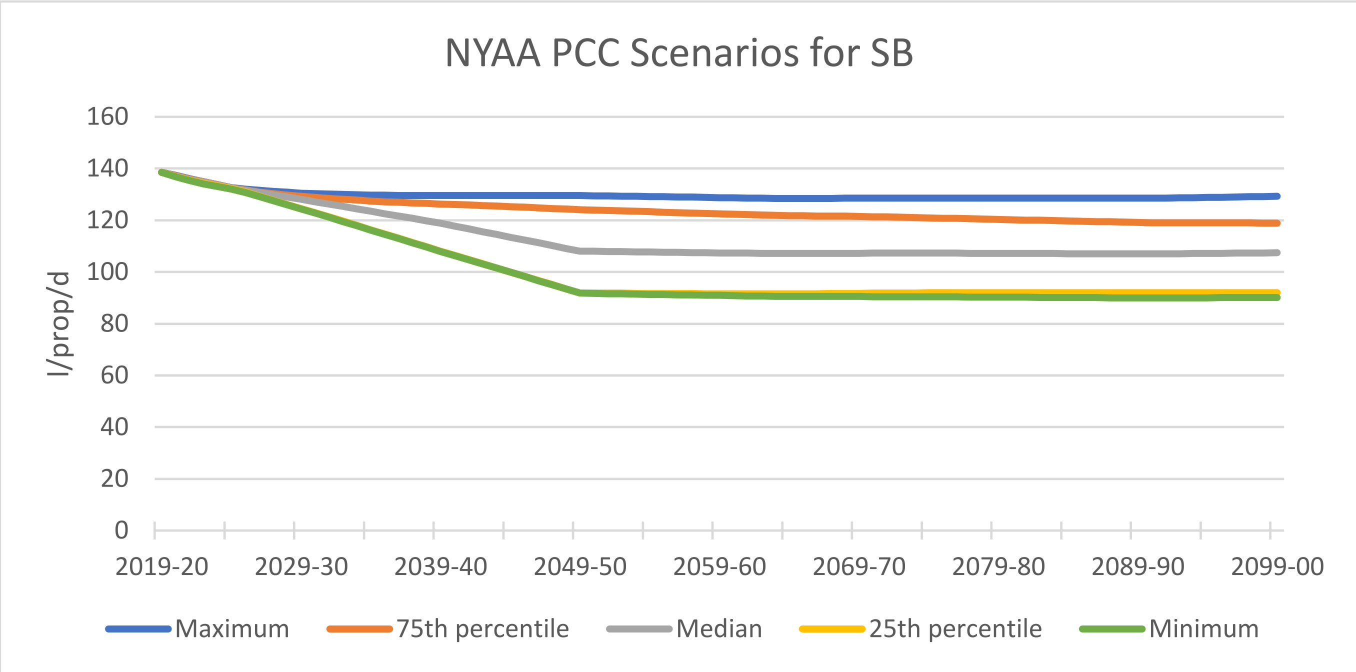


Figure 86: Range of DYAA PCC results

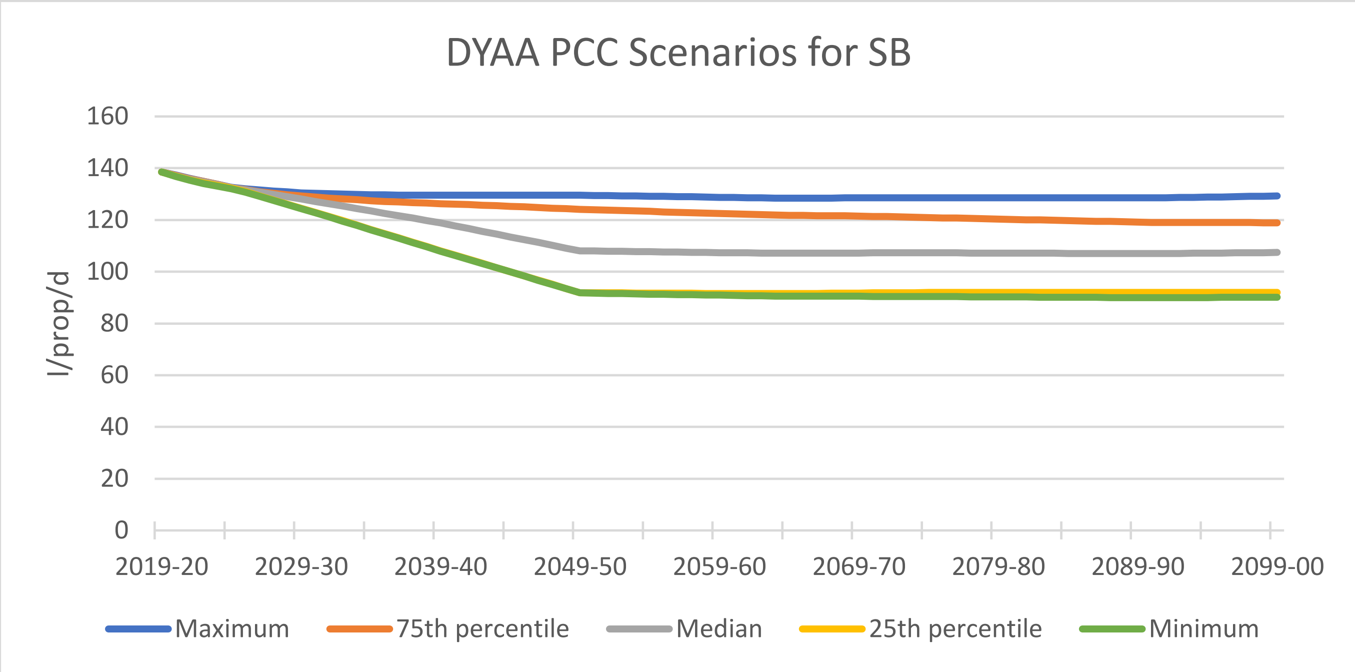



Figure 87: Range of DYCP PCC results

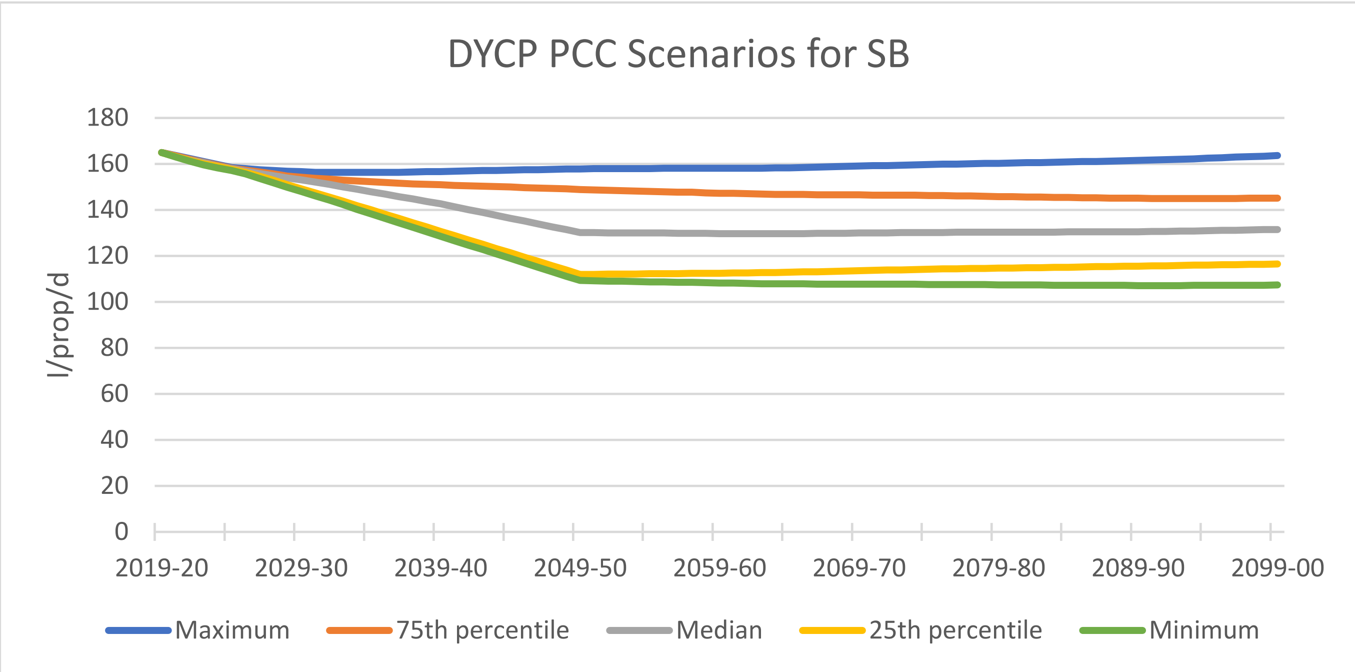
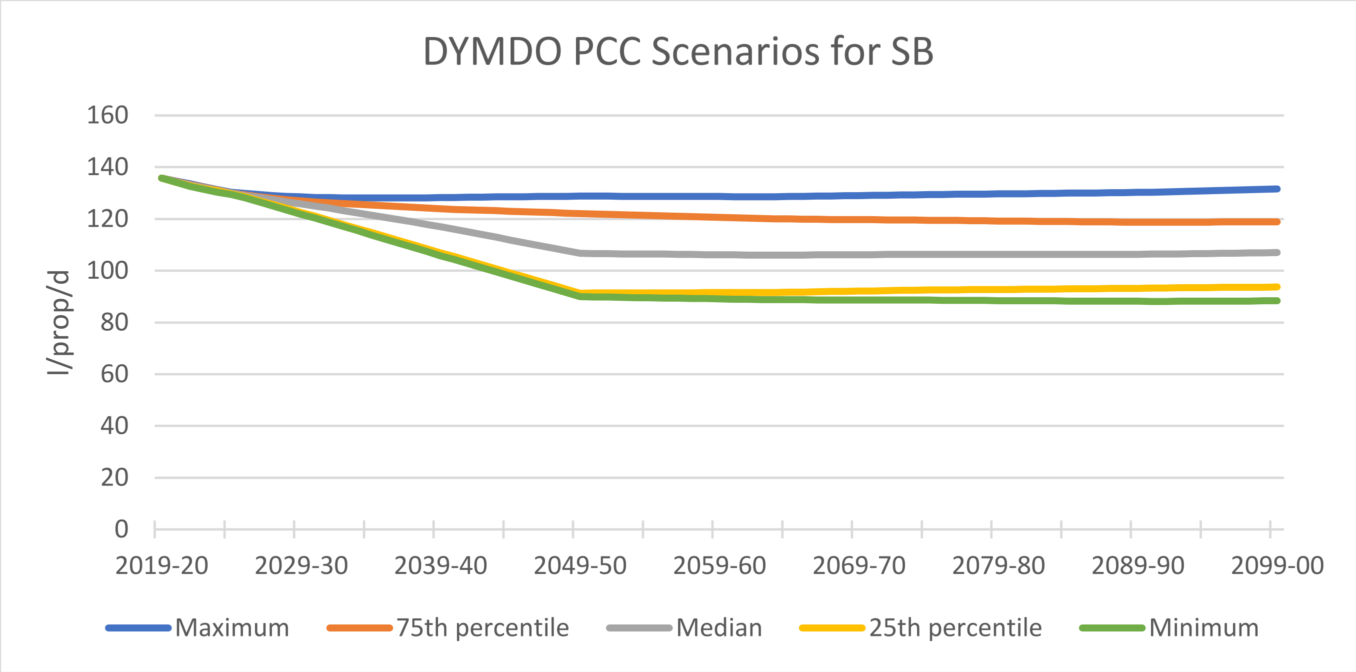


**Figure 88: Range of DYMDO PCC results**




## B.11. Kent Medway East (KME)

**Figure 89: Range of NYAA Distribution Input results**

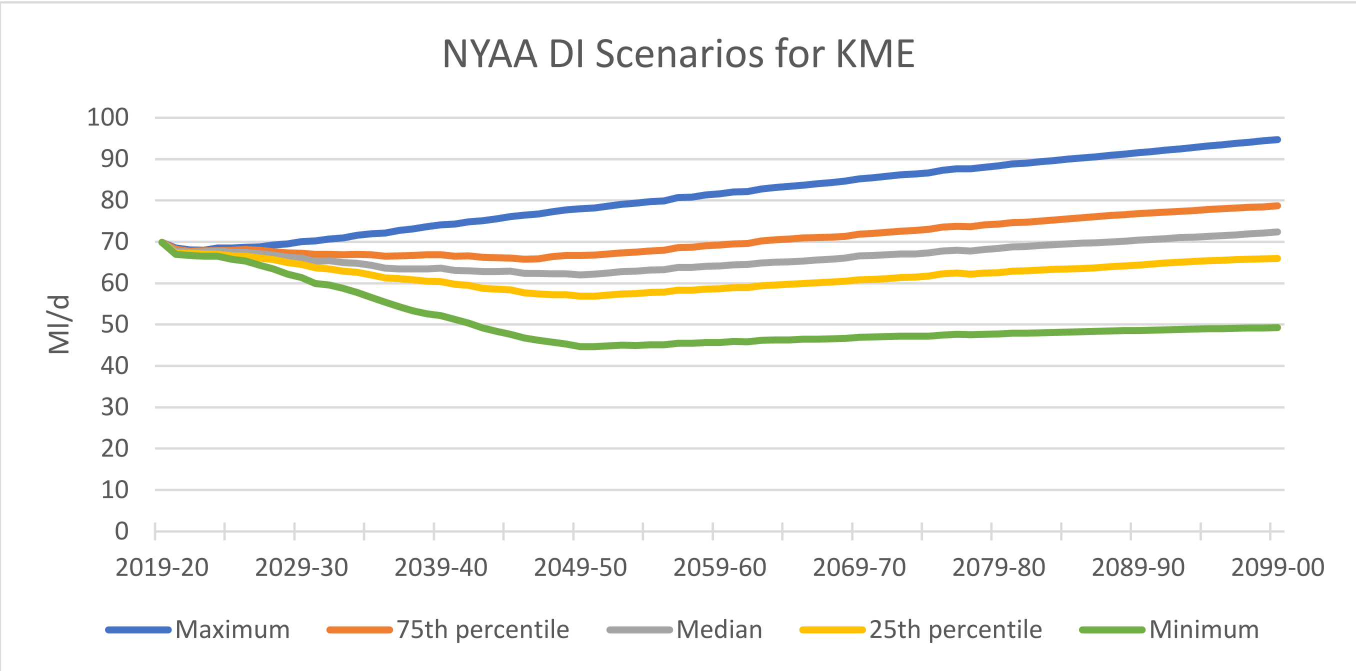


**Figure 90: Range of DYAA Distribution Input results**

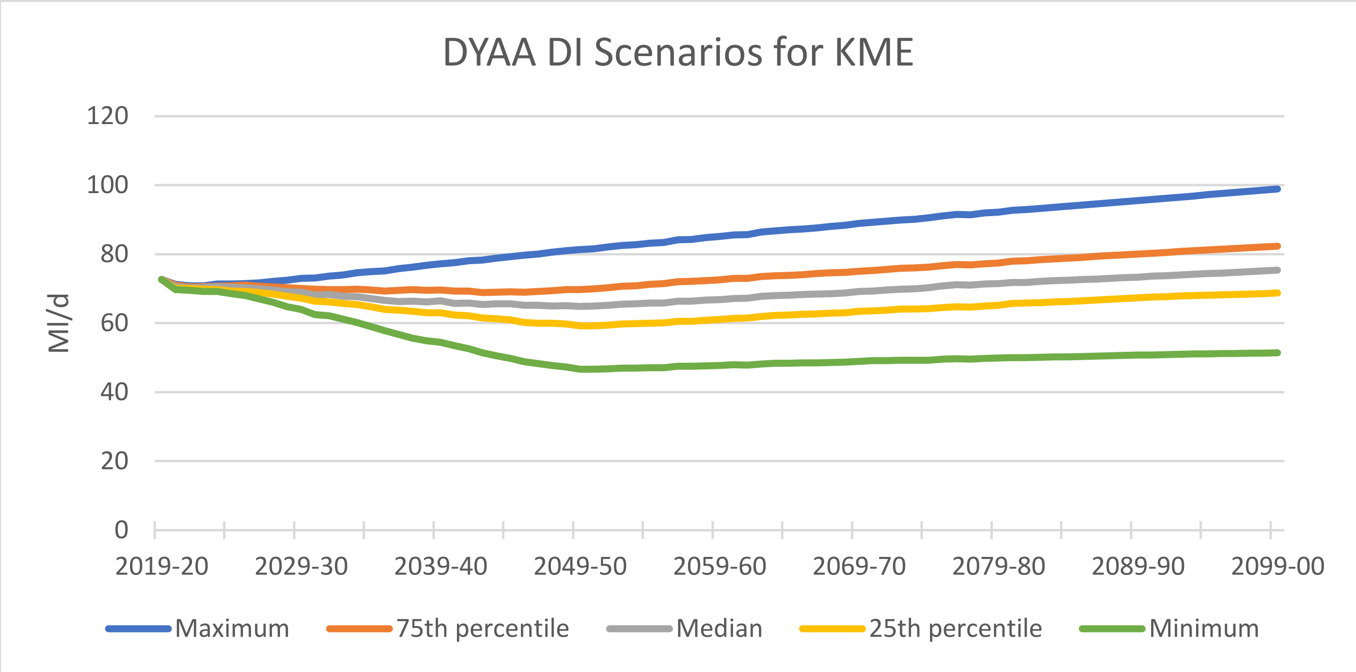



**Figure 91: Range of DYCP Distribution Input results**

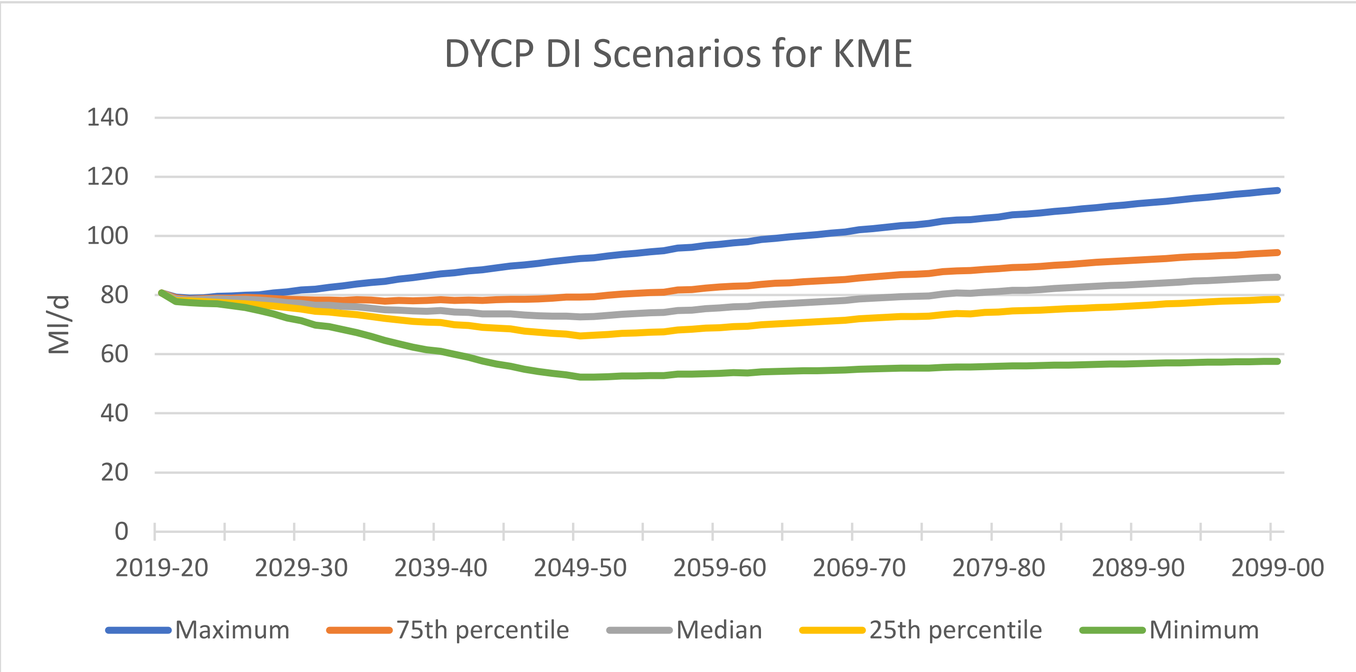


**Figure 92: Range of DYMDO Distribution Input results**

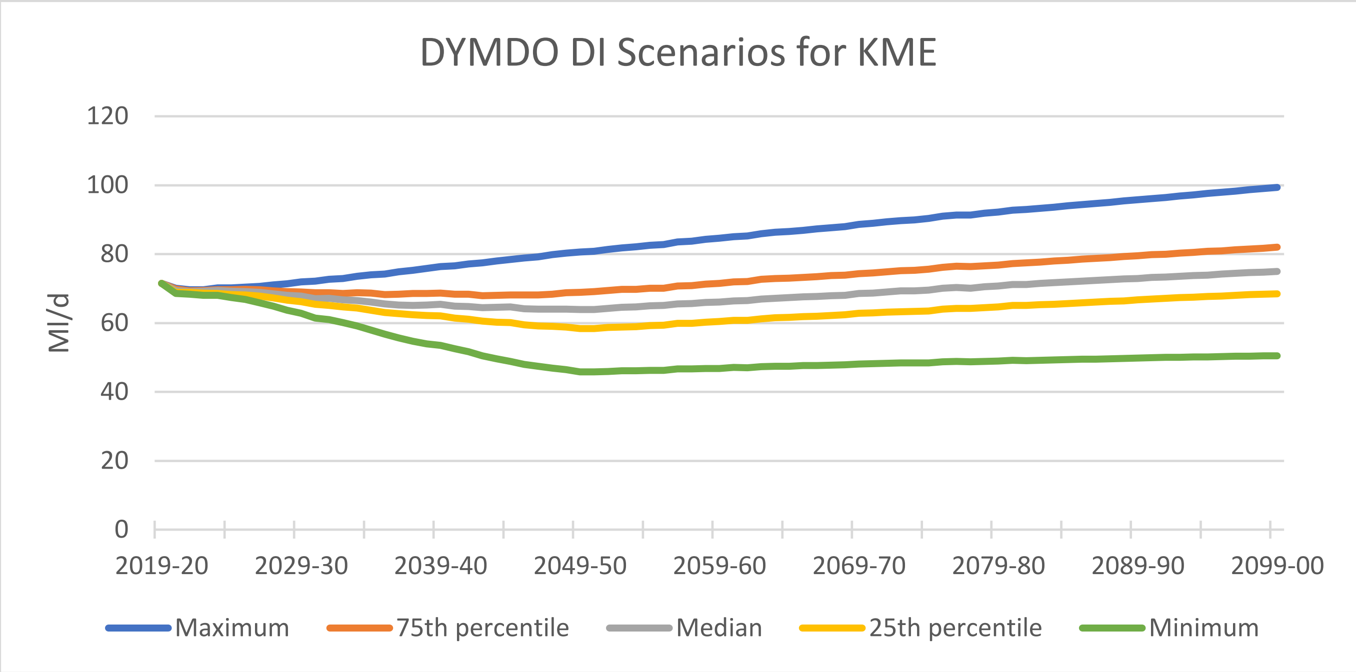



**Figure 93: Range of NYAA PCC results**

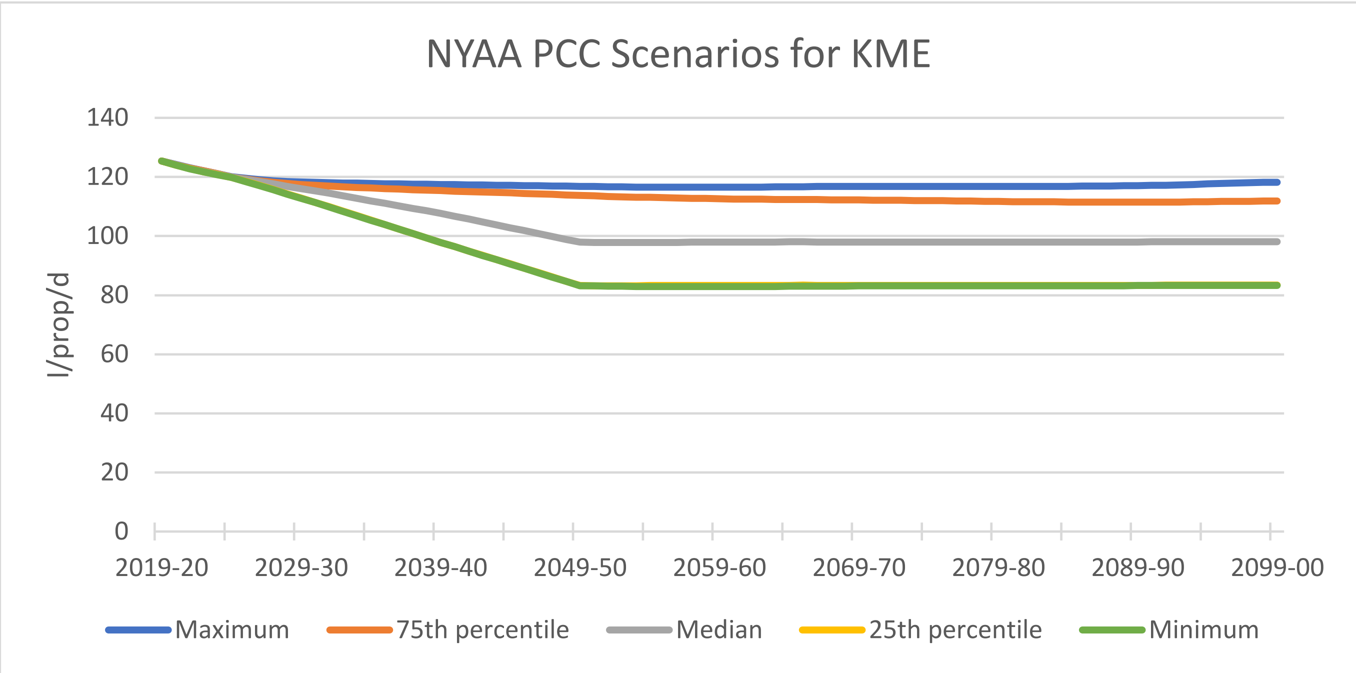


**Figure 94: Range of DYAA PCC results**

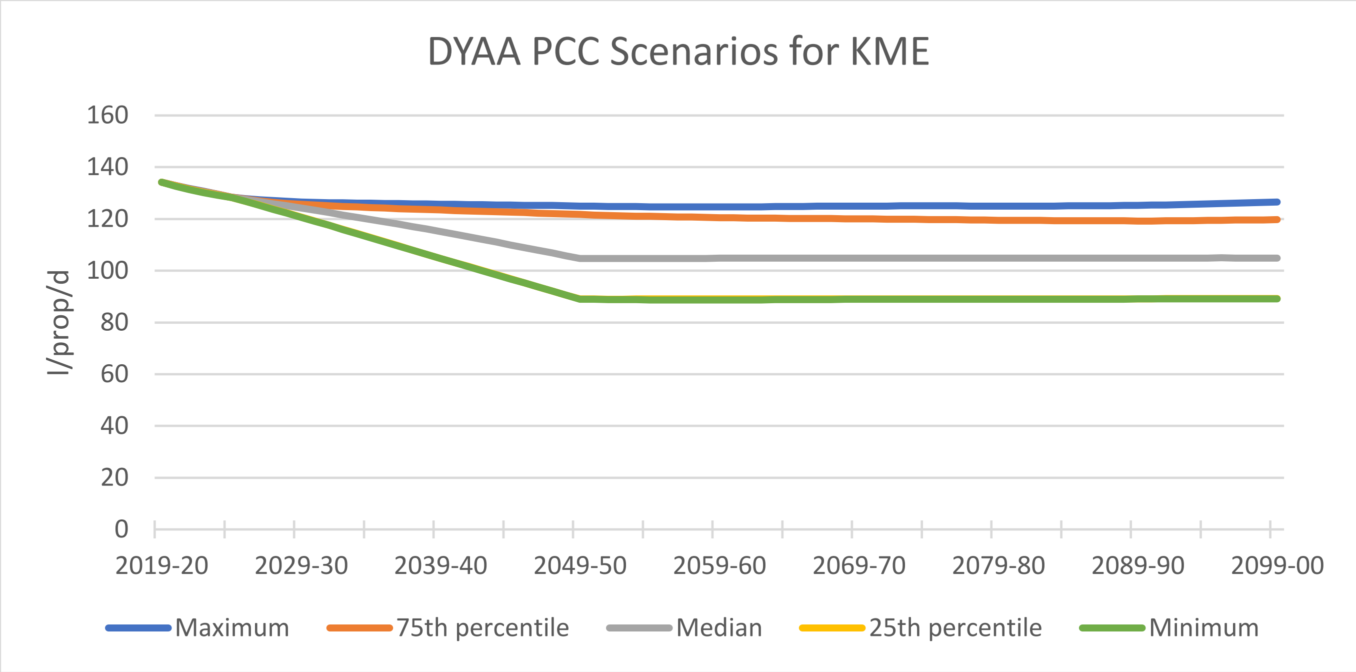



**Figure 95: Range of DYCP PCC results**

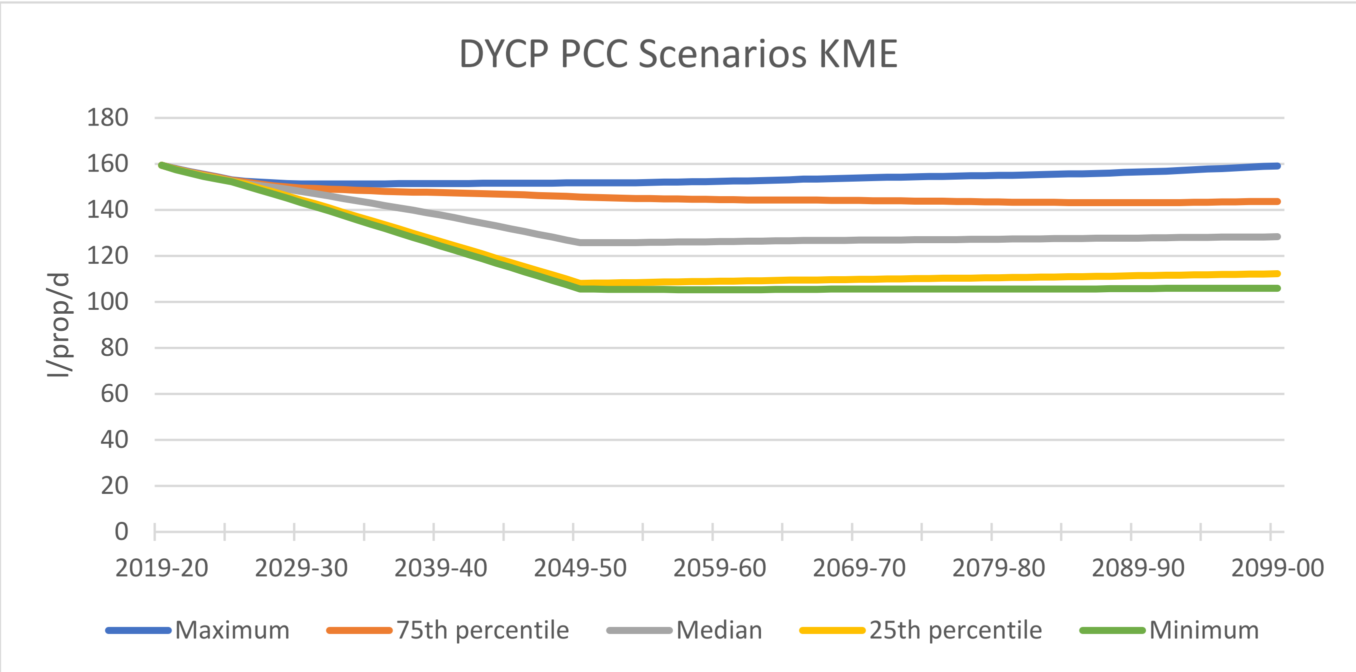
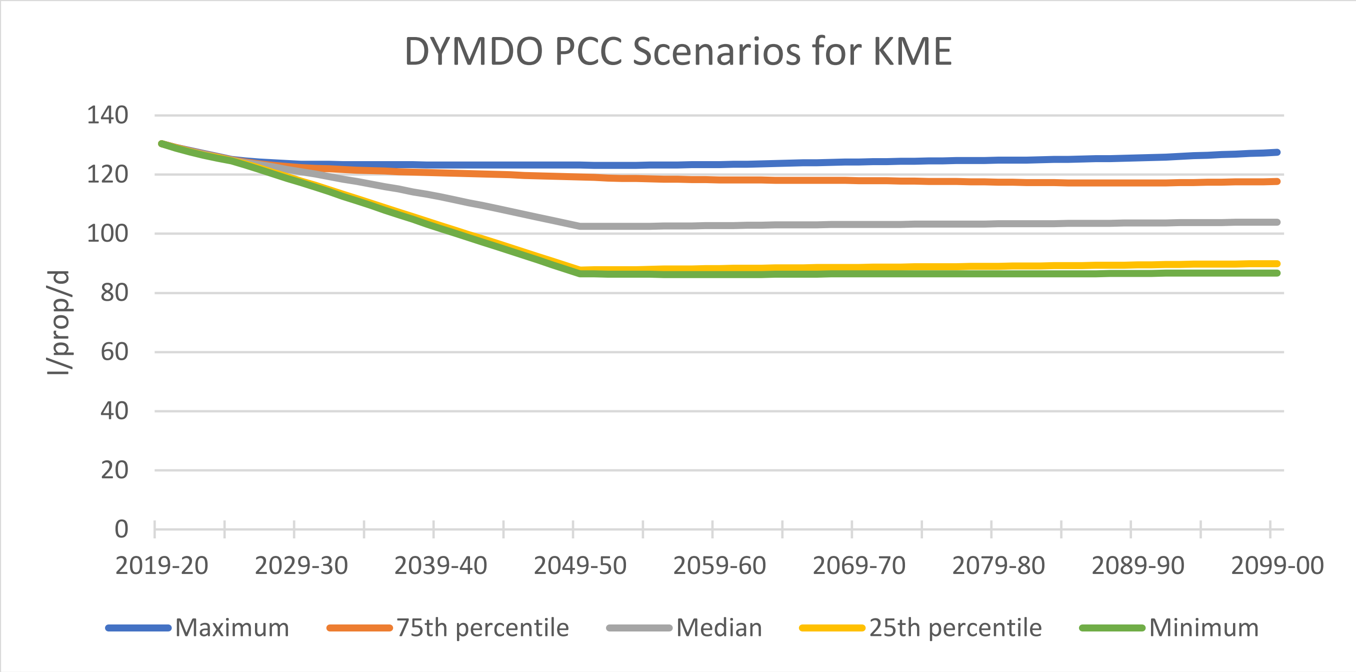


Figure 96: Range of DYMDO PCC results




## B.12. Kent Medway West (KMW)

Figure 97: Range of NYAA Distribution Input results

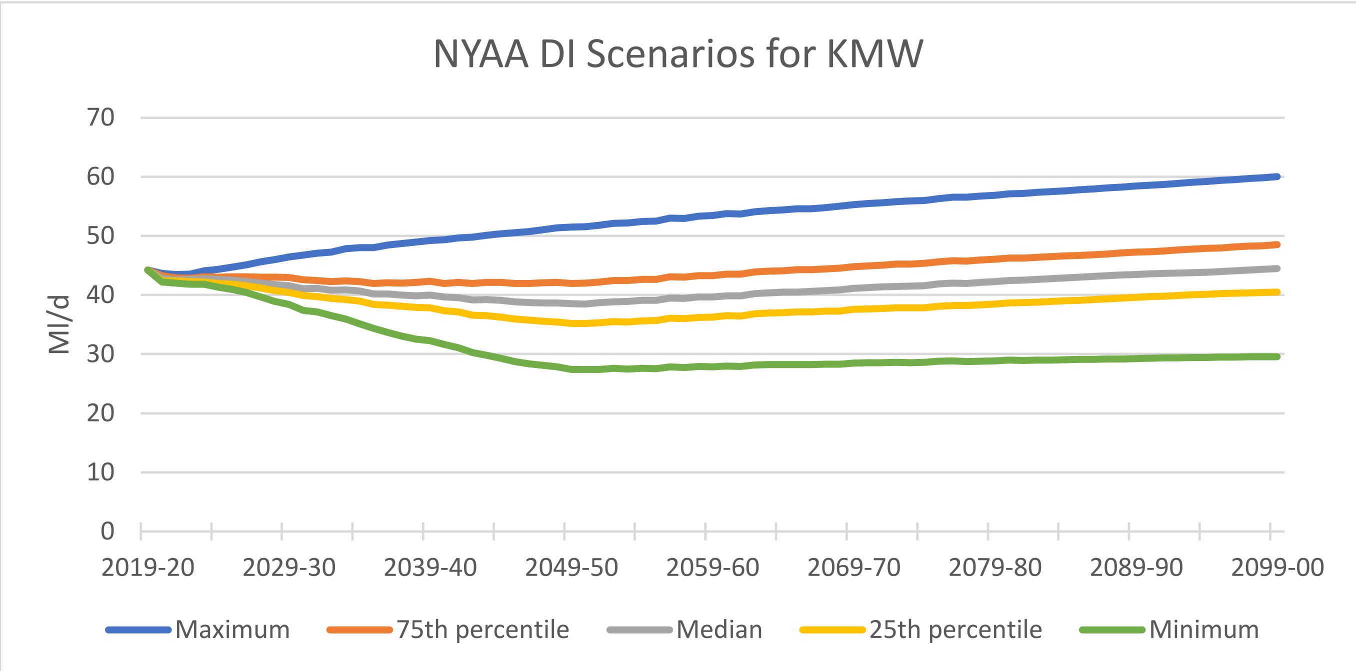


**Figure 98: Range of DYAA Distribution Input results**

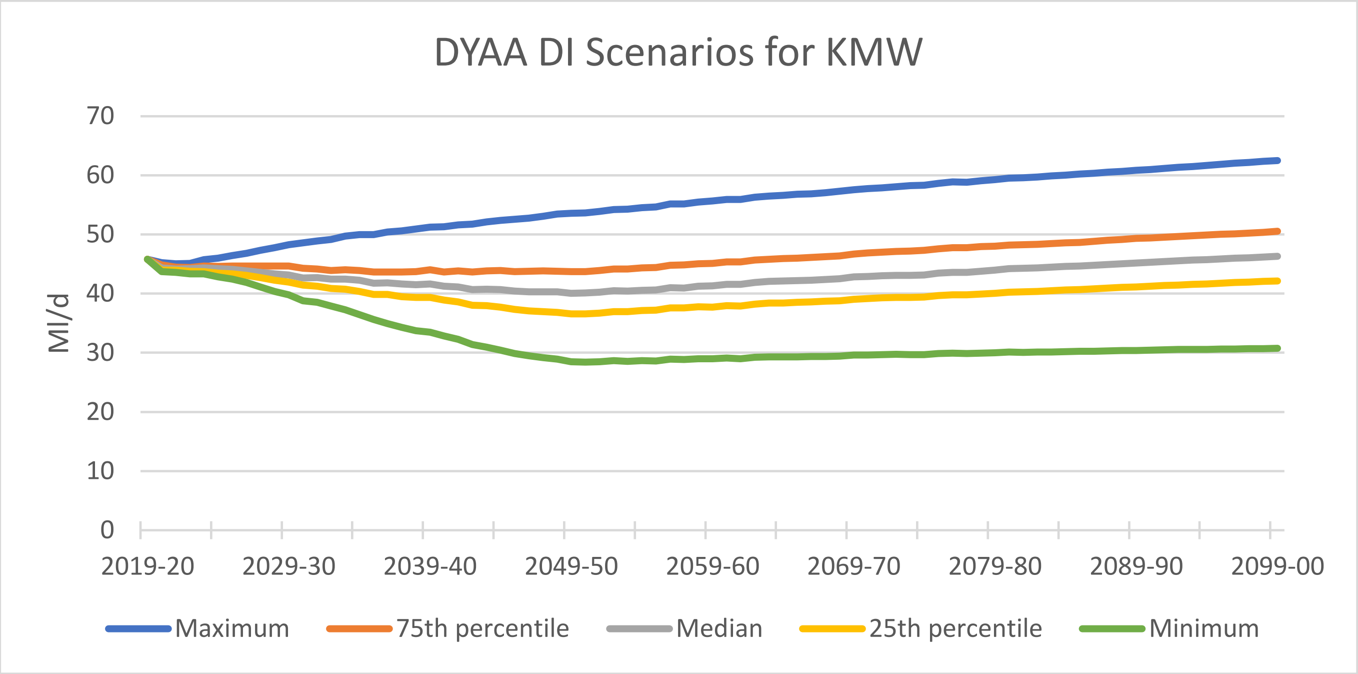



**Figure 99: Range of DYCP Distribution Input results**

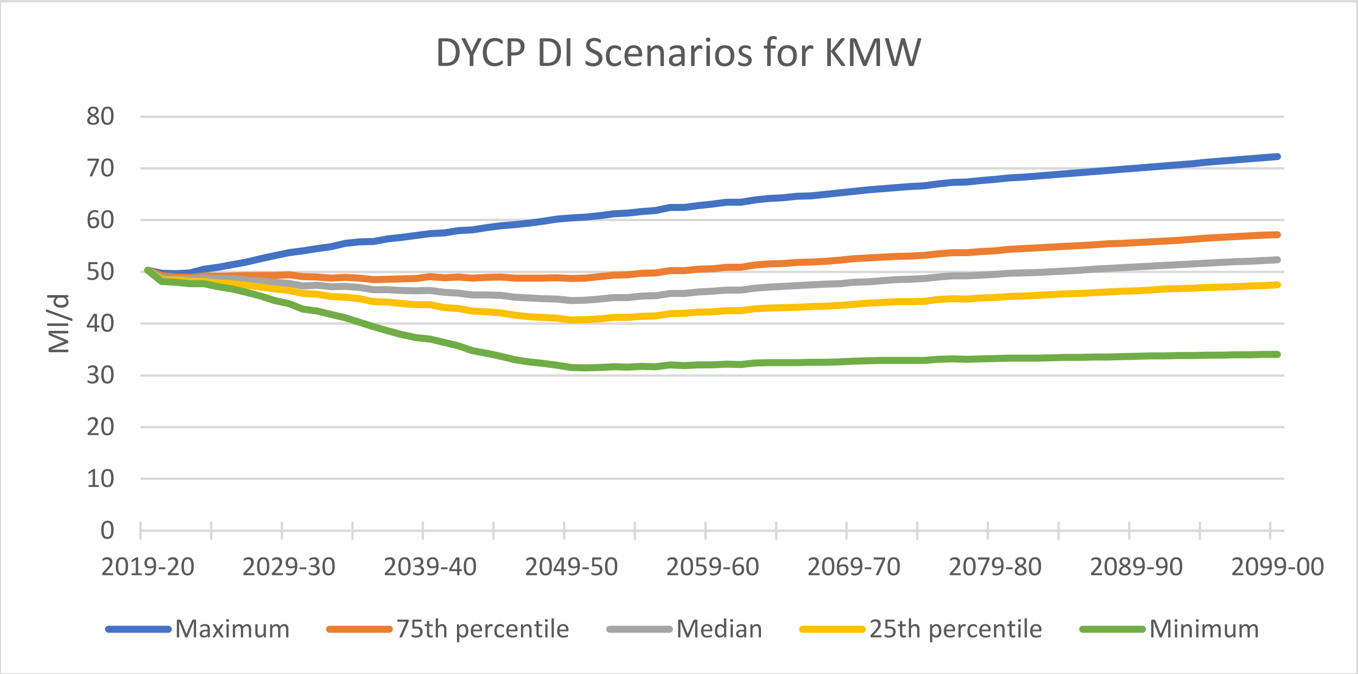


**Figure 100: Range of DYMDO Distribution Input results**

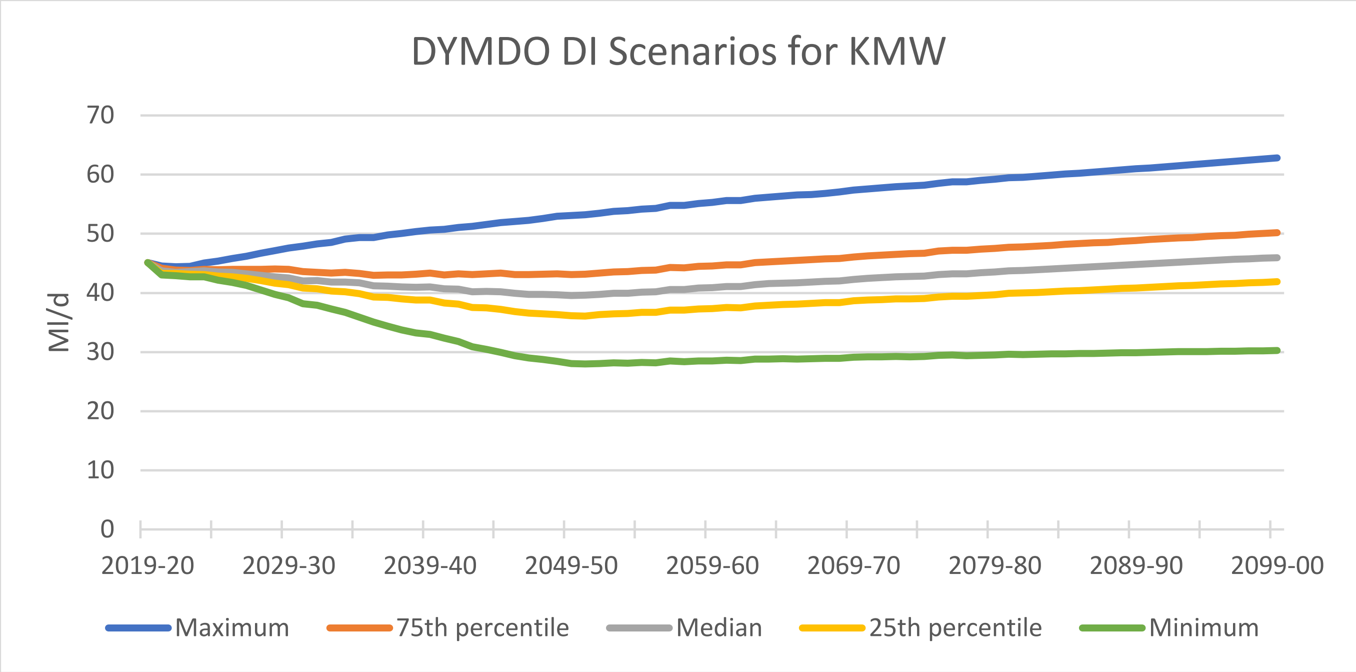



**Figure 101: Range of NYAA PCC results**

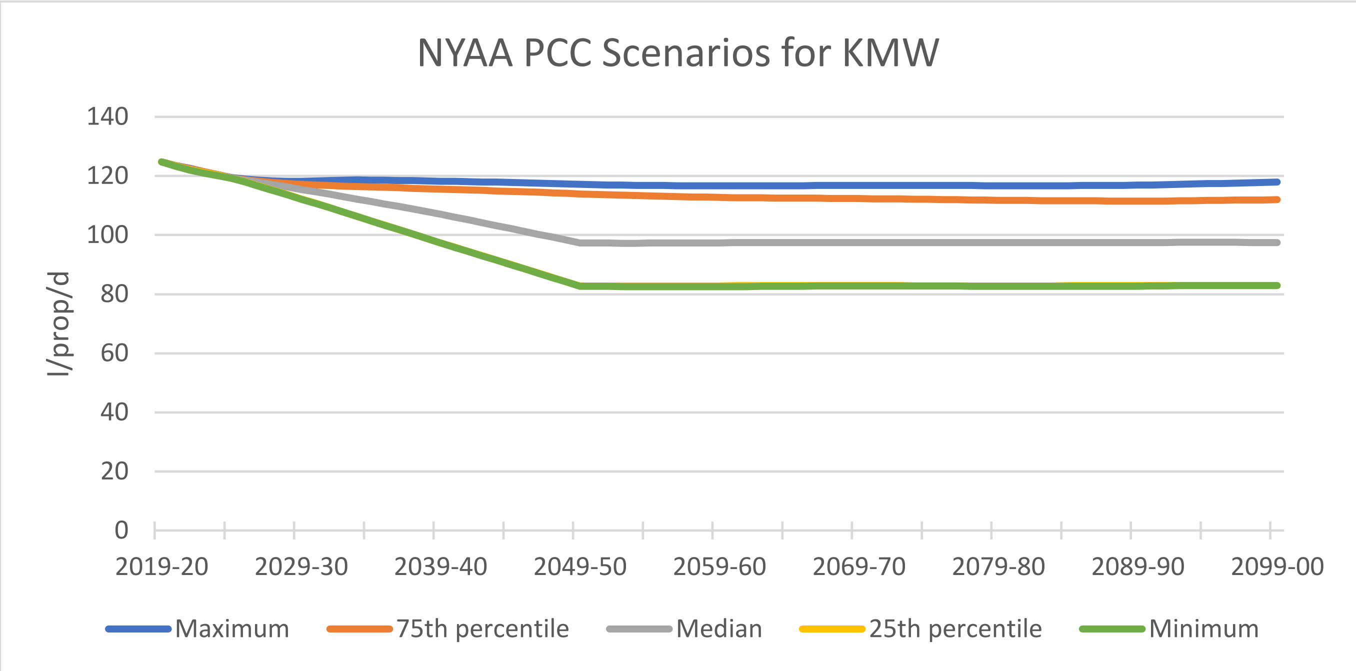


**Figure 102: Range of DYAA PCC results**

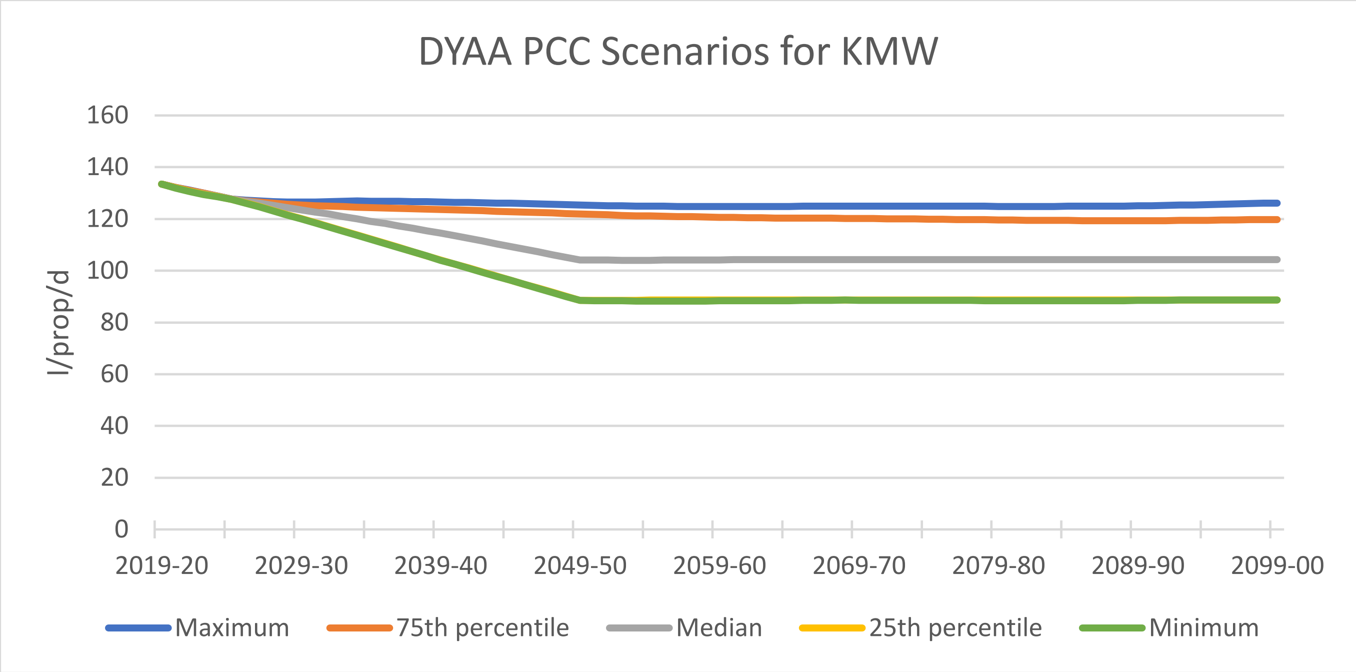



**Figure 103: Range of DYCP PCC results**

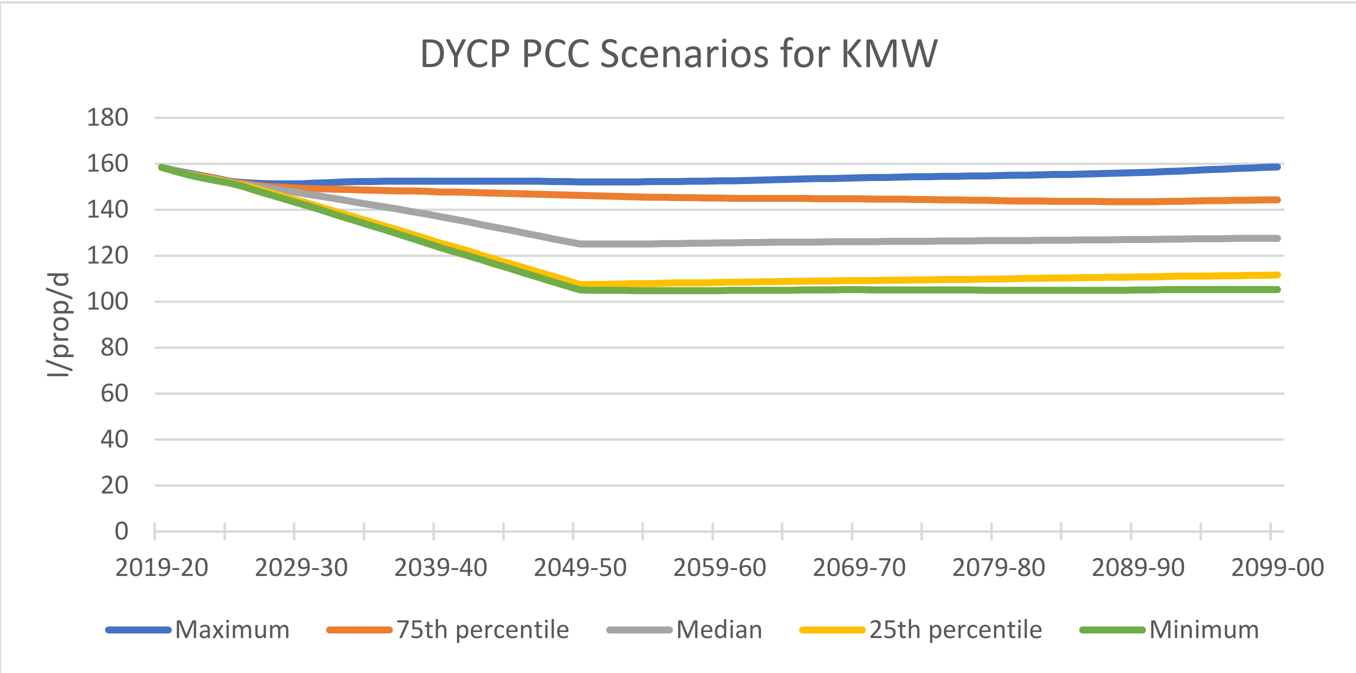
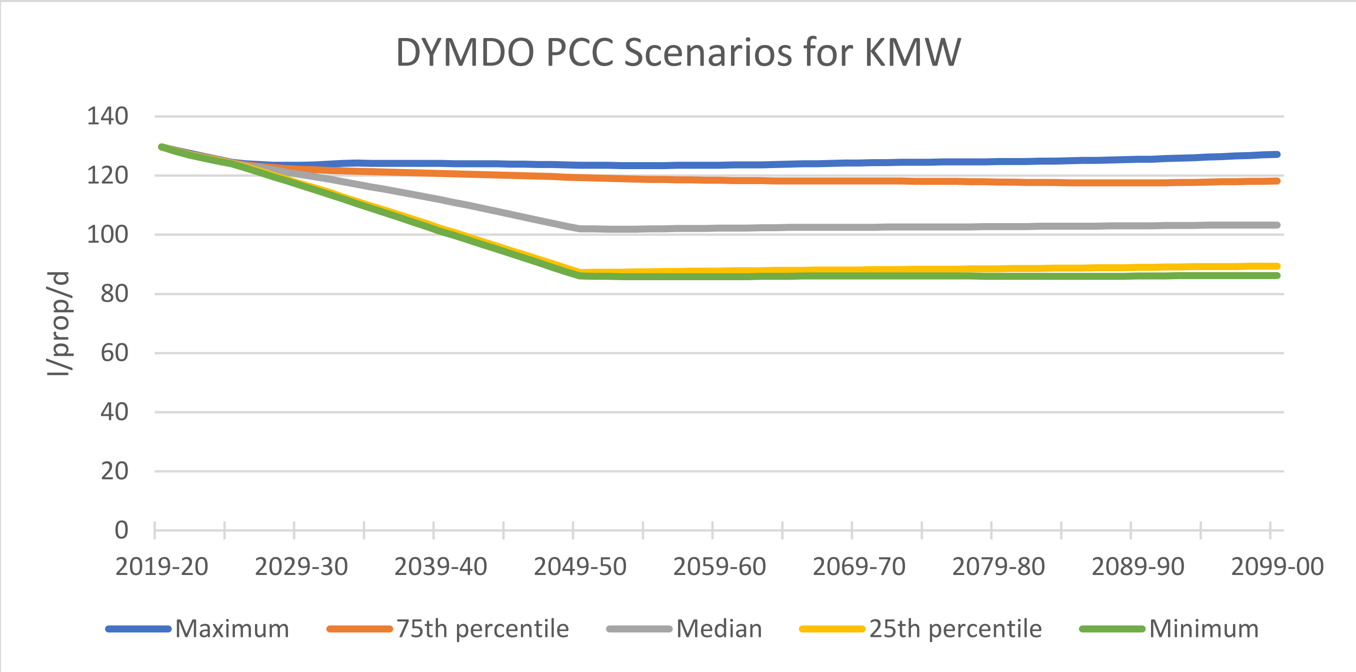


**Figure 104: Range of DYMDO PCC results**




## B.13. Kent Thanet (KT)

**Figure 105: Range of NYAA Distribution Input results**

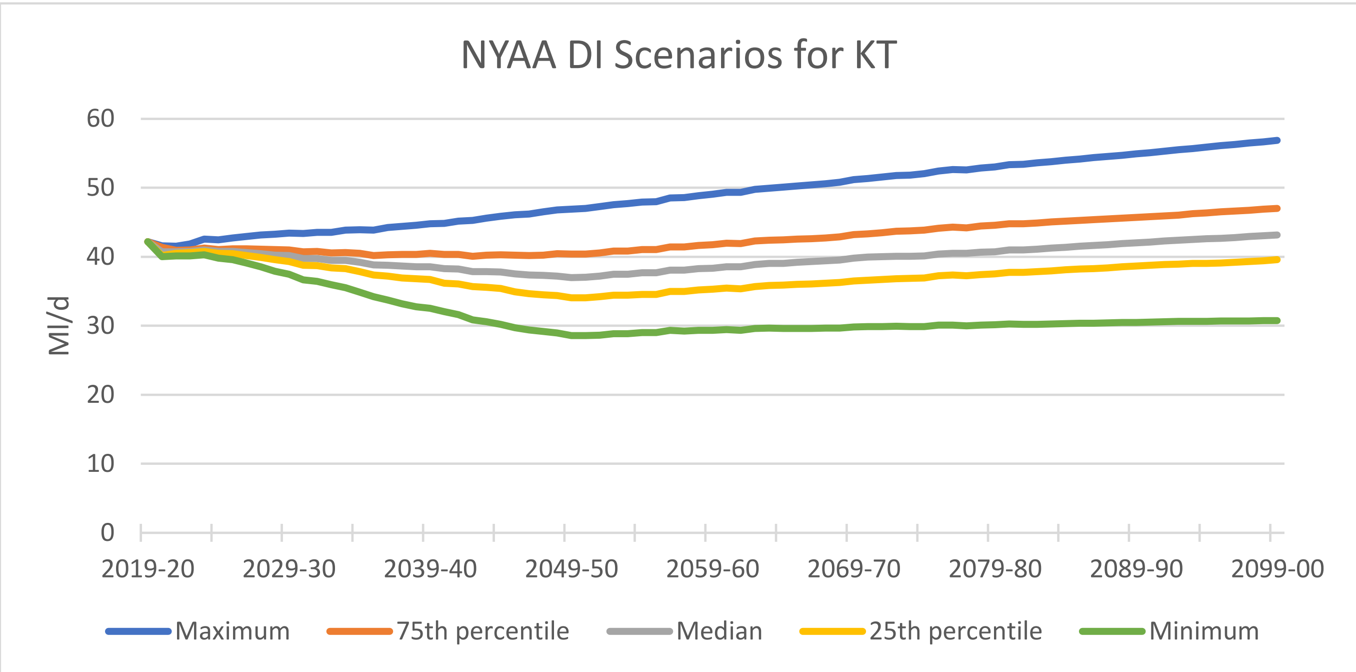


Figure 106: Range of DYAA Distribution Input results

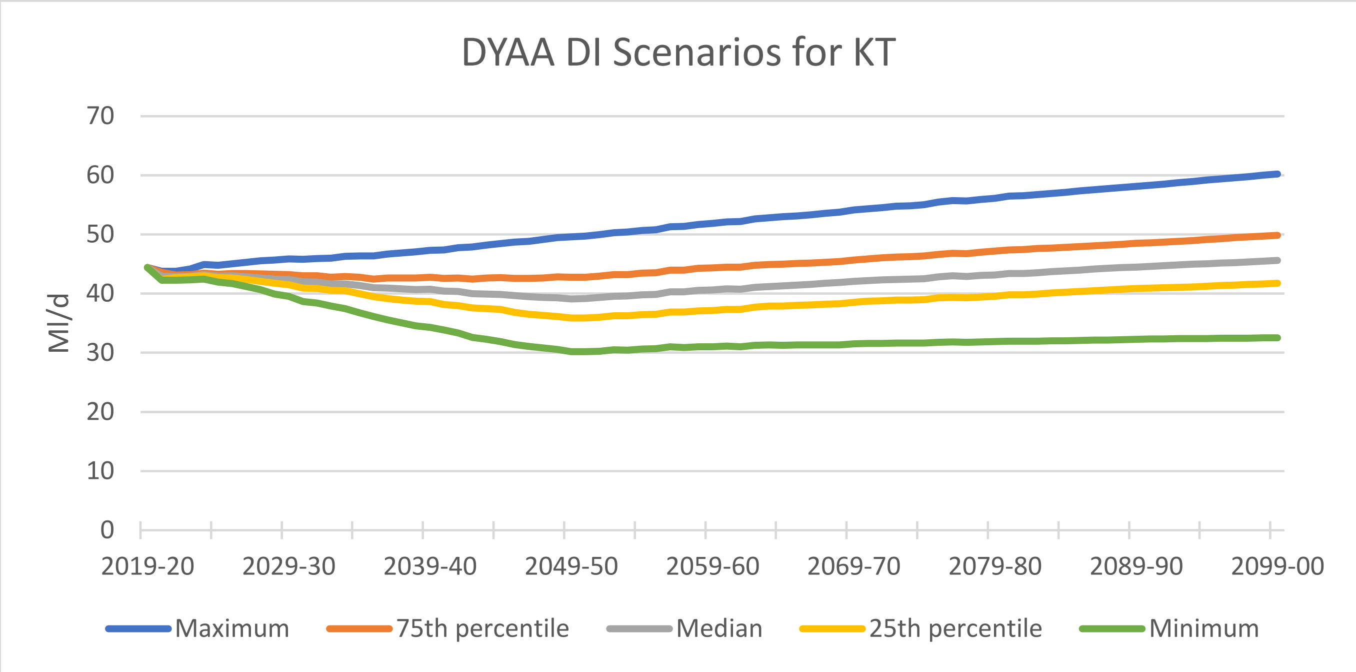



Figure 107: Range of DYCP Distribution Input results

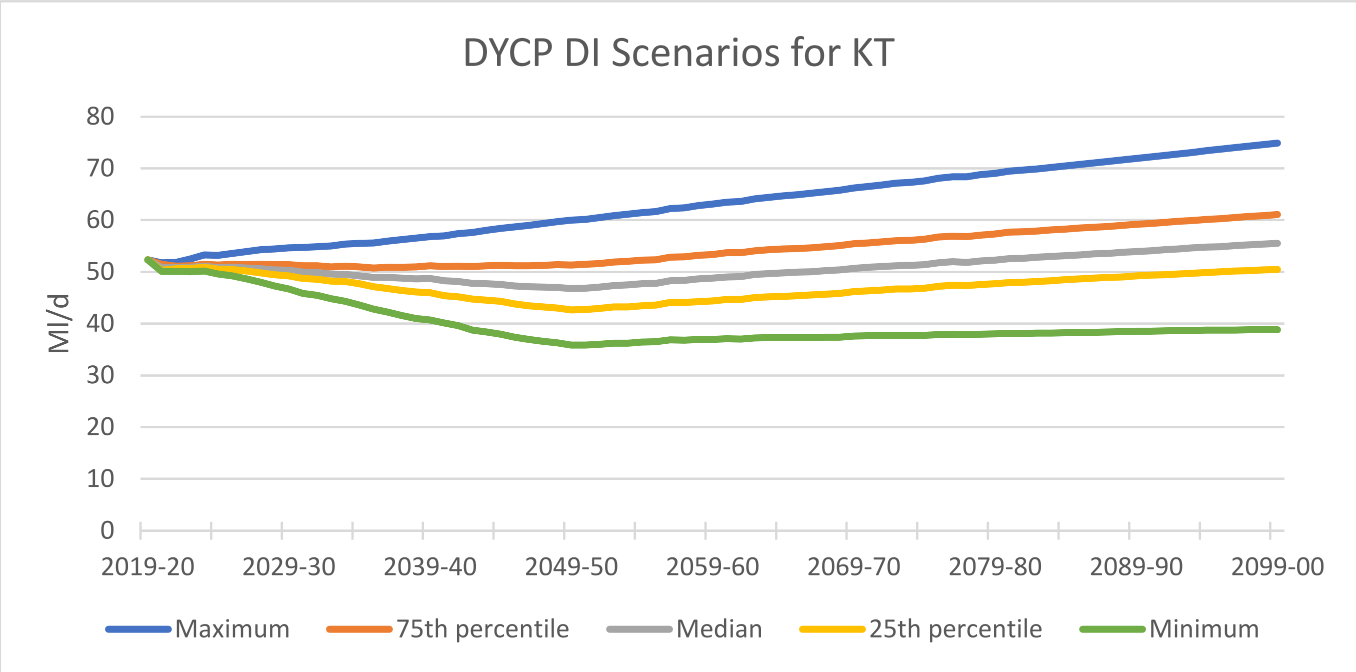


Figure 108: Range of DYMDO Distribution Input results

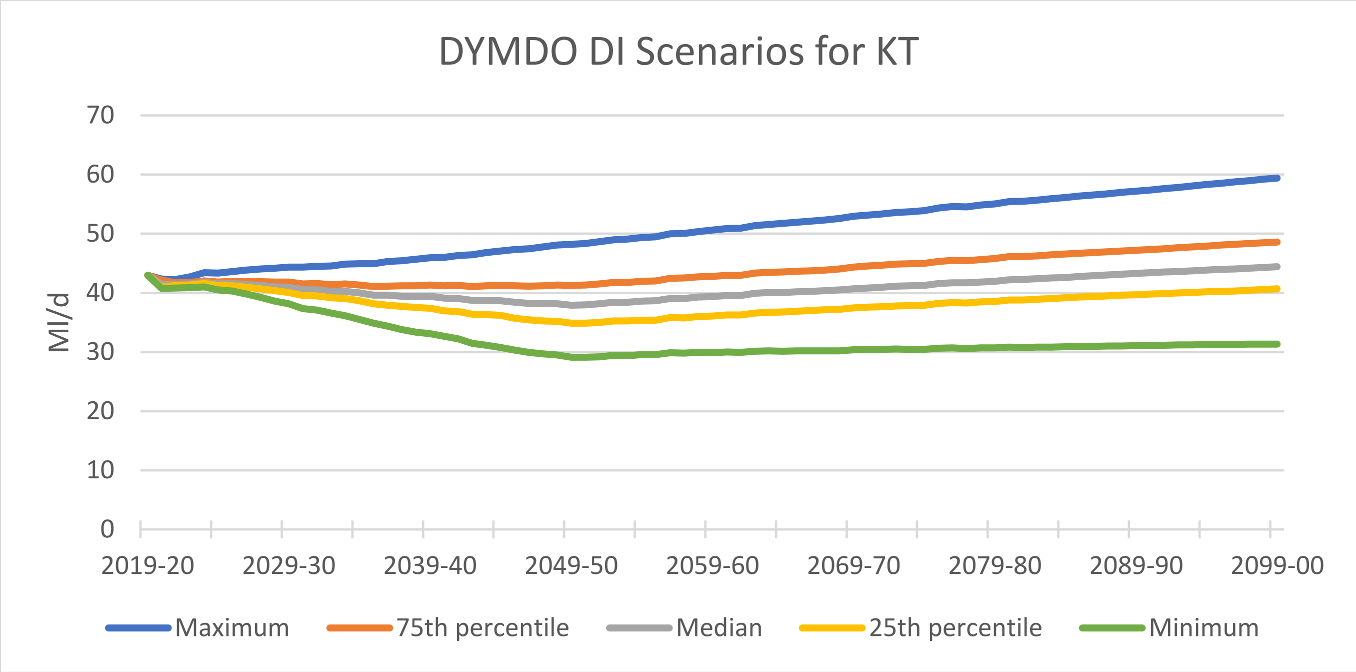



Figure 109: Range of NYAA PCC results

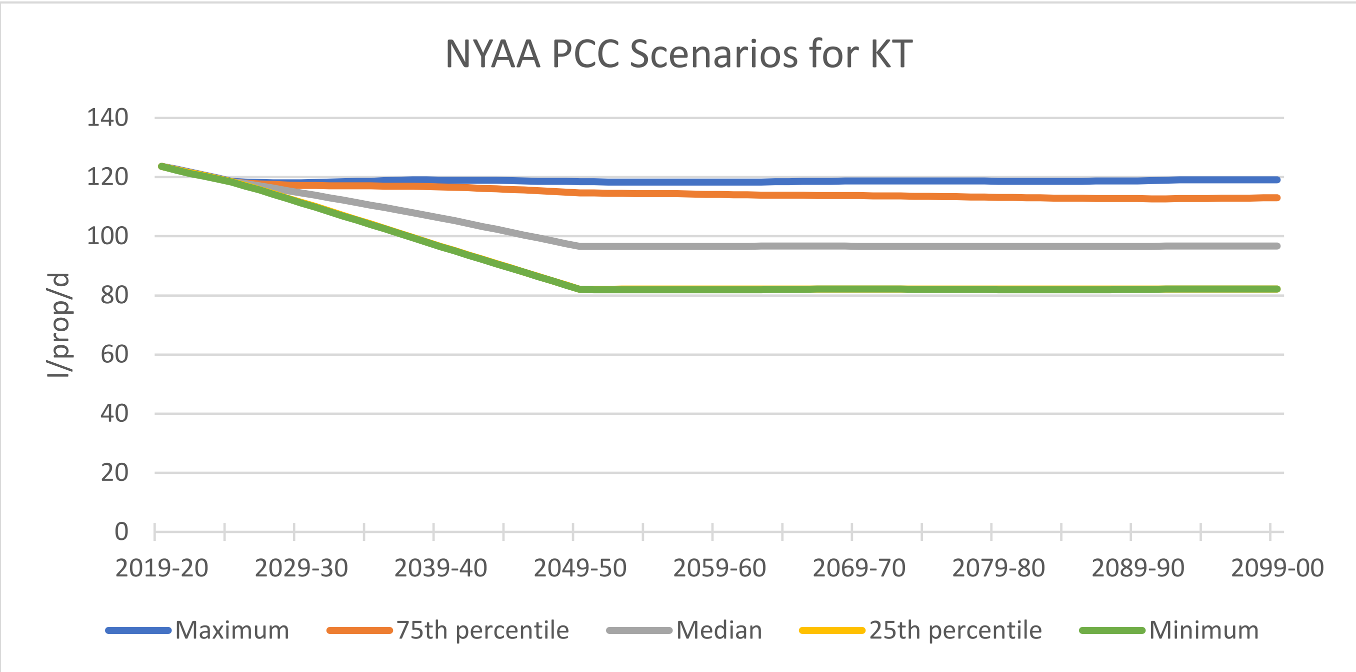


**Figure 110: Range of DYAA PCC results**

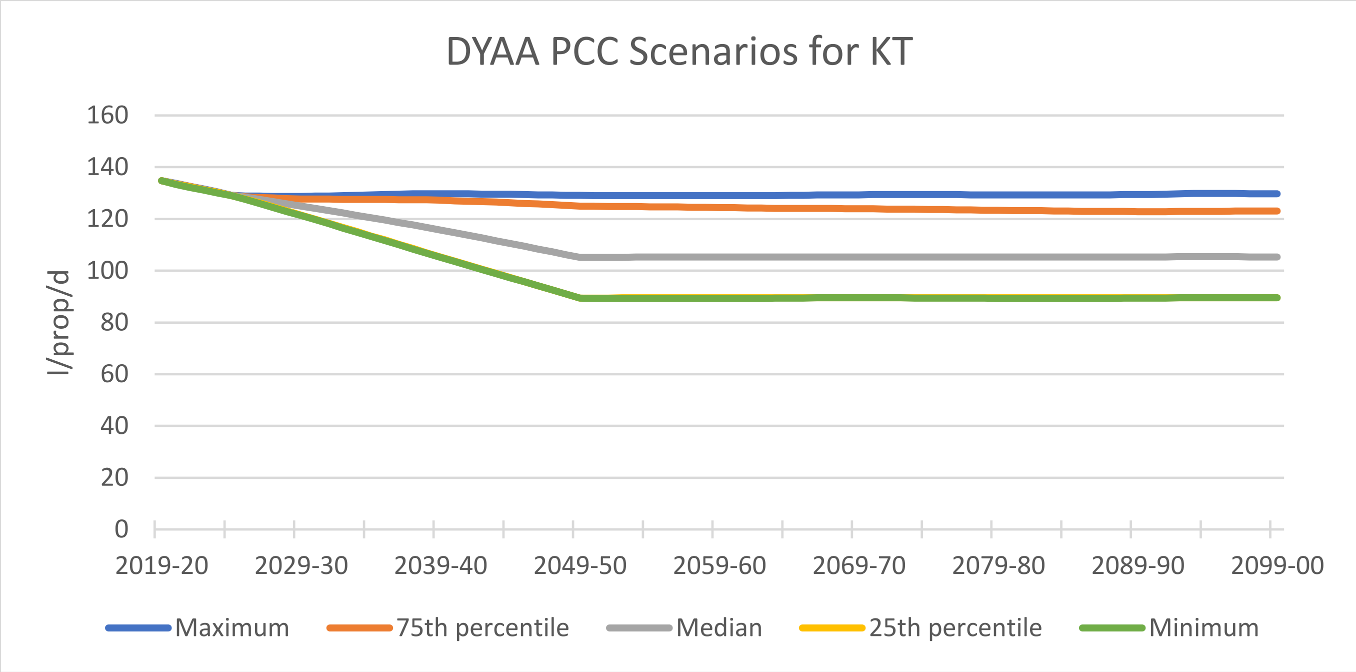



**Figure 111: Range of DYCP PCC results**

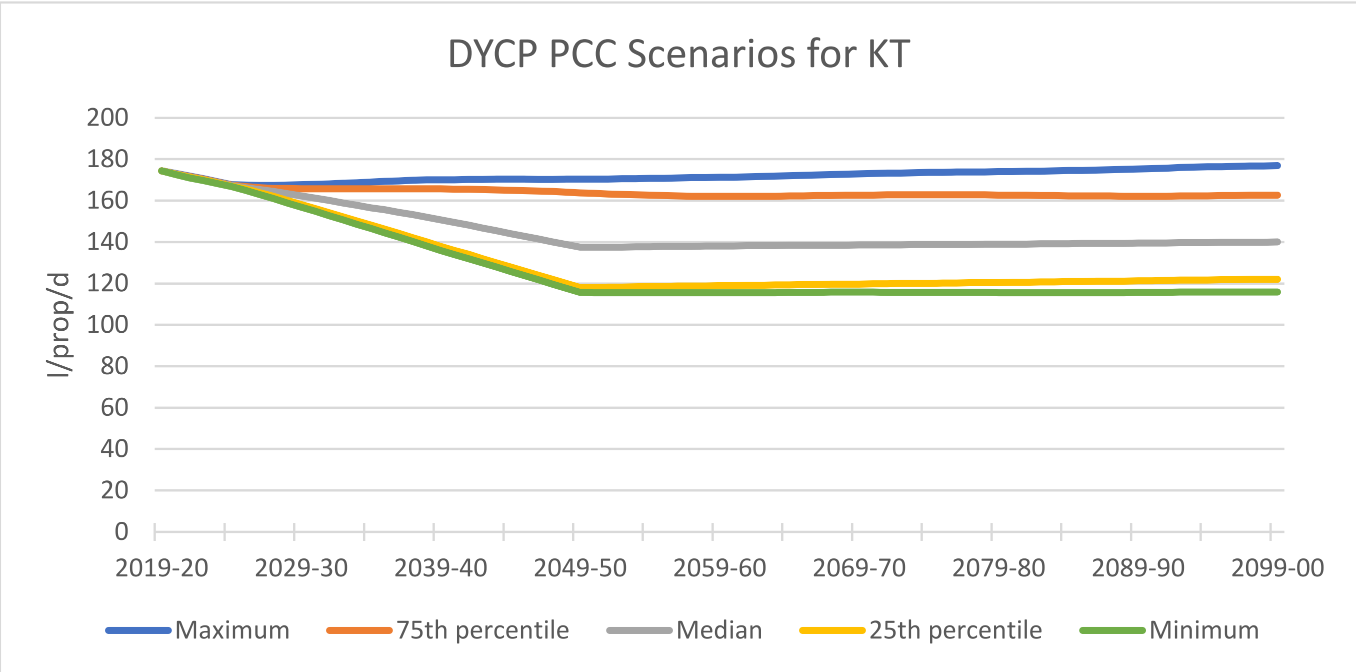
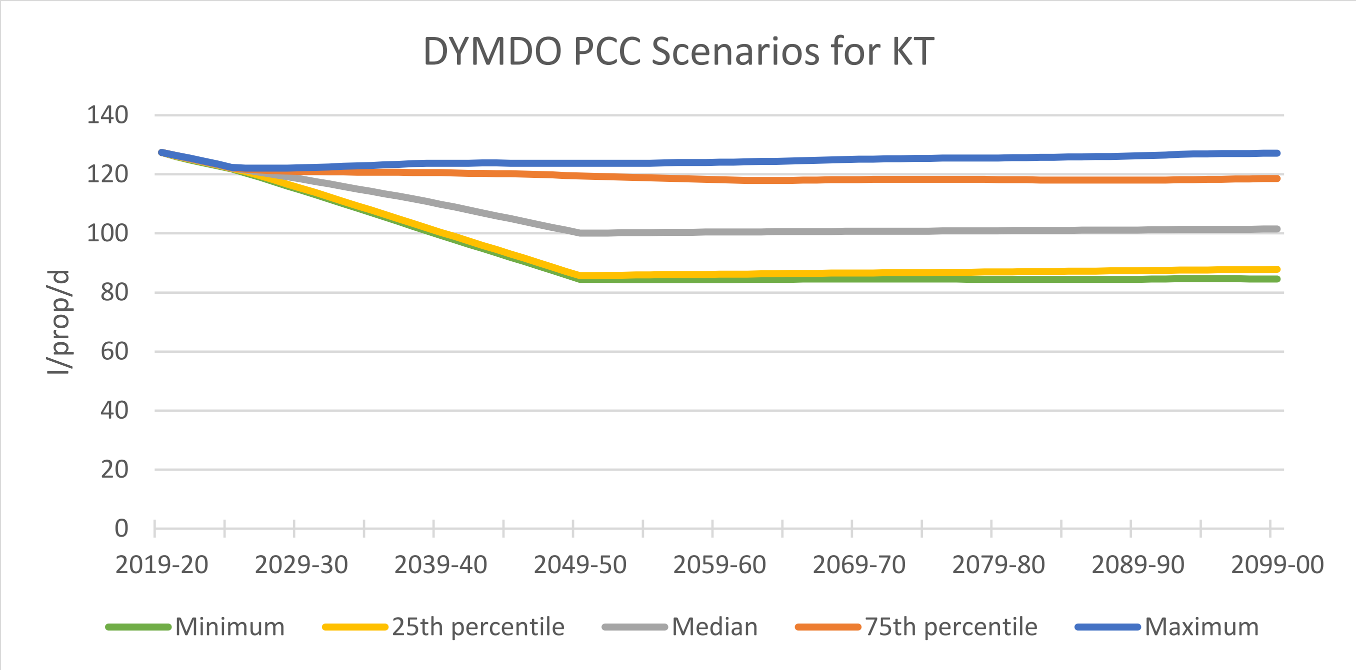


Figure 112: Range of DYMDO PCC results




## B.14. Sussex Hastings (SH)

Figure 113: Range of NYAA Distribution Input results

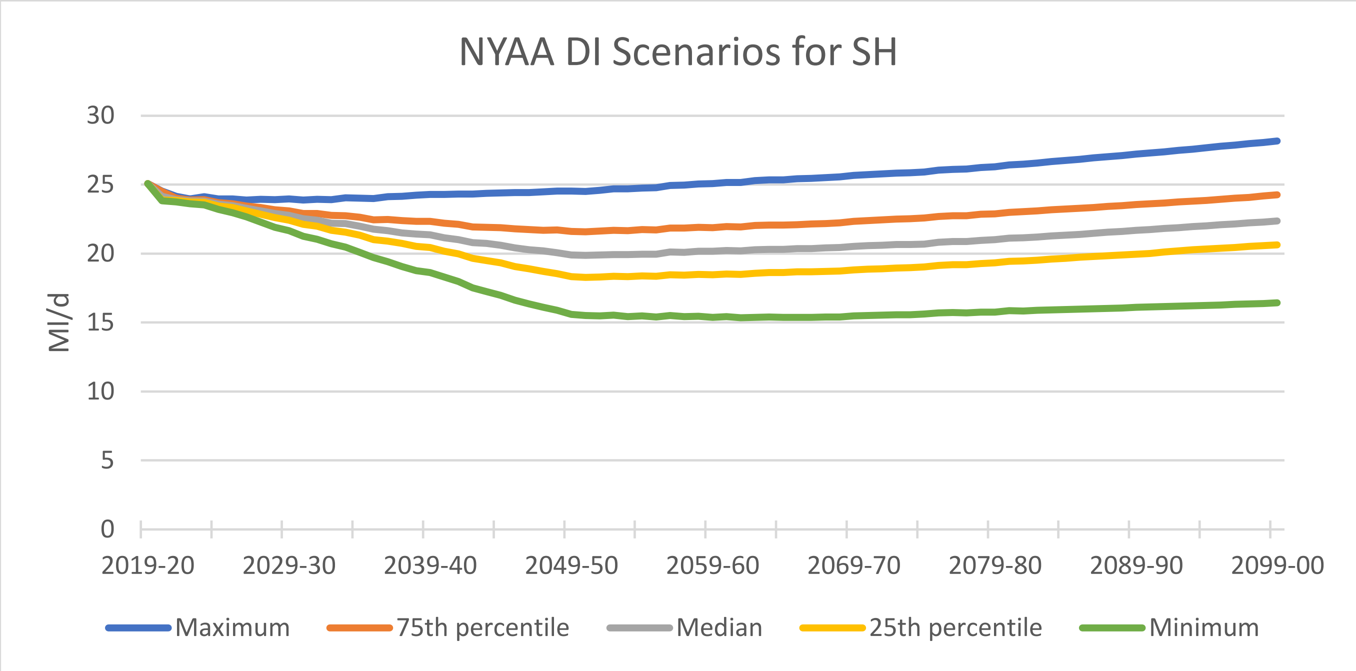


**Figure 114: Range of DYAA Distribution Input results**

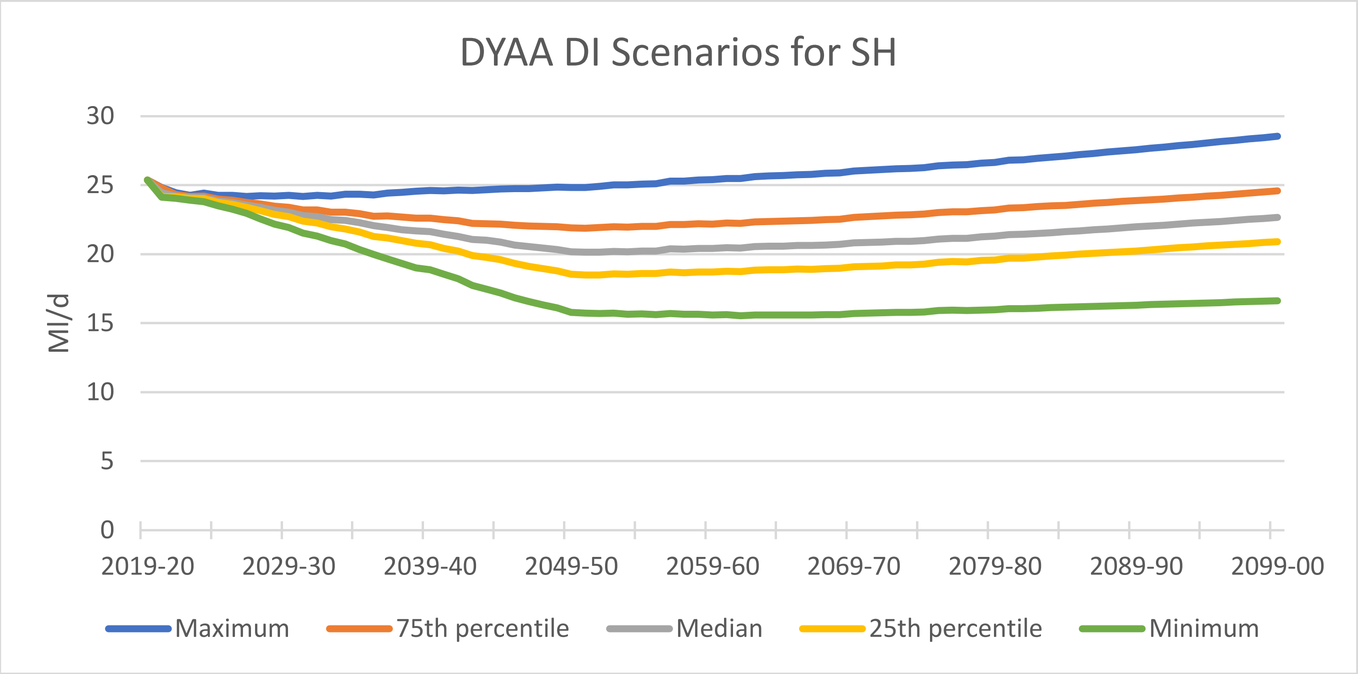



**Figure 115: Range of DYCP Distribution Input results**

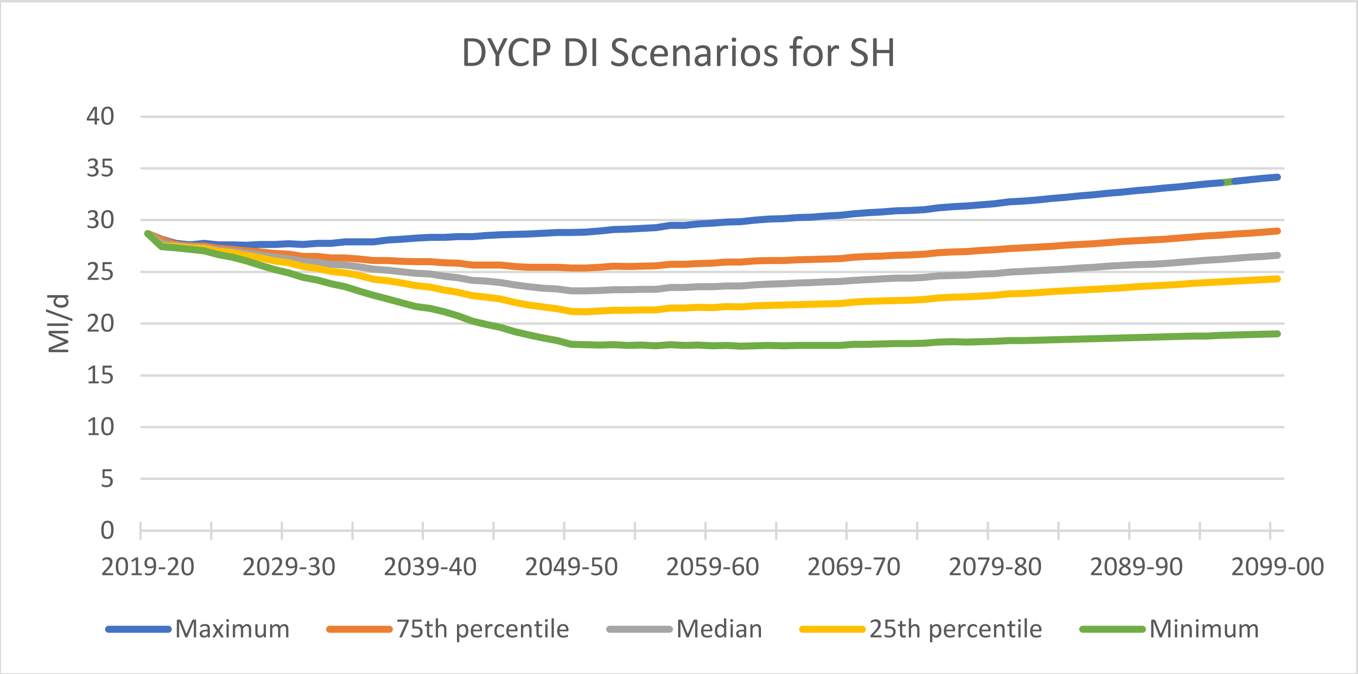


**Figure 116: Range of DYMDO Distribution Input results**

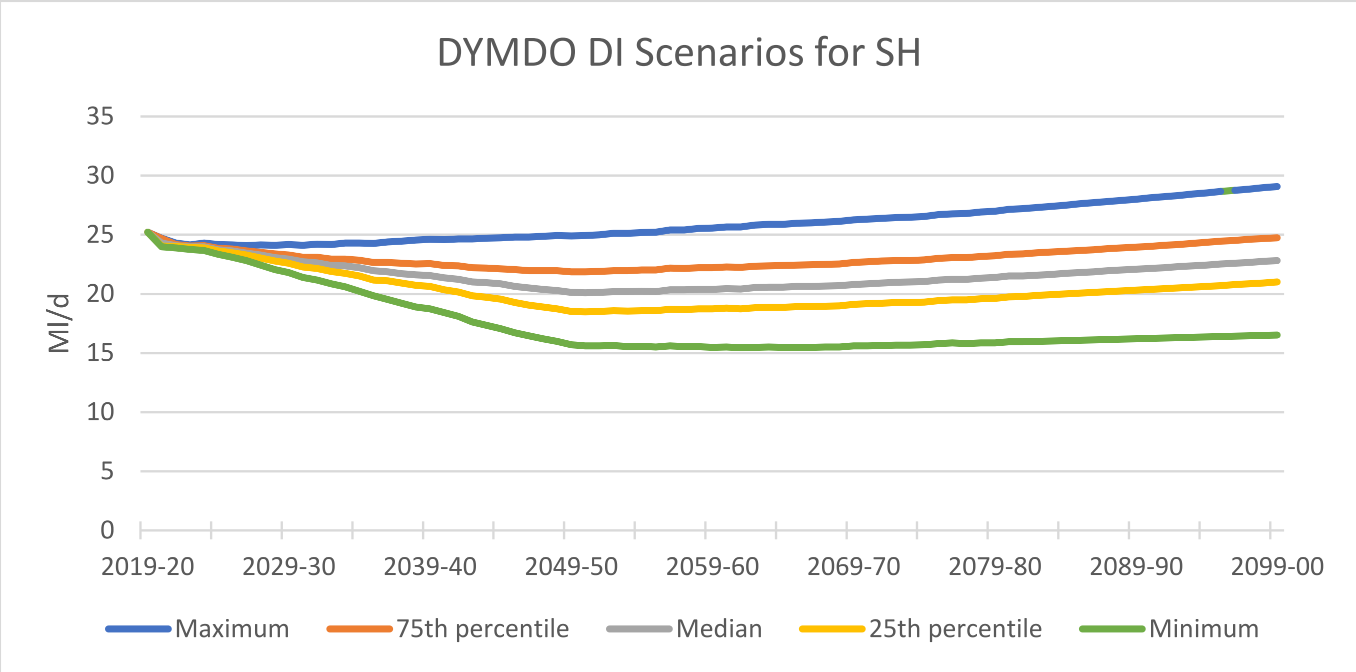



**Figure 117: Range of NYAA PCC results**

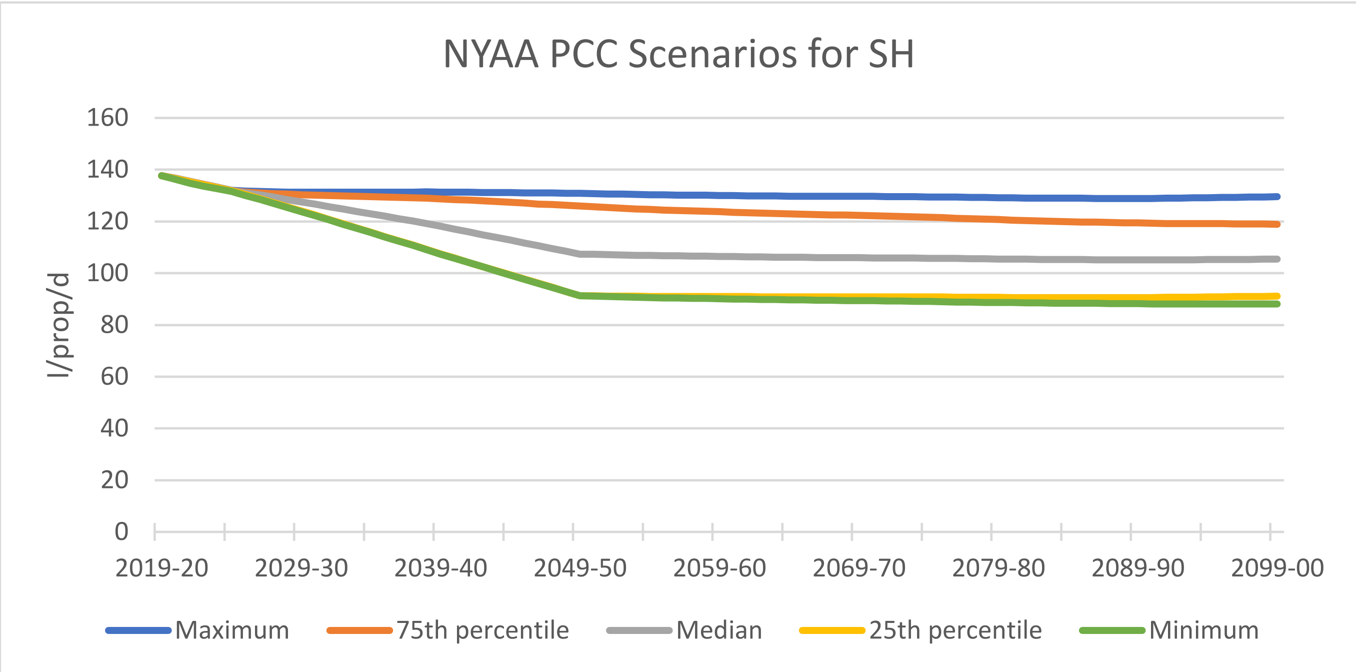


Figure 118: Range of DYAA PCC results

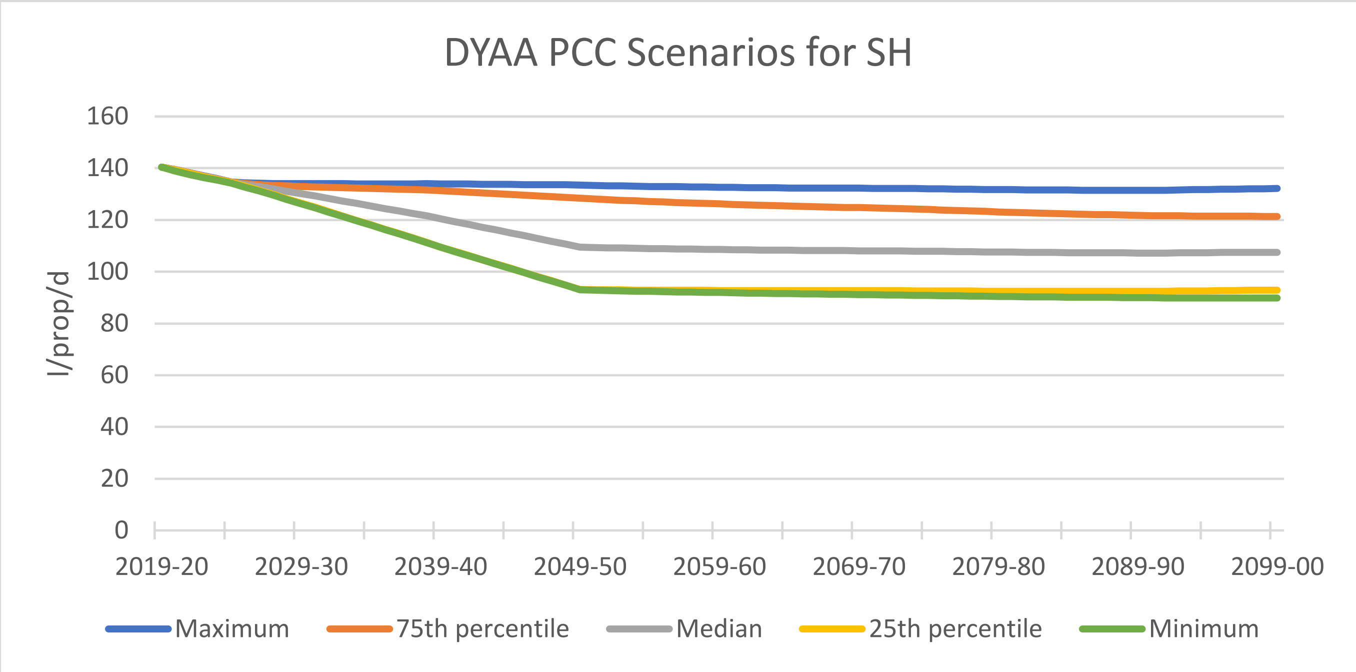



Figure 119: Range of DYCP PCC results

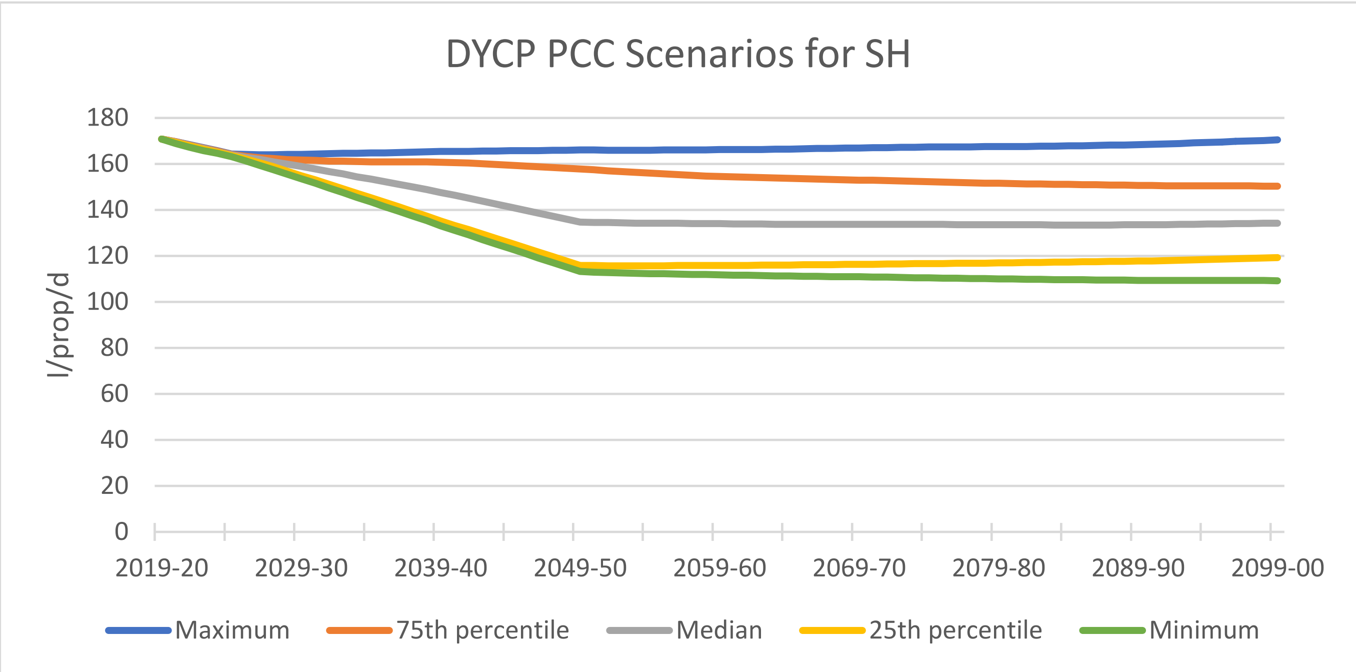
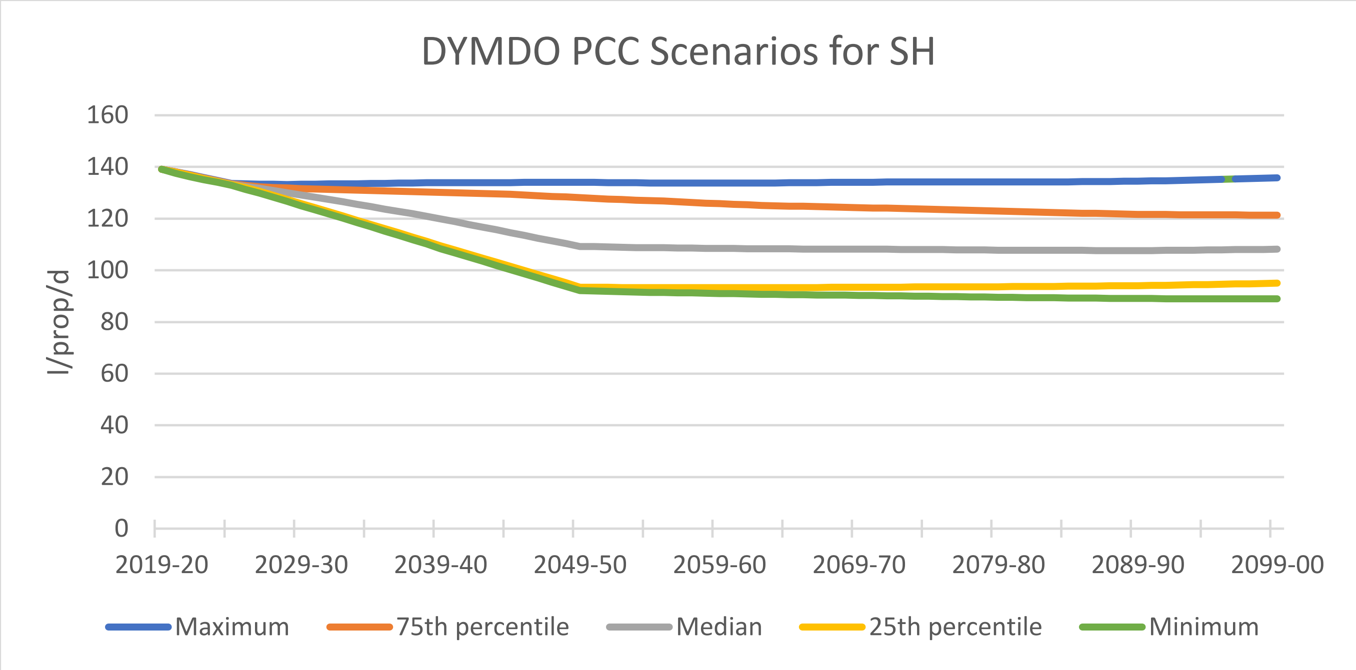


**Figure 120: Range of DYMDO PCC results**



# 4. Annex 7d: NHH Demand Forecast

# Water Resources South East – Southern Water

## Non-household demand forecasts 2020 to 2100

## Company report - Final

Project reference: 2467

Report number: AR1395

2020-12-14

www.artesia-consulting.co.uk

| | |
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| Date: | 2020-12-14 |
| Client: | Water Resources South East – Southern Water |
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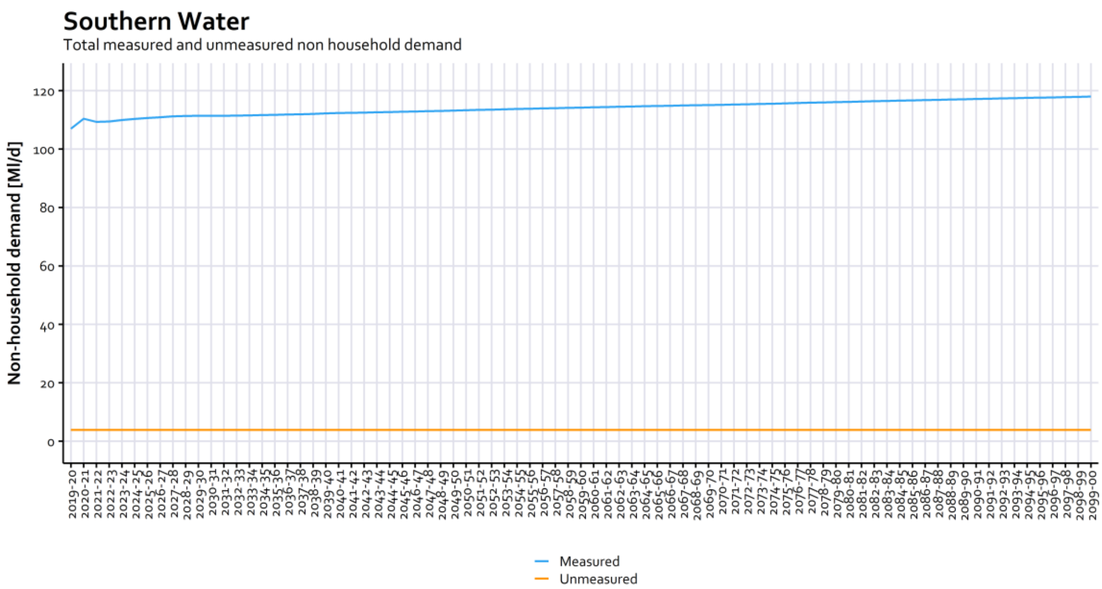
# Executive summary

Water companies in England and Wales are required to develop a Water Resource Management Plan (WRMP) under the Water Industry Act 1991 where they set out their plans to ensure that they will have sufficient resources to meet demand under different climate conditions over a minimum of 25 years. Forecasting future demand for water is a key part of the process and consumption by the non-household sector is a major component of demand. This report describes the initial development of the demand forecasts for non-households in the Water Resources South East (WRSE) region.

We have produced a set of non-household demand forecasts for all 37 water resource zones in the WRSE region from 2019-2020 out to 2099-2100. These are presented for metered and unmetered properties at company level, water resource zone level and dis-aggregated by industrial sector. The approach used follows existing industry best practice, taking into account the recommendations from a review of non-household demand forecasting methods carried out by WRSE in early 2020. Robust multiple linear models have been produced for 4 cohorts of industrial sectors for each company in WRSE, using explanatory factors that include population, gross value-added metrics, employment rates, population density and other factors. This report provides an overview of the WRSE results and detailed results for Southern Water.

The overall conclusion is that non-household demand in the Southern Water region at the start of the planning period (2025), is predicted to be 115 Ml/d within an overall range of 71 to 142 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL. By the end of the planning period the non-household demand is predicted to be 122 Ml/d (an increase of 7 Ml/d) within a range of 107 Ml/d to 207 Ml/d.




We have also made a prediction of the amount of non-public water supply (non-PWS) demand in the Southern Water region and how this might change over the planning period. For Southern Water, the current estimate of non-PWS non-household demand of 52.6 Ml/d in 2019-20 is predicted to increase to 64.1 Ml/d by 2050.

The first year of the forecast (2020) has seen an unprecedented change in non-household demand due to the policies introduced to combat the COVID-19 pandemic. This creates added uncertainty going forward as we still do not fully understand what the enduring impacts will be from changes in working practices, such as increased working from home. The sector also faces a number of future unknowns in demand from non-households, such as population change, Brexit, climate change and how water efficiency will be delivered in the non-household sector. Since the last set of non-household forecasts were completed for WRMP19, the non-household retail sector has undergone a transformation with the introduction of retail competition. We have observed a change in data quality and consistency since the change in 2017, which has complicated the modelling and has increased the uncertainty around the demand forecasts. Therefore, we have included all these factors in the scenario and uncertainty modelling.

We have presented the forecasts from a base year of 2019-20. The intermediate years 2020-21 through to 2024-25 are presented for information prior to the start of the planning period in 2025-26. These intermediate years are potentially volatile with a number of unknowns around the impact of the COVID-19 pandemic and the impact from Brexit on non-household consumption. Therefore, we recommend that the baseline and scenario forecasts are updated prior to the submission of the final water resource management plans.

During the course of the work, we have identified a number of improvements that could be implemented for future forecasts. These are included in the recommendations section of the report and cover: improving data quality, investigating different industrial sectors, looking at modelling WRZ groups by the way they behave as opposed to by company, and producing forecasts more frequently to reduce the step change transitions between forecasts every 5 years.

# Glossary

| Term | Description |
| --- | --- |
| A classification of residential neighbourhoods (ACORN) | This is a socio-demographic classification of neighbourhoods published by CACI Ltd. The system is based on the assumption that people who live in similar neighbourhoods are likely to have similar behavioural and consumption habits. |
| Abstraction | The removal of water from any source, either permanently or temporarily. |
| Active leakage control (ALC) | Management policies and processes used to locate and repair unreported leaks from the water company supply system and customer supply pipes. |
| Annual average demand | The total demand in a year, normally measured as the amount of treated water entering the distribution system at the point of production, divided by the number of days in the year. |
| Annual return | An annual report made to Ofwat by water companies to advise on progress within that Asset Management Period. |
| Asset management period (AMP) | Five-year period for which water companies are funded by Ofwat according to their Business Plans. |
| Base year | The first year of the planning period/horizon, forming the basis for the water demand and supply forecasting of subsequent years. |
| Baseline forecast | A demand forecast of customer consumption without any further water company intervention during the planning period. A baseline customer demand forecast should take account of: customer demand without any further water efficiency or metering intervention, forecast population growth, change in household size, changes in property numbers and the impact of climate change on customers' behaviour. Leakage in the baseline forecast should remain static from the start of the plan to the end of the planning period. |
| Business plan | Business Plans are produced by the water companies for Ofwat and set out the investment programme for the water industry. These plans are drawn up through consultation with the Environment Agency and other bodies to cover a five-year period. Ofwat accept the Business Plan following detailed scrutiny and review. |
| Capital expenditure (Capex) | Spending on capital equipment. This includes spending on machinery, equipment and buildings. Capital expenditure is also termed investment. |
| Central market operating system (CMOS) | This is the computer system that manages all the electronic transactions involved in switching customers and provides usage and settlement data which is used in the billing process. |
| Consumption monitor | A sample of properties whose consumption is monitored in order to provide information on the consumption and behaviour of households served by the company. |

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| Demand management | The implementation of policies or measures which serve to control or influence the consumption or waste of water (this definition can be applied at any point along the chain of supply). |
| Department for Environment, Food and Rural Affairs (Defra) | UK Government department with responsibility for water resources in England. |
| Deployable output (DO) | A measure of the available water resource during a drought year for a given level of service. |
| Distribution input (DI) | The amount of water entering the distribution system at the point of production. |
| Dry year annual average (DYAA) | The dry year annual average represents a period of low rainfall and unrestricted demand and is used as the basis of a water company's WRMP. |
| Dry year critical period (DYCP) | The generic term for the planning scenario which drives investment, i.e. at what point during the dry year (1 in 10 years severity of conditions) is the water supply most at risk of failing to meet planned levels of service. |
| Environment Agency | UK government agency whose principal aim is to protect and enhance the environment in England and Wales. |
| Final planning demand forecast | A demand forecast which reflects a company's preferred policy for managing demand and resources through the planning period, after taking account of all options through full economic analysis. |
| Mega litres per day (Ml/d) | One mega litre = one million litres (1,000 cubic metres) per day. |
| Meter optants | Properties in which a meter is voluntarily installed at the request of its occupants. |
| Micro-component analysis (MCA) | Detailed analysis of individual components of a customer's water use. |
| Non-households (NHH) | Properties receiving potable supplies that are not occupied as domestic premises, for example, factories, offices and commercial premises. |
| Normal year annual average (NYAA) | The total demand in a year with normal or average weather patterns, divided by the number of days in the year. |
| Operating expenditure (Opex) | Operating expenditure comprises day-to-day (planned and unplanned) routine expenses, which have no effect on the decline in service potential. |
| Optant metering | Customer led metering programme. |
| Peak demand | The highest demand that occurs, measured, either hourly, daily, weekly, monthly or yearly over a specified period of observation. |
| Per capita consumption (PCC) | The average annual consumption expressed in litres per person per day. Per capita consumption in an area is defined as the sum of measured household consumption and unmeasured household consumption divided by the total household population. |
| Per household consumption (PHC) | The average annual consumption expressed in litres per household per day. Per household consumption in an area is defined as the sum of measured household consumption and |

| | |
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| | unmeasured household consumption divided by the total number of households. |
| Planning period | An agreed look ahead period for which the WRMP is prepared. |
| Social tariff | Tariff where the customer charge takes into account factors such as household size, medical needs, income levels or if certain state benefits are claimed. |
| Statement of response | A document that is produced at the end of the public consultation period for the draft WRMP. The document outlines the comments received from customers and the changes that will be made to the draft WRMP as a result of these comments. |
| Supply pipe losses | The sum of underground supply pipe losses and above ground supply pipe losses. |
| Target headroom | Headroom is a margin of safety which serves as a buffer between supply and demand. Target headroom is the threshold of minimum acceptable headroom which would trigger the need for water management options to either increase water available for use or decrease demand. |
| Underground supply pipe losses | Losses between the point of delivery and the point of consumption. |
| Void property | A property connected to the distribution network but not charged because it has no occupants. |
| Water available for use (WAFU) | Deployable output – less any sustainability reductions – plus any bulk supply imports – less any bulk supply exports – less any reductions made for outage allowance. |
| Water resource zone (WRZ) | The largest possible zone in which all resources including external transfers can be shared, and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall. |
| Water resources management plan (WRMP) | A water company's plan for supplying water to meet demand over a 25-year period. |
| Water resource planning guidelines (WRPG) | Guidance produced by the Environment Agency for developing water resource plans. |

# Contents

# Figures

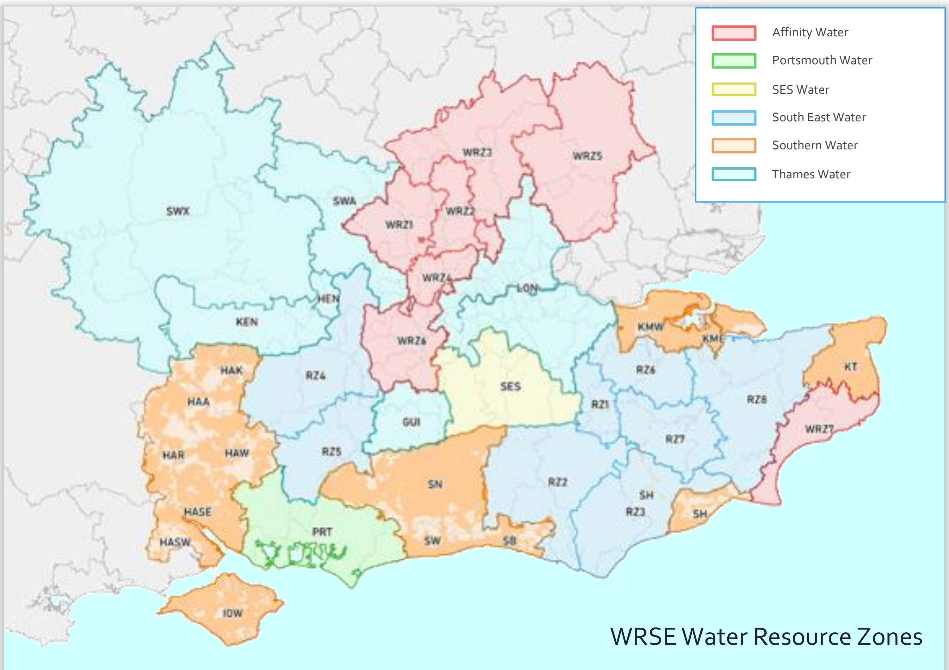
# Tables

# 1 Introduction

## 1.1 Background

Water companies in England and Wales are required to develop a Water Resource Management Plan (WRMP) under the Water Industry Act 1991 where they set out their plans to ensure that they will have sufficient resources to meet demand under different climate conditions over a minimum of 25 years. The plans are updated every 5 years. Forecasting future demand for water is a key part of the process and consumption by the non-household sector is a major component of demand. Robust assessment of future demand is a pre-requisite for developing credible and resilient plans. This report describes the initial development of the demand forecasts for non-households in the Water Resources South East (WRSE) region (Figure 1).

**Figure 1 WRSE region showing the 37 water resource zones**




WRSE is one of the five regional groups looking to provide strategic oversight and co-ordination of water resources within the context of the new National Water Resources Framework[1]. The aim of the regional groups is to build resilience to drought and other pressures in a cost-effective way, taking account of regional and inter-regional solutions.

WRSE will be producing a sustainable regional resilience plan later in 2020. This plan will inform the Water Resource Management Plans of each member water company within the WRSE alliance. It will set out the schemes, investments and other actions which companies and other stakeholders will need to take to deliver our shared objective. It will also link with

[1] Meeting our future water needs: a national framework for water resources. Environment Agency. 2020.

the other regional plans across England to form the national picture for water resources management.

## 1.2 Regulatory requirements

The Environment Agency sets out its expectations and guidance for non-household demand forecasts in the Water Resource Management Plan (WRMP24) Guidelines (WRPG, currently draft)[2]. Water companies are required to forecast the demand for water being used by non-household premises (such as businesses and industrial processes) and for the population living in communal establishments (for instance hospitals, prisons and educational establishments).

Since the last non-household demand forecasts were developed, the non-household market has been opened for competition. The definition of non-households should be in line with Ofwat's guidance on whether non-household customers in England and Wales are eligible to switch their retailer[3] [4]. For WRMP24, water companies are also expected to work with non-household customers to improve water efficiency where you believe there are savings to be made.

The broad needs of the regulators are:

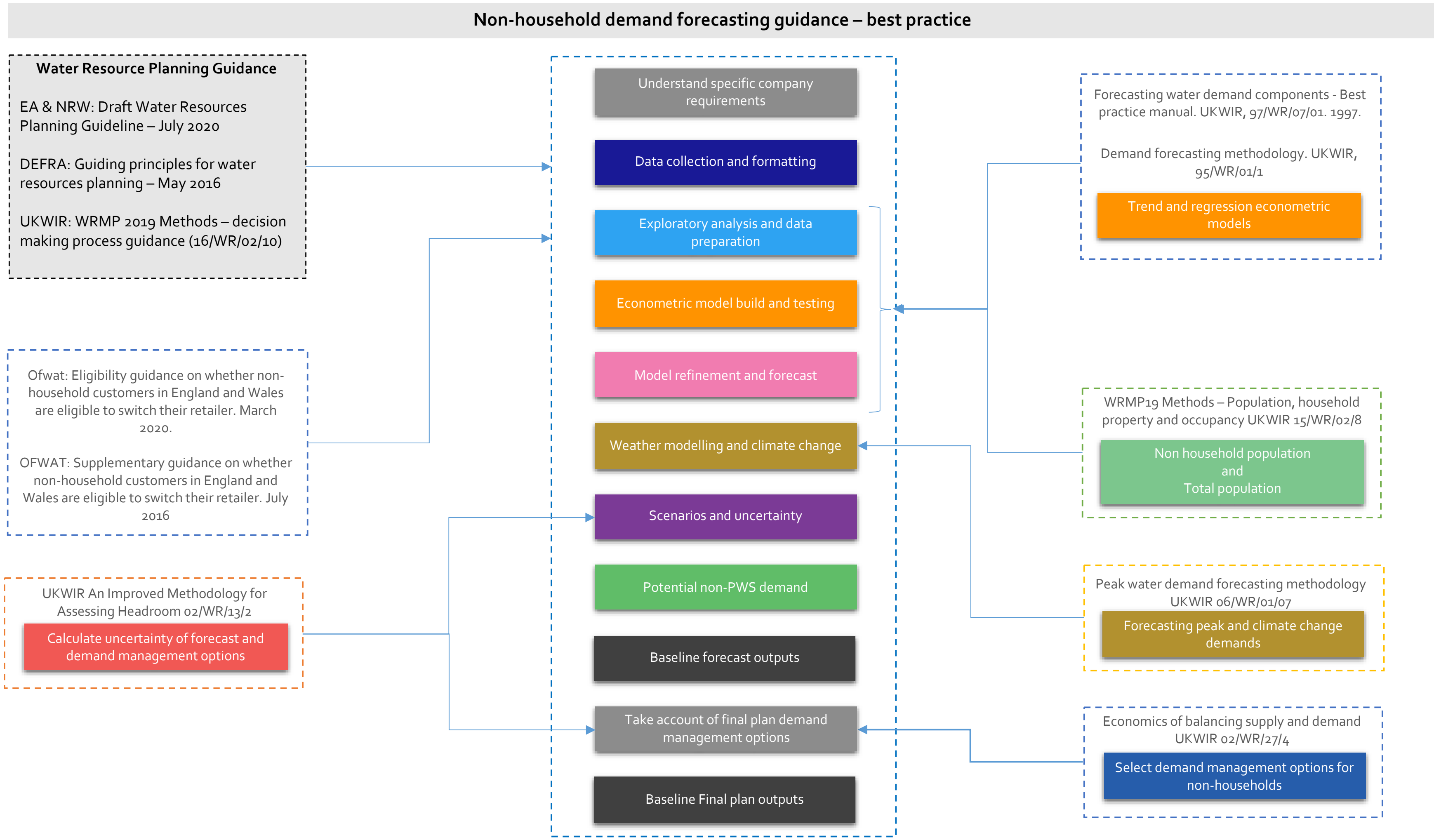
- A plan that contains an estimated demand forecast for non-households.
- To work with retailers and through regional groups (where applicable) to share information, data and expertise to ensure the forecasts and solutions are robust.
- A description of how figures and assumptions in the forecast have been derived.
- The plan makes use of the Market Operator Services Ltd (MOSL) system that stores retail company data as needed.
- The plan describes the makeup of non-household demand in different sectors either by using the service and non-service split (identifying the main sectors), or by using Standard Industrial Classification (SIC) categories published by the Office for National Statistics.
- We explain the existing water efficiency initiatives planned by both the wholesaler and retailer. The baseline forecast should reflect non-household demand without any further intervention.
- The final plan should include any forecast savings from water efficiency programmes.
- Consideration of non-household water efficiency as an option to manage the supply-demand balance.
- To consider any uncertainty associated with reducing demand and show how you will monitor the water efficiency programme and how the plan can be adapted if required
- That the plan considers the potential demand for other sources such as: agriculture and those on private water supply in a significant drought.

## 1.3 Best practice for developing non-household demand forecasts

There are a series of best practice documents in addition to the regulatory requirements, and an overview of these is presented in Figure 2.

[2] Water Resource Planning Guideline, draft for consultation July 2020. Environment Agency.
[3] https://www.ofwat.gov.uk/wp-content/uploads/2016/07/Eligibility-Guidance.pdf
[4] https://www.ofwat.gov.uk/wp-content/uploads/2016/03/pap_gud201607suppretaileligibility.pdf

**Figure 2 Non-household demand forecasting best practice overview**



## 1.4 WRSE requirements for the non-household demand forecast

### 1.4.1 Review of methods used in previous forecasts

Prior to updating the non-household demand forecasts, WRSE commissioned a study[5] to review the current methods used by water companies for non-household demand forecasts and compare them to the water resources planning guidance.

This study developed a number of conclusions and recommendations. The key ones in relation to the non-household forecasts for regional and WRMP24 planning are:

- The use of data derived from Central Market Operating System (CMOS); information from the previous billing systems is increasingly outdated and by 2024 the last year of non-MOSL consumption data will be 8 years old.
- Accounting for the potential impacts of water efficiency improvements due to the retail market, beyond long term trends are already present within the model.
- Any influences of the Covid-19 pandemic on long-term trends in non-household consumption should be included in the forecasts.
- All WRMP stakeholders need to recognise that the quality of CMOS data is an issue for non-household demand forecasting.
- There is a general risk associated with models developed from poor quality data producing inaccurate or misleading outputs. This is exacerbated when there are changes in data quality over time as the models may reflect changes in data quality, rather than trends in the underlying data.
- The following set of industry groupings would form a reasonable stratification that balances data limitations with separating out those industries likely to have different underlying drivers for non-household consumption:
    - Agriculture (and other weather dependent industries)
    - Non-service industries (excluding Agriculture)
    - Service industries – population driven
    - Service industries – economy driven
    - Unclassified
- An alternative stratification could be used if this is shown to provide a better model.
- Due to COVID-19 and an unusually hot spring/summer, it is clear that reporting year 2020-21 will be unusual in terms of both the macro-economic climate and non-household consumption. The important aspects to consider for non-household demand forecasting to support WRMPs and regional planning are any long-term impacts of the current recession and the growth trajectory thereafter.
- Climate change scenarios need to be included for Agriculture and any other industries where weather is shown to be a significant explanatory factor for consumption, to identify their impact on consumption.
- The national framework report also considers a low demand scenario with a 4% reduction in non-household consumption by 2050 compared to the base case. In the absence of further evidence, this would represent a reasonable assumption for a water efficiency scenario driven by Government policy to reduce water demand.

5 https://www.wrse.org.uk/media/h1nhiuyg/wrse_file_1345_wrse-non-household-demand-forecast-methodology.pdf

- WRSE member companies should in general adopt a standard set of scenarios and assumptions regarding economic growth, except where there are specific issues to a particular area of supply that need to be accounted for.
- WRSE member companies should use the information within the UK Climate Projections (UKCP18) datasets to develop scenarios of climate change for incorporation where weather is shown to be a significant influence on consumption.
- WRSE member companies should identify whether there are any major customers that should be treated separately because they have a significant impact on the supply-demand balance for a Water Resource Zone (WRZ). It may be appropriate to model scenarios related to these customers if they are likely to impact on the preferred option selection.

### 1.4.2 WRSE specific requirements

Following the recommendations from the review of current non-household demand forecasts (section 1.4.1), WRSE developed a specification for the initial non-household demand forecast. The scope of this work was to develop a non-household demand forecasting model and produce a non-household demand forecast for the period 2025-2100 that is fully compliant with the WRPG. The key tasks carried out against this requirement are described below.

***Segmentation of customers and base year demand***

The WRPG requires segmentation of non-household customers into appropriate industrial sectors and forecasting demand separately for each sector, taking account of the factors that affect demand in the sector. The review commissioned by WRSE (see section 1.4.1) has recommended the following five segments for this purpose.

- Agriculture and other weather dependent sectors
- Non-service industries (excluding agriculture and other weather dependent sectors)
- Service industries – population driven
- Service industries – economy driven
- Unclassified.

The source data for this work comes from the Central Market Operating System (CMOS) operated by Market Operator Services Ltd (MOSL) for the period 2017 to 2020. MOSL has regulated the non-household sector since the separation of household and non-household water retail services on 1 April 2017. Additional data from the pre-MOSL period has also been used to develop longer term trends in historic non-household consumption data.

Standard Industrial Classification (SIC) codes are a convenient way of the sub-dividing customers into sectors, especially when the nature of the business cannot be directly inferred from the business name. However, the SIC code data within CMOS dataset is neither complete nor entirely accurate. Several companies have datasets which use AddressBase Classifications for industry sectors, and these have been used to augment or cross check the SIC classifications.

In the process of segmenting the non-household consumption into the industrial sectors described above, we have attempted to keep the number of customers in the 'unclassified' segment as low as possible, ideally not exceeding 20% in any WRZ. In some instances, this has not been possible due to the nature of the data provided and we have described these cases in the following sections.

Non-household demand in certain WRZs may primarily be driven by a single customer. Examples include airports, universities and large manufacturing units. We have attempted to identify these and exclude them from the modelling. This is not always possible due to water companies' different policies on data protection, and also where consumption data is provided already aggregated into sectors. In these cases, we have developed alternative means for excluding large customers, and these are described in subsequent sections.

The base year for this initial forecast is 2019-20 and all companies have calculated non-household demand in each WRZ for annual regulatory reporting. Once segmentation of the customers and modelling was completed, we rebased the base-year consumption to the annual reported volume for 2019-20.

***Identify explanatory factors for each customer segment***

We have identified the key factors that influence demand in the sector and derived historic and predicted values for these factors from:

- Oxford Economics (region specific gross value added and employment)
- Edge Analytics (Population predictions)
- Water companies (historic population data and property data).
- Office of National Statistics (Population density).

***Assess the impact of climate change***

We have assessed the impact of climate change on the demand by various sectors and developed scenarios that include climate change impacts on demand.

***Assess the impact of water efficiency***

A key objective behind creation of a separate retail market for non-household customers was to promote water efficiency. There is limited evidence to suggest water efficiency in the non-household sector has improved beyond historical trends since market separation (see section 1.4.1). We have therefore included the recommended 4% reduction in demand by 2050 (in line with the National Framework[6]), and also included a range of other glidepaths in alternative scenarios.

***Assess demand by other sectors***

Going forward, water companies are expected to take account of demand by sectors that do not currently take water from public water supplies (PWS) but may be required to do so in case of severe droughts and/or climate change. Wood plc have recently completed a study[7] on behalf of the Environment Agency that has looked at demand by other sectors.

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

[7] Understanding future water demand outside of the water industry, Defra, 28/02/2020

There are however gaps in the Wood report and we have carried out additional analysis to supplement the report with additional information and provided estimates of demand by other sectors at the WRZ level.

***Develop a demand forecasting model***

We have then developed a demand forecasting model that brings together outputs from the tasks above and allows demand for each sector to be forecast over the planning period. The model:

- Has been developed at the company and WRZ level and aggregated regional level for each sector.
- Includes multiple scenarios that have been generated to take account of uncertainties in various assessments.
- Has been developed to be fully transparent and able to withstand scrutiny at a public inquiry.
- The outputs have been incorporated into a commonly used tool that allows companies to select the various outputs and scenarios at different levels. We are in discussion with WRSE about how best to make the model available in an open way to the WRSE group.

***Recommend improvements***

As we have gone through the tasks above and analysed the data, we have identified a number of areas where the modelling, forecasting and outputs can be improved going forward. These are explained and in the recommendations section.

# 2 Methodology

This section provides additional details on the methodology we implemented to meet the requirements detailed in section 1.4.2.

## 2.1 Data collection and formatting

A consistent data requirement specification was provided to each of the companies is WRSE.

| Ref | General data requirements | Data type |
|---|---|---|
| 1 | Data transfer preferences (e.g. email, SharePoint, DropBox, etc.) | Information |
| 2 | Key data contact | Information |
| 3 | Forecast granularity | Information |
| 4 | Number of areas | Number |
| 5 | Base year | Year |
| 6 | Population (total) forecasts by WRZ (from Base Year) | Population |
| 7 | Non-HH property forecasts by WRZ (from Base year) - Split measured and unmeasured | Property |
| 8 | Historic annual return: non-HH property numbers split by measured and unmeasured by WRZ | Property |
| 9 | Historic annual return: total population numbers by WRZ | Population |
| 10 | Pre 2017 annual non-HH consumption data (per property or per segment or industry code) | Consumption |
| 11 | 2017 to 2020 annual non-HH consumption data (per property or per segment or industry code) | Consumption |
| 12 | Data to link non-HH consumption to industry code (SIC, ABP or Land Registry) | Data link |
| 13 | Data to link non-HH consumption to WRZ | Data link |
| 14 | Weather data for each WRZ: Monthly (or finer) mean temperature and mean rainfall | Weather |
| 15 | GVA and employment data by WRZ and industry segment (historic and forecast) | Economic Activity |
| 16 | Historic annual return consumption data up to and including base year | Consumption |
| 17 | Base year consumption data for each property linked to WRZ and Segment (may be included in Ref. 11) | Consumption |
| 18 | Climate change scenario predictions for temperature and rainfall | Climate |
| 19 | Scenario trend data | Trend |
| 20 | Non-PWS demand predictions | non-PWS |
| 21 | WRMP19 non-household consumption forecast outputs | Information |

Each of the water companies provided data against these requirements. This data was assessed and formatted consistently for each company and water resource zone. Some companies had missing data, or different levels of granularity/length of time series. These differences were captured and discussed with relevant persons from the water companies. Additional data was collected where possible if gaps were identified. In some cases, full data was not available, and in these cases amendments to the process were agreed.

## 2.2 Exploratory analysis and data preparation

The outputs from the exploratory analysis and data preparation, were a set of consistent data frames. These consisted of:

- Segmented consumption
- Explanatory variables
- Annual return data

### 2.2.1 Consumption data

### Data granularity

Consumption data was provided by companies at either individual property level or aggregated to industry classification (normally SIC[8] or AddressBase[9]). Table 1 shows the breakdown of how the data was provided by company.

**Table 1 Consumption data granularity**

| Company | Consumption data granularity |
|---|---|
| **Affinity Water** | Property level |
| **Portsmouth Water** | Aggregated to SIC level |
| **SES Water** | Property level |
| **South East Water** | Property level |
| **Southern Water** | Property level |
| **Thames Water** | Property level |

### Voids and large users

If consumption data was provided at property level, and if we received data on which properties were void, we could exclude void data from the modelling stage. Having consumption data at property level also allows us to also identify and exclude large users, which may have a significant impact on consumption at WRZ level. Some companies provided us with data on specific large users. We were able to use this to determine a consumption threshold value above which we could classify users as a large user. We determined that this threshold should be set at 2%, i.e. if a single user consumes greater than

[8] https://www.gov.uk/government/publications/standard-industrial-classification-of-economic- activities-sic
[9] https://www.ordnancesurvey.co.uk/business-government/products/addressbase-premium

2% of the WRZ non-household consumption then we would flag this property as a large user. Table 2 highlights which companies could have voids and large users excluded.

**Table 2 Inclusion of voids and large users**

| Company | Voids | | Large users | |
|---|---|---|---|---|
| | Include | Exclude | Include | Exclude |
| Affinity Water | | x | | x |
| Portsmouth Water | x | | x | |
| SES Water | x | | x | |
| South East Water | | x | | x |
| Southern Water | x | | | x |
| Thames Water | x | | | x |

## Data checks

Data quality checks were performed, looking at the following:

- Proportion of properties that were unclassified or unmatched to a SIC group, split by year.
- Percentage of reported (annual return) volume that is contained within either the classified or unclassified consumption data.

### 2.2.2 Population data

Population forecast data and annual return by year and WRZ are imported and combined to create a joint population dataset. Populations for overlapping years (2019-20) for both historical and forecast data are compared to check data accuracy.

For the baseline population we use Housing Plan - P.

### 2.2.3 Industry sector mapping

SIC groups or AddressBase classifications are mapped to industry grouping using various mapping files, we developed mapping files for SIC_1980, SIC_1992, SIC_2003, SIC_2007 and

AddressBase. These were then used to group the properties' consumption into the industrial sectors shown in Table 3.

**Table 3 Industry groupings**

| Industry grouping | SIC_2007 sections | Reference |
|---|---|---|
| Agriculture (and other weather dependent industries) | A | 1 |
| Non-service industries (excluding Agriculture) | B, C, D, E, F | 2 |
| Service industries – population driven | O, P, Q, R, S, T | 3 |
| Service industries – economy driven | G, H, I, J, K, L, M, N | 4 |
| Unclassified | | 5 |

Table 4 shows the proportion of properties and the proportion of consumption for each company that falls into each of the industry groupings identified in Table 3.

**Table 4 Proportion of properties and consumption in each industry group by company (2019-20)**

| Company | Industry grouping | Proportion of properties in group | Proportion of consumption in group |
|---|---|---|---|
| **Affinity Water** | Agriculture | 1% | 1% |
| | Non-service | 4% | 4% |
| | Service – population | 10% | 17% |
| | Service – economy | 46% | 28% |
| | Unclassified | 39% | 50% |
| **Portsmouth Water** | Agriculture | NA | 12% |
| | Non-service | NA | 22% |
| | Service – population | NA | 27% |
| | Service – economy | NA | 37% |
| | Unclassified | NA | 2% |
| **SES Water** | Agriculture | 2% | 2% |
| | Non-service | 14% | 14% |
| | Service – population | 26% | 26% |

| | | | |
|---|---|---|---|
| | Service - economy | 55% | 55% |
| | Unclassified | 3% | 3% |
| **South East Water** | Agriculture | 13% | 13% |
| | Non-service | 15% | 15% |
| | Service – population | 65% | 66% |
| | Service – economy | N/A | N/A |
| | Unclassified | 8% | 6% |
| **Southern Water** | Agriculture | 3% | 3% |
| | Non-service | 9% | 10% |
| | Service – population | 34% | 35% |
| | Service – economy | 45% | 39% |
| | Unclassified | 9% | 13% |
| **Thames Water** | Agriculture | 2% | 3% |
| | Non-service | 5% | 7% |
| | Service – population | 18% | 27% |
| | Service – economy | 29% | 31% |
| | Unclassified | 46% | 34% |

### 2.2.4 *Weather data*

Compiled weather data is loaded with average daily rainfall and average maximum temperature by year.

### 2.2.5 *Econometric data*

Econometric data was provided by Oxford Economics (OE). This data is formatted into employment and gross value added (GVA) by SIC group and region. All WRSE companies currently use the "South East" region, with the only exception being Thames Water where the London WRZ uses the "London" OE region. Historic data was provided from 1991, and forecast data was provided to 2040.

### 2.2.6 *Data collation*

A maximal theoretical dataset was created by creating all combinations of year (from OE, weather, consumption, and population datasets), WRZ (weather, consumption, and population) and SIC/industry groups (consumption), with all variables joined to these where available.

This is then aggregated to industry grouping level, with group-specific numerical variables summed (consumption, employment, GVA) and other numerical variables re-joined at aggregated level (weather and population).

Both the SIC and industry grouping aggregation datasets are output for use in subsequent modules.

## 2.3 Model build, testing and refinement for baseline forecasts

### 2.3.1 *Non-household forecast modelling*

The non-household forecast modelling is carried out in line with best practice[10] and takes into account the findings of the WRSE review of non-household demand forecasts (section 1.4.1).

Choosing the right modelling process is a complex task that needs to take into consideration statistical model performances, but also many other variables that require the modeller's expert judgement (availability of variables, reliability of data, overfitting problems, and more). Therefore, the modelling process is based on offering all the statistical tools to the modeller, who then takes a decision based on all considered aspects.

The non-household (NHH) forecast modelling process is divided in the following steps:

1. Build the MLR model based on past aggregated consumption data, considering Oxford Economic variables and potentially other factors.

2. Calibrate the model for the base year, in this case 2019-20, first by industry sector using the property consumption data, then by WRZ using the Annual Return (AR) consumption.

3. Apply the MLR model and the calibration to future explanatory variables to estimate future NHH consumption.

The MLR modelling is done at company level, but considering industry groups independently. Calibration is instead performed at WRZ level.

At each stage adjustments and improvements can be made specifically for each company, depending on the specifics of the data. Therefore, in Appendix A there is a complete modelling report for Southern Water which identifies all the specific modelling details.

### 2.3.2 *MLR modelling*

Multi linear regression (MLR) modelling aims at finding a linear relationship between the observed consumption and explanatory variables. At first, all available explanatory variables are considered. Subsequently, the model is refined choosing only the significant variables. The choice is based on:

- model performances excluding the variables one by one
- interaction between variables

[10] Forecasting water demand components - Best practice manual. UKWIR, 97/WR/07/01. 1997.

- logical inclusions/exclusions based on the relationship between the expected effect of each variable on consumption, and the estimated coefficients
- exclusion of outliers
- other modellers' considerations.

Southern Water specific results for each MLR model for each industry sector are included in Appendix A and include the following:

- model term
- estimate
- standard error
- p value.

### 2.3.3 Calibration

The MLR model is based on MOSL data in the base year, which may not represent the total annual reported NHH Measured consumption. For this reason, the results of the model need to be calibrated against the Annual Report data for the base year, in this case 2019-20. This also helps account for differences between WRZ, not accounted for building the model at company level.

To ensure the proportion between different sectors is maintained, the calibration has been further refined:

- First, modelled consumption is calibrated against property consumption for each industry group and WRZ, deriving an additive factor,

- Then the total measured consumption is calibrated against AR data at WRZ, deriving a multiplicative factor.

Appendix A includes the calibration factors for Southern Water and each WRZ for each industry sector.

### 2.3.4 Baseline forecasts

Final NHH baseline forecasts are obtained separately for the measured and the unmeasured component.

For the measured component, NHH is forecast with the following steps:

- apply the MLR model separately for each industry group and WRZ,

- apply the two-step calibration,

- forecasts are then extended from 2040-41 to 2099-00 using a combination of the trend along with modelling using the population, depending on the presence of population in the baseline model, as follows:

  - where population is not present in the baseline model, then the forecast is kept constant after 2040-41

  - where population is used, either alone or in combination with other variables in the baseline model, then a new simpler linear model is used to find a relationship between the consumption forecasted between 2025-26 and 2040-41 and the population forecast for the same years. The linear model is then used to forecast consumption between 2040-41 and 2099-00.
- minimum consumption is set to 10% of the observed years' average, with exclusion of 2020-21 that is allowed to go to zero considering the COVID crisis.

A simpler approach is followed for unmeasured non-household demand, as this is a minor component of the total non-household consumption. Unmeasured forecasts are obtained extending the base year unmeasured consumption as reported in the AR up to 2040. Then the extension from 2040-41 to 2099-00 is achieved using the same total company trend used for all other components.

The forecast outputs are presented and discussed in Appendix A, and a summary of the WRSE high level company outputs are presented in section 3.1.

## 2.4 Scenarios and uncertainty

### *2.4.1 Introduction*

The concepts of uncertainty and scenarios are often used interchangeably and partially overlap in terms of meaning. Both represent unknowns that may affect water consumption forecasts. For the purpose of the WRMP24 non-household demand forecasts we need to separate the concepts through definitions:

- **Uncertainty** refers primarily to the variability we have in forecasts due to data uncertainty and unexplainable variability uncertainty. Uncertainty is non-zero even in the present figures and grows with time in a gradual way, due to uncertainty propagation. Uncertainty can be described by probability distributions and derived statistics, like mean, standard deviation, or quantiles.
- **Scenarios** refer to the variability in future projections due to foreseeable (at least in terms of happening) events. Scenarios' variability is only applicable to future figures, not to the present, and can grow or decrease in time according to the specific events we are considering. Scenarios are usually represented by a discrete number of alternative forecasts.

As the WRMP24 non-household (NHH) forecasts are derived through a complex process, the sources of uncertainty can be many and very little is known about the quantification of uncertainty. Similarly, the number of factors that can affect NHH water consumption can be large and unexpected events and technologies may alter the way we will consume water; therefore, it is very difficult to consider all plausible scenarios.

In this work, we introduce some approximations to overcome the unknown quantification and the technical limitations involved in modelling both the uncertainty and the scenarios. We first proceed in delineating a large number of foreseeable scenarios, from which we derive plausible central, lower and upper thresholds. Then we proceed in applying uncertainty estimations for quantifiable factors on the three selected thresholds.

Details on the scenarios' definition and the uncertainty quantification are reported in following sections.

### 2.4.2 Modelling scenarios

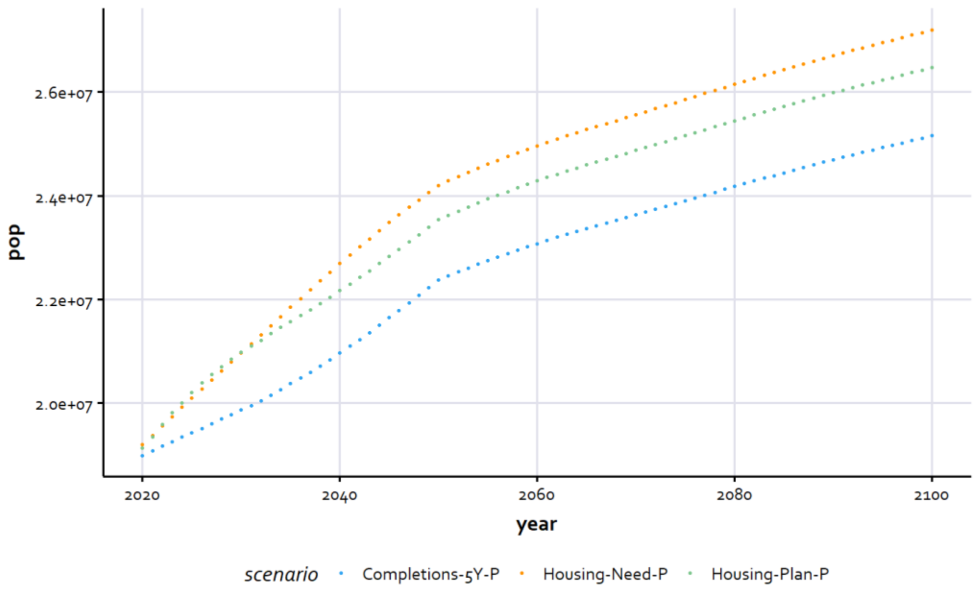
The scenarios represented in the WRMP24 NHH forecasts are chosen based on scenarios that are likely to happen in the short and long term and considering how these may quantitatively affect the NHH water consumption forecasts. We consider six factors, each represented by an upper, central and lower scenario. All combinations are tested, resulting in $3^6$ scenarios, i.e. 729 individual scenarios.

## Population scenarios

Population scenarios are chosen from the 72 Edge Analytic population forecasts. The scenario used for the baseline, Housing-Plan-P, is already on the upper range of Edge Analytic population scenarios. To maintain it the central scenario, to keep a balanced forecast, and to keep the risk-adverse approach, three scenarios on the upper spectrum are selected and these are shown in Figure 3:

- Population upper scenario: Housing-Need-P
- Population central scenario: Housing-Plan-P
- Population lower scenario: Completion-5Y-P

**Figure 3 Three population scenarios are chosen from the 72 Edge Analytic scenarios**




## Brexit

At the moment of writing this report, the United Kingdom has left the European Union and is in the transition period for which the majority of EU regulations are maintained, while the government negotiates an exit deal. The outcome of such negotiations is expected to impact the economy and the immigration scenarios for both the short and the long term. However, the short-term forecasts consider both Brexit and Covid-19 impacts on the economy, and these two factors are difficult to separate. So, we decided to apply only the long-term impacts for the Brexit scenarios, as the short-term effects are already represented in the three COVID-19 scenarios.

NHH water consumption is modelled considering GVA, employment and population among other factors, and these factors are the ones impacted by Brexit.

The impact on population is estimated from Lomax, 2019[11], considering the percentage variation between the three reported Brexit scenarios: EU-membership, soft Brexit and hard Brexit. Considering our baseline as the middle scenario, we can consider a change in population of +2.6% by 2040 under the upper Brexit scenario, and a decrease of -2.6% under the lower Brexit scenario.

For employment estimates, we considered the HM Government report *HM Treasury analysis: the long-term economic impact of EU membership and the alternatives*[12], which states that "unemployment would reach 7% to 8% in 2020, compared with a projected rate of 5% if the UK remained in the EU". Assuming our estimates correspond to the central, we can consider a variability around 3%, so +/- 1.5% for the upper and lower scenarios. Not having further temporal information, we keep this steady in time.

In terms of GVA (proportional to GDP if fixed taxation is assumed), the report proposes wider ranges, going between 1.2% and 2.8%, considering the uncertainty. For consistency we consider 1.5% like for the employment estimates. The summary of Brexit impacts is presented in Table 5.

**Table 5 Brexit scenarios and their impact**

| | Population | GVA | Employment |
|---|---|---|---|
| **Upper Brexit scenario** | +2.6% by 2040 | +1.5% fixed | +1.5% fixed |
| **Central Brexit Scenario** | baseline | baseline | baseline |
| **Lower Brexit Scenario** | -2.6% by 2040 | -1.5% fixed | -1.5% fixed |

## *COVID-19*

COVID-19 has had a strong negative impact on the economy and on NHH water consumption, due to lockdown measurements and economic recession, as well as due to remote-working measurements. At the time of writing this report, a vaccine is estimated to be available in 2021, and the impact of the pandemic is expected to gradually reduce after. The impact of COVID-19 is modelled in three different ways:

[11] Lomax, N., Wohland, P., Rees, P. & Norman, P. The impacts of international migration on the UK's ethnic populations. J. Ethn. Migr. Stud. 46, 177–199 (2019).

[12] HM Government. *HM Treasury analysis: the long-term economic impact of EU membership and the alternatives*, 2016, Cm 9250, Web ISBN 9781474130905

1. GVA and Employment are modified on the short term, according to the expected impact on the economy.
2. Water consumption is reduced across all sectors.
3. Water consumption is shifted between sectors.

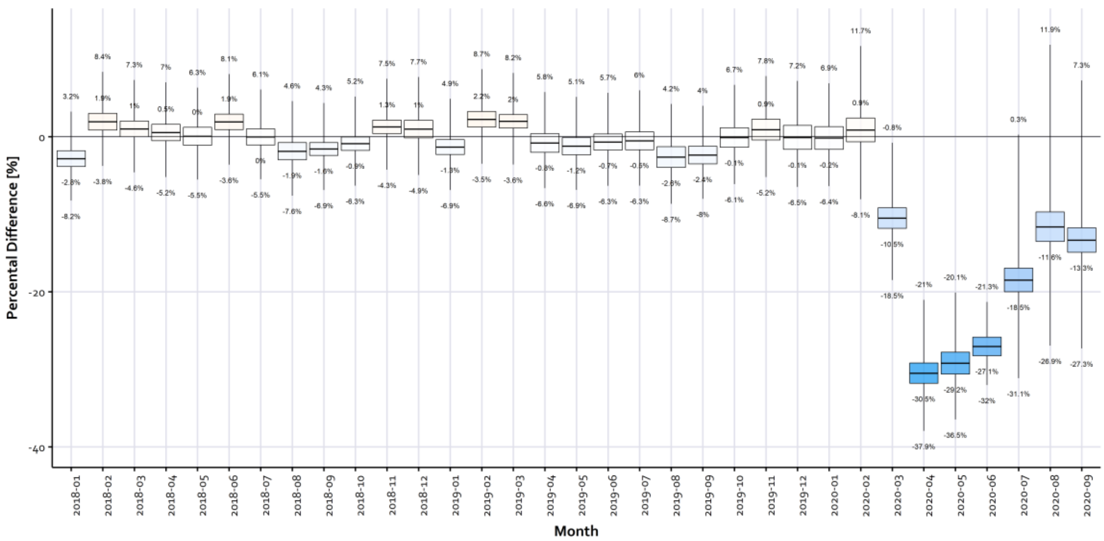
### *COVID-19 impact on GVA and Employment*

The impact of COVID-19 on GVA and Employment is estimated from the *Forecasts for the UK economy 2020* by the HM Treasury[13]. The report compares independent forecasts. The baseline was estimated using the Oxford Economic (OE) forecasts for GVA and Employment. From the report the upper and the lower thresholds are estimated for GVA (derived from GDP, Table M1 of the report, with the assumption of proportionality) and for employment (derived from unemployment forecasts, table M5 of the report), using the upper and the lower independent estimate. For GVA, OE is a central forecast, therefore is used as the central scenario, while for employment OE is already the upper forecast, so it is used as the upper scenario. The result is a set of percentage changes to apply to the baseline for years 2019-2024. These estimates also include the short-term impact of Brexit.

### *NHH water consumption reduction due to COVID-19*

Beyond the effects on the economy, COVID-19 has an effect on water consumed by businesses and non-household properties due to different operations and remote working. Artesia has conducted an independent study on the impact of COVID-19 on the NHH sector. Figure 4 shows the reduction in water consumption during summer 2020, compared to the previous year, considering weather, holidays, and other influencing factors.

**Figure 4 Reduction in NHH water consumption during summer 2020 months compared to previous months.**




The three scenarios are considered as follows:

- Upper COVID-19 scenario: no variation on the baseline.

[13] HM Treasury, Forecasts for the UK economy: a comparison of independent forecasts, 2020, No. 397, ISBN 978-1-913635-61-9

- Central COVID-19 scenario: -12% in 2020-21 and -6% in 2021-22, then baseline.
- Lower COVID-19 scenario: -20% in 2020-21 and -10% in 2021-22, then -3% on the baseline (long terms effects due to permanent home-working adjustments and business closing).

### *Shift between sectors due to COVID-19*

The COVID-19 impact on water consumption is due to its impact on the economy and the change of operations due to a mass remote-working approach. However, both these factors, quantified above as a total effect, affect differently the different economic sectors. Therefore, a final step of the modelling is to shift water consumption across sectors.

To do so, we use data from the ONS Business Impact of COVID-19 Survey (BICS) from September 2020[14] (assumed to be the best representation to date to the post-lockdown COVID-19 scenario). The dataset reports both the changes in turnover and the percentage of workers working remotely, by sector. Combining the two factors we could derive that under the September 2020 conditions, NHH water consumption is likely to have shifted:

- Agriculture +0.4%
- Non-service +9.1%
- Service-economy -4.1%
- Service-population -5.8%
- Unclassified +0.4%

The shift is only considered in the lower COVID-19 scenario, where long term impact of remote-working is considered. Note that the figures above only report a shift (they sum up to zero) because the reductions per sectors are accounted at the previous step.

### *Summary of COVID-19 scenarios*

Table 6 lists the summary of the COVID-19 scenarios and their impact.

**Table 6 COVID-19 scenarios and their impact**

| | GVA | Employment | Consumption reduction | Sector shift |
|---|---|---|---|---|
| **Upper COVID-19 scenario** | Upper independent forecast | OE forecast | baseline | baseline |
| **Central COVID-19 Scenario** | OE forecast | Central independent forecast | -12% in 2020-21<br>-6% in 2021-22<br>then baseline | baseline |
| **Lower COVID-19 Scenario** | Lower independent forecast | Lower independent forecast | -20% in 2020-21<br>-10% in 2021-22 | Agric: +0.4%<br>Non-serv: +9.1% |

[14] ONS, BICS Wave 14 edition of this dataset 7 September to 20 September 2020.

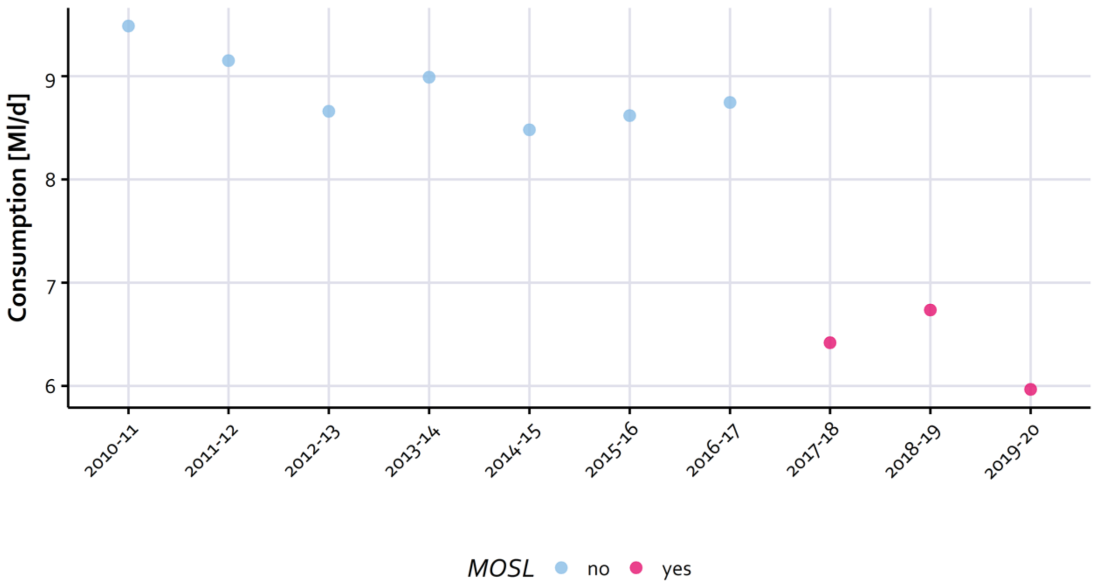
| | | | | |
|---|---|---|---|---|
| | | | then -3% | Serv-eco: -4.1%<br>Serv-pop: -5.8%<br>Unclass: +0.4% |

## *MOSL*

The liberalisation of the water market for the commercial sector has had an impact on the water consumption reporting, operated by MOSL, the market operator for the water retail market in England. During this time, MOSL has failed to deliver some of its targets for improving data quality (notably in the "Long term unread meter category" and the "level of properties flagged as vacant" areas)[15]. The MOSL annual market performance report identifies that 1 in 6 premises is now flagged as vacant, and meters unread for more than a year have increased from 7% at 2017 to 15% at March 2019, with one-third of these not being read since market opening.

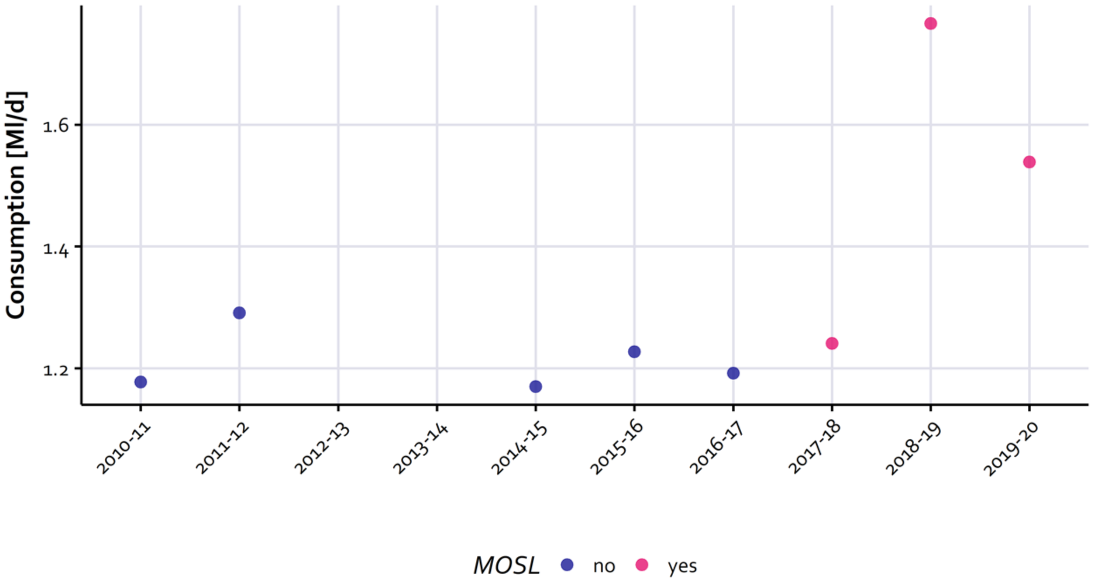
The effects are observable as the difference between the reporting before 2017 and after 2017. Step changes can be seen in the property level data that is used for the modelling, and if these step changes are not taken into consideration, they will impact the robustness of the models. Examples of this can be seen in Figure 5 and Figure 6. To account for this in the modelling a flag is used, which is set to zero before 2017 and set to 1 after.

**Figure 5 Example (SEW-Maidstone) step change in property level consumption data post 2016**




[15] Annual Market Performance Report 2019/20. MOSL.

**Figure 6 Example (SWS-Hampshire Andover) step change in property level consumption data post 2016**




However, there are commitments from MOSL to improve in this area and signs in 2019 that progress is being made. We are unsure how these improvements will impact reporting in the future, depending on how the water retail market evolves. Therefore, the following three scenarios are considered, quantifying the impact that the shift to MOSL reporting has had on each water resource zone and industry group separately:

- Upper MOSL scenario: the MOSL effect doubles in 2030, then remains at that level (data quality deteriorates).
- Central MOSL scenario: the MOSL effect remains constant in the future (data quality remains the same).
- Lower MOSL scenario: the MOSL effect gradually declines to zero in 2030 and remains at that level (data quality improves to pre-2017 levels).

## Climate change

### Modelling residuals

To consider weather effects on water consumption, a residual model is used, i.e. the difference between the actual consumption and the one that the MLR model estimates (residuals) are further modelled as a function of weather variables like temperature and rainfall.

Building the residual models for each WRZ independently is correct theoretically, but due to the low number of points in time it can result in unstable models. Therefore, we changed the approach to consider all residuals from all WRZs and all companies in one model. To make the residuals comparable, we standardised them, dividing them by the consumption itself:

$$residuals = \frac{(consumption - prediction)}{consumption}$$

Using this method, the resulting model predicts standardised residuals in the future as a function of weather variables (*average rainfall* and *average maximum temperature*). The residuals can then be adapted to each WRZ by multiplying them by the mean consumption of past years.

### *Modelling historic weather trends*

The first step in the analysis is to establish the change in weather patterns that are occurring due to climate change. The weather variables under examination are *average maximum temperature* and *average rainfall*. Figure 7 and Figure 8 show that the trends of these variables over the years can be well represented with linear regressive models.

**Figure 7: A plot showing the trend of peak daily temparatures since 1959.**

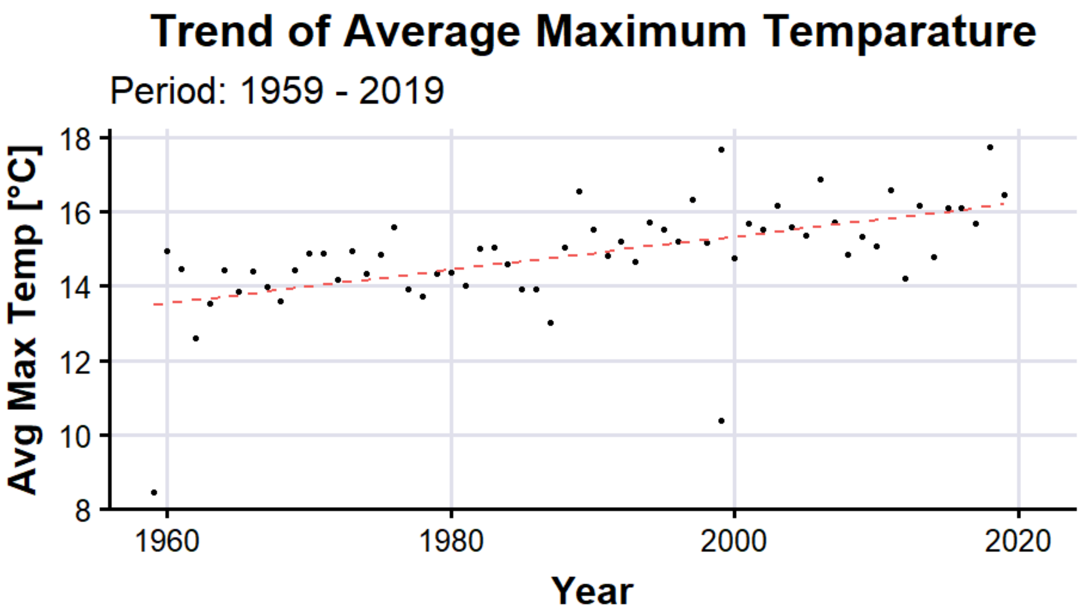
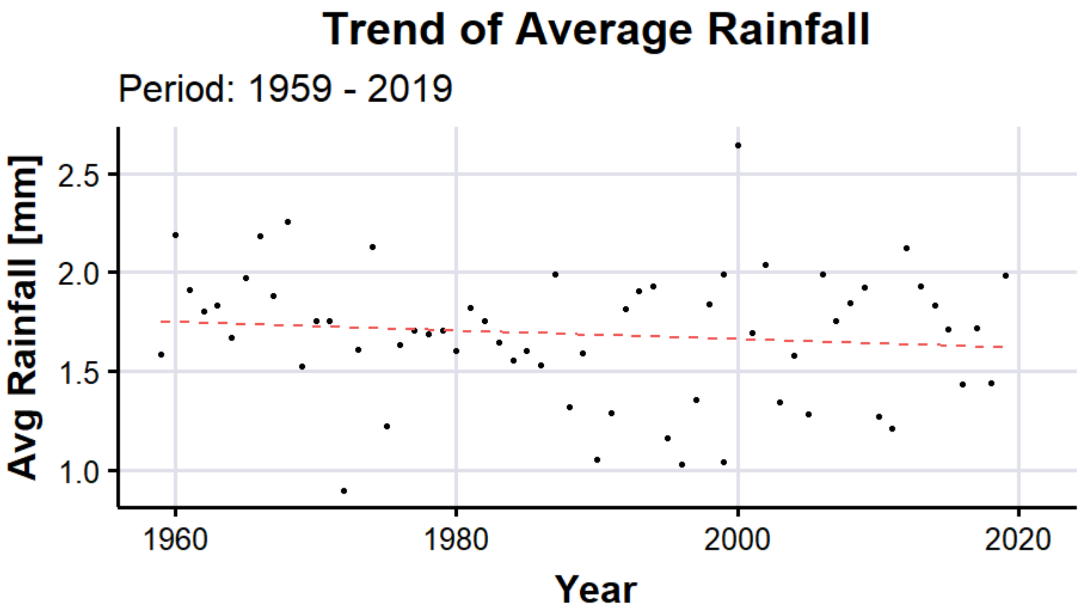


**Figure 8: A plot showing the trend of average daily rainfall over since 1959.**




### *Forecasting Weather and Climate Change Residuals*

The weather models developed in Figure 7 and Figure 8 are used to forecast *average maximum temperature* and *average rainfall* through the forecast period.

We used additive climate change models in conjunction with the weather forecasts. These models provide 12 scenarios of potential temperature and rainfall patterns.

The forecasts of the weather variables are each summed with the 12 relevant climate change scenarios to produce 12 forecasts for *average maximum temperature* and *average rainfall*. The 12 scenarios for each are then fed into the residual model to obtain residual forecasts.

However, all 12 scenarios are not required for this analysis, only a *low*, *central*, and *high* scenario. To extract three scenarios from the 12, the 10$^{th}$, 50$^{th}$, and 90$^{th}$ quantile of the scenarios are taken for each financial year.

The climate change scenarios only go up to the year 2080, whereas we need forecasts up to the year 2100. The forecasts must therefore be extended to meet client needs. To perform this extension, a linear regressive model is fitted to each of the *low*, *central*, and *high* scenarios and used to predict the final 20 years to the desired end year, 2100.

## *Water efficiency*

The evolution of technology and regulations is expected to contribute reducing NHH water consumption, by improving water efficiency.

The three water efficiency scenarios below were selected in consultation with the WRSE steering group:

- Upper water efficiency scenario: water consumption is reduced by 2% by 2050-51.
- Central water efficiency scenario: water consumption is reduced by 7.5% by 2050-51.
- Lower water efficiency scenario: water consumption is reduced by 16% by 2050-51.

### 2.4.3 Combining scenarios

All the scenarios described above result in a total of 729 scenarios for each Company/WRZ. This is a large number to report, so they are summarised as a central, upper, and lower thresholds. The thresholds have been derived as:

- Upper threshold: 90th percentile of all the scenarios each year.
- Central threshold: 50th percentile of all the scenarios each year.
- Lower threshold: 10th percentile of all the scenarios each year.

An example of 81 of the 729 scenarios is shown in Figure 9. A derivation of the Upper, Central and Lower thresholds from all 729 scenarios is illustrated in Figure 10 for Affinity Water as an example.

**Figure 9 Example of 81 of the 729 scenarios for Affinity Water**

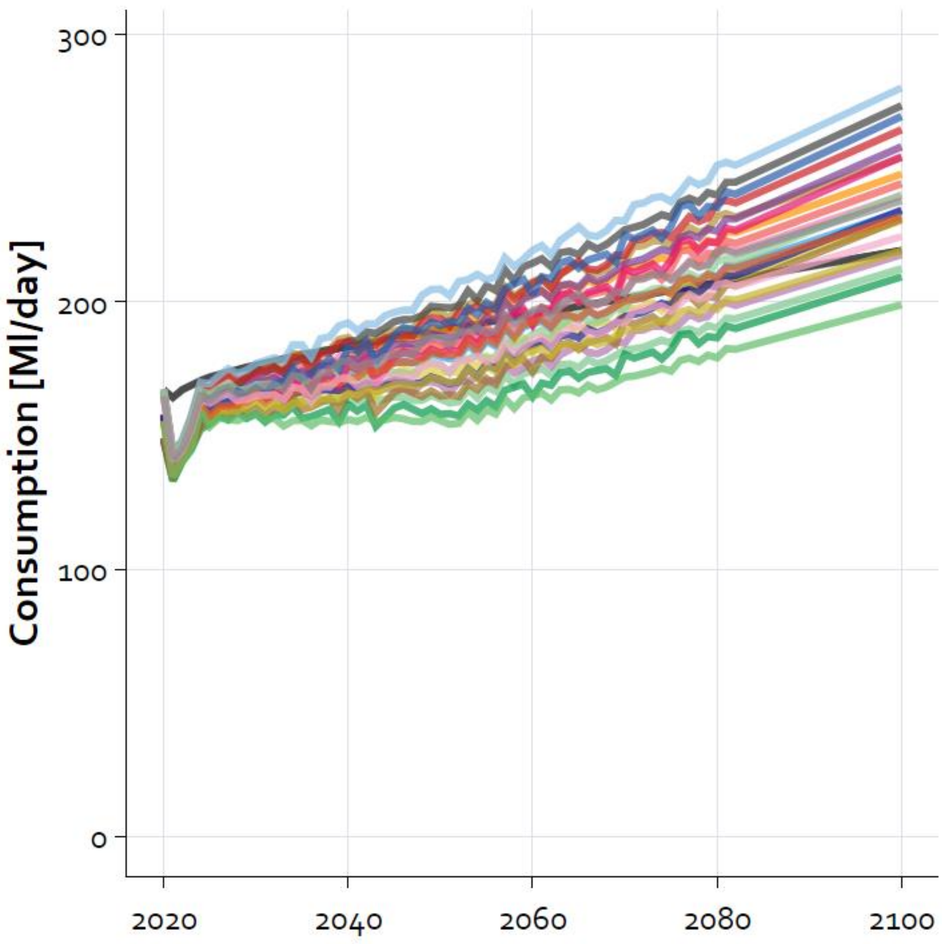
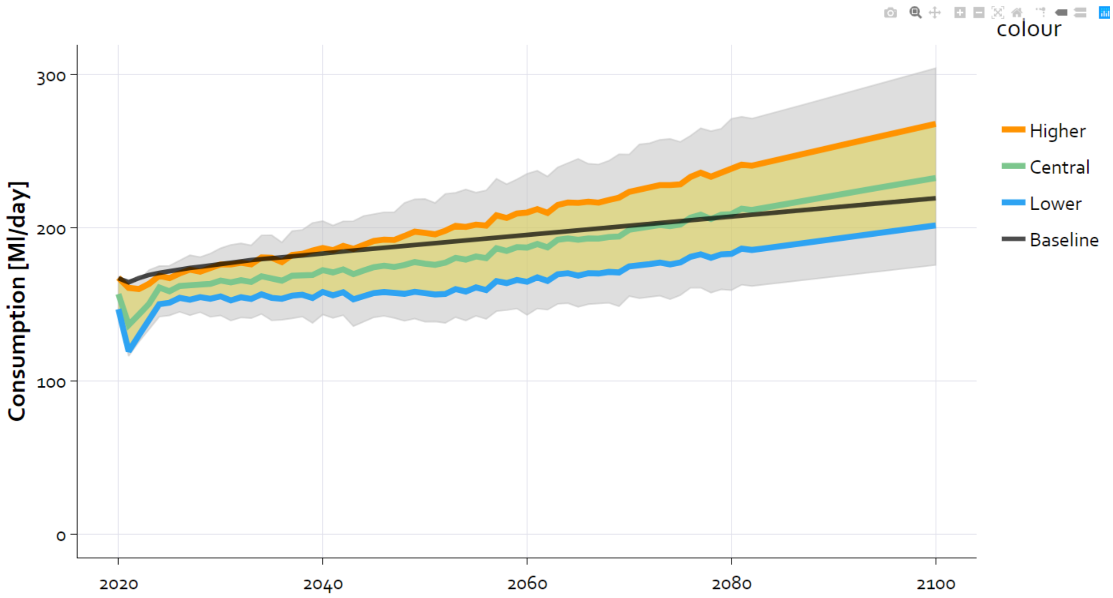


**Figure 10 Example derivation of the Upper, Central, and Lower thresholds from the total scenario variability for Affinity Water**




## 2.4.4 *Modelling uncertainty*

Every single element of the complex WRMP24 NHH forecasts is affected by a certain degree of uncertainty, but the quantification is difficult. Therefore, we decided to focus on the elements the have the biggest impact on the forecasts:

- the explanatory variables used in the model
- the model
- climate change.

The quantification of uncertainty for each component is described in the following sections.

### *Explanatory variable uncertainty*

Each explanatory variable is affected by a different degree of uncertainty. It is not easy to separate the uncertainties and to evaluate the effects of each on the resulting water consumption. However, thanks to the linear nature of the model, if we consider the explanatory variables to have the same uncertainty, e.g. ±10%, we can derive that the same uncertainty will affect water consumption. The following explanatory variables are considered for uncertainty:

- GVA
- Employment
- Population

Other minor explanatory variables are expected to have a lower uncertainty and to affect the water consumption estimations to a smaller degree.

Observing the population scenarios from Edge Analytics, we can observe that their uncertainty is very small in the present and grows steadily in the future, reaching a value of ±6% to ±12% depending on what scenarios we consider.

In terms of GVA and employment we can observe in the *Forecasts for the UK economy 2020* by the HM Treasury, the larger uncertainty is actually in the short term and varies between ±30% to ±50% for GVA to ±1.5% to ±3% for Employment.

Considering the uncertainties estimated above, the general uncertainty for the explanatory variables is estimated as:

- ±8% of the water consumption in 2019-20.
- Growing to ±12% of the water consumption in 2025-26.
- Growing to ±18% of the water consumption in 2099-00.

### Model uncertainty

Model uncertainty is estimated separately for the considered industry groups and companies, as different models are used. A model's $R^2$ value represents the variability in the data that the model is able to explain. We estimate the model uncertainty as $1 - R^2$, i.e. the variability in the data that the model is not able to explain. This is a simplification, as effects such as overfitting can increase the $R^2$ value beyond what the real capabilities of the model are, but overall it is a good proxy for the model uncertainty.

### Climate change uncertainty

Climate change uncertainty has been estimated from the UKCP18 Climate Change Over Land infographic[16], that estimates the following:

- Rainfall is expected to show a variability up to ±25-30% in summer and ±12-19% in winter by 2060-79. It can be approximated as a ±20% on a yearly basis by 2060-79.
- Temperature is expected to show a total variability between 2.5-3.5 °C in winter and 3.3-4.7 °C in the summer, so about 4 °C on a yearly basis by 2060-79. Assuming an average yearly temperature around 15°C, that is about 15°C±2°C, i.e. ±13%. by 2060-79.

Combining the two estimates, we can consider a climate variability of about 16% by 2070, so we assume 18% by 2099.

## 2.4.5 Application of uncertainty

Once the uncertainty of the single components is defined, as stated in the previous sections, they are then combined in a quadratic way:

$$u = \sqrt{u_{EV}^2 + u_{model}^2 + u_{climate}^2}$$

[16] Met Office, 2018, UKCP18 Science Overview Report – November 2018 (Updated March 2019) – Infographic Headline Findings

The resulting uncertainty, estimated for each Company, WRZ, industry group and year, is applied on the three derived scenario thresholds.

## 2.5 Potential non-PWS demand

### 2.5.1 *Data*

For the calculation and forecast of non-PWS demand we used the output created for the Wood plc study for Defra and the Environment Agency, specifically the spreadsheet:

- Existing and new authorisations in SouthEast.xlsx

From this spreadsheet we mainly used data from the following TABS:

- **Existing_Abstractions_All** which contains combined surface water abstractions (SWABS) and groundwater abstractions (GWABS) point-purpose licence (extracted from WRGIS database February 2019) including multiple GWABS entries where impacts are apportioned to multiple surface water bodies.
- **New authorisations data** which contains any new abstraction licences since February 2019.

### 2.5.2 *Analysis*

#### *Existing abstractions*

Firstly, we removed all the public water supply abstractions by filtering them out using the "PWS" flag in the "secondary code" column. We then need to segment the non-PWS observations into industrial sectors. This was done using the codes shown in Table 7.

The data is then checked for duplicates and any duplicates removed.

**Table 7 Sector segmentation – exisitng abstractions**

| Ref | Sector | How to reference |
|---|---|---|
| **E1** | Spray irrigation | Use the following Tertiary codes:<br>380<br>390<br>400<br>410<br>420 |
| **E2** | Paper and pulp | Use secondary code:<br>PAP |
| **E3** | Chemicals | Use secondary code:<br>CHE |
| **E4** | Food and Drink | Use secondary code:<br>FAD |
| **E5** | Power | Use primary code:<br>P |

| | | |
|---|---|---|
| **E6** | Agriculture (non-spray irrigation) | All remaining agriculture after E1 is removed. |
| **E7** | Navigation | Use secondary code: NAV |
| **E8** | Minerals and extraction | Use secondary codes: EXT and MIN |
| **E9** | Other | Anything that is left |

The abstractions are then grouped by industry code and WRZ. We then for each WRZ, sum the following:

- Recent actual point purpose annual quantity in m3/year, consumptive quantities only (RAPTPANQM3).
- Consumptive only - Best Estimate Growth Factor Applied to RAPTPANQM3
- Consumptive only - 75th Percentile Growth Factor Applied to RAPTPANQM3.

The derivation of the "Best estimate growth" and the "$75^{th}$ percentile growth" factors are described in the Wood plc report[7].

Annual predicted non-PWS needs projecting from 2025 to 2100. For 2025 to 2050 use a linear interpolation between baseline and growth to 2050. For 2051 to 2100 we keep the non-PWS flat for this first iteration (alternative scenarios for post 2050 growth could be applied later).

## New authorisations

The new authorisations sheet does not include WRZ information. So, for the purpose of this analysis, the field "NA_Catchment" was matched to water company through visual inspection. This results in sometimes allocating more than one water company to a catchment. In these cases, the volumes were split equally across the companies. This could be improved in the future.

The data is then checked for duplicates and any duplicates removed. We then need to select which industry sectors should be included, along with the best estimate growth factors. These are shown in Table 8.

**Table 8 Sector segmentation – new authorisations**

| Ref | Sector | How to reference | Best estimate growth |
|---|---|---|---|
| **N1** | Horticultural watering | abpAbsPurposeDesc | 2.01 |
| **N2** | Make up or top up water | abpAbsPurposeDesc | 1.00 |
| **N3** | Spray irrigation -direct | abpAbsPurposeDesc | 1.44 |
| **N4** | Spray irrigation – storage | abpAbsPurposeDesc | 1.44 |
| **N5** | Trickle irrigation – direct | abpAbsPurposeDesc | 1.44 |

| | | | |
|---|---|---|---|
| **N6** | Trickle irrigation - storage | abpAbsPurposeDesc | 1.44 |

For new abstractions we only have the licenced volume, and therefore will assume that is an approximation to actual consumptive volume. The industry groups we have selected are the ones likely to have consumptive demand. After grouping by industry code, we then sum the following:

- Abstraction quantity per year ('apnAbsQtyYear').
- Compute the best estimate of growth to 2050 using the growth rate in Table 8.

The derivation of the "Best estimate growth" is based on similar sectors in the Wood plc report.

Annual predicted non-PWS needs projecting from 2025 to 2100. For 2025 to 2050 use a linear interpolation between baseline and growth to 2050. For 2051 to 2100 we keep the non-PWS flat for this first iteration (alternative scenarios for post 2050 growth could be applied later).

# 3 Results

## 3.1 Baseline forecast for non-household public water supply demand

Baseline forecast outputs are provided in the following attached file "01_Artesia-WRSE_NonHousehold-Demand-Forecasts_Phase1-final-results_20201008.xlsx". This file includes the following breakdown of baseline non-household consumption forecasts from 2019-2020 through to 2099-2100:

- 01: Forecasts of measured non household demand for each industry sector in each water resource zone.
- 02: Forecasts of unmeasured non household demand for each WRZ (currently flat forecasts).
- 03: Aggregates of measured non household demand forecasts for each WRZ.
- 04: WRZ total forecasts (measured plus unmeasured).
- 05: Company total forecasts (measured plus unmeasured).
- 06: WRSE region total forecasts (measured plus unmeasured).

It is important to consider the baseline forecasts in the context of the uncertainty in the data and modelling, as well as future uncertainties (described in section 2.4). Therefore, we have produced scenarios for non-household demand forecast outputs are provided in the following attached files for the central, lower and upper scenarios:

- "01_Artesia-WRSE_NonHousehold-Demand-Forecasts_central_Scenario_preliminary_result_20201016.xlsx".
- "01_Artesia-WRSE_NonHousehold-Demand-Forecasts_lower_Scenario_preliminary_result_20201016.xlsx"
- "01_Artesia-WRSE_NonHousehold-Demand-Forecasts_upper_Scenario_preliminary_result_20201016.xlsx"

These files includes the following breakdown of scenario non-household demand forecasts from 2019-2020 through to 2099-2100:

- 1_PWS_WRZ_ measured_scenario
- 2_PWS_WRZ_unmeasured_scenario
- 3_PWS_WRZ_total _scenario
- 4_PWS_Company_ measured_scenario
- 5_PWS_Company_ unmeasured_scenario
- 6_PWS_Company_ total _scenario
- 7_PWS_Region_ measured_scenario
- 8_PWS_Region_ unmeasured_scenario
- 9_PWS_Region_ total _scenario

WRSE level graphs of non-household baseline demand and scenarios are presented in Figure 11, Figure 12 and Figure 13. Company graphs for non-household demand scenarios are then shown in Figure 14 through to Figure 31.

### 3.1.1 WRSE regional results

At start of the planning period (2025), the WRSE region total non-household demand is predicted to be 921 Ml/d within an overall range of 594 to 1121 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL.

By the end of the planning period the non-household demand is predicted to be 1032 Ml/d (an increase of 111 Ml/d) within a range of 630 Ml/d to 1637 Ml/d.

**Figure 11 WRSE region measured and unmeasured non-houshold demand forecasts**

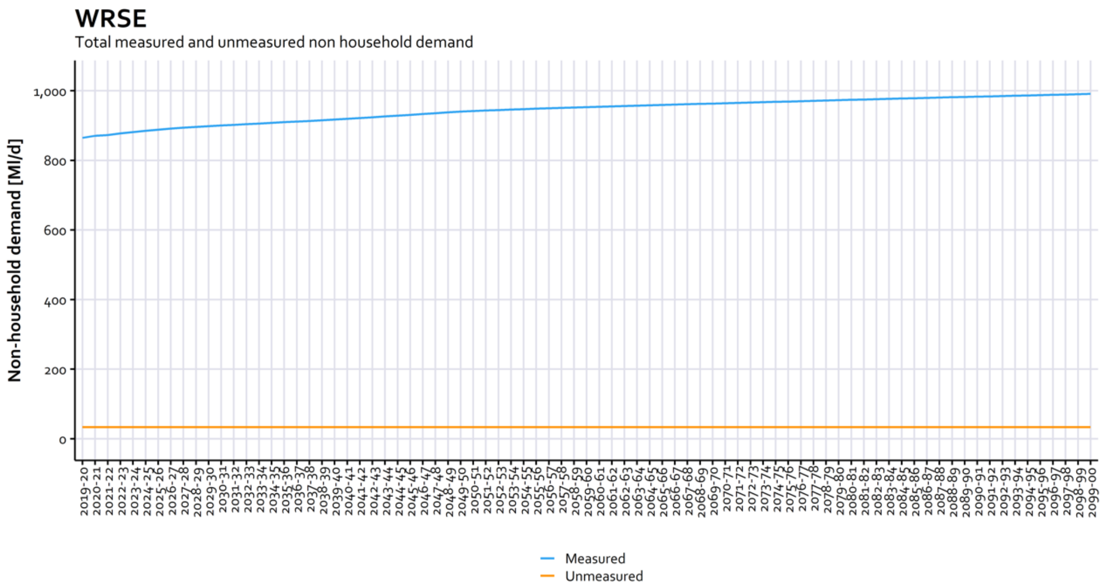



**Figure 12 WRSE region non-houshold consumption central, lower and upper scenarios**

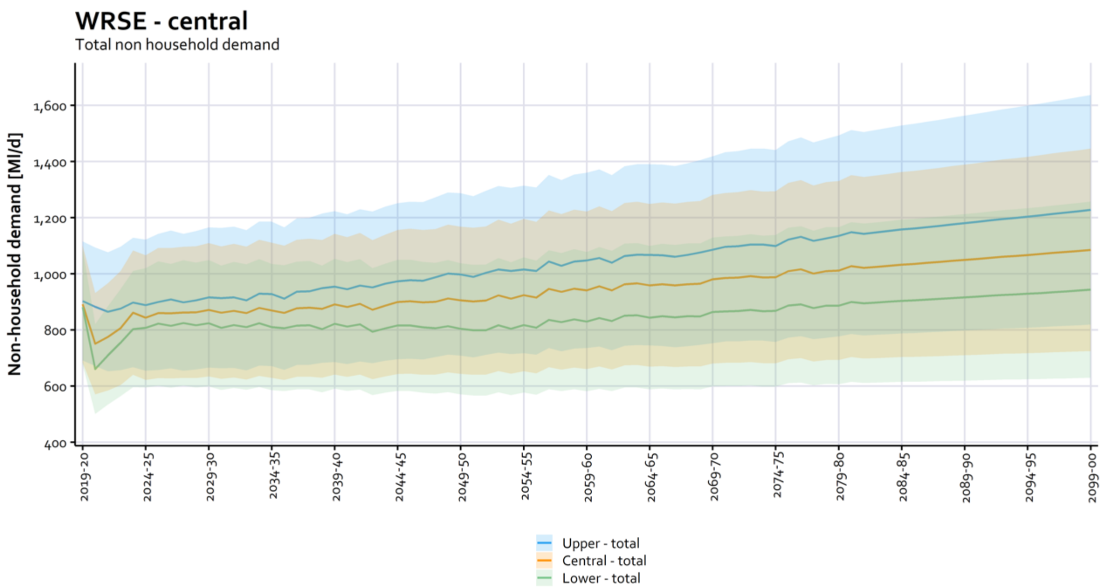
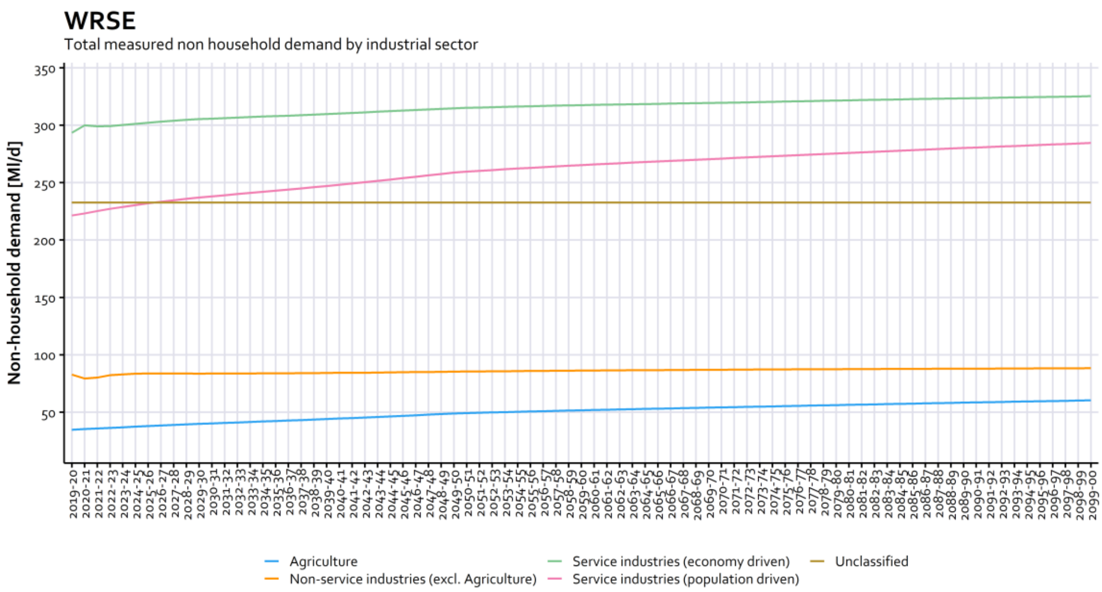


Figure 13 shows how the non-household demand is broken down into the standard industry sectors. There is limited growth in the 'non-service industries' i.e. manufacturing etc. Most of the growth is in the service sectors, which are driven by population and economy.

Approximately one quarter of the non-household demand in the WRSE region falls into the 'unclassified' category. These are properties that could not be allocated into an industry sector because either the property has no industry code assigned to it or the industry code is incorrectly recorded and cannot be matched to a sector. We did attempt to model this unclassified sector, but because of the inconsistency in the data it was not possible to derive meaningful relationships or models, therefore we held the forecast for the unclassified sector flat across the planning period.

**Figure 13 WRSE region non-houshold demand forecasts by industry sector**




## 3.1.2 *Affinity Water results*

The results for Affinity Water are shown in Figure 14 to Figure 16. At start of the planning period (2025), the Affinity region total non-household demand is predicted to be 174 Ml/d within an overall range of 87 to 242 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL.

By the end of the planning period the non-household demand is predicted to be 208 Ml/d (an increase of 34 Ml/d) within a range of 100 Ml/d to 371 Ml/d.

**Figure 14 Affinity Water measured and unmeasured non-housheold consumption**

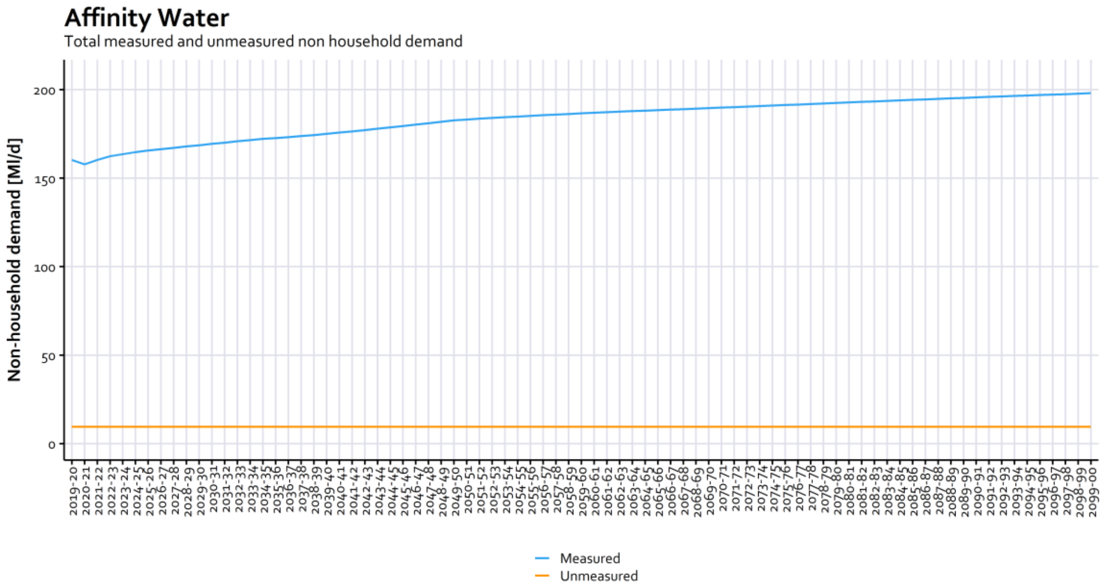
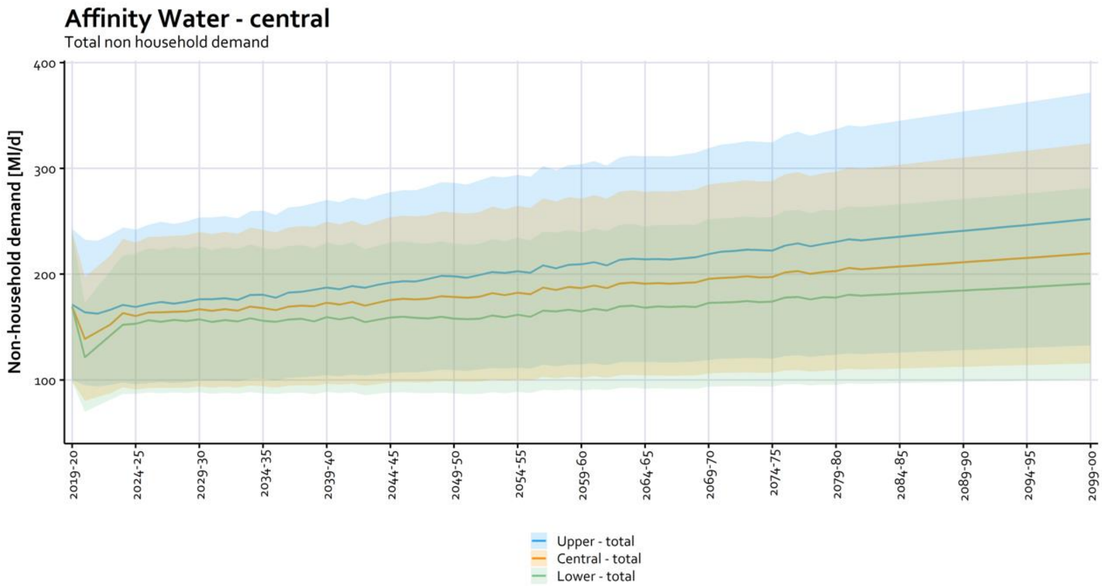
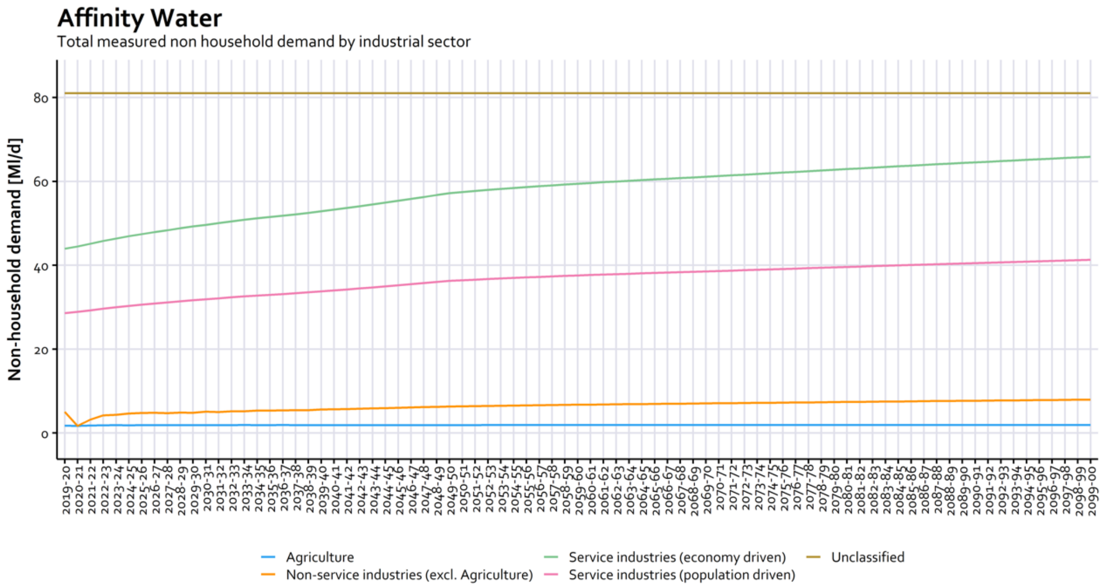



**Figure 15 Affinity Water region non-houshold consumption central, lower and upper scenarios**




Most of the growth in the Affinity region comes from the service sectors, with the non-service sector and agriculture remaining approximately flat across the planning period. Approximately one third of the demand in the Affinity region falls into the unclassified group, and as explained in section 3.1.1, this is held flat across the planning period.

**Figure 16 Affinity Water non-housheold consumption by industry sector**




## *3.1.3 Portsmouth Water results*

The results for Portsmouth Water are shown in Figure 17 to Figure 19. At start of the planning period (2025), the Portsmouth region total non-household demand is predicted to be 35 Ml/d within an overall range of 23 to 41 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL.

By the end of the planning period the non-household demand is predicted to be 40 Ml/d (an increase of 5 Ml/d) within a range of 20 Ml/d to 69 Ml/d.

**Figure 17 Portsmouth Water measured and unmeasured non-housheold consumption**

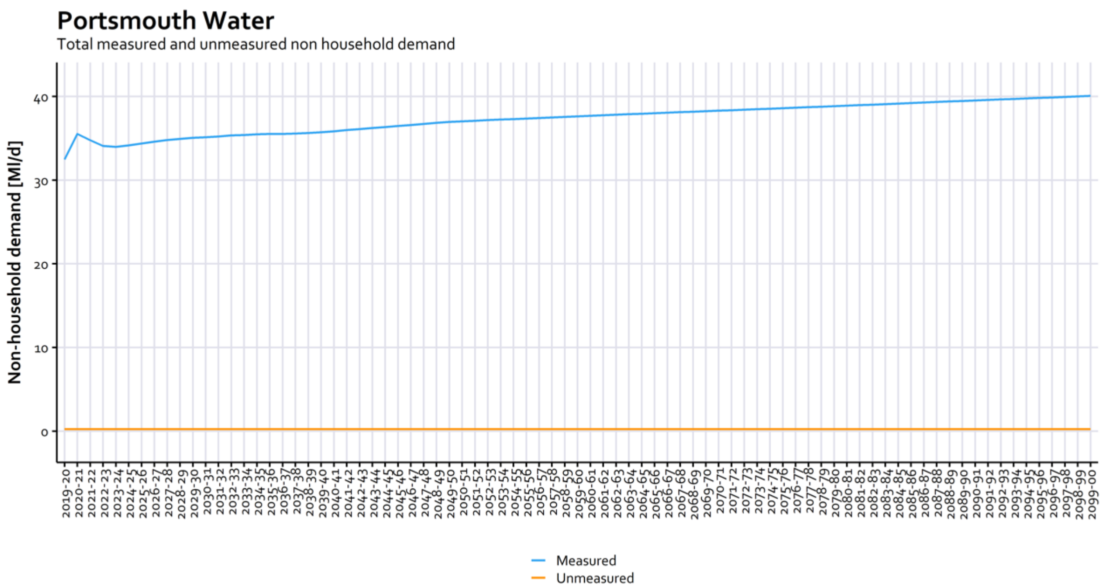
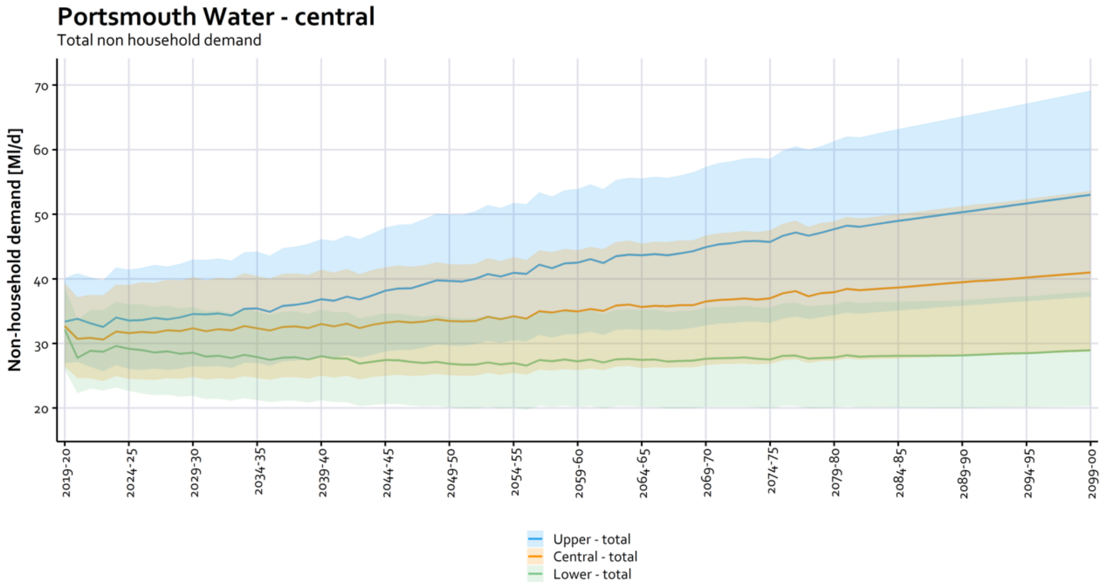
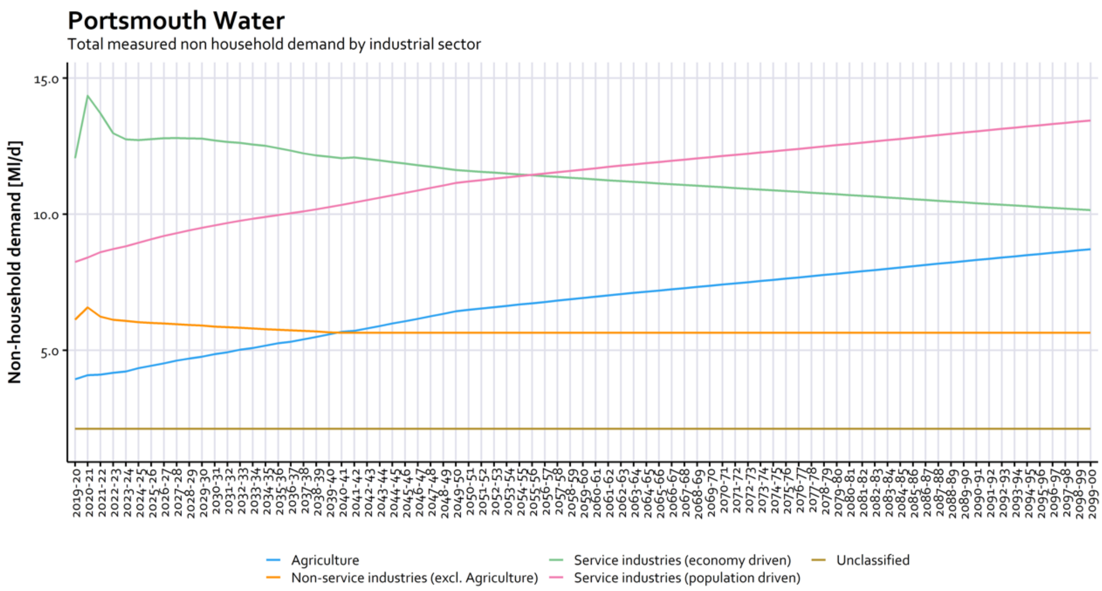


**Figure 18 Portsmouth Water region non-houshold consumption central, lower and upper scenarios**




Most of the growth in the Portsmouth region comes from the service-population driven and agriculture sectors, with the service-economy and non-service sector reducing across the planning period. Less than 1% of the demand in the Portsmouth region falls into the unclassified group, and as explained in section 3.1.1, this is held flat across the planning period.

**Figure 19 Portsmouth Water non-housheold consumption by industry sector**



### 3.1.4 SES Water results

The results for SES Water are shown in Figure 20 to Figure 22. At start of the planning period (2025), the SES region total non-household demand is predicted to be 25 Ml/d within an overall range of 17 to 30 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL.

By the end of the planning period the non-household demand is predicted to be 24 Ml/d (an decrease of 1 Ml/d) within a range of 16 Ml/d to 38 Ml/d.

**Figure 20 SES Water measured and unmeasured non-housheold consumption**

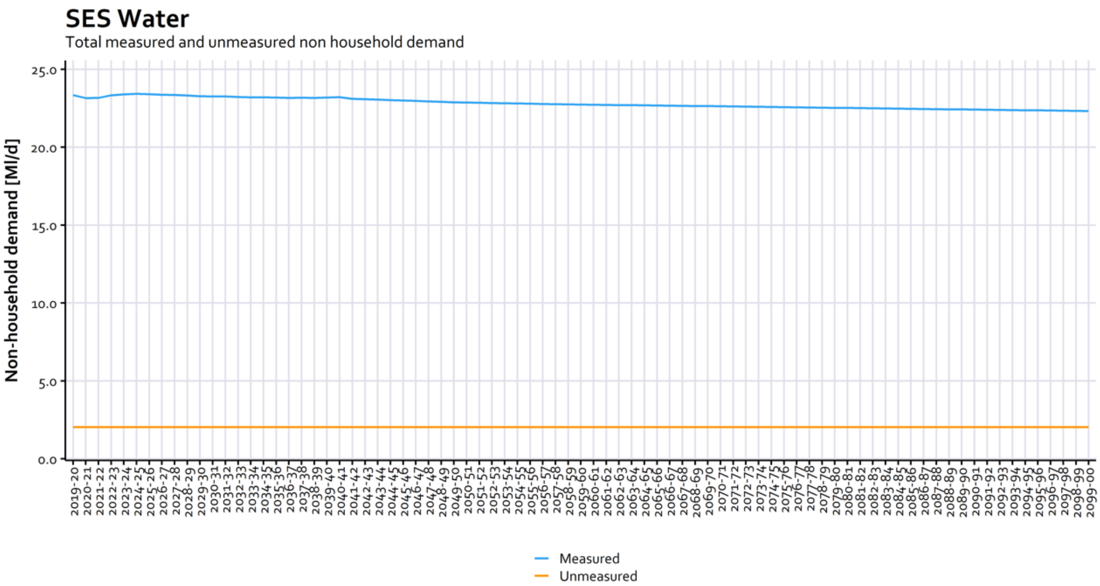
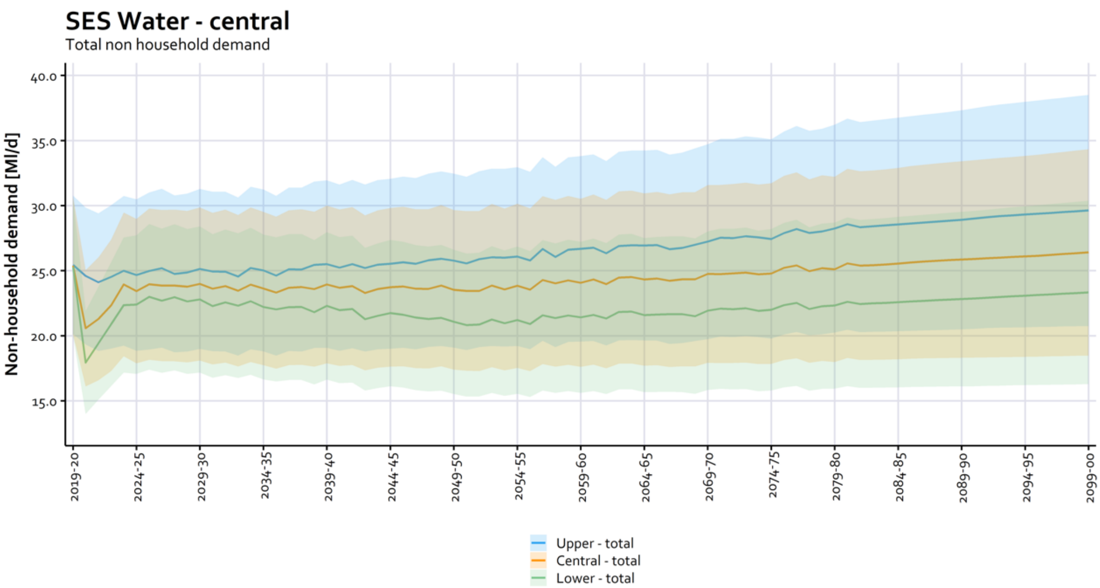
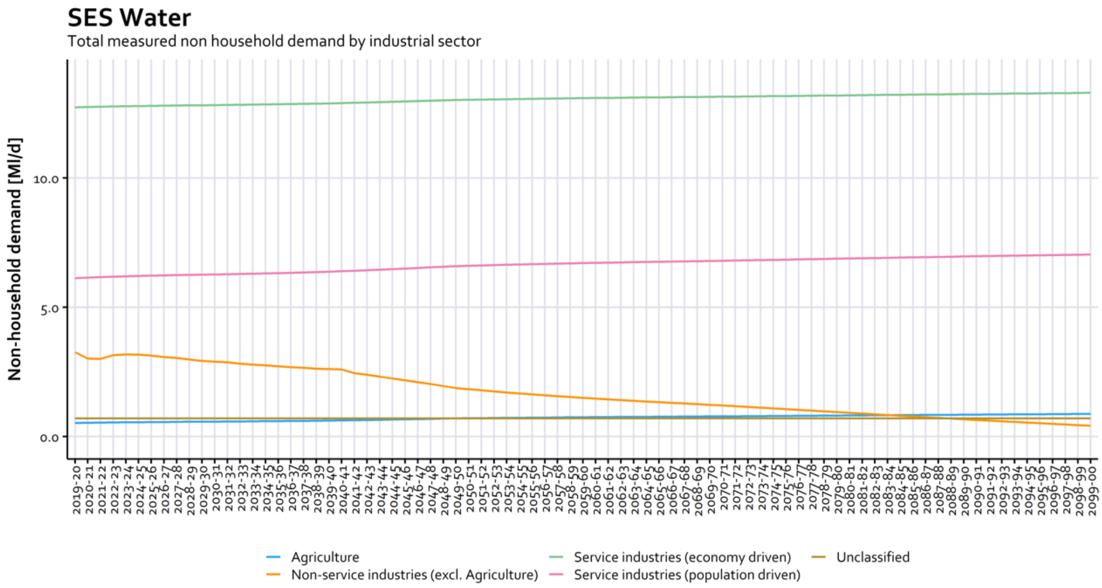



**Figure 21 SES Water region non-houshold consumption central, lower and upper scenarios**



There is slight growth in the SES region from the service sectors, with the non-service sector reducing across the planning period. About 3% of the demand in the SES region falls into the unclassified group, and as explained in section 3.1.1, this is held flat across the planning period.

**Figure 22 SES Water non-housheold consumption by industry sector**




### 3.1.5 South East Water results

The results for South East Water are shown in Figure 23 to Figure 25. At start of the planning period (2025), the South East Water total non-household demand is predicted to be 98 Ml/d within an overall range of 63 to 120 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL.

By the end of the planning period the non-household demand is predicted to be 113 Ml/d (an increase of 15 Ml/d) within a range of 72 Ml/d to 180 Ml/d.

**Figure 23 South East Water measured and unmeasured non-housheold consumption**

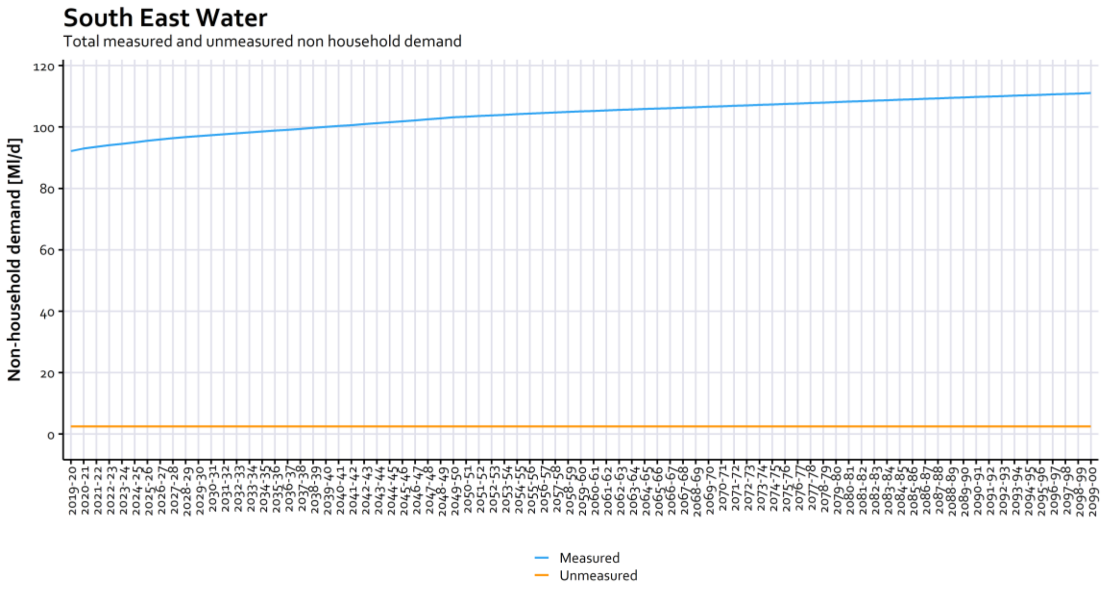
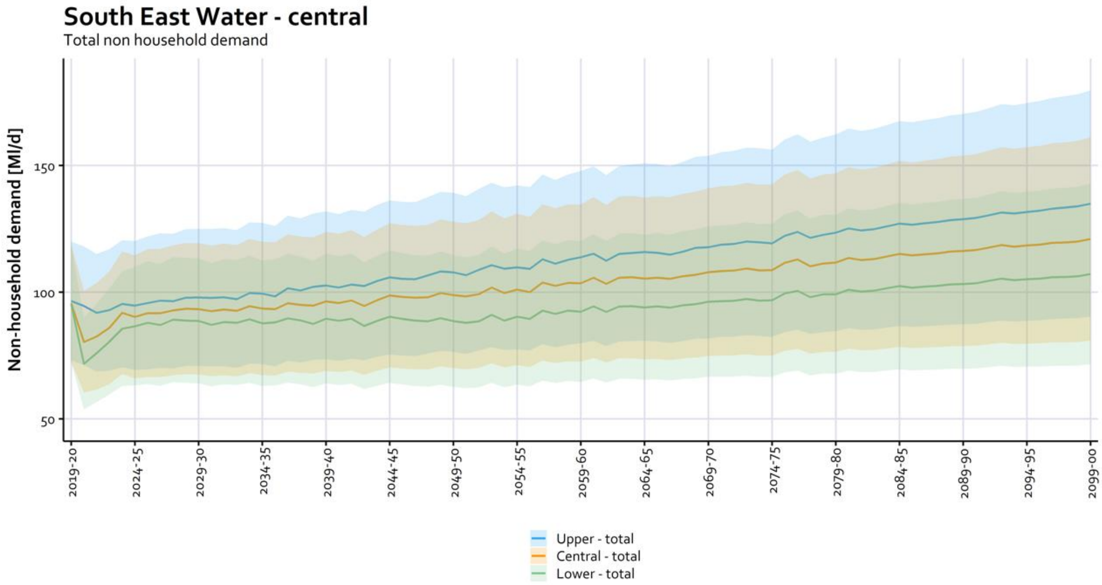
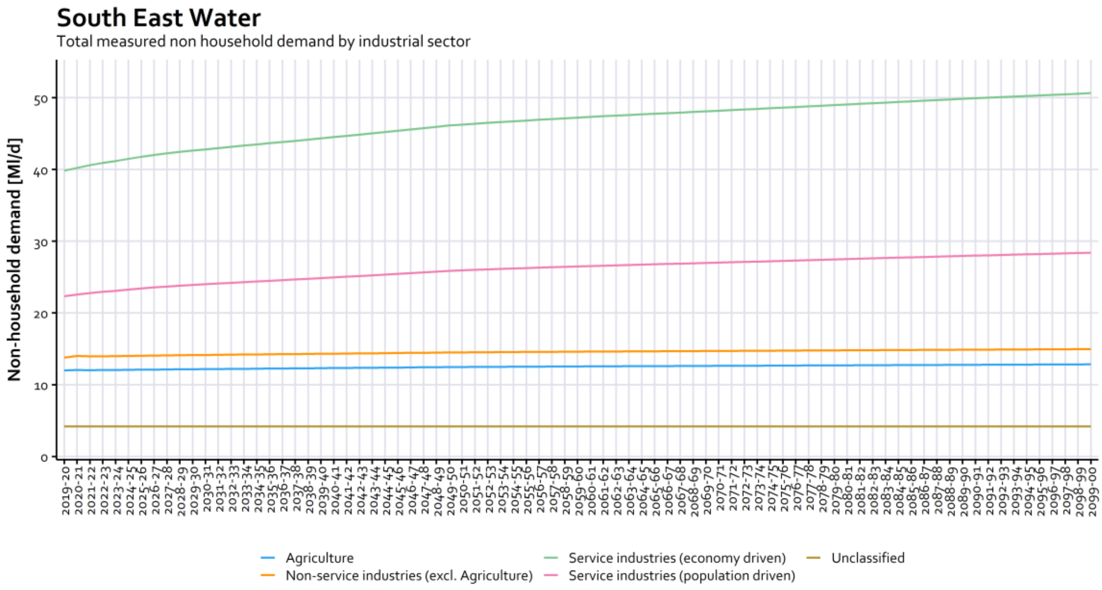



**Figure 24 South East Water region non-houshold consumption central, lower and upper scenarios**




There is growth in the South East region from the service sectors, with the non-service sector and agriculture sectors remaining flat across the planning period. About 4% of the demand in the South East Water region falls into the unclassified group, and as explained in section 3.1.1, this is held flat across the planning period.

**Figure 25 South East Water non-housheold consumption by industry sector**




## *3.1.6 Southern Water results*

The results for Southern Water are shown in Figure 26 to. Figure 28. At start of the planning period (2025), the Southern Water region total non-household demand is predicted to be 115 Ml/d within an overall range of 71 to 142 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL.

By the end of the planning period the non-household demand is predicted to be 122 Ml/d (an increase of 7 Ml/d) within a range of 107 Ml/d to 207 Ml/d.

**Figure 26 Southern Water measured and unmeasured non-housheold consumption**

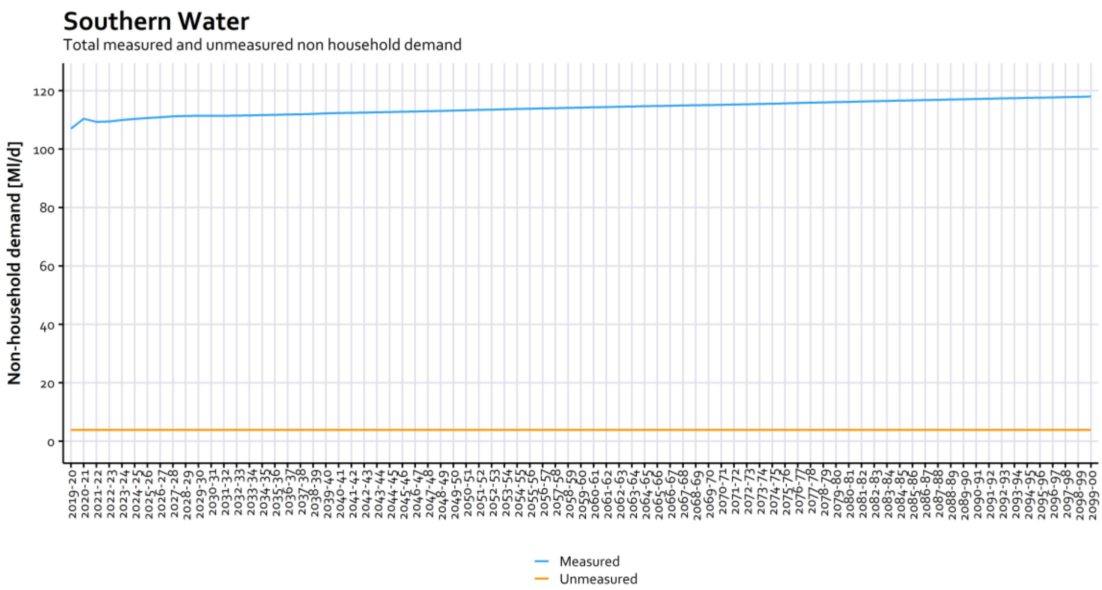
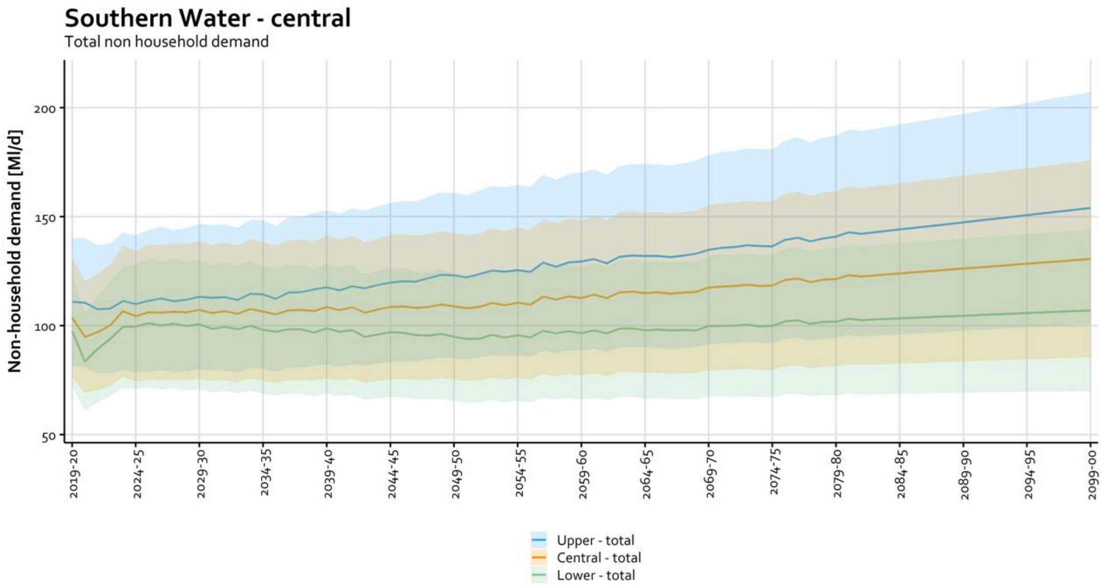
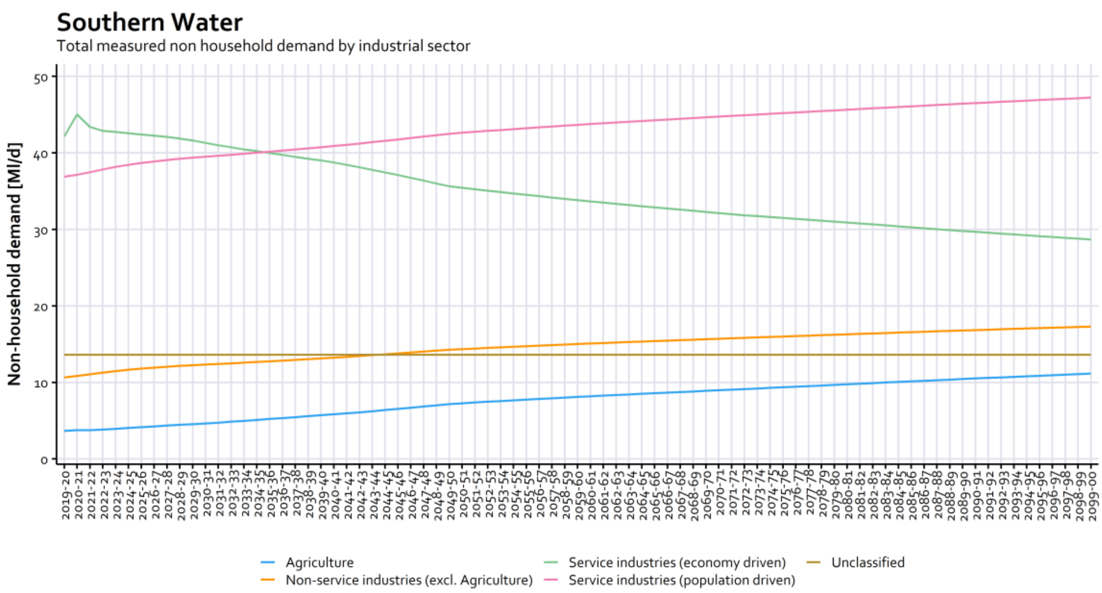


**Figure 27 Southern Water region non-houshold consumption central, lower and upper scenarios**




There is growth in the Southern Water region from the population service, non-service and agriculture sectors, with economy service sector reducing across the planning period. About 12% of the demand in the Southern Water region falls into the unclassified group, and as explained in section 3.1.1, this is held flat across the planning period.

**Figure 28 Southern Water non-housheold consumption by industry sector**



### 3.1.7 Thames Water results

The results for Thames Water are shown in Figure 29 to Figure 31. At start of the planning period (2025), the Thames Water region total non-household demand is predicted to be 471 Ml/d within an overall range of 334 to 546 Ml/d. Much of the early uncertainty is due to the impact of COVID-19 and uncertainty over the quality of non-household consumption data from MOSL.

By the end of the planning period the non-household demand is predicted to be 516 Ml/d (an increase of 45 Ml/d) within a range of 351 Ml/d to 771 Ml/d.

**Figure 29 Thames Water measured and unmeasured non-housheold consumption**

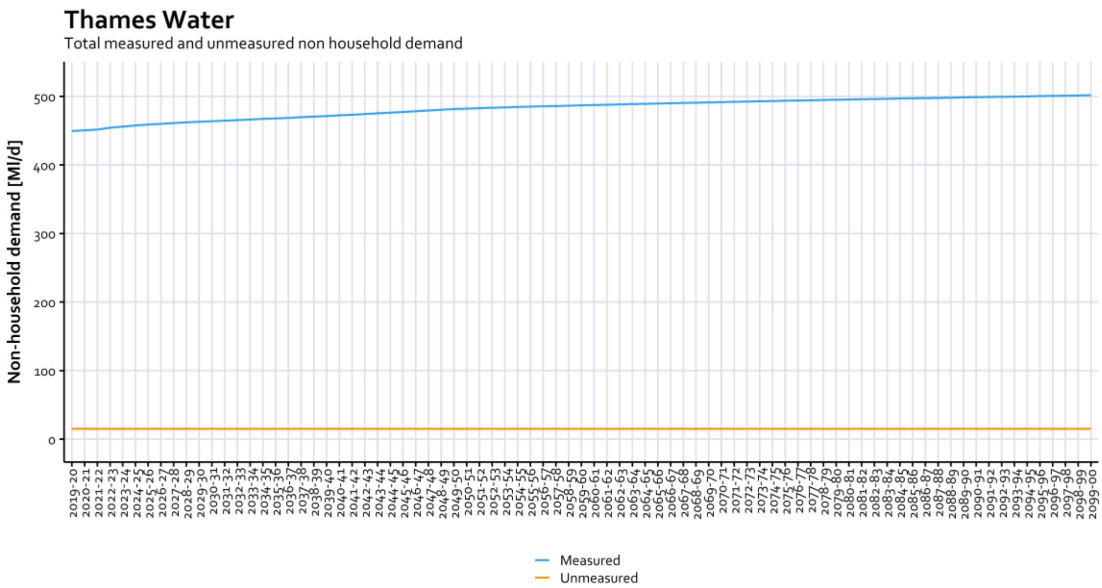
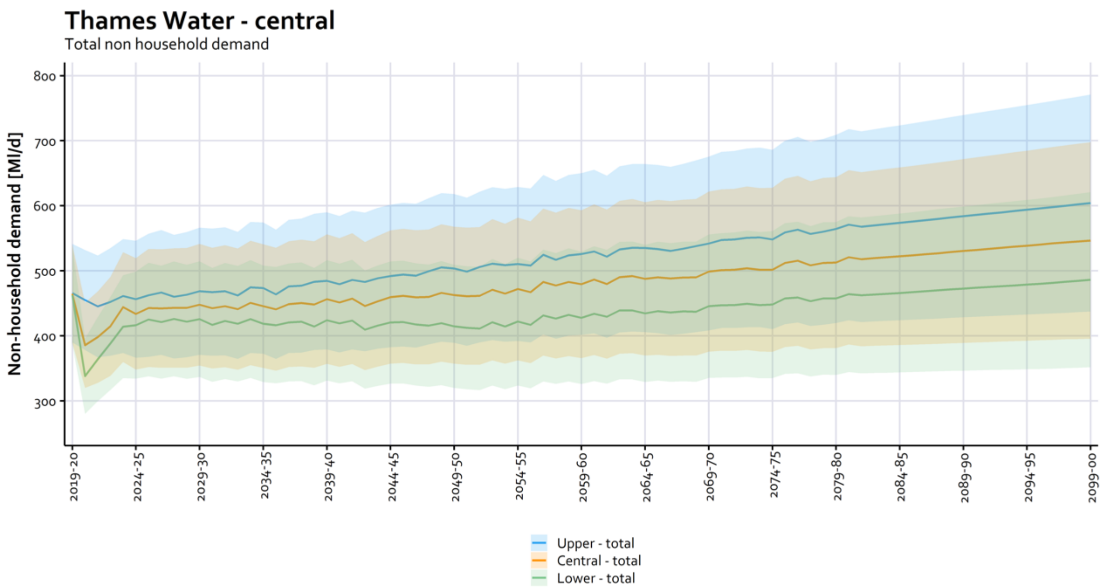


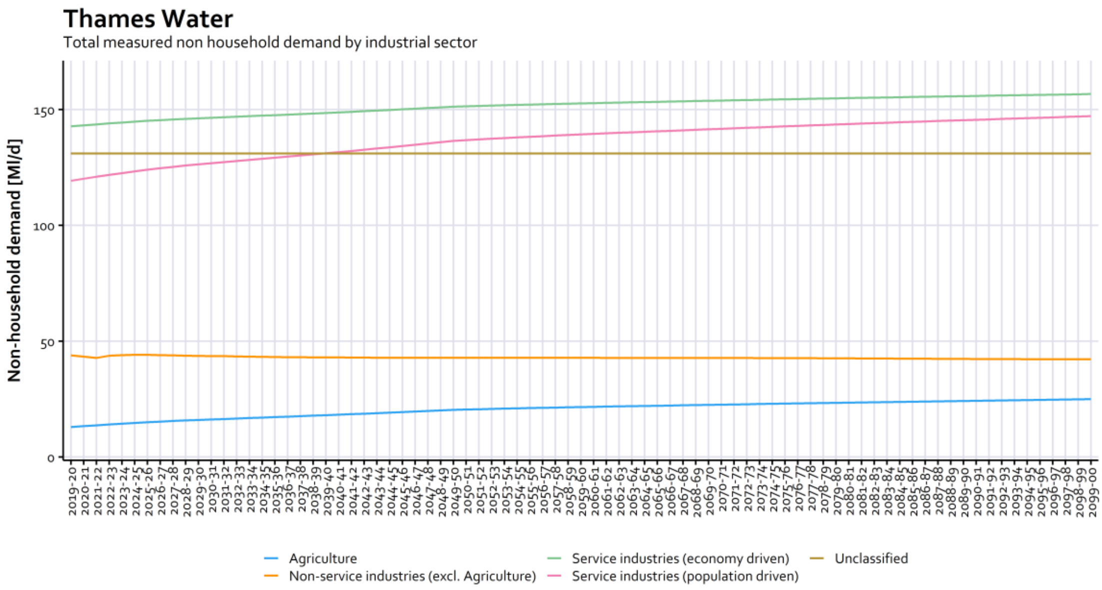

**Figure 30 Thames Water region non-houshold consumption central, lower and upper scenarios**



There is growth in the Thames Water region from the service sectors, with a small increase in agriculture, the non-service sector remains flat across the planning period.

About 27% of the demand in the Thames Water region falls into the unclassified group, and as explained in section 3.1.1, this is held flat across the planning period. These are properties that could not be allocated into an industry sector because either the property has no industry code assigned to it or the industry code is incorrectly recorded and cannot be matched to a sector. We did attempt to model this unclassified sector, but because of the inconsistency in the data it was not possible to derive meaningful relationships or models, therefore we held the forecast for the unclassified sector flat across the planning period.

**Figure 31 Thames Water non-housheold consumption by industry sector**




## 3.2 Potential non-public water supply demand

Projections for non-PWS non-household demand are provided in the following file "01_Artesia-WRSE_NonHousehold-Demand-Forecasts_non-PWS_Phase1-final-results_20201008.xlsx".

These files includes the following breakdown of scenario non-household demand forecasts from 2019-2020 through to 2099-2100:

- 1 Existing abstraction, Best estimate, Recent actual consumptive volume with growth to 2050, By WRZ and sector
- 2 Existing abstraction, 75th percentile, Recent actual consumptive volume with growth to 2050, By WRZ and sector
- 3 New licence, New licenced volume with growth to 2050, By WRZ and sector
- 4 Existing abstraction, Best estimate, Recent actual consumptive volume with growth to 2050, Summed to WRZ
- 5 Existing abstraction 75th percentile Recent actual consumptive volume with growth to 2050 Summed to WRZ
- 6 New licence, New licenced volume with growth to 2050, Summed to WRZ

- 7 Total non_PWS, Best estimate, Recent actual consumptive volume plus new abstractions with growth to 2050, At WRZ
- 8 Total non_PWS, 75th percentile, Recent actual consumptive volume plus new abstractions with growth to 2050, At WRZ
- 9 Total non_PWS, Best estimate, Recent actual consumptive volume plus new abstractions with growth to 2050, At company
- 10 Total non_PWS, 75th percentile, Recent actual consumptive volume plus new abstractions with growth to 2050, At company
- 11 Total non_PWS, Best estimate, Recent actual consumptive volume plus new abstractions with growth to 2050, At region
- 12 Total non_PWS, 75th percentile, Recent actual consumptive volume plus new abstractions with growth to 2050, At region

The base year abstraction by sector is shown in Figure 32, with the best estimate of growth to 2050 shown in Figure 33. The estimated new abstractions by sector are shown for the base year in Figure 34, with the projected growth to 2050 shown in Figure 35.

These have been aggregated to regional level in Figure 36. The figures are then segregated to water company level and are shown in Figure 37, split out by water company with the best estimate, 75th percentile estimate and new abstractions for the base year (2019-20) and for 2049-50.

**Figure 32 Base year exisitng abstractions by sector for the WRSE region**

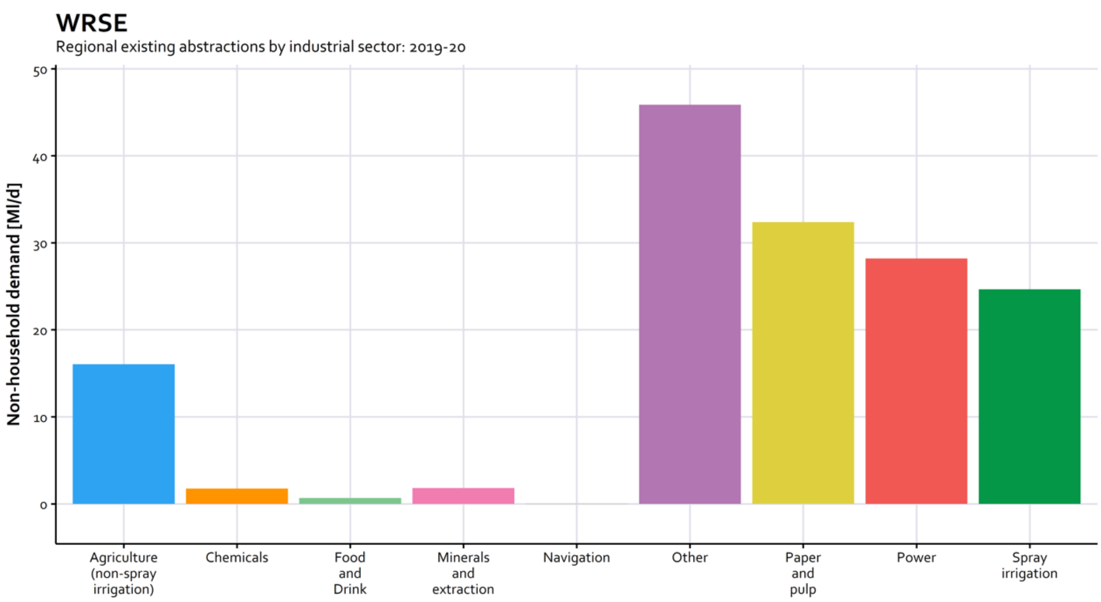


**Figure 33 Best estimate of exisitng abstractions growth to 2050 by sector for WRSE region**

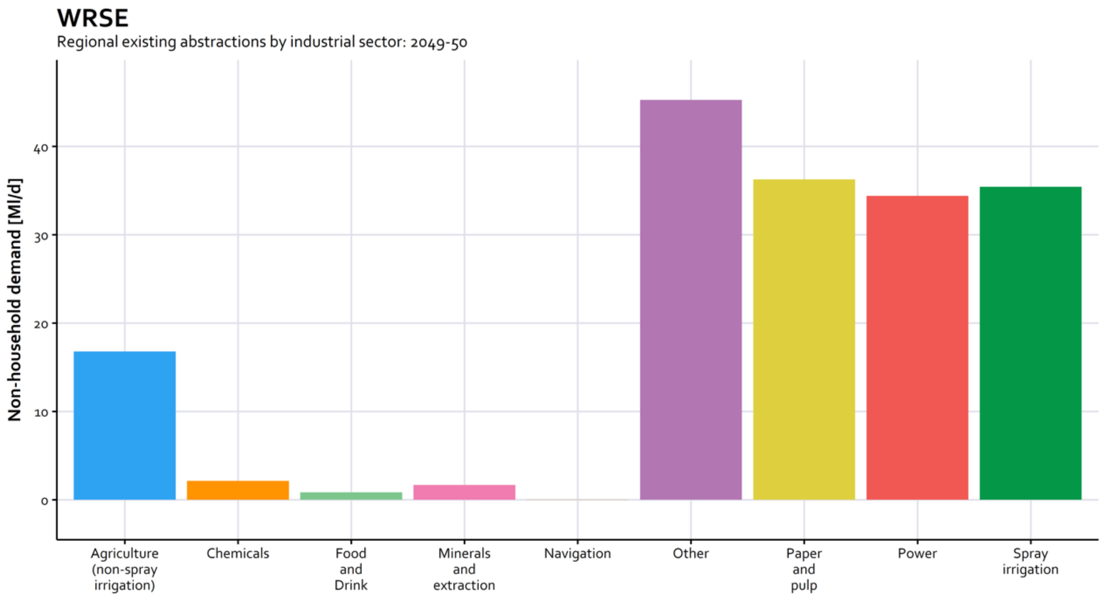



**Figure 34 Base year new abstractions by sector for WRSE region**

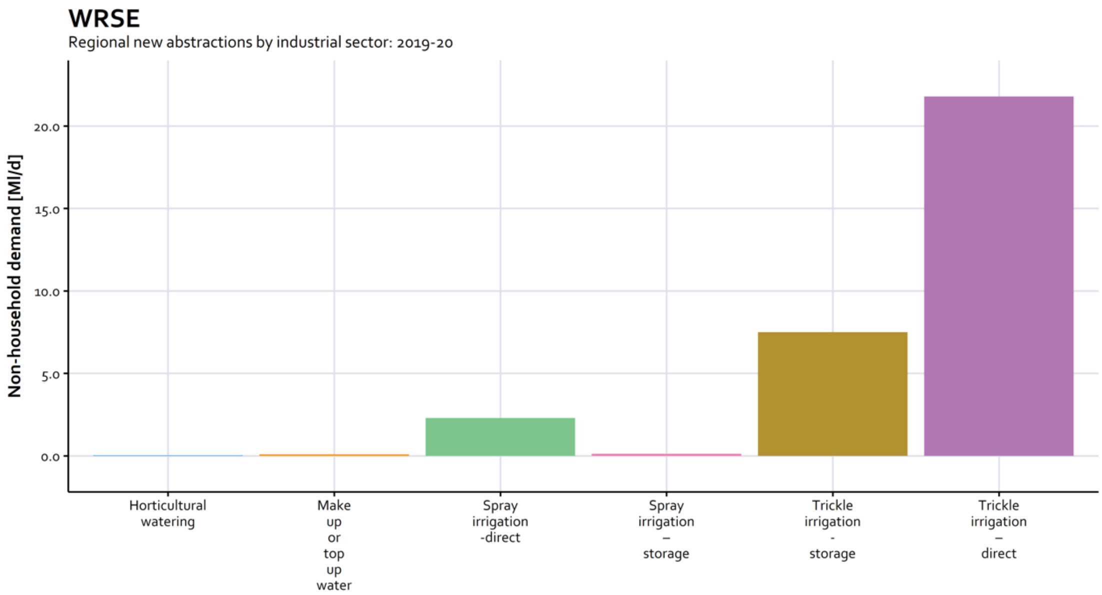


Figure 35 Best estimate of new abstractions growth to 2050 by sector for WRSE region

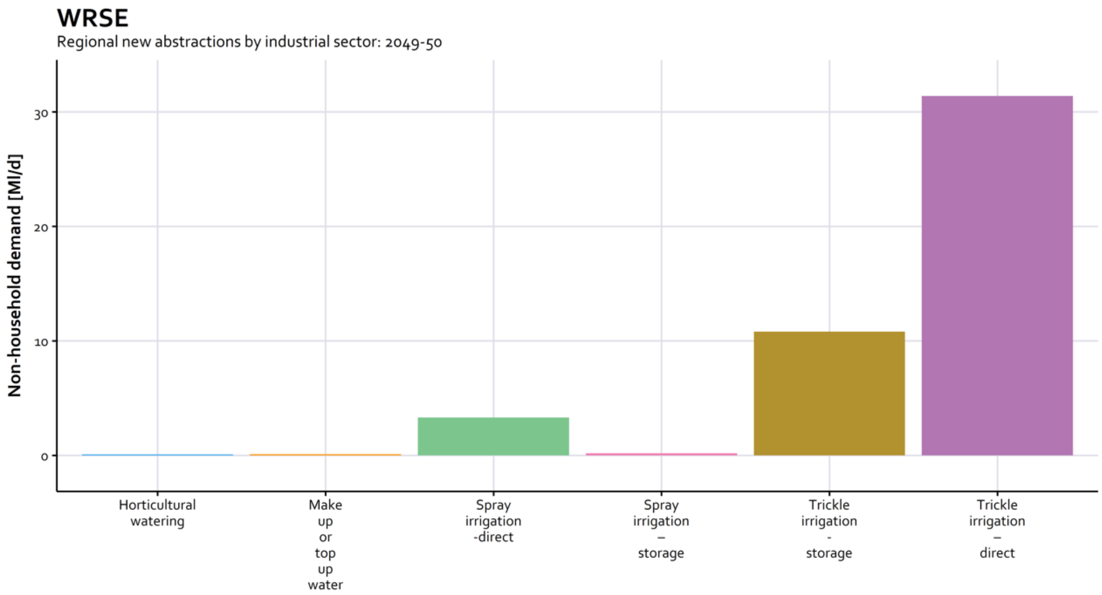



Figure 36 Non PWS in base year and 2050 at WRSE region split out by best and 75th percentile estimate and new abstractions

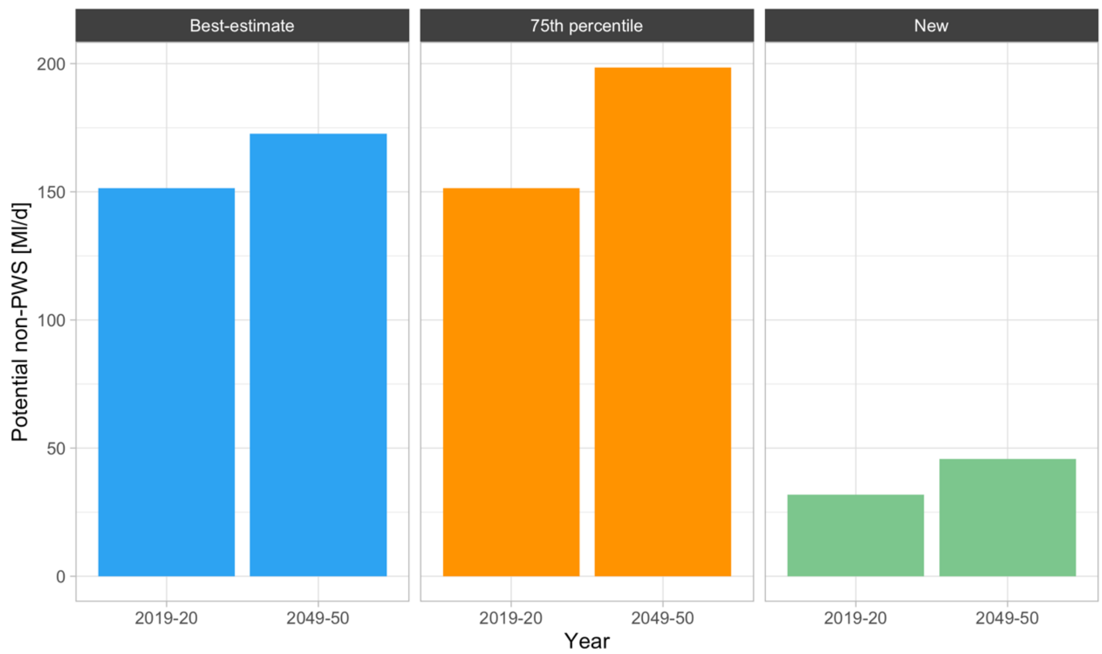
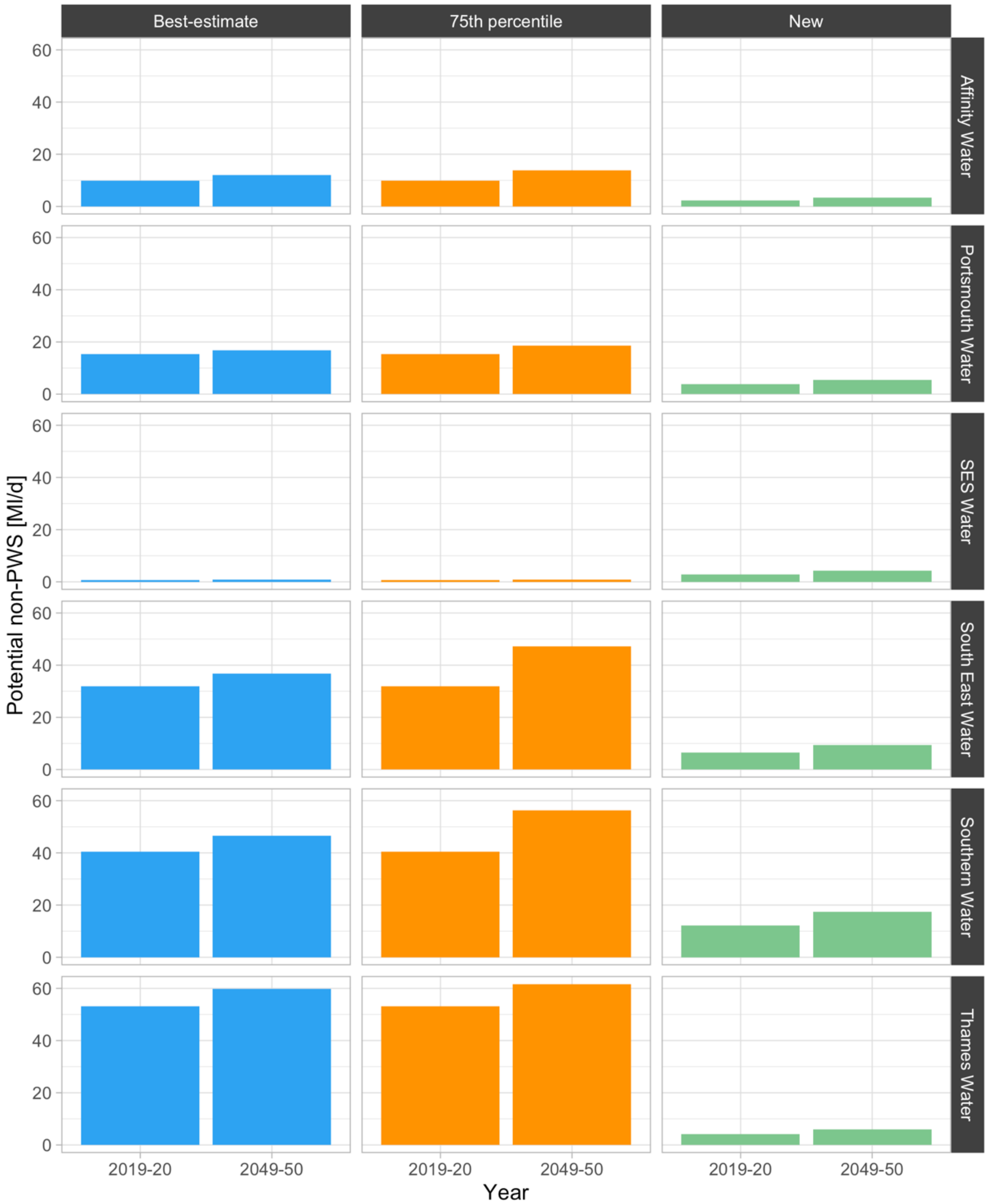


Figure 37 Non PWS in base year and 2050 by company split out by best and 75th percentile estimate and new abstractions



# 4 Discussion of findings

This section discusses the overall results and findings that are consistent across WRSE, any company specific findings are discussed in Appendix A. The discussion is broken down into the following sections:

- The modelling approach used for this study.
- Uncertainty in the predictions.
- Data issues.
- Potential alternative industry segments.
- Weather impacts.
- Other potential improvements.

## 4.1 Modelling approach

As explained in sections 1.4.1 and 1.4.2, this project followed well prescribed approach, based on an initial review of best practice and previous WRMP company models carried out by WRSE. This has ensured that a consistent approach has been applied to modelling non-household consumption across all 37 WRZs in the WRSE region. As part of this approach, the industry sector grouping, along with expected drivers for each group, were prescribed in Table 3 of the WRSE review[5] described in section 1.4.1. The groups and drivers are set out in Table 9. This grouping seems sensible based on the review of previous non-household models, and therefore was used for this study.

**Table 9 Industry sector groupings and drivers from the initial WRSE review**

| Sector_Name | Sector _Description |
|---|---|
| **Agriculture** | Agriculture clearly has a stronger relationship to weather than other sectors, and therefore if it is significant it warrants separate treatment, particularly in the context of climate change scenarios. There may be other weather-dependent industries that behave similarly. |
| **Non-service industries (excl. Agriculture)** | These are again more likely to show trends related to the economy, but are likely to contain different trends in patterns of water use and efficiency. |
| **Service industries (economy driven)** | Other areas of the service sector, such as retail and entertainment, are more likely to show trends related to the size of the economy or employment. |
| **Service industries (population driven)** | Certain areas of the service sector, such as education and health, are more likely to be driven by population size rather than measures of economic output, and therefore it is worth including these as a separate grouping. |

| | |
|---|---|
| **Unclassified** | Some non-households may not readily be assigned to any of the other categories. It is also unlikely to be able to assign industry sectors to every property, and a significant volume of consumption will not be assigned to one of the previous sectors. Care needs to be taken that strong trends in this sector are not simply reflecting changes in data quality over time. |

In the process of developing the non-household consumption models we started with the different drivers for each sector group. However, some models were weak, and therefore we allowed the data for each sector's model to guide us in the selection of the explanatory variables, i.e. all explanatory variables were applied to each sector model and the models refined through a process of variable reduction until the strongest models remained. The resulting significant variables for each company model across WRSE are shown in Table 10.

**Table 10 Significant explanatory variables in each sector model**

| Company | Sector model | Population | GVA | Employment | MOSL flag | Other |
|---|---|---|---|---|---|---|
| **Affinity** | Agriculture | X | X | X | X | |
| | Non-service | X | X | X | X | |
| | Service-economy | X | | | X | |
| | Service-population | X | | | X | |
| **Portsmouth** | Agriculture | X | X | X | X | |
| | Non-service | | X | | X | |
| | Service-economy | X | X | X | X | X |
| | Service-population | X | | X | X | X |
| **SES Water** | Agriculture | X | | | | X |
| | Non-service | X | | X | | X |
| | Service-economy | X | | | | X |
| | Service-population | X | | | | X |
| **South East** | Agriculture | X | X | | X | X |
| | Non-service | X | X | | X | X |

| Company | Sector model | Population | GVA | Employment | MOSL flag | Other |
|---|---|---|---|---|---|---|
| | Service-economy | x | | | x | |
| | Service-population | x | | | x | |
| Southern | Agriculture | x | | x | x | x |
| | Non-service | x | | | x | x |
| | Service-economy | x | x | | x | |
| | Service-population | x | | x | x | x |
| Thames | Agriculture | x | | | x | x |
| | Non-service | x | | x | | x |
| | Service-economy | x | | | x | x |
| | Service-population | x | | | x | x |

What we see is quite a mix of explanatory factors, with population having a strong influence in nearly all models. Economy (GVA) is a factor in some of the non-service and service-economy models. Employment is a factor in some of the models across all four sector groupings. The MOSL flag (discussed in sections 2.4.2 and 4.3.1) is significant in nearly all models. Some models contain an additional factor which would typically be added following an analysis of residuals were relationships in the residuals are observed, for example population density. Note, that for the unclassified sector there was too much variation in the data to establish any robust models, therefore these were held flat across the planning period.

Overall, the picture is a lot more varied than the anticipated factors from the initial review (Table 9). For some of the segments the resulting models using the explanatory factors described above were very weak, so we expanded the modelling to allow all the explanatory factors to be used for each segment to develop stronger models. Where some of the models remained weak, we looked for other explanatory factors such as population density. We also did some additional exploratory work on why the segments as defined, didn't always result in strong models. This identified that within some of the segments we were seeing different SIC divisions showing a positive relationship with the explanatory variables whilst others showed a negative relationship which were cancelling each other out.

There are some opportunities to improve the industry groupings and explore some initial analysis on this in section 4.4 below.

However, all the models developed and used in this report are robust, but some will have wider uncertainty bands. In addition, the consistency of the approach across the WRZs within

WRSE brings additional benefits in comparing the results between zones and applying them in a consistent way to the planning solution.

## 4.2 Uncertainty in predictions

We have estimated unknowns that may affect water consumption forecasts through applying uncertainties and scenarios around the baseline forecasts. We have estimated uncertainties due to the data uncertainty and unexplained variability, and applied these across the forecasts such that they grow in a gradual way over time. For unknowns in future projections we have used scenarios to estimate the future variability. We created scenarios that include future variations in population, Brexit impacts, COVID-19 impacts, MOSL data quality, climate change and water efficiency. These are all explained in section 2.4.

The result is some significant uncertainty around the future projections of non-household consumption. For example, at WRSE level, the results show an uncertainty (including the scenarios) in the starting point of the forecast of approximately +22% and -35%, with these increasing to approximately +58% and -39% by 2100.

The forecasts start from a base year of 2019-20 and some of the early uncertainty will be due to Covid-19 impacts. Within the baseline models Covid-19 causes a decline in the GVA forecast from Oxford Economics in 2020/21, then a return to normal, however we have shown in section 2.4.2 that the effect on Covid-19 on demand is likely to be larger than this and so a larger adjustment for Covid-19 is made in the scenario forecasts.

The scenarios are produced independently to the baseline forecast. The baseline just takes into account the future trend in the explanatory factors. The scenarios allow us to that include future variations in population, Brexit impacts, COVID-19 impacts, MOSL data quality, climate change and water efficiency (these are all explained in detail in section 2.4).

The central scenario is not intended to be the same as the baseline, but should be similar, generally the baseline is slightly below central, and above the lower scenario. The baseline forecast is the outcome of the timeseries linear modelling as described in best practice and section 2, it is a prediction based just on the relationship between economic variables and the historic consumption. The central, and the upper and lower scenarios have additional data and assumptions behind them. Central is the 50th percentile of all of the 729 different combinations of assumptions around Covid-19, Brexit, water efficiency, climate change, population change and impact of MOSL data. The upper scenario is the 90th percentile and the lower is the 10th percentile. Uncertainties have been provided around each of the scenarios which have been based on modelling and data errors that are propagated through the forecasts and scenarios.

Therefore, companies may consider selecting a forecast which differs slightly from the baseline, but within the scenario ranges, depending on their own local knowledge and approach to risk.

## 4.3 Data issues

As anticipated in the review stage (section 1.4.1) we found a range of data issues whilst carrying out the work. These are discussed below.

### 4.3.1 MOSL data

The quality of the MOSL data had a direct impact on the quality of the forecasts. We found some significant step changes in consumption in the years since 2017, in the aggregate consumption data and in annual reported data. Most of these step changes are downward, although for some WRZs they are in the other direction.

Figure 38 to Figure 40 show examples of big swings in reported non-household consumption following 2016 for 3 WRZs from 3 different companies. In all cases the step changes in a single year are greater than observed in the historic company reported data. MOSL reported data is in pink. In the first example the change is about 28% in one year, in the second two the change is about 11%. As the forecasts are rebased to the annual reported consumption in the based year (2019-20), the accuracy of this data is important.

**Figure 38 Example (Thames-SWOX) step change in reported non-household consumption post 2016**

Figure 39 Example (SES Water) step change in reported non-household consumption post 2016

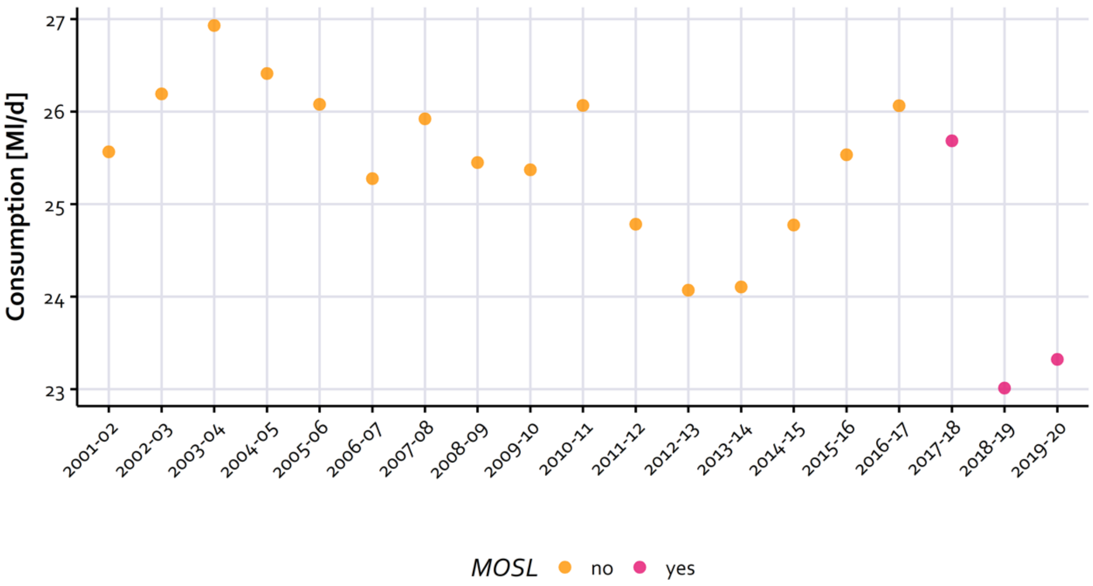
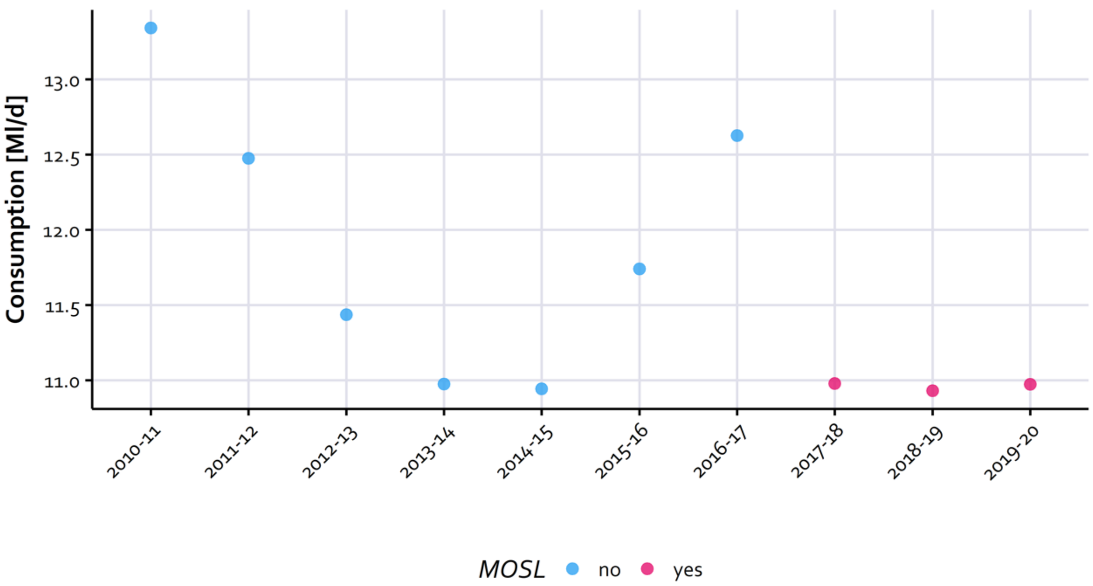



Figure 40 Example (SEW-Maidstone) step change in reported non-household consumption post 2016




We have dealt with the uncertainty about the data since 2017 in two ways. Firstly, we added a flag to the model to indicate the MOSL data, which allows the models to take into account any step changes resulting from the transition of retail separation.

Secondly, it would be useful to understand better whether the changes in the annual return aggregated property level data from MOSL are a long-term change or a short-term result of data issues during retail separation. MOSL's report for 2019-20 identifies that there are specific problems with long term un-read meters and high numbers of vacant properties (some with high consumption values)[15]. Therefore, we have included three future scenarios, one where the data improves, one where it deteriorates and one where it stays as it is currently.

For future forecasts, we need to consider further whether can we make better adjustments for the effects from retail separation, and consider if this is the new normal (e.g. due to the redefinition of NHHs to HHs) or is it due to erroneous data, that will eventually be resolved. It might be useful to flag to MOSL, Ofwat and the Environment Agency the significance of these data errors.

### 4.3.2 Matching pre and post MOSL data

Another factor that impacts the modelling in data post MOSL is the standard industry classification data. Data is often presented as a mix of SIC_1980, SIC_1992, SIC_2003 and SIC_2007 and often the SIC codes presented cannot be matched accurately to the correct SIC classification. Improvements in this area of data quality would help modelling.

Some companies have better matching of properties and industry classifications pre and post MOSL. This definitely helps build better models as there is a more consistent set of time series data for modelling.

### 4.3.3 Property level consumption data

Not all companies were able to provide property level consumption data (sometimes it was provided already aggregated to industry code level).

Having property level consumption data improves the identification of large users and voids, it improves consistency of data and allows for better quality checks on the data; all of which will improve the model results. It would be better to have a consistent smaller set of properties that are representative of an area, than try and reduce the overall size of the unclassified group.

For example, the Affinity Water data set had lower coverage than some, but the data was very consistent and tidy over time and provides a good coverage of industry types. This means that the variation that we observe is genuine and can be modelled better.

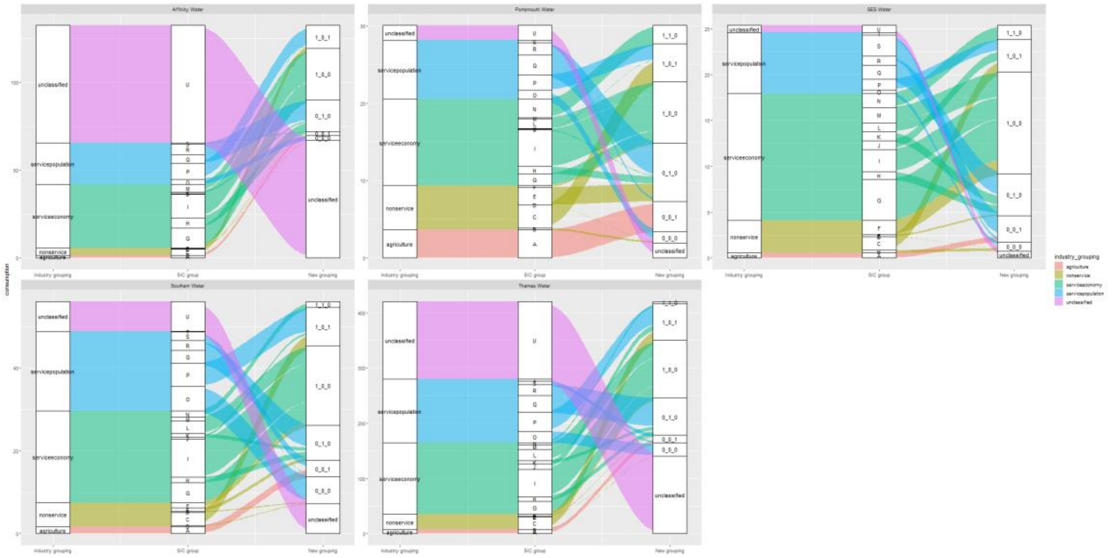
## 4.4 Industrial sector segments

Through analysing all the non-household data in the WRSE region we found that the industry grouping recommended in the earlier review (section 1.4.1), whilst logical, is probably too coarse and is masking some of the genuine relationships. This is based on what the data is telling us.

When we examined the 19 SIC divisions and how they mapped onto the 5 industry groupings we find that in some groupings there are competing trends, i.e. some are increasing and some decreasing. This is also true for some of the explanatory factor data (GVA and employment) which was also provided at the 19 SIC division level.

We did some analysis starting with the 19 SIC divisions and looked at grouping these together so that explanatory factors have coefficients that are in the intended direction and are significant in the modelling. Preliminary results of this are shown in Figure 41.

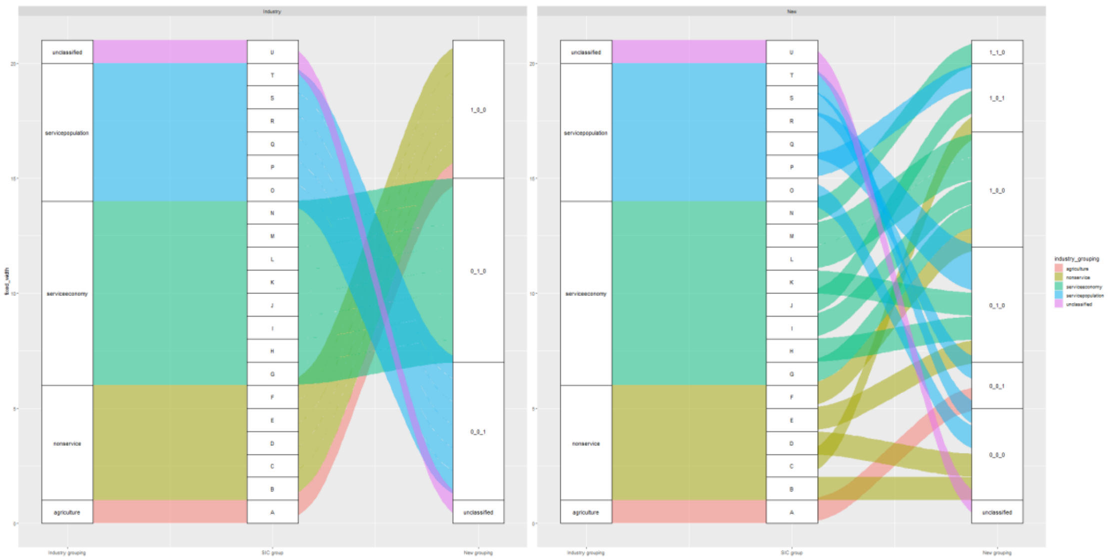
**Figure 41 Exploring alternative industry groupings for each company**



In Figure 41 we show the impact of grouping the SIC divisions so that the explanatory factor coefficients are in the correct direction and significant (new groupings on the right hand side of each figure), and then show this against the original industry grouping on the left side of the figure.

The groupings vary across the companies, but there is some consistency, and a version of this process for the whole region is shown in Figure 42, with the existing grouping on the left and the alternate grouping on the right.

**Figure 42 Exploring alternative industry groupings for the region**



This may be worth exploring further by taking the best and most consistent quality data from across the region to provide a single data set.

We also found that there were other significant explanatory factors, in addition to the econometric GVA and employment factors. We introduced a population density factor in the

Southern Water model (which had a positive impact), and it is likely that there are other factors that would improve models further.

## 4.5 Weather

The outputs from this modelling are raw un-normalised forecasts of non-household demand, calibrated to the reported values for AR 2019/20. This is in line with the scope of the project. The Water Resource Planning guidance does not specifically require companies to apply weather factors to non-household demand. The preliminary review of non-household forecasting carried out by WRSE states that "Companies should include weather variables for those industries and/or areas where this can be shown to be a significant factor in modelling non-household consumption".

Companies wishing to derive and apply NY (normal year) or DY (dry year) factors to the non-household demand forecasts derived in this project should consider the relative size of the weather driven non-household demand (i.e. from the agricultural sector) in their region and individual WRZs, compared to other non-household and total demand. They should also take into account the quality of the data for deriving these factors.

## 4.6 Other improvements

There is clearly an impact on the forecasts from the quality of the data. There should be further work to help water companies improve the quality the data they use for forecasts. It might be more cost effective to do this as a regional group, rather than individually.

The current best practice (developed in 1997) suggests the econometric approach and this has been applied quite consistently by individual companies over the past few WRMPs. However, looking at the data from the WRSE companies across the region shows that some of these relationships are quite weak and there might be alternative forecasting techniques that might be better given the quality constraints on some of the data. WRSE (or all the regions) should consider whether it is worth carrying out some wider industry research to evaluate alternate methods for modelling and forecasting.

Another option worth considering is a greater level of aggregation within the WRSE region. In this study we have modelled each company consistently, but independently. We have seen that there are limitations in the data, and it might be possible to look at all the WRZs across the region and group together WRZs based on how their non-household consumption behaves (as opposed to a company geographical boundary). This may allow more data to be pooled, and when combined with a more sophisticated approach to grouping industrial sectors (section 4.4), this may result in stronger models being developed.

# 5 Conclusions

We have produced a set of non-household demand forecasts for all 37 water resource zones in the WRSE region from 2019-2020 out to 2099-2100. These are presented for metered and unmetered properties at company level, water resource zone level and dis-aggregated by industrial sector.

The approach used follows existing industry best practice, taking into account the recommendations from a review of non-household demand forecasting methods carried out by WRSE in early 2020. Robust multiple linear models have been produced for 4 cohorts of industrial sectors for each company in WRSE, using explanatory factors that include population, gross value-added metrics, employment rates, population density and other factors.

Since the last set of non-household forecasts were completed for WRMP19, the non-household retail sector has undergone a transformation with the introduction of retail competition. A significant impact from this is that metered non-household consumption data is now the responsibility new retailers, managed by the new Market Operator Services Ltd (MOSL). We have observed a change in data quality and consistency since the change in 2017. This has complicated the modelling (which relies on a consistent set of time series data) and has increased the uncertainty around the demand forecasts. This has been taken into account in the models, uncertainty and scenario estimates.

The first year of the forecast (2020) has seen an unprecedented change in non-household demand due to the policies introduced to combat the COVID-19 pandemic. This increases uncertainty going forward as we still do not fully understand what the enduring impacts will be from changes in working practices, such as increased working from home. Therefore, we have included the COVID-19 impact in the scenarios and uncertainty estimates.

The sector also faces a number of future unknowns in demand from non-households, such as population change, Brexit, climate change and how water efficiency will be delivered in the non-household sector. Therefore, these have also been included in the scenario and uncertainty modelling.

The overall conclusion is that non-household demand in the WRSE region at the start of the planning period (2025), is predicted to be 921 Ml/d within an overall range of 594 to 1121 Ml/d. This is predicted to increase by the end of the planning period (2100) to 1032 Ml/d (an increase of 111 Ml/d) within a range of 630 Ml/d to 1637 Ml/d.

We have also made a prediction of the amount of non-public water supply (non-PWS) demand in the WRSE region and how this might change over the planning period. The non-PWS demand includes all existing abstractions used for non-household demand plus any new authorisations since February 2019. This is broken down by sector and water resource zone. Overall for the WRSE region, the current estimate of non-PWS non-household demand of 183 Ml/d in 2019-20 is predicted to increase to 218 Ml/d by 2050. Due to the uncertainty in the data we have held the forecast flat for the remainder of the planning period.

We have identified a number of improvements that could be implemented for future forecasts, and these are included in the recommendations.

# 6 Recommendations

Companies in WRSE should use the baseline and scenario forecasts presented in this report to select an initial WRMP baseline forecast for the metered and unmetered non-household demand forecast lines in the Environment Agency's water resource planning tables.

We have presented the forecasts from a base year of 2019-20. The intermediate years 2020-21 through to 2024-25 are presented for information prior to the start of the planning period in 2025-26. These intermediate years are potentially volatile with a number of unknowns around the impact of the COVID-19 pandemic and the impact from Brexit on non-household consumption. Therefore we recommend that the baseline and scenario forecasts are updated prior to the submission of the final water resource management plans.

For the first time we have presented an initial view of non-PWS forecasts. We suggest these should be used as an upper limit for the amount of non-PWS demand that could switch to PWS under drought conditions.

During the course of the work to develop the non-household demand forecasts we have identified a number of potential improvements to achieve more accurate forecasts. These are set out below.

WRSE should inform MOSL of the importance of getting consistent good quality data on non-household consumption for forecasts. MOSL's report for 2019-20 identifies that there are specific problems with long term un-read meters and high numbers of vacant properties. These have caused some volatility in the consumption data since the introduction of market reform, which have impact on the robustness of future forecasts.

The ability to allocate non-households to specific industry sectors through tools such as SIC or AddressBase Premium also aids the robustness of forecasts. Across the WRSE there is quite a bit of variability in the proportion of properties that need to be placed in the "unclassified" sector due to the quality, quantity or availability of non-household sector classifications. Companies in WRSE should investigate the most efficient way of improving this information for future forecasts. Note, it is important that there is good quality and consistency of data over time for a good coverage of industry types, which in turn means that the variation that we observe is genuine and can be modelled better.

WRSE should consider investigating different industrial sector groupings than those selected for use in this study. We have done some preliminary analysis that shows there are potentially better sector groupings that could improve the quality of the model outputs.

The consistency of approach and method across the WRZ's in WRSE is beneficial. As well as looking at improved sector groupings, we recommend investigating the grouping of WRZs based on how their non-household consumption behaves (as opposed to a company geographical boundary). This may help to overcome some of the data limitations.

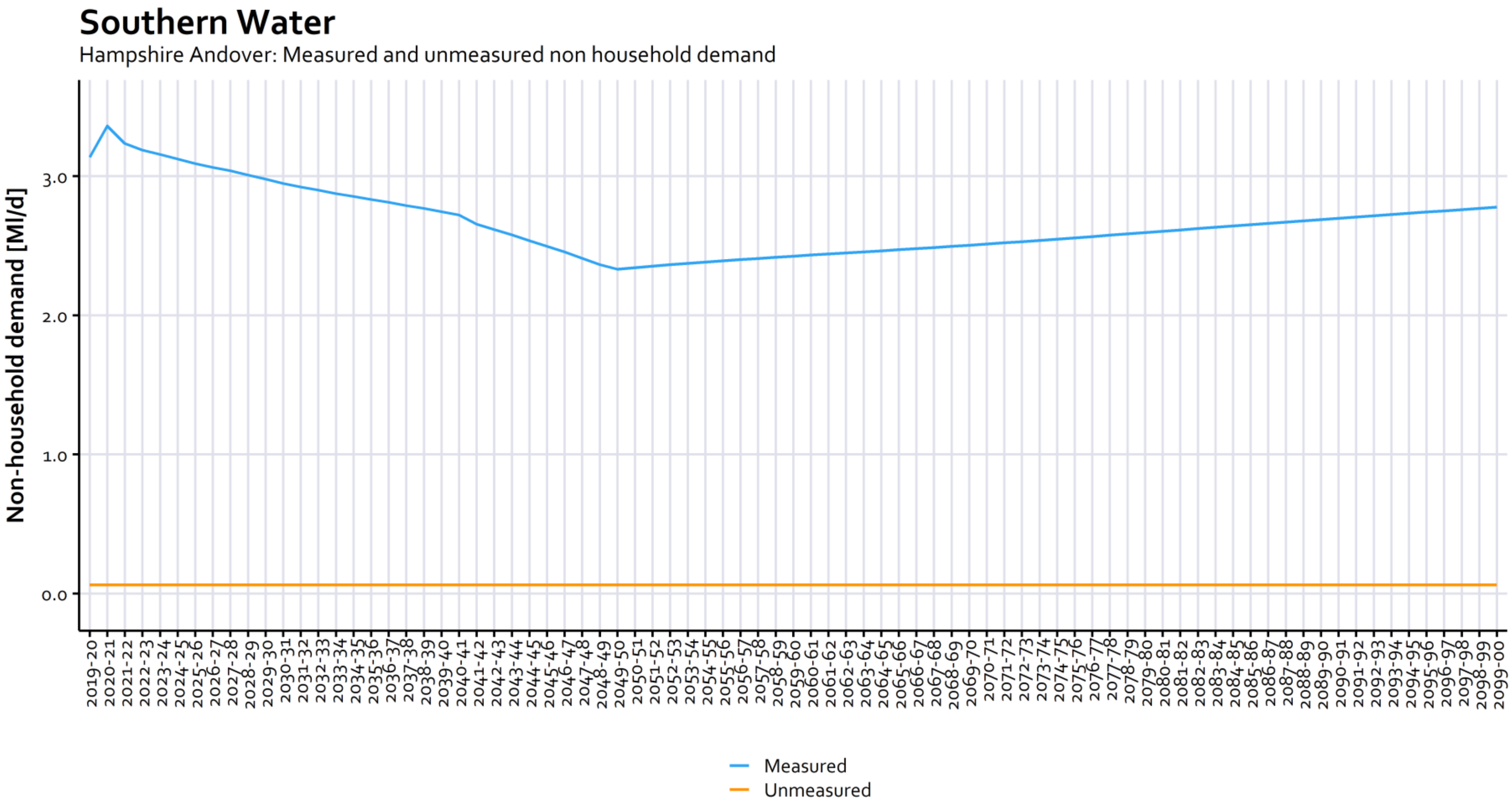
The forecast modelling in this study has been carried out using a functional programming approach that allows forecasts to be run and evaluated more efficiently. This approach allows forecasts to be produced more frequently, potentially sub-annually, as data is updated. A more continuous forecasting approach would remove the step-like transitions between AMP forecasts and could improve the robustness of the forecasts. The functional approach would also allow for different sectors grouping or WRZ grouping to be applied quickly and efficiently.

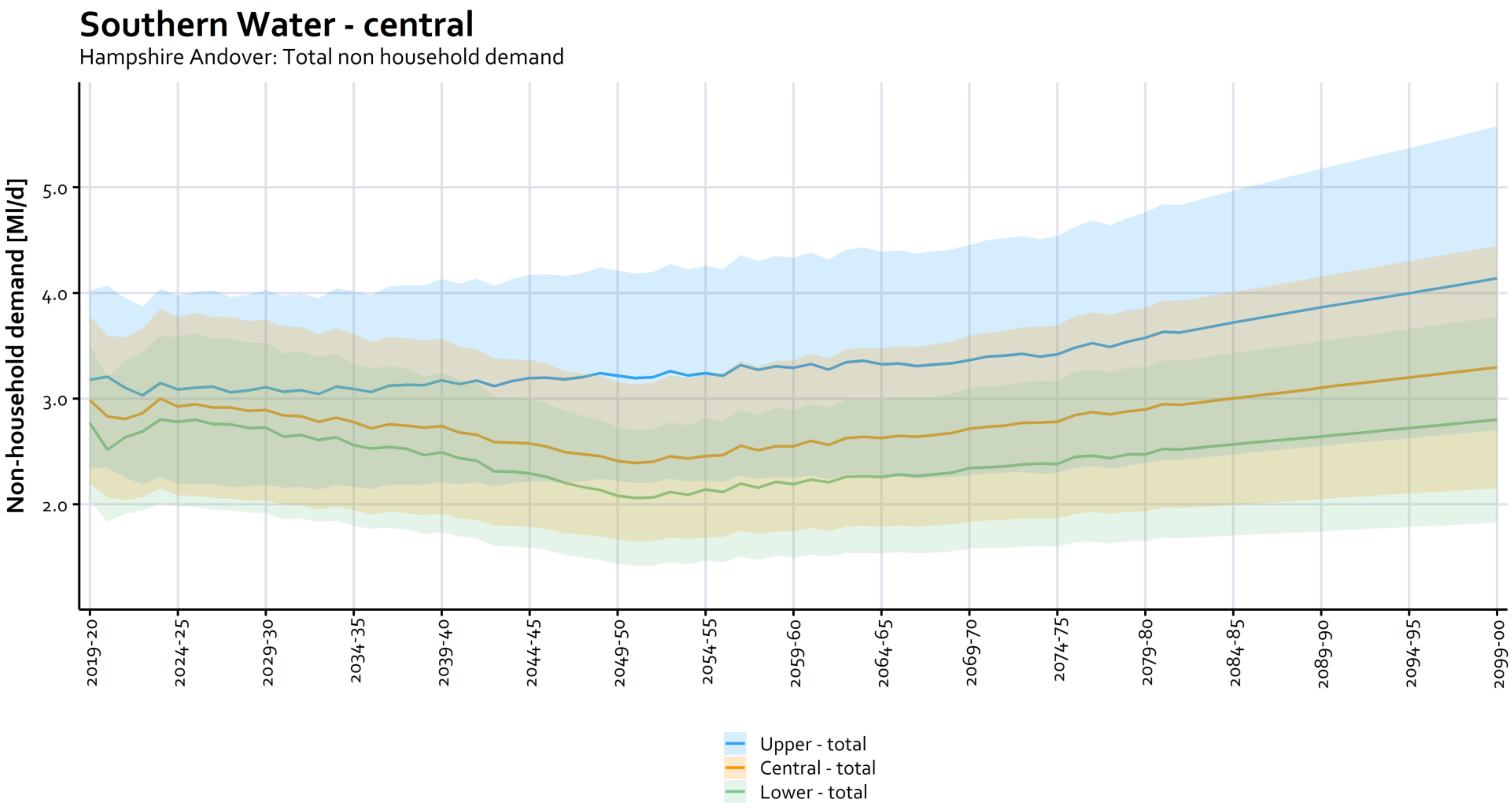
# Appendix A: Southern Water modelling results

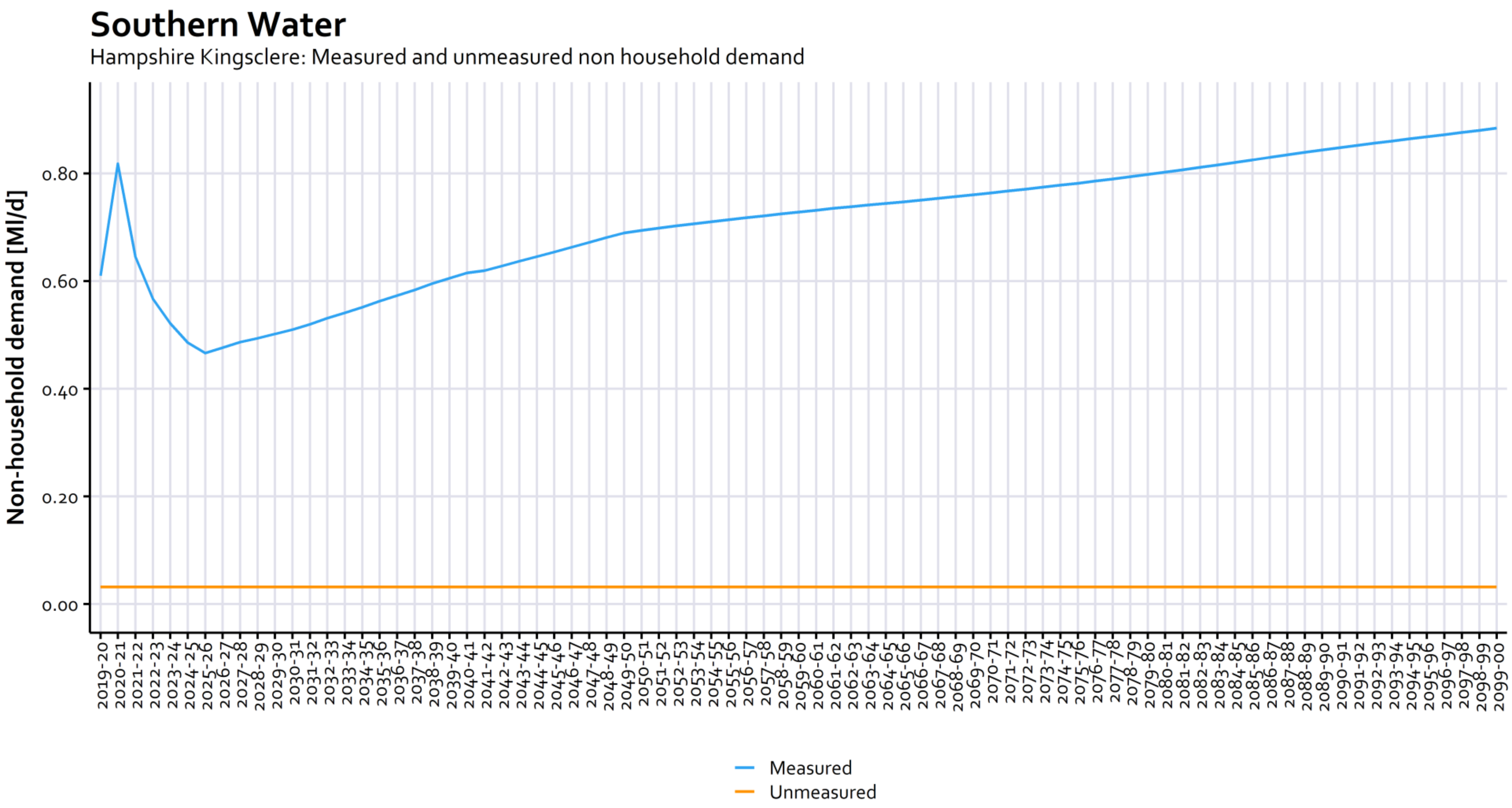
Note this appendix is presented in landscape format to improve the presentation of the graphs. Firstly we present the WRZ graphs for metered and unmetered NHH consumption, along with the scenario graphs. The we present the sector graphs for each WRZ. Then we present the MLR (multi linear regression model metrics for each section to identify the drivers for the forecast in each zone. Then we present the calibration factors for each WRZ and sector. A full set of graphs and tabulated sets of yearly forecasts for PWS and non-PWS demand are hosted on the WRSE SharePoint site.

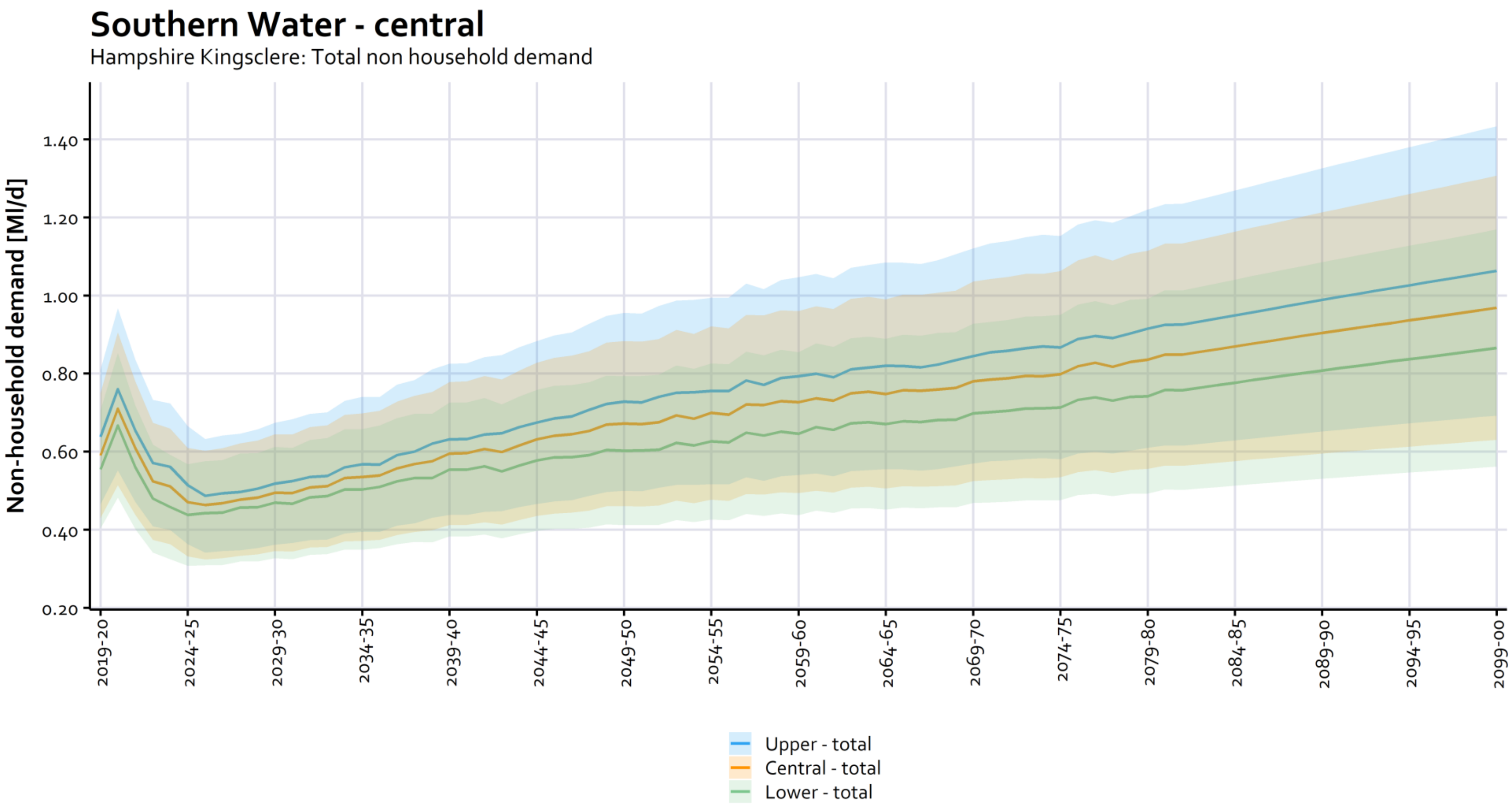
 

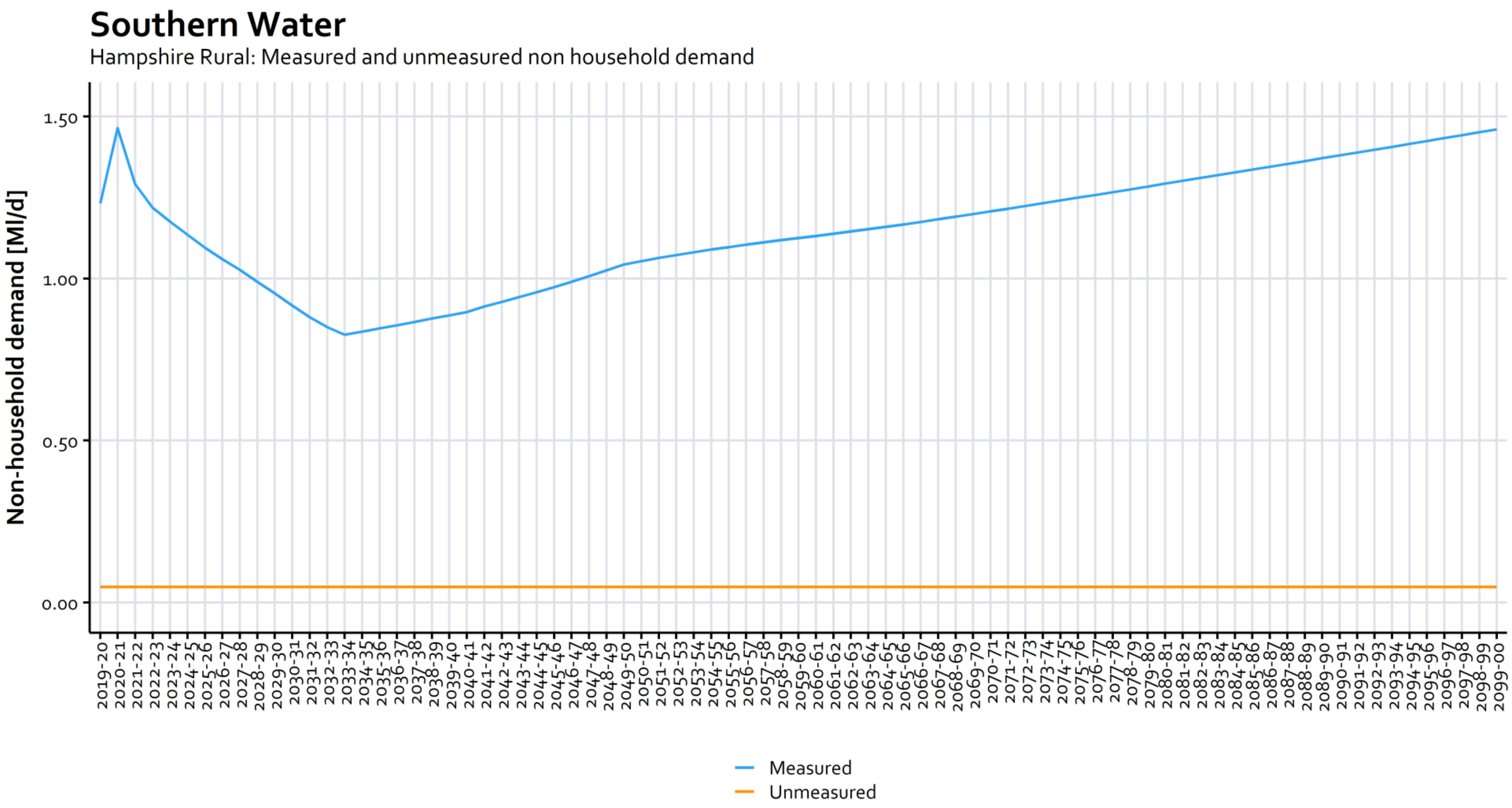
## Overview of WRZ results

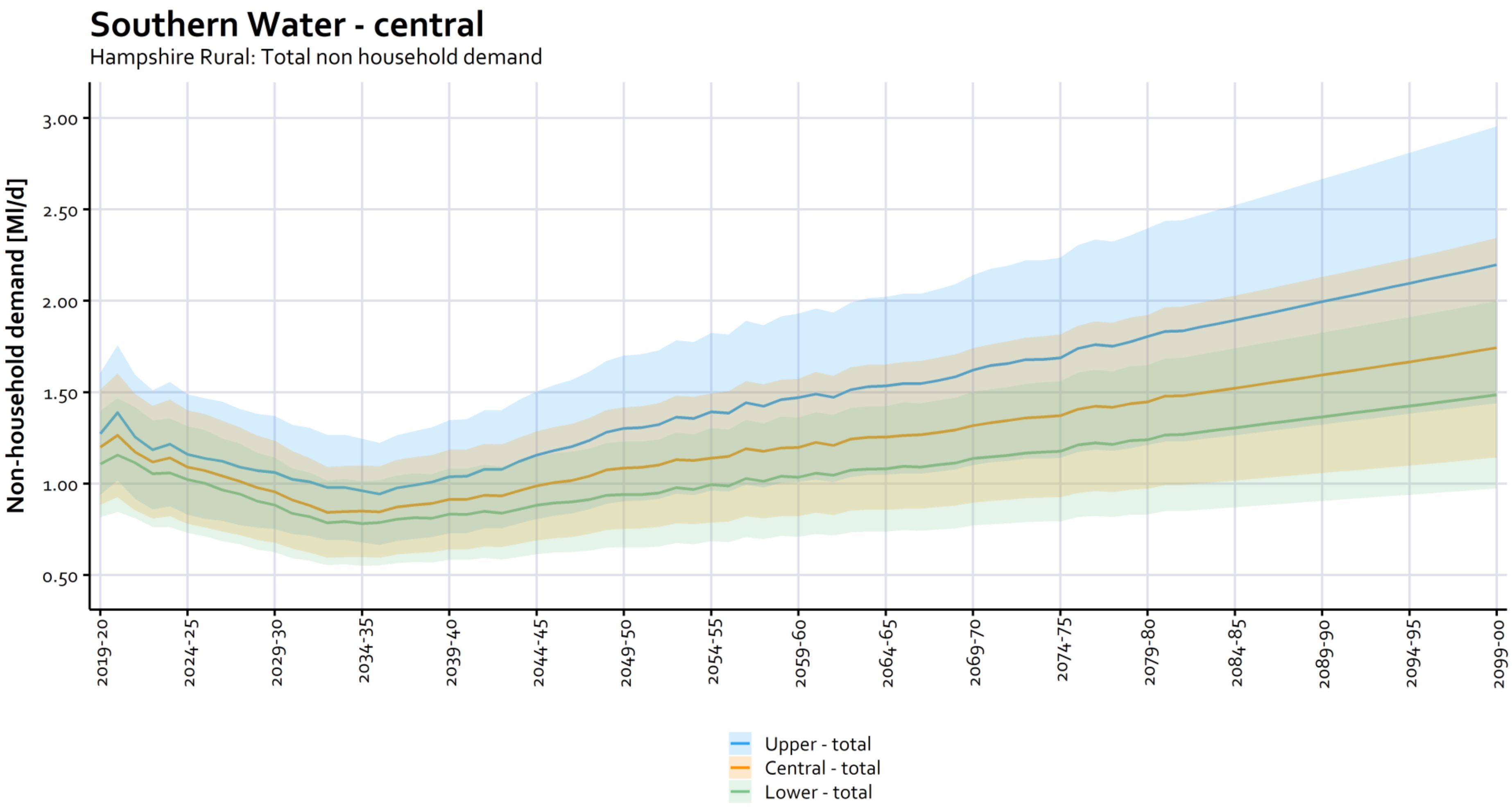



Southern Water - central
Hampshire Andover: Total non household demand
Non-household demand [Ml/d]
5.0
4.0
3.0
2.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total


Southern Water
Hampshire Kingsclere: Measured and unmeasured non household demand
Non-household demand [Ml/d]
0.00
0.20
0.40
0.60
0.80
2019-20
2099-00
Measured
Unmeasured


Southern Water - central
Hampshire Kingsclere: Total non household demand
Non-household demand [Ml/d]
1.40
1.20
1.00
0.80
0.60
0.40
0.20
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total


Southern Water
Hampshire Rural: Measured and unmeasured non household demand
Non-household demand [Ml/d]
1.50
1.00
0.50
0.00
2019-20
2099-00
Measured
Unmeasured


Southern Water - central
Hampshire Rural: Total non household demand
Non-household demand [Ml/d]
3.00
2.50
2.00
1.50
1.00
0.50
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
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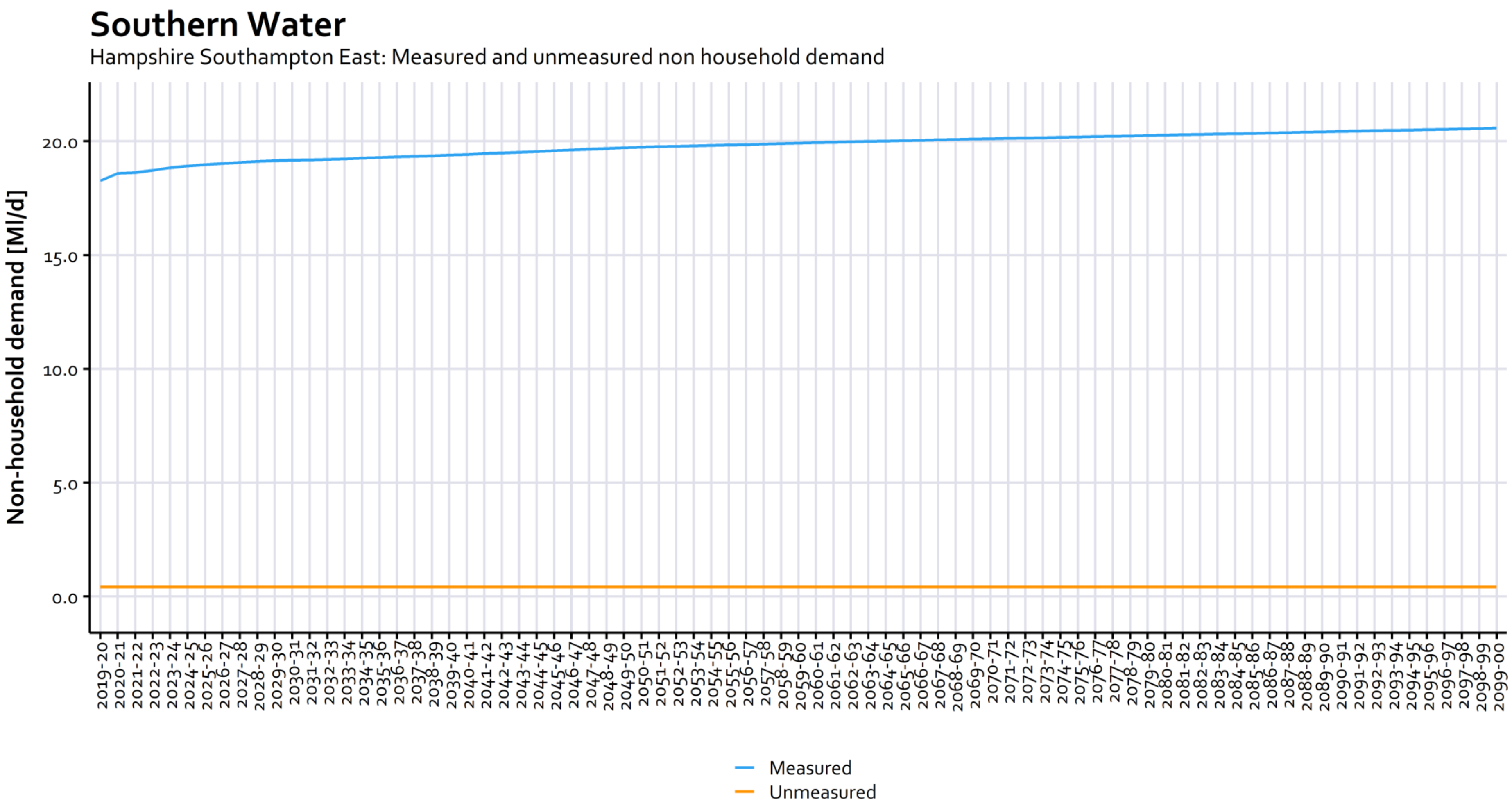
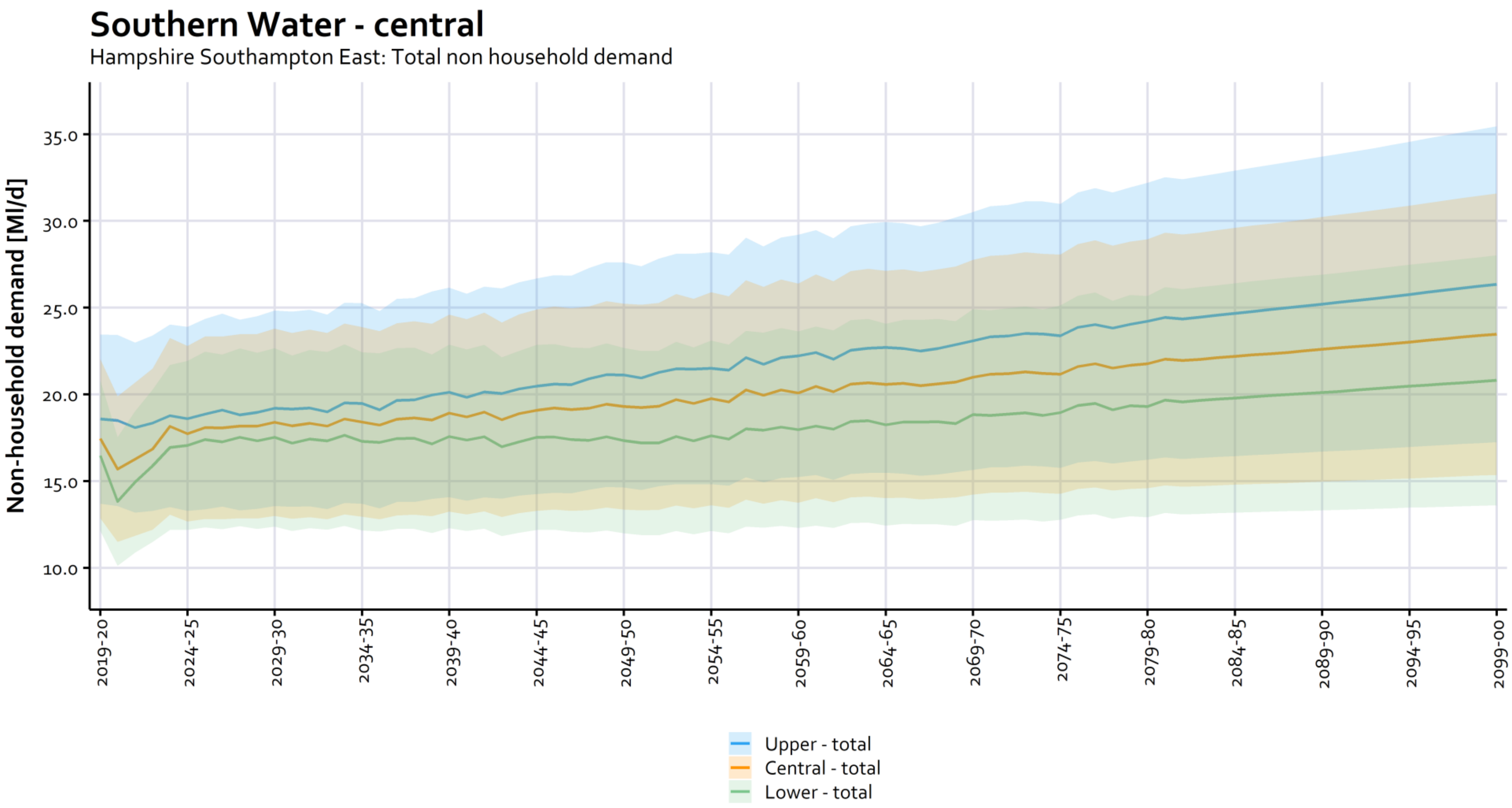
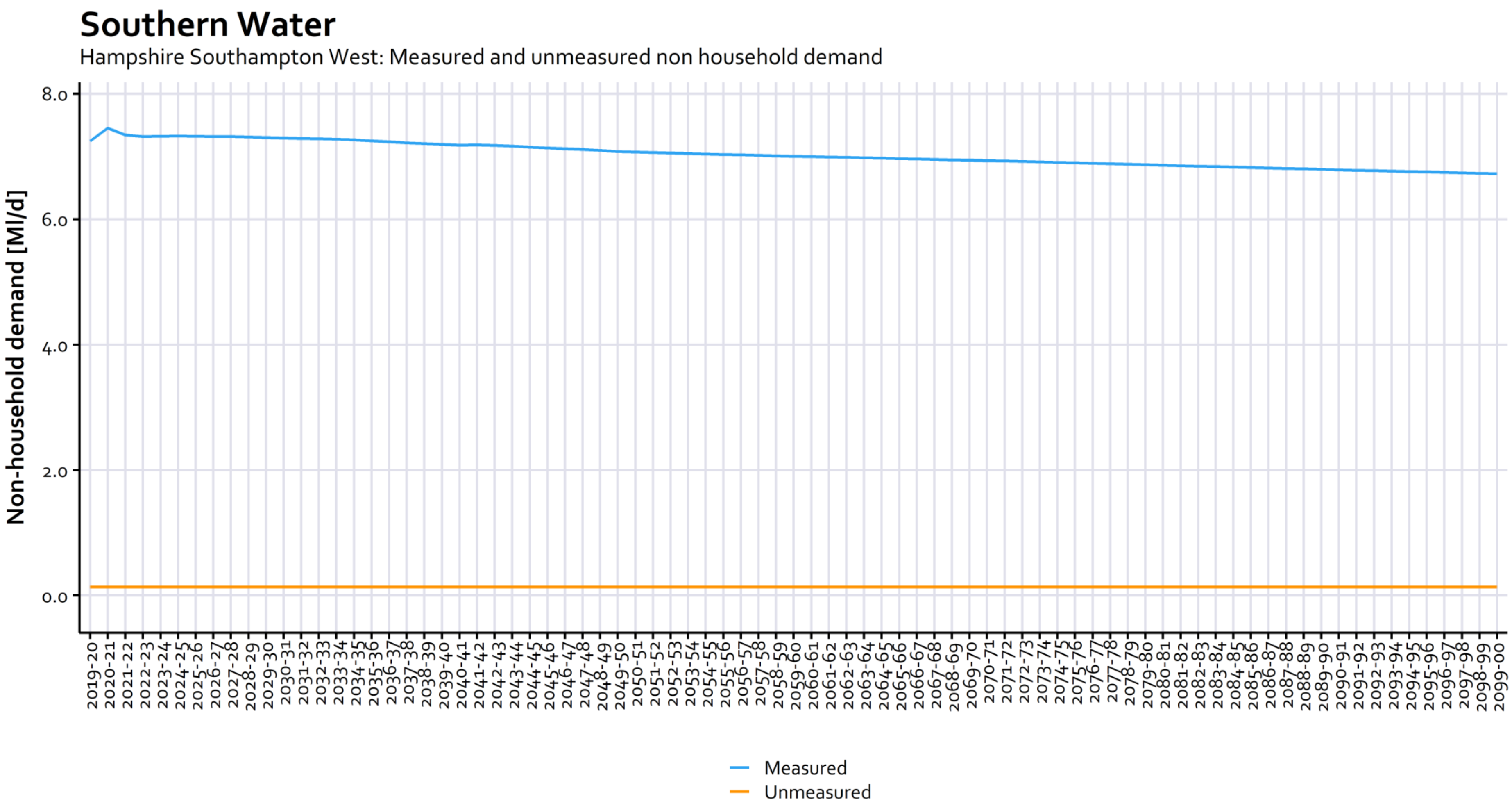
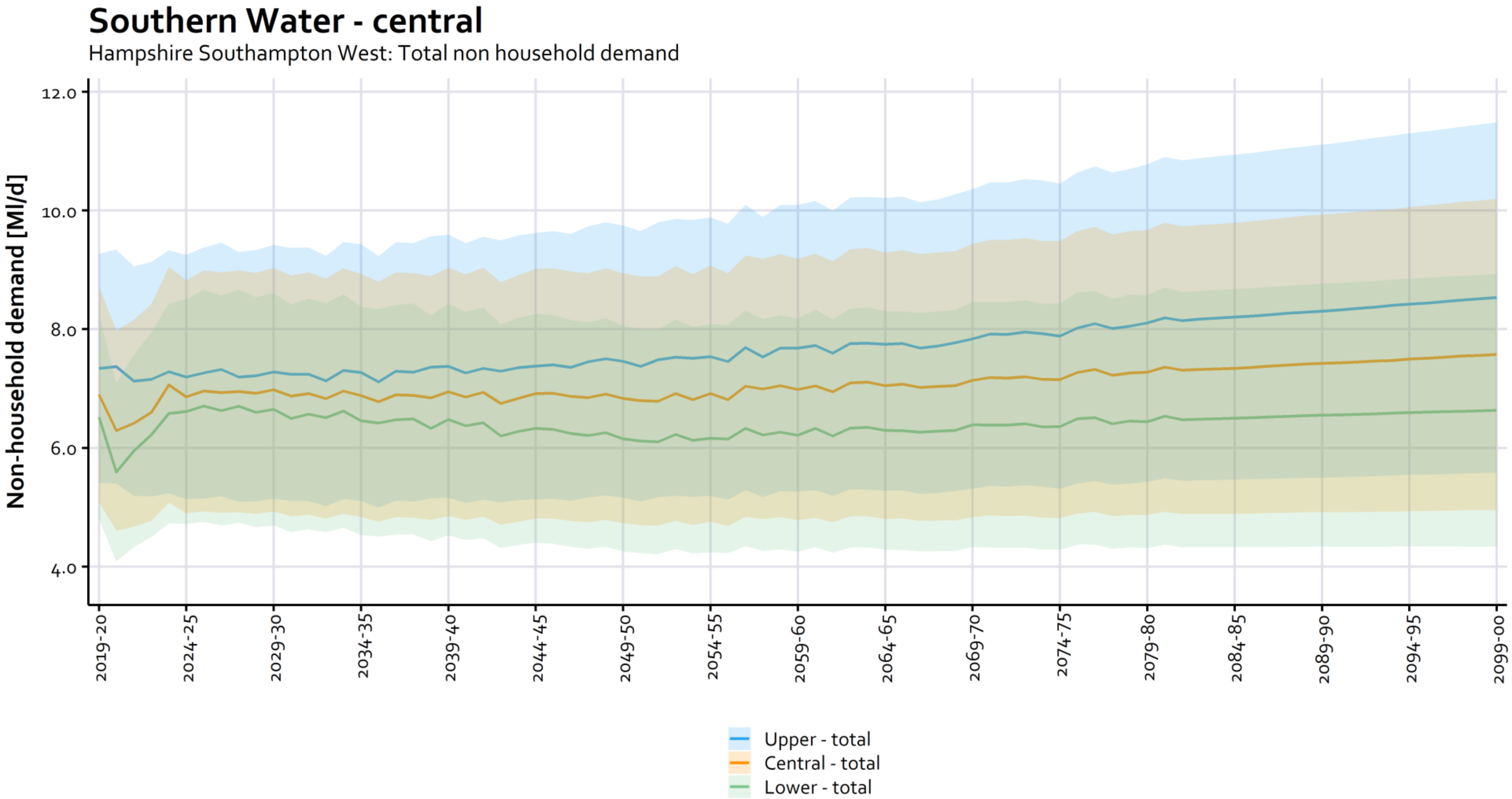
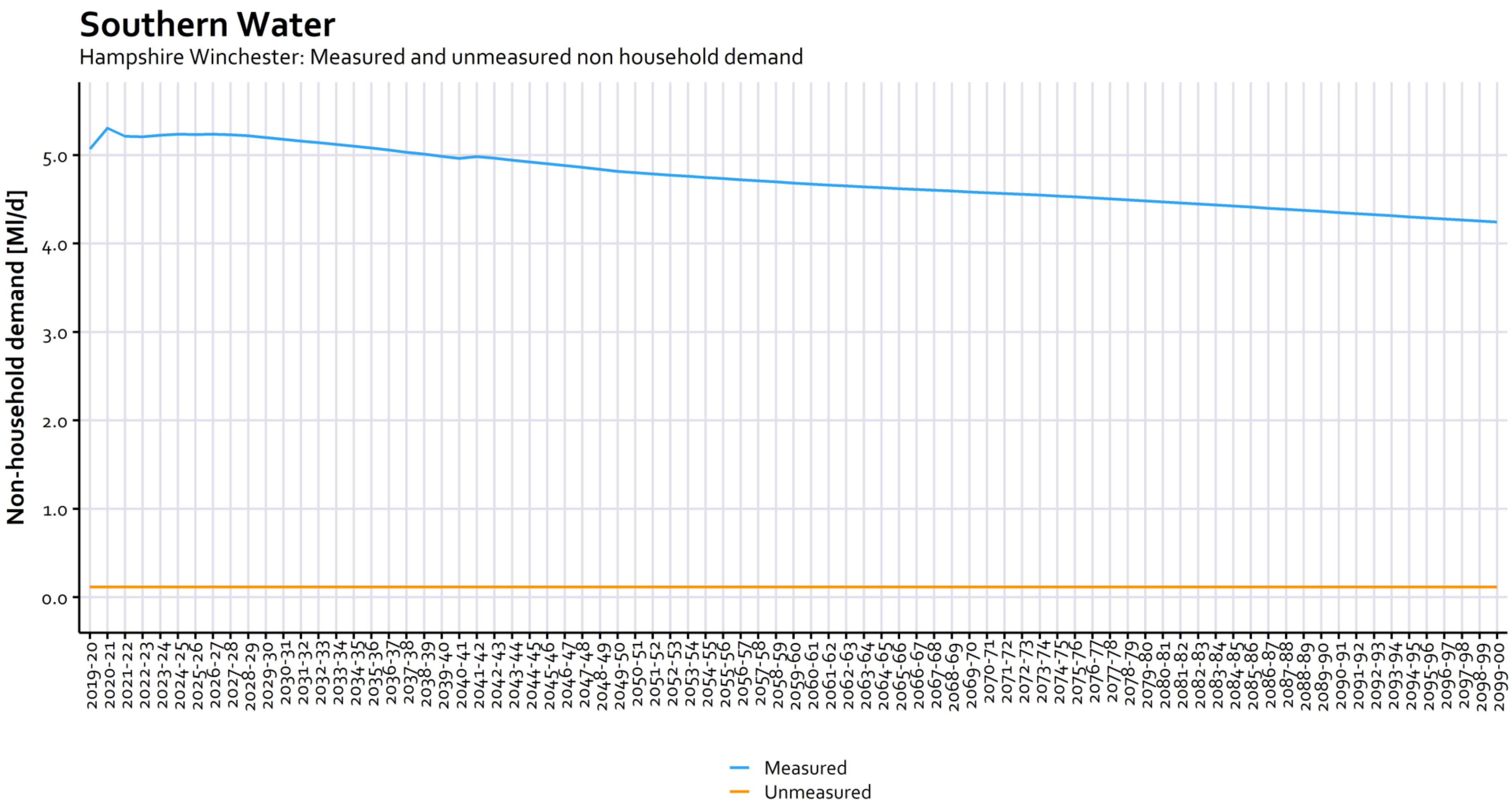
2099-00
Upper - total
Central - total
Lower - total

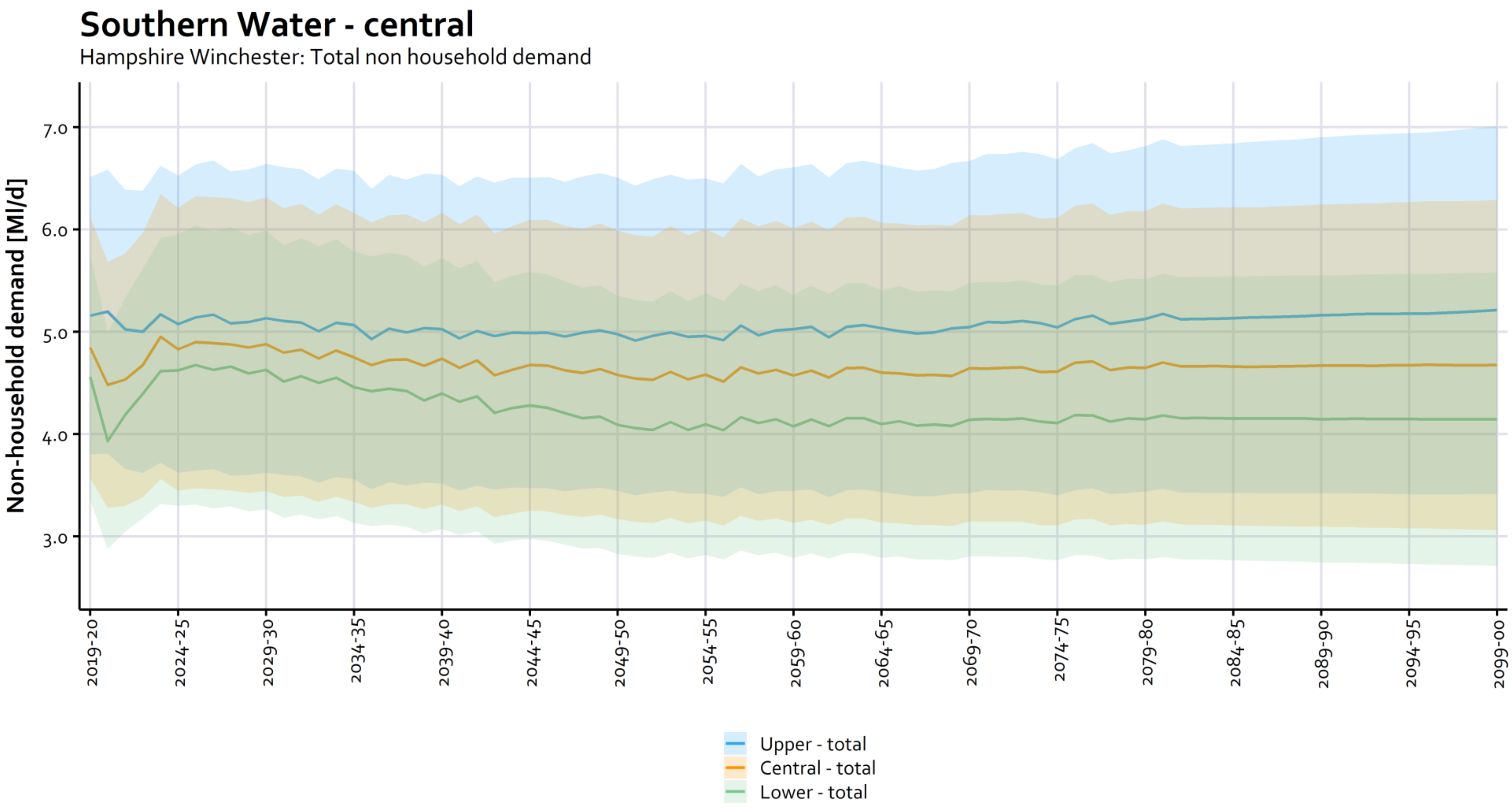

Southern Water
Hampshire Southampton East: Measured and unmeasured non household demand
Non-household demand [Ml/d]
20.0
15.0
10.0
5.0
0.0
2019-20
2099-00
Measured
Unmeasured

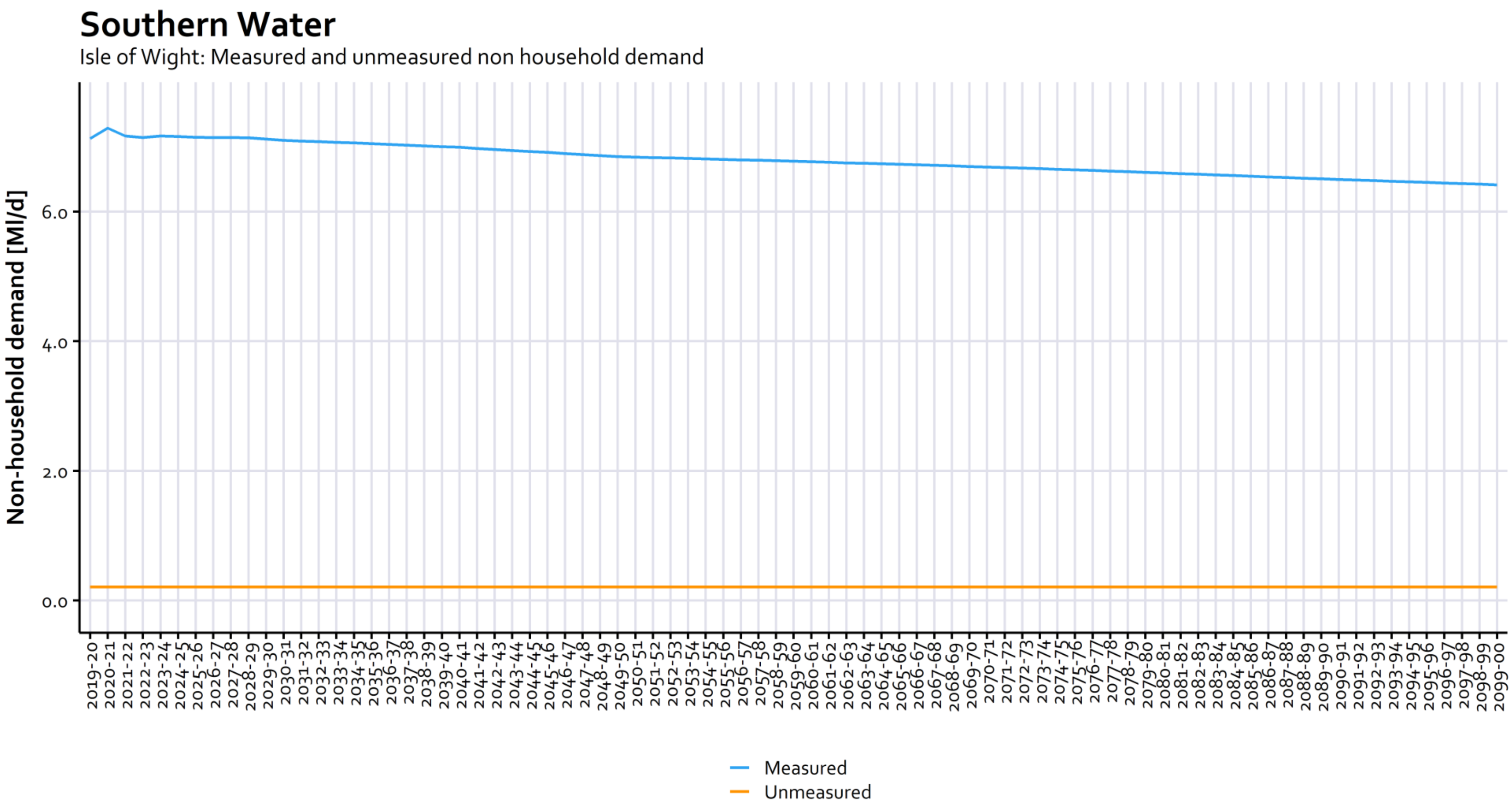

Southern Water - central
Hampshire Southampton East: Total non household demand
Non-household demand [Ml/d]
35.0
30.0
25.0
20.0
15.0
10.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

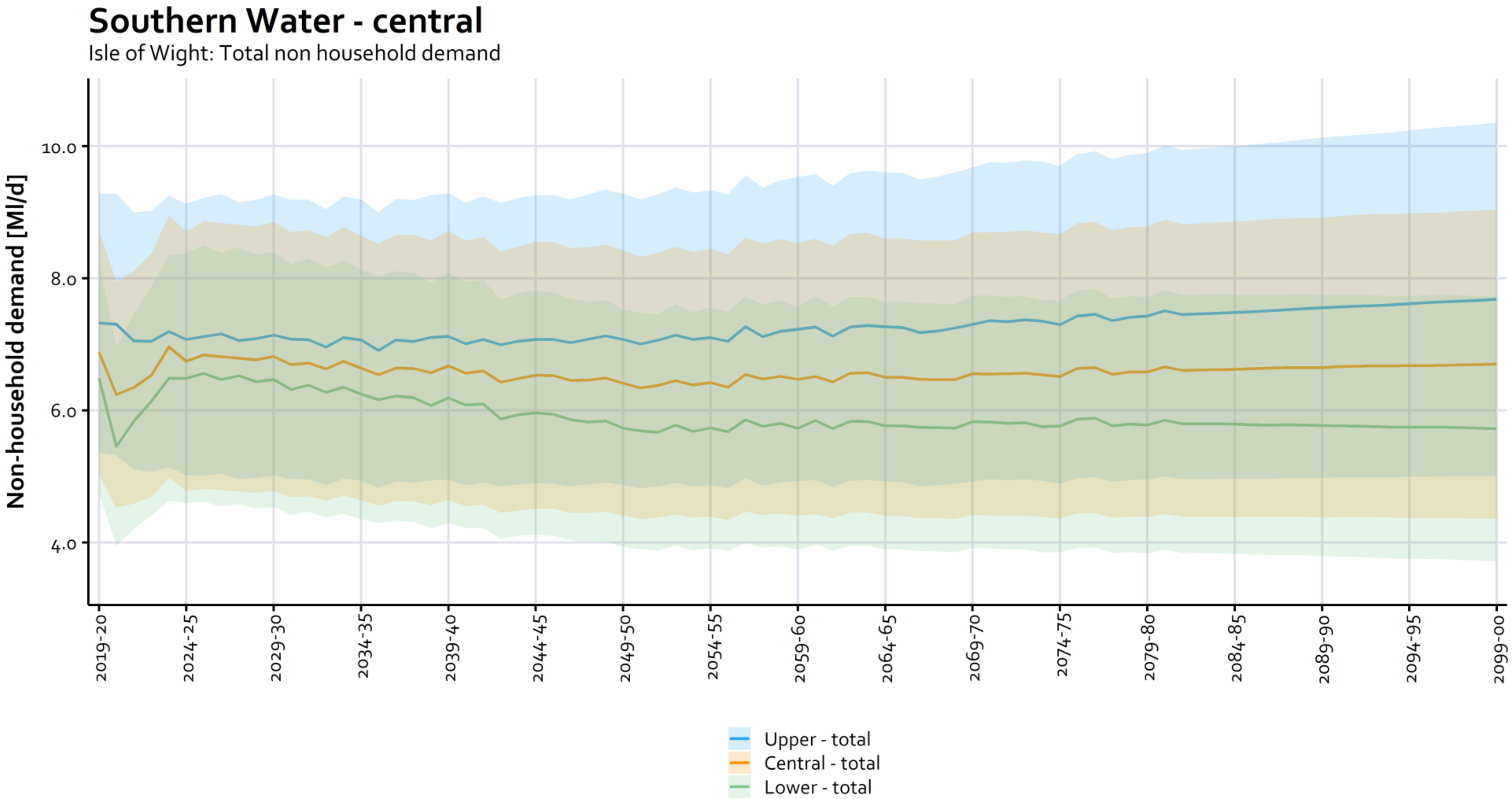

Southern Water
Hampshire Southampton West: Measured and unmeasured non household demand
Non-household demand [Ml/d]
8.0
6.0
4.0
2.0
0.0
2019-20
2099-00
Measured
Unmeasured

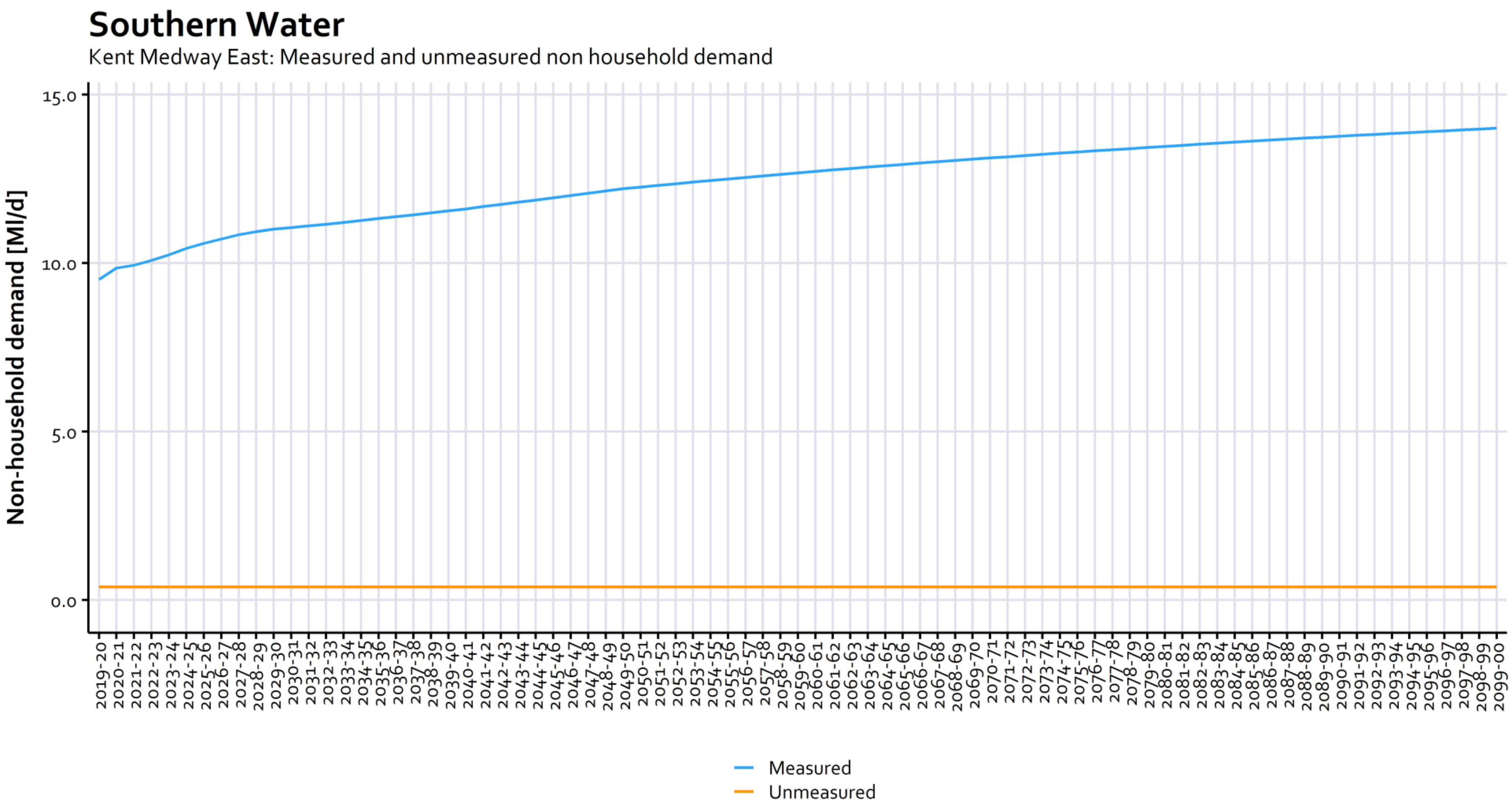

Southern Water - central
Hampshire Southampton West: Total non household demand
Non-household demand [Ml/d]
12.0
10.0
8.0
6.0
4.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total


Southern Water
Hampshire Winchester: Measured and unmeasured non household demand
Non-household demand [Ml/d]
5.0
4.0
3.0
2.0
1.0
0.0
2019-20
2099-00
Measured
Unmeasured

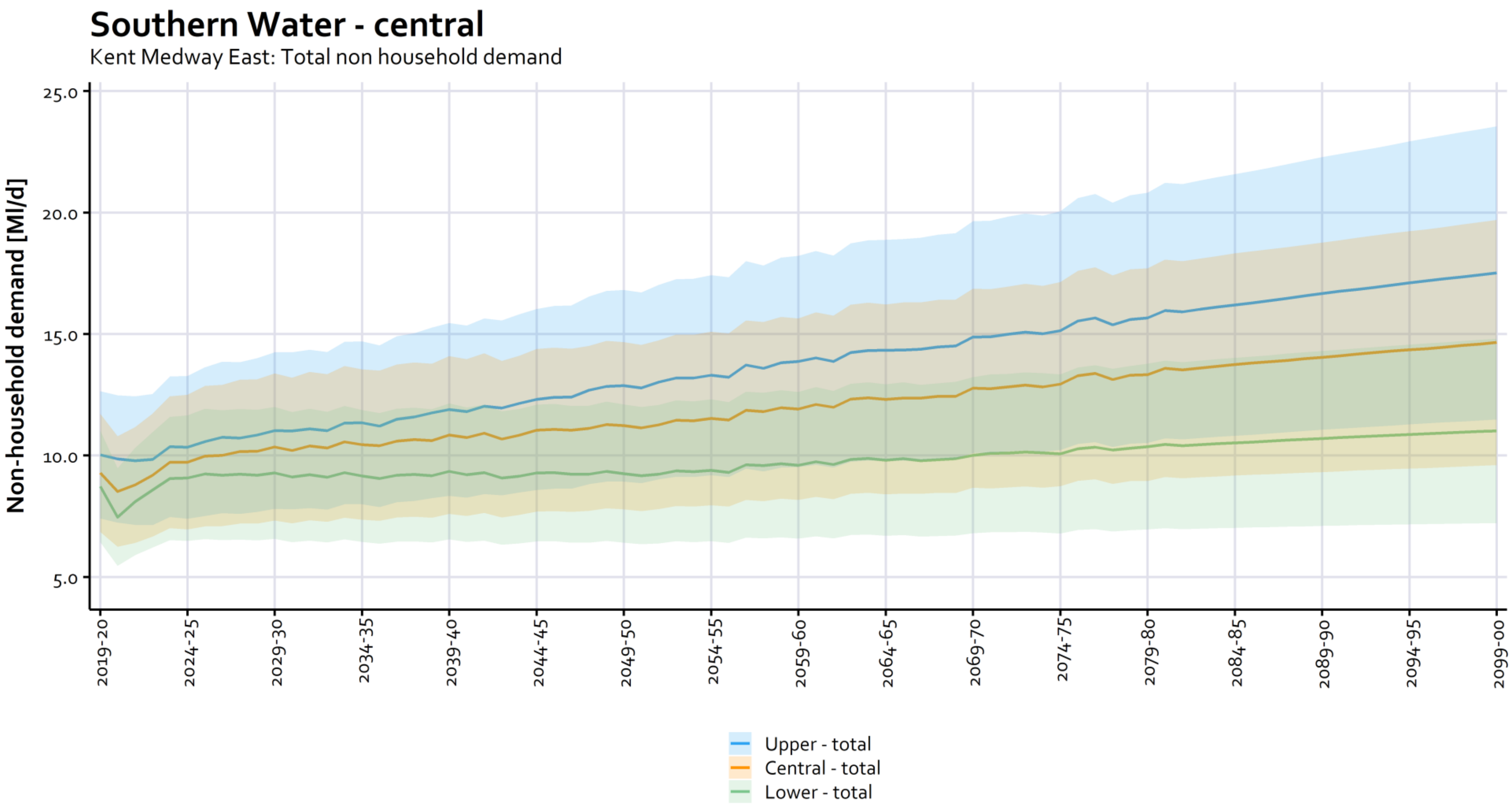

Southern Water - central
Hampshire Winchester: Total non household demand
Non-household demand [Ml/d]
7.0
6.0
5.0
4.0
3.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

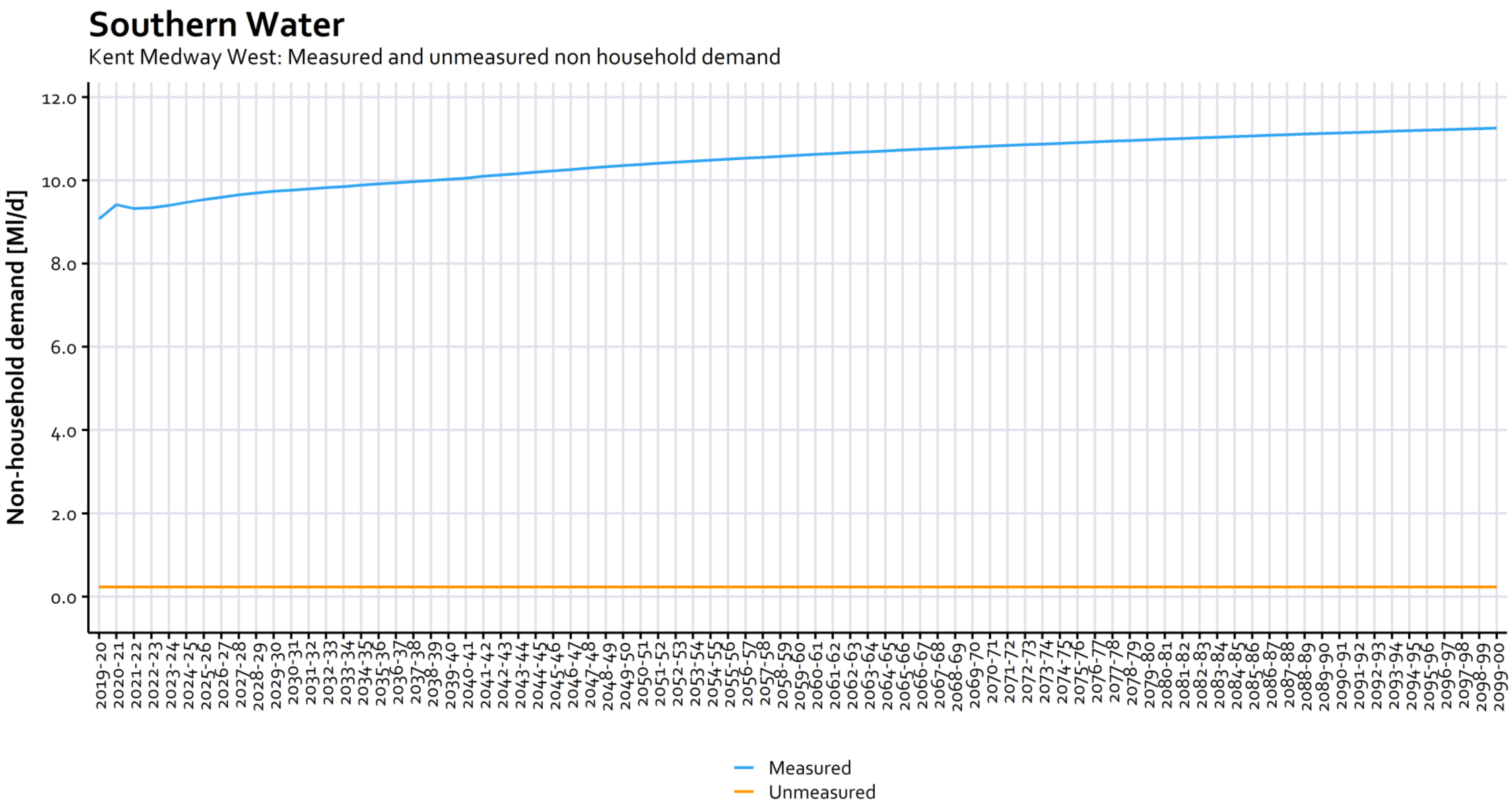

Southern Water
Isle of Wight: Measured and unmeasured non household demand
Non-household demand [Ml/d]
6.0
4.0
2.0
0.0
2019-20
2099-00
Measured
Unmeasured

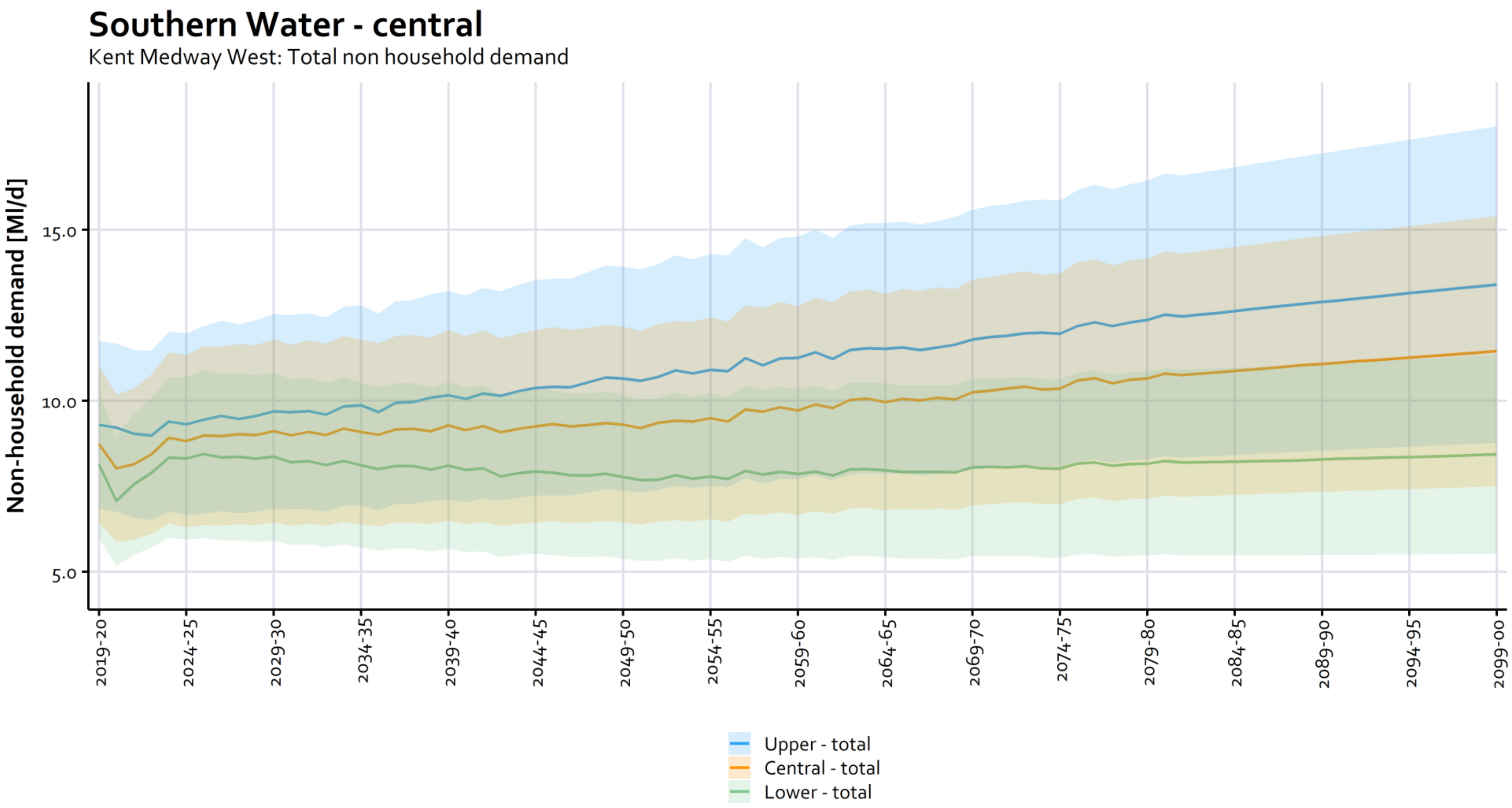

Southern Water - central
Isle of Wight: Total non household demand
Non-household demand [Ml/d]
10.0
8.0
6.0
4.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

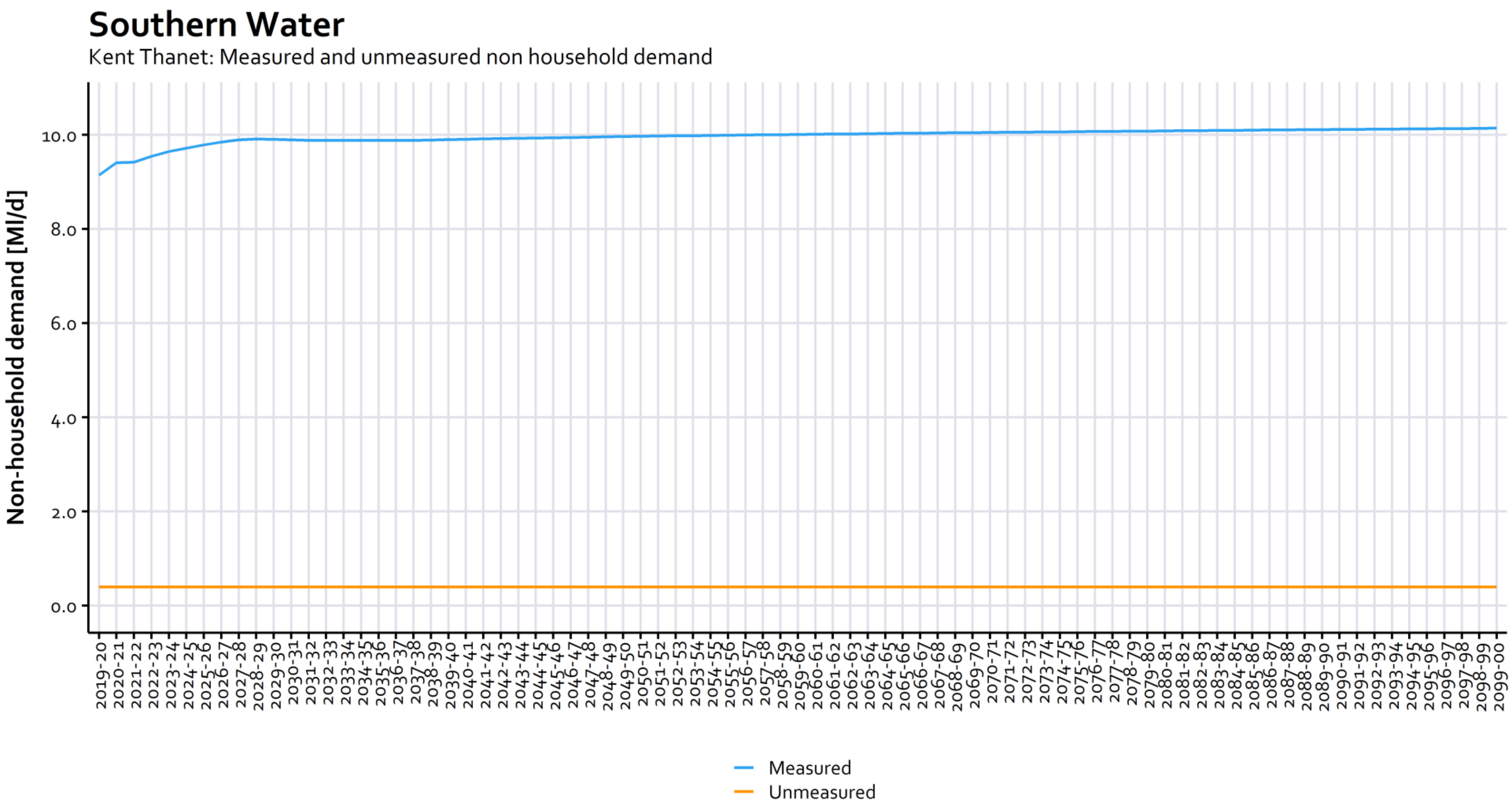

Southern Water
Kent Medway East: Measured and unmeasured non household demand
Non-household demand [Ml/d]
15.0
10.0
5.0
0.0
2019-20
2099-00
Measured
Unmeasured

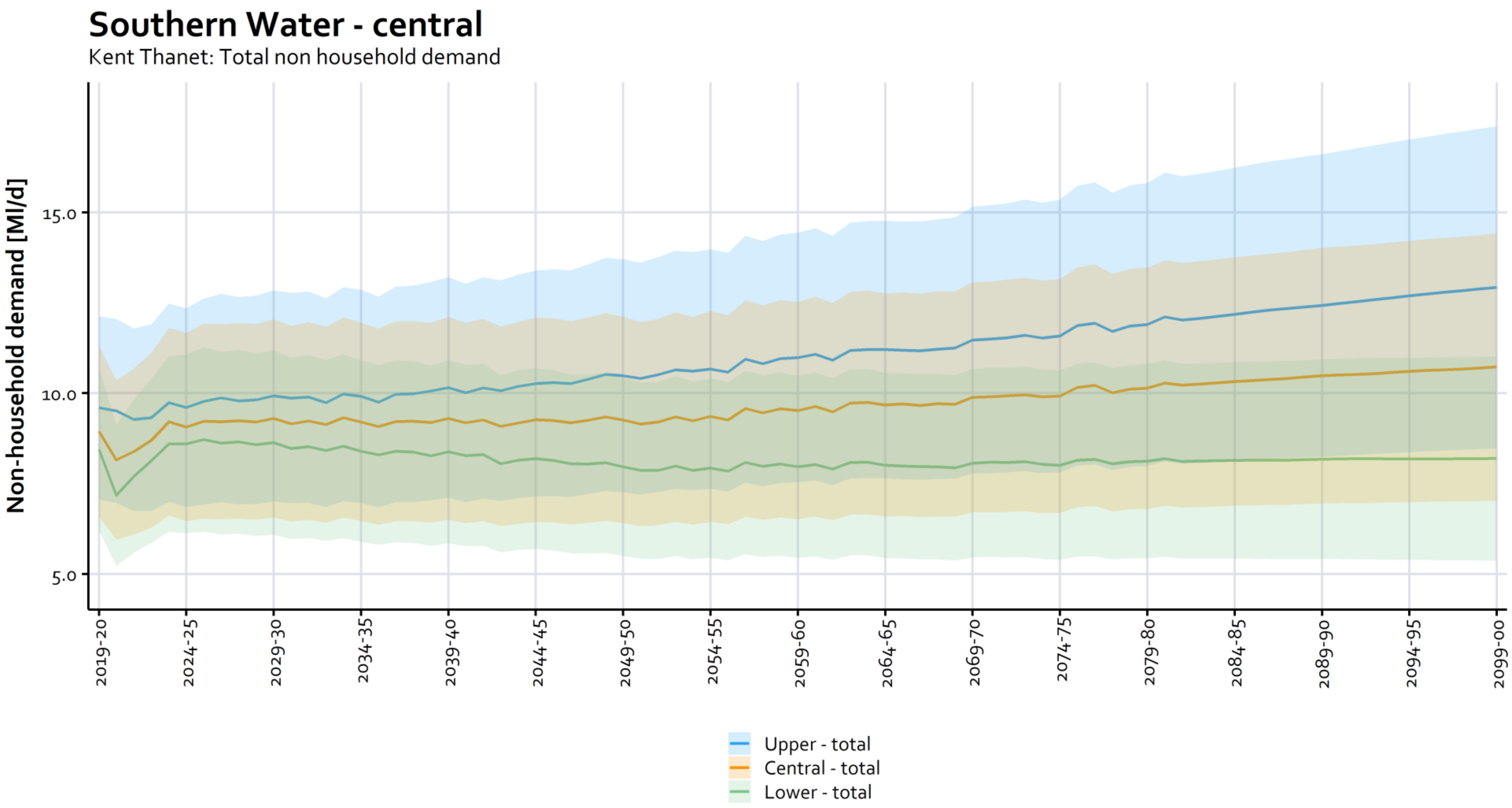
 


Southern Water - central
Kent Medway East: Total non household demand
Non-household demand [Ml/d]
25.0
20.0
15.0
10.0
5.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

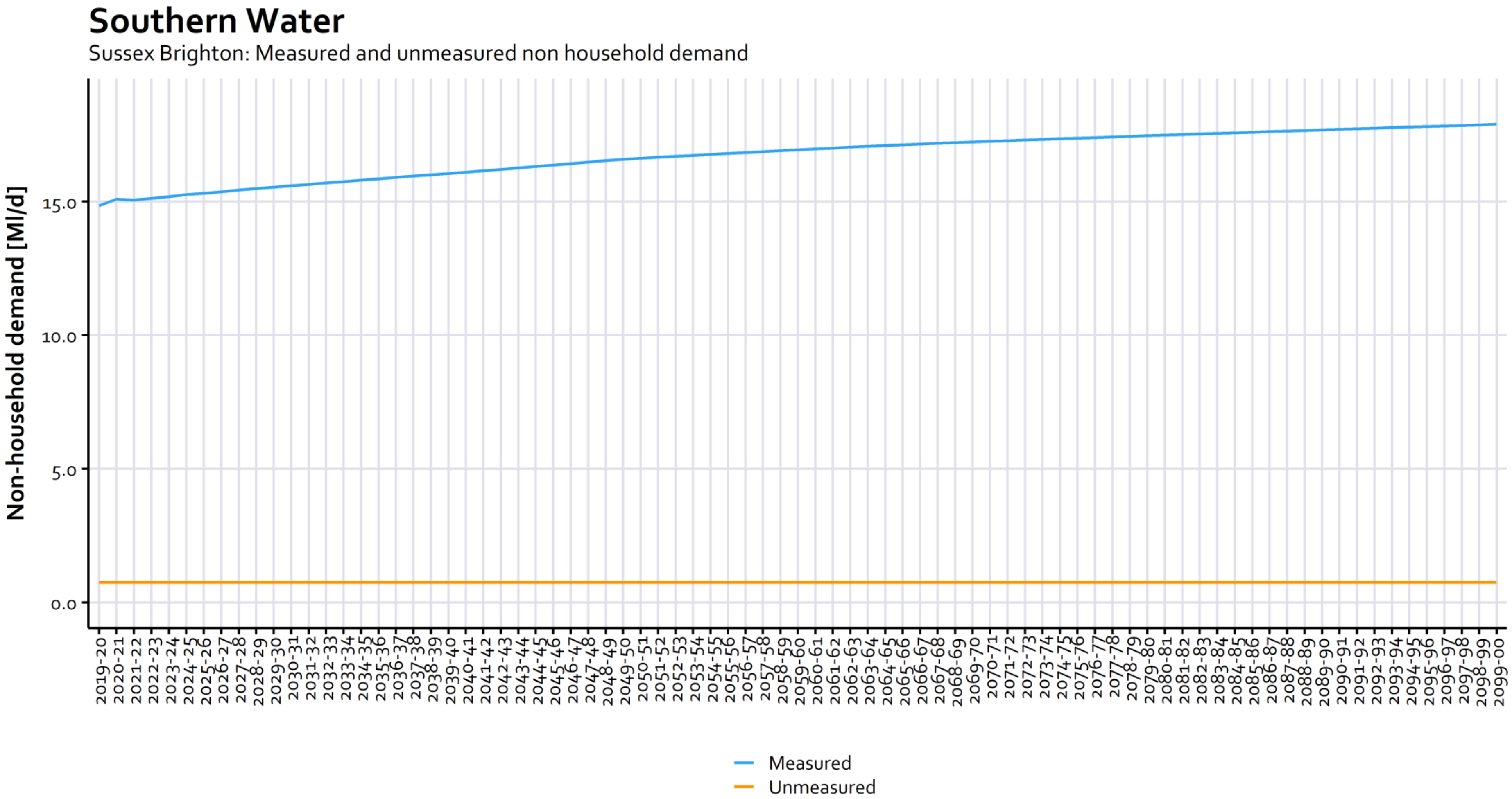

Southern Water
Kent Medway West: Measured and unmeasured non household demand
Non-household demand [Ml/d]
12.0
10.0
8.0
6.0
4.0
2.0
0.0
2019-20 2020-21 2021-22 2022-23 2023-24 2024-25 2025-26 2026-27 2027-28 2028-29 2029-30 2030-31 2031-32 2032-33 2033-34 2034-35 2035-36 2036-37 2037-38 2038-39 2039-40 2040-41 2041-42 2042-43 2043-44 2044-45 2045-46 2046-47 2047-48 2048-49 2049-50 2050-51 2051-52 2052-53 2053-54 2054-55 2055-56 2056-57 2057-58 2058-59 2059-60 2060-61 2061-62 2062-63 2063-64 2064-65 2065-66 2066-67 2067-68 2068-69 2069-70 2070-71 2071-72 2072-73 2073-74 2074-75 2075-76 2076-77 2077-78 2078-79 2079-80 2080-81 2081-82 2082-83 2083-84 2084-85 2085-86 2086-87 2087-88 2088-89 2089-90 2090-91 2091-92 2092-93 2093-94 2094-95 2095-96 2096-97 2097-98 2098-99 2099-00
Measured
Unmeasured

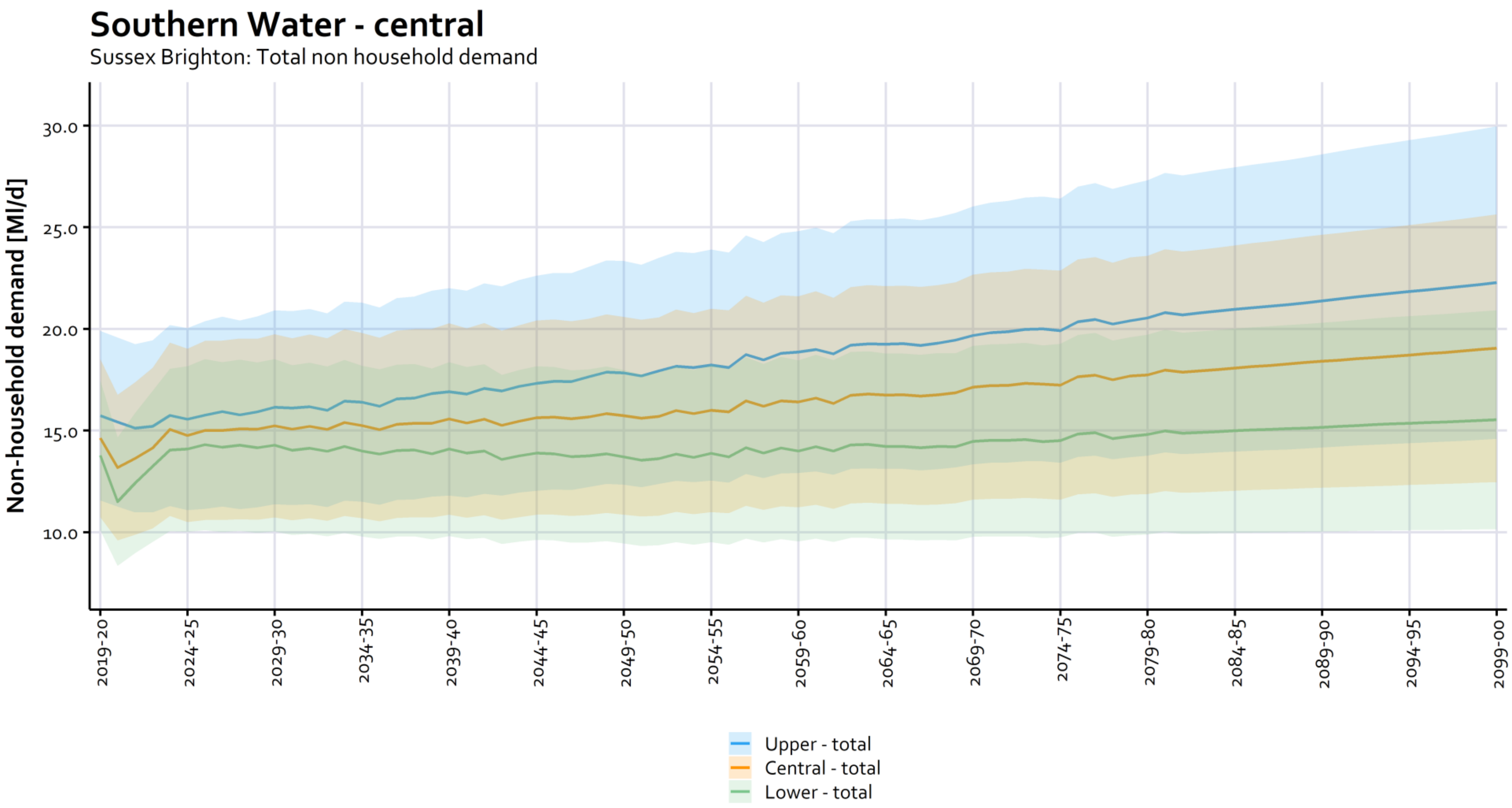

Southern Water - central
Kent Medway West: Total non household demand
Non-household demand [Ml/d]
15.0
10.0
5.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total


Southern Water
Kent Thanet: Measured and unmeasured non household demand
Non-household demand [Ml/d]
10.0
8.0
6.0
4.0
2.0
0.0
2019-20
2099-00
Measured
Unmeasured

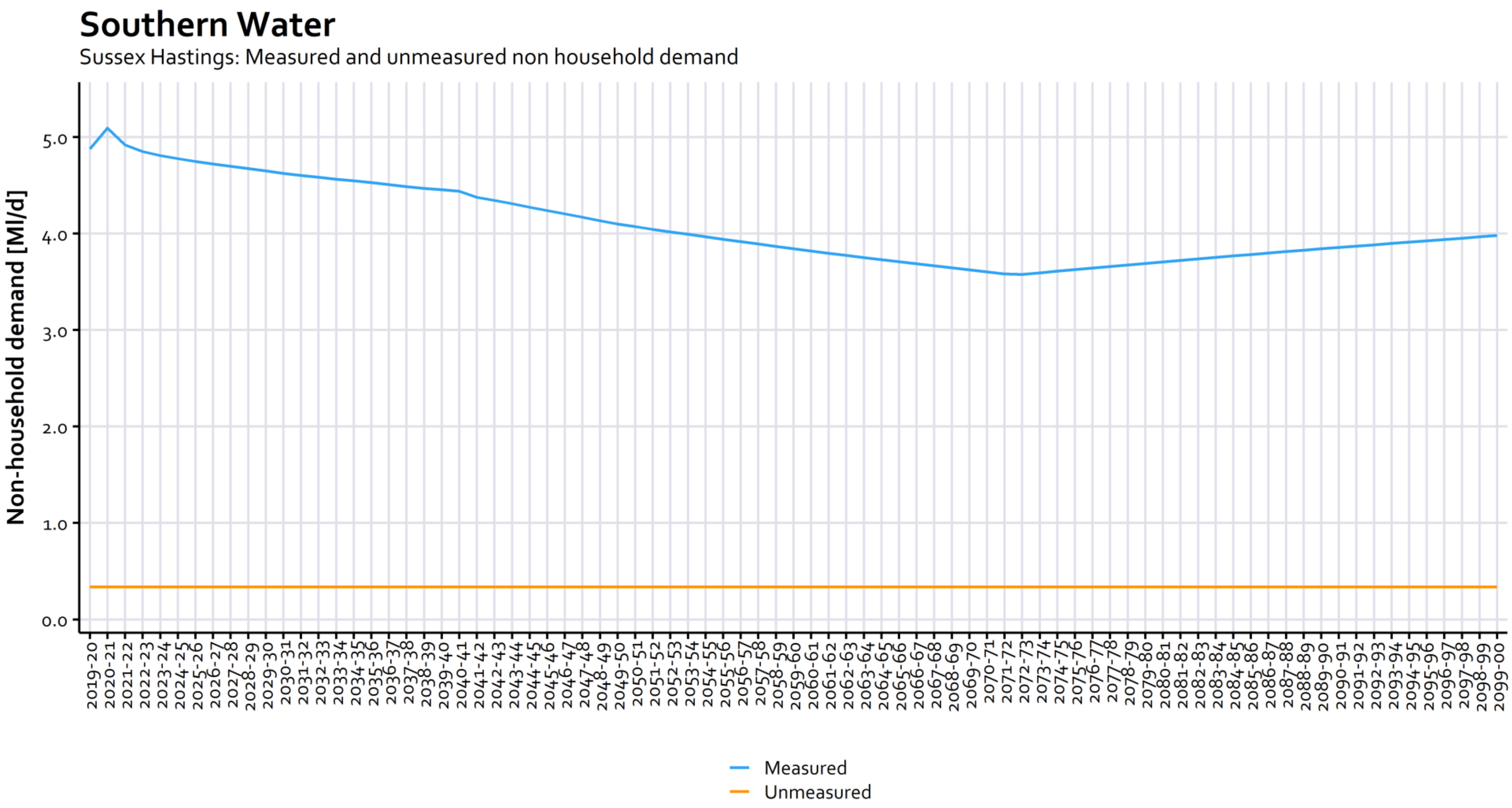

Southern Water - central
Kent Thanet: Total non household demand
Non-household demand [Ml/d]
15.0
10.0
5.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

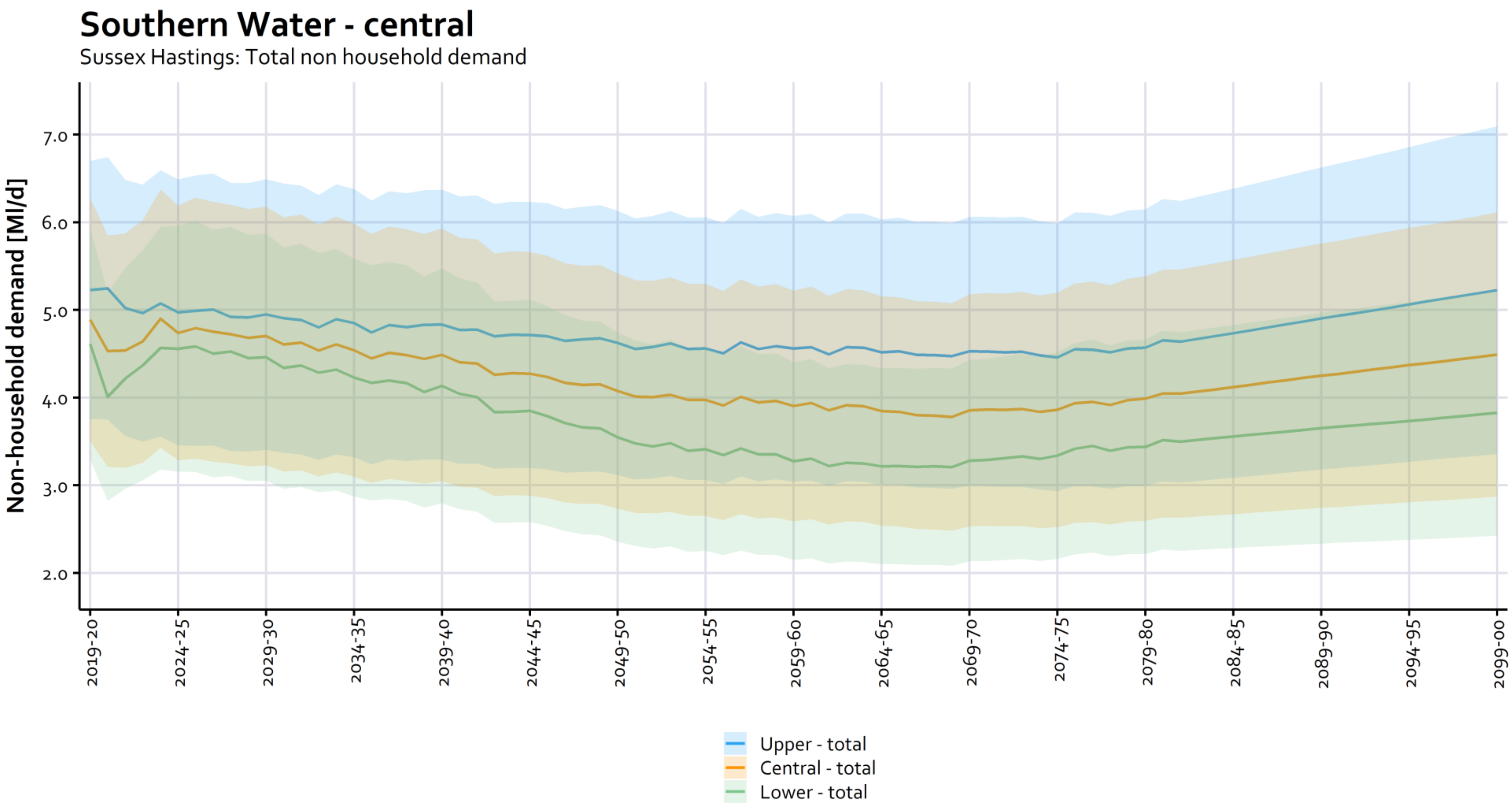

Southern Water
Sussex Brighton: Measured and unmeasured non household demand
Non-household demand [Ml/d]
15.0
10.0
5.0
0.0
2019-20
2099-00
Measured
Unmeasured

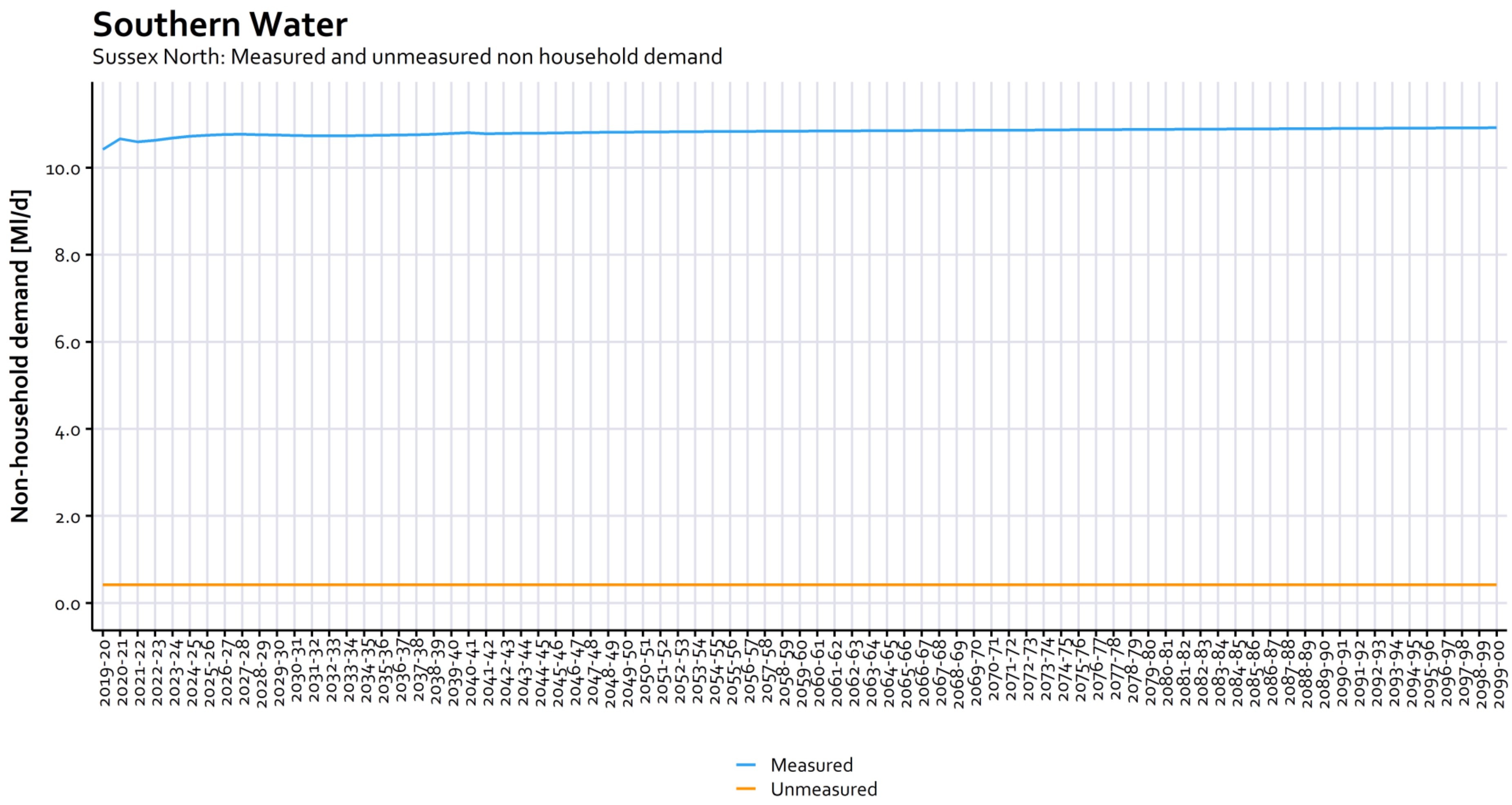

Southern Water - central
Sussex Brighton: Total non household demand
Non-household demand [Ml/d]
30.0
25.0
20.0
15.0
10.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

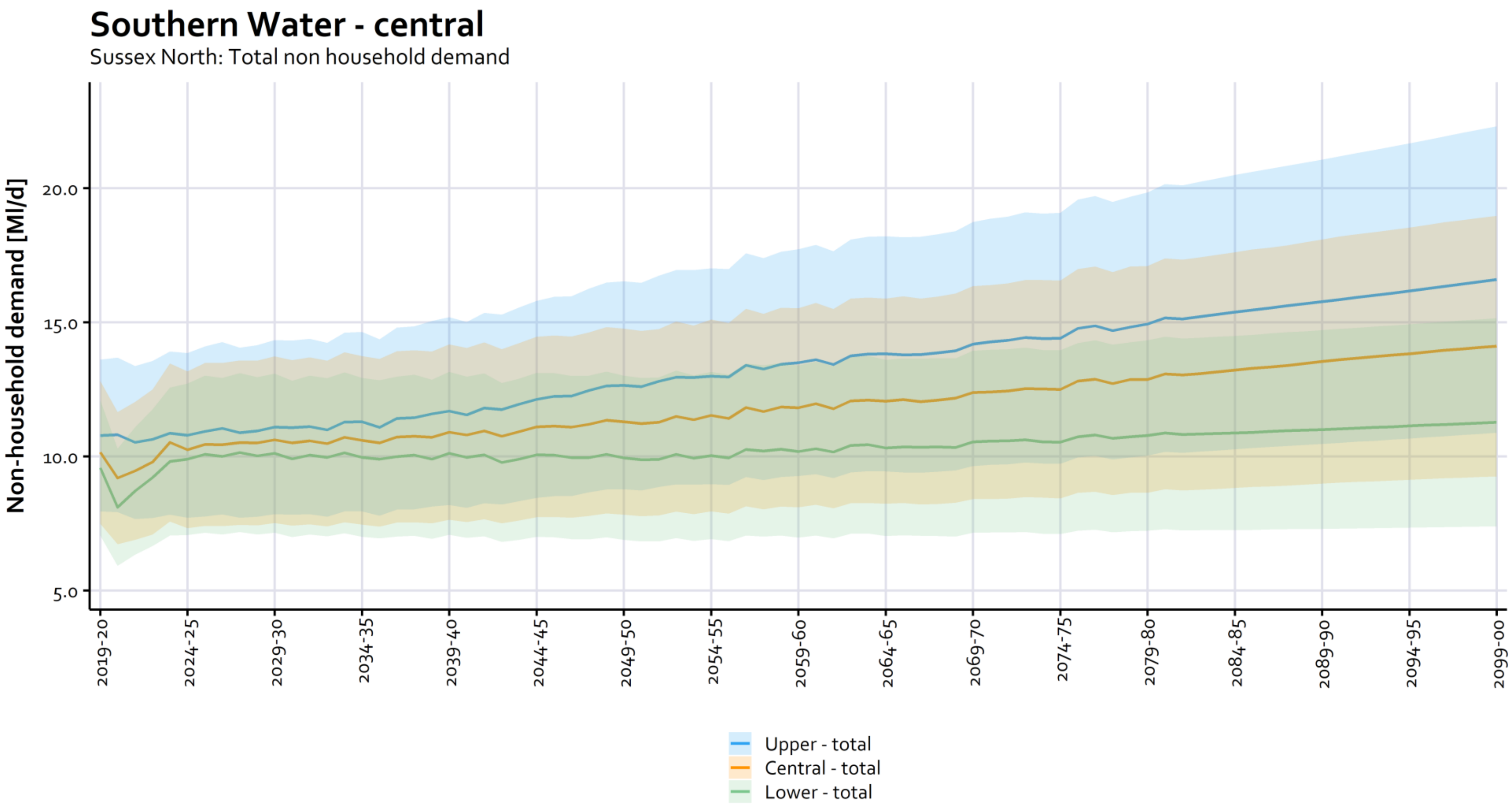
 


Southern Water
Sussex Hastings: Measured and unmeasured non household demand
Non-household demand [Ml/d]
0.0
1.0
2.0
3.0
4.0
5.0
2019-20
2099-00
Measured
Unmeasured


Southern Water - central
Sussex Hastings: Total non household demand
Non-household demand [Ml/d]
7.0
6.0
5.0
4.0
3.0
2.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

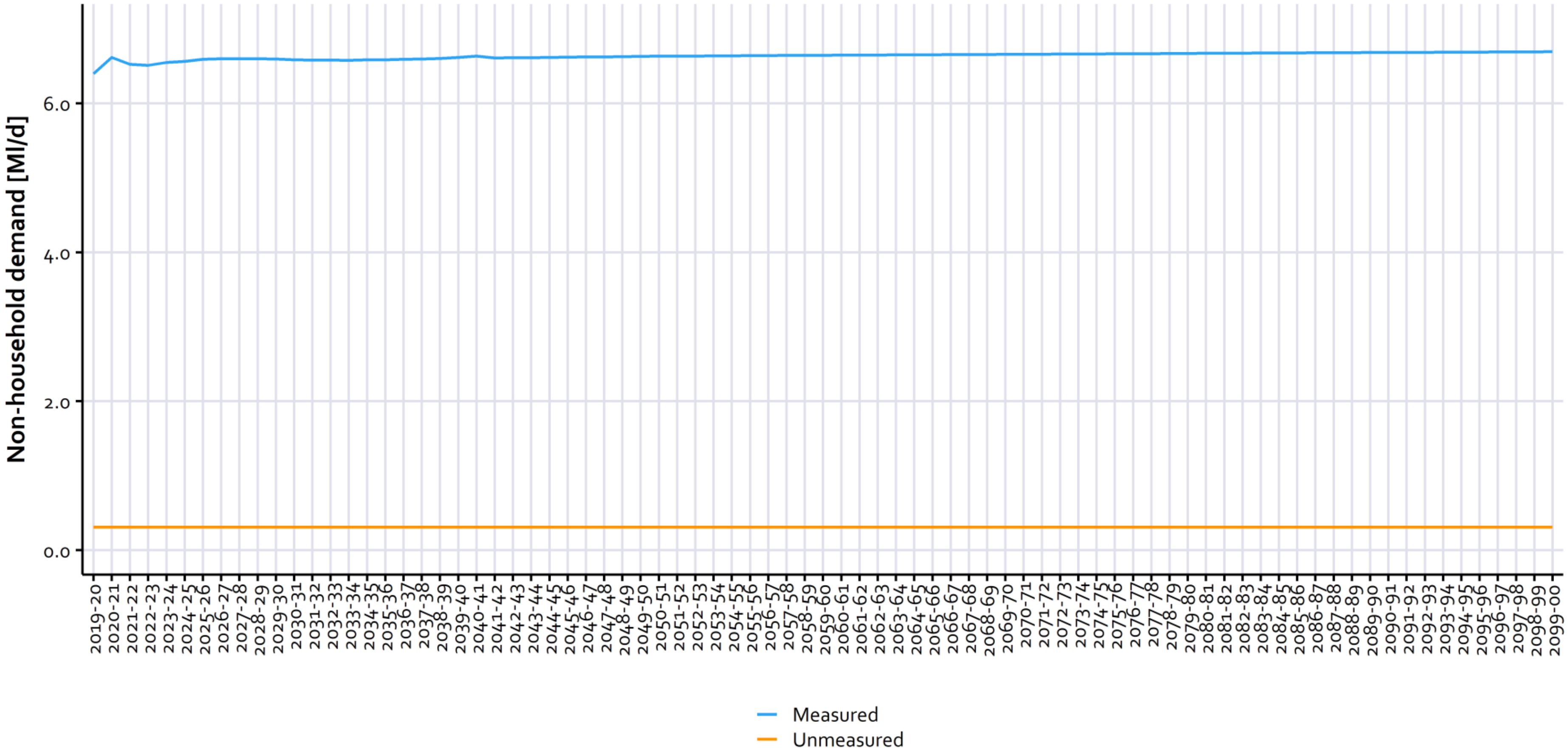

Southern Water
Sussex North: Measured and unmeasured non household demand
Non-household demand [Ml/d]
10.0
8.0
6.0
4.0
2.0
0.0
2019-20
2099-00
Measured
Unmeasured

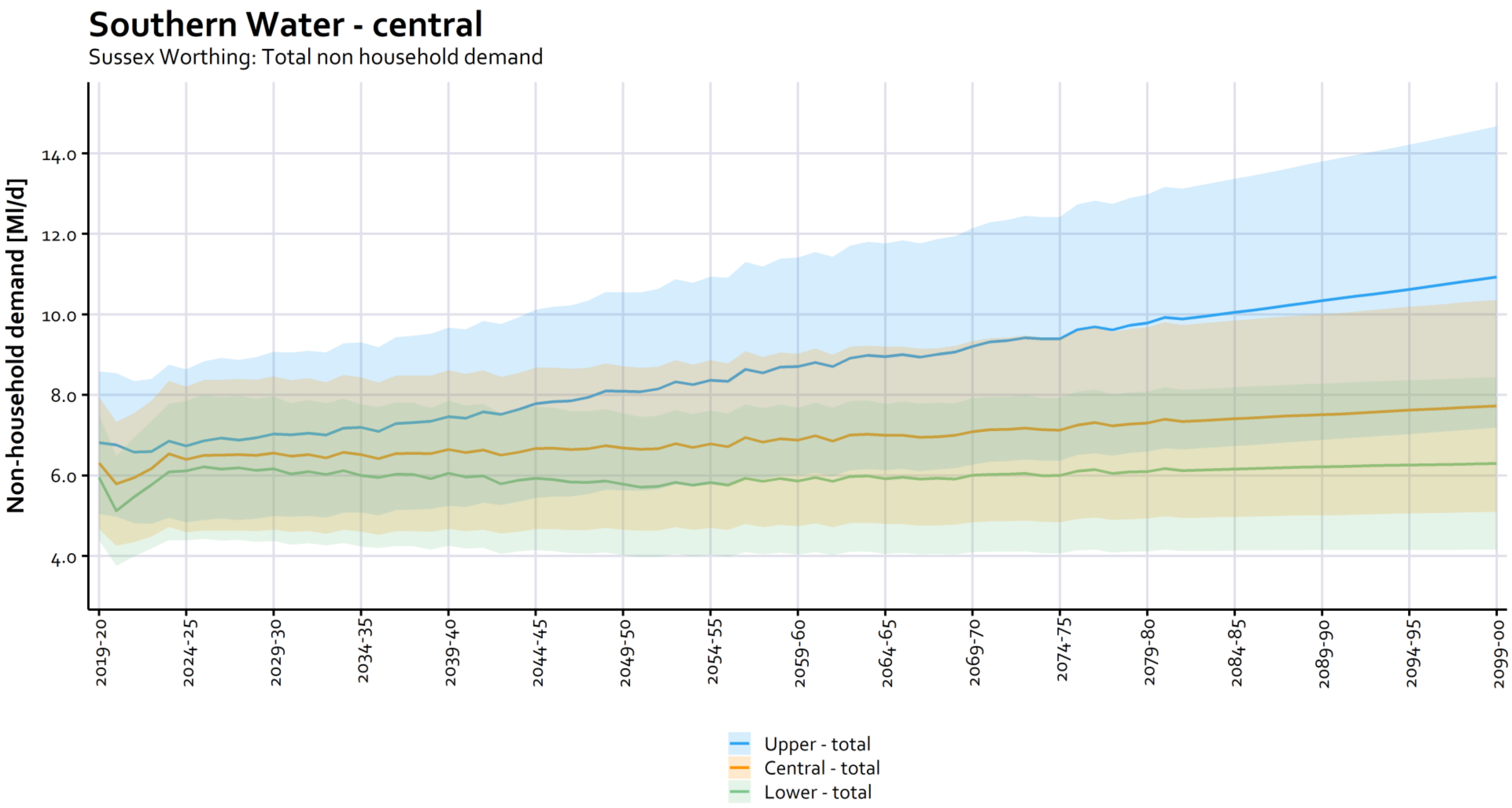

Southern Water - central
Sussex North: Total non household demand
Non-household demand [Ml/d]
20.0
15.0
10.0
5.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

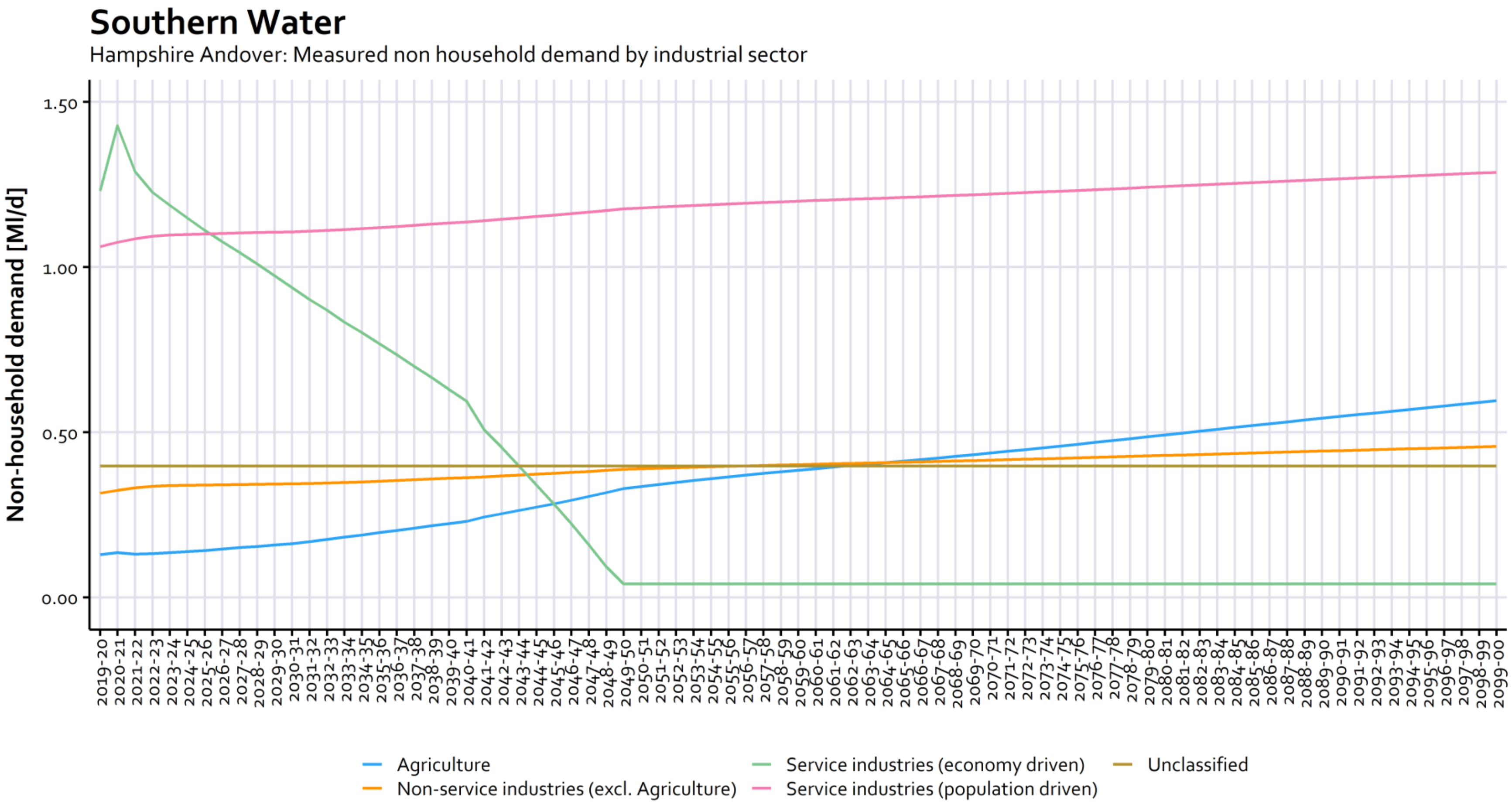
## Southern Water

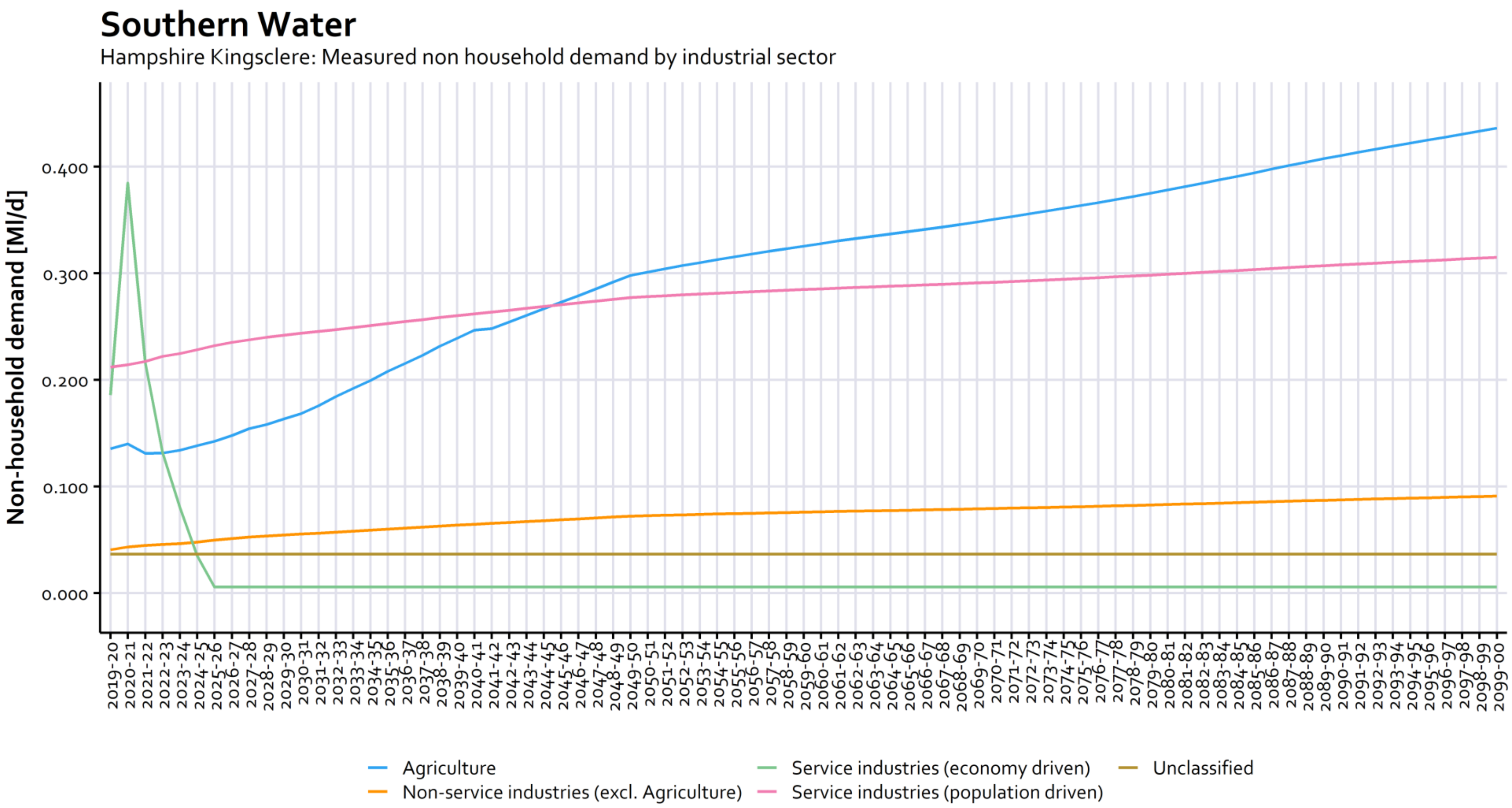
Sussex Worthing: Measured and unmeasured non household demand

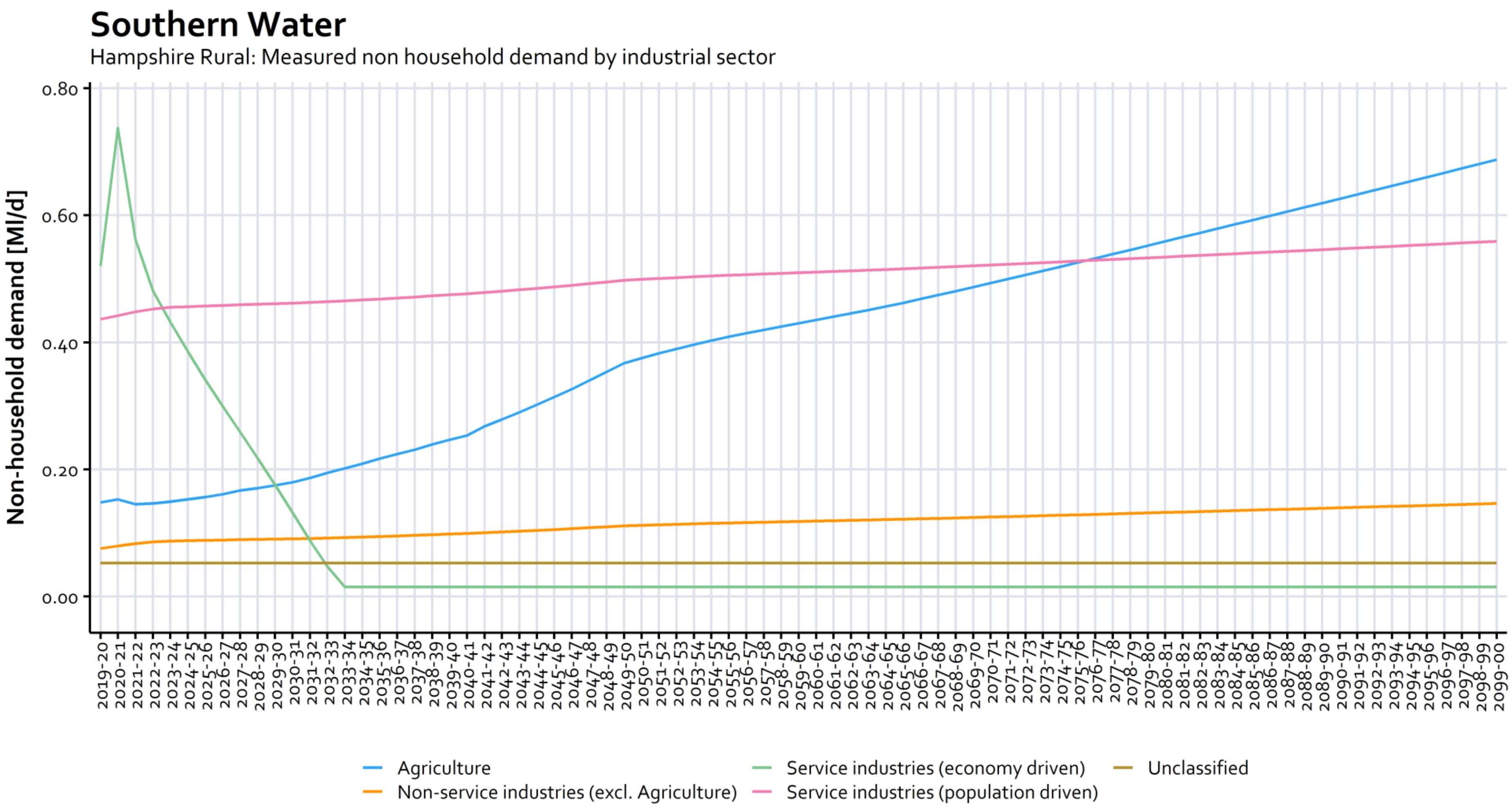



Southern Water - central
Sussex Worthing: Total non household demand
Non-household demand [Ml/d]
14.0
12.0
10.0
8.0
6.0
4.0
2019-20
2024-25
2029-30
2034-35
2039-40
2044-45
2049-50
2054-55
2059-60
2064-65
2069-70
2074-75
2079-80
2084-85
2089-90
2094-95
2099-00
Upper - total
Central - total
Lower - total

## WRZ industry sector results

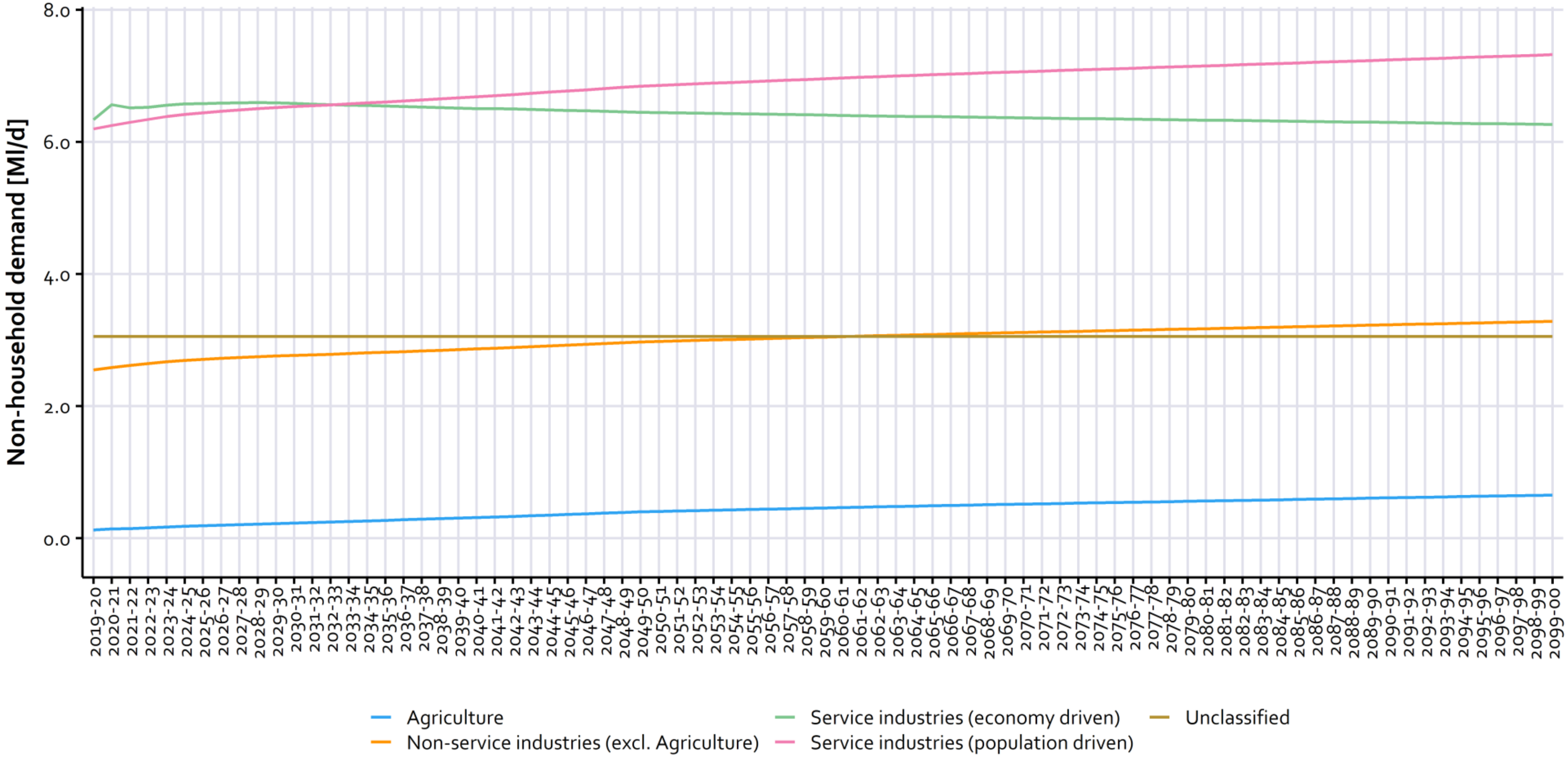


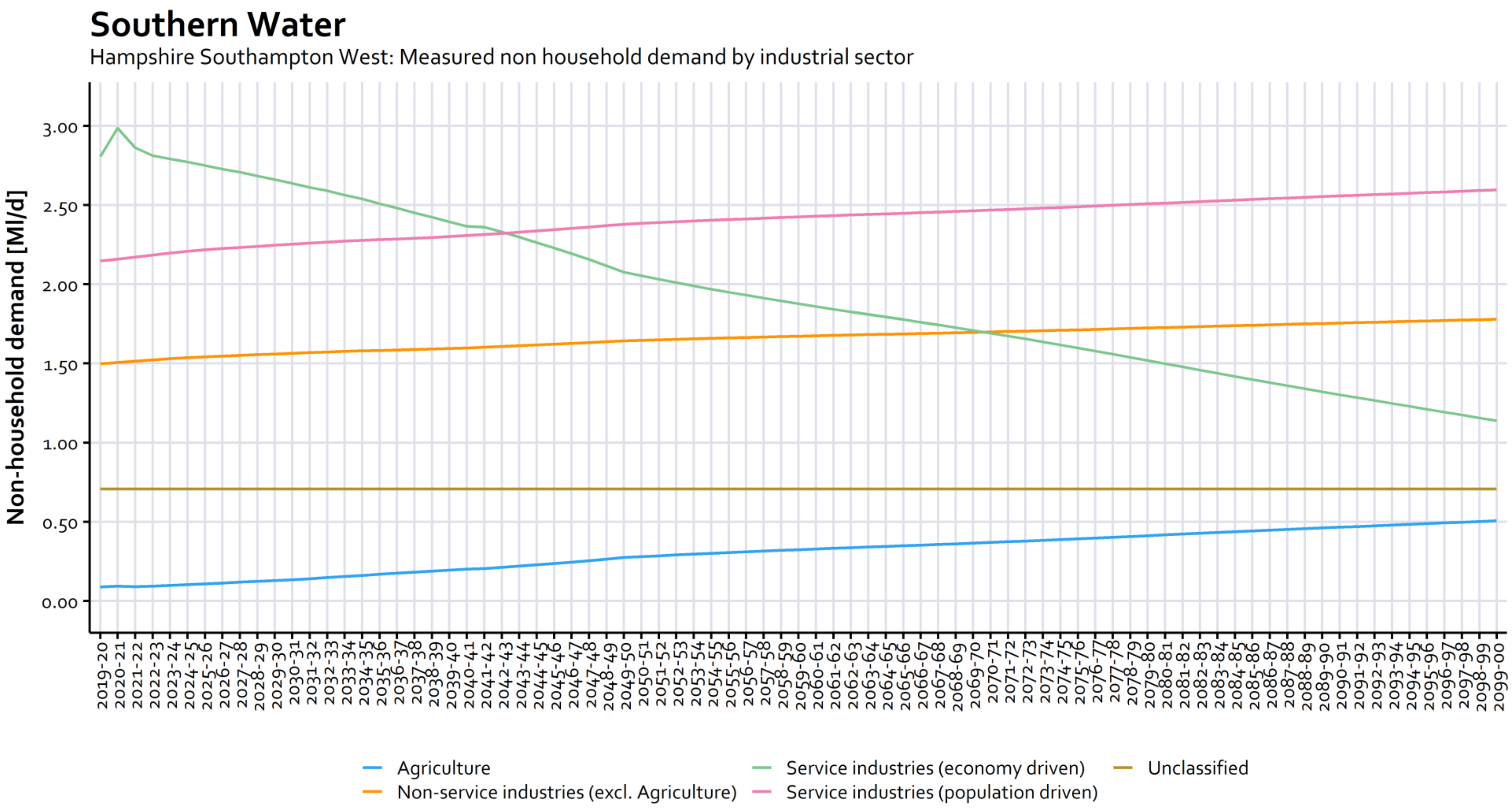

Southern Water
Hampshire Kingsclere: Measured non household demand by industrial sector
Non-household demand [Ml/d]
0.400
0.300
0.200
0.100
0.000
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

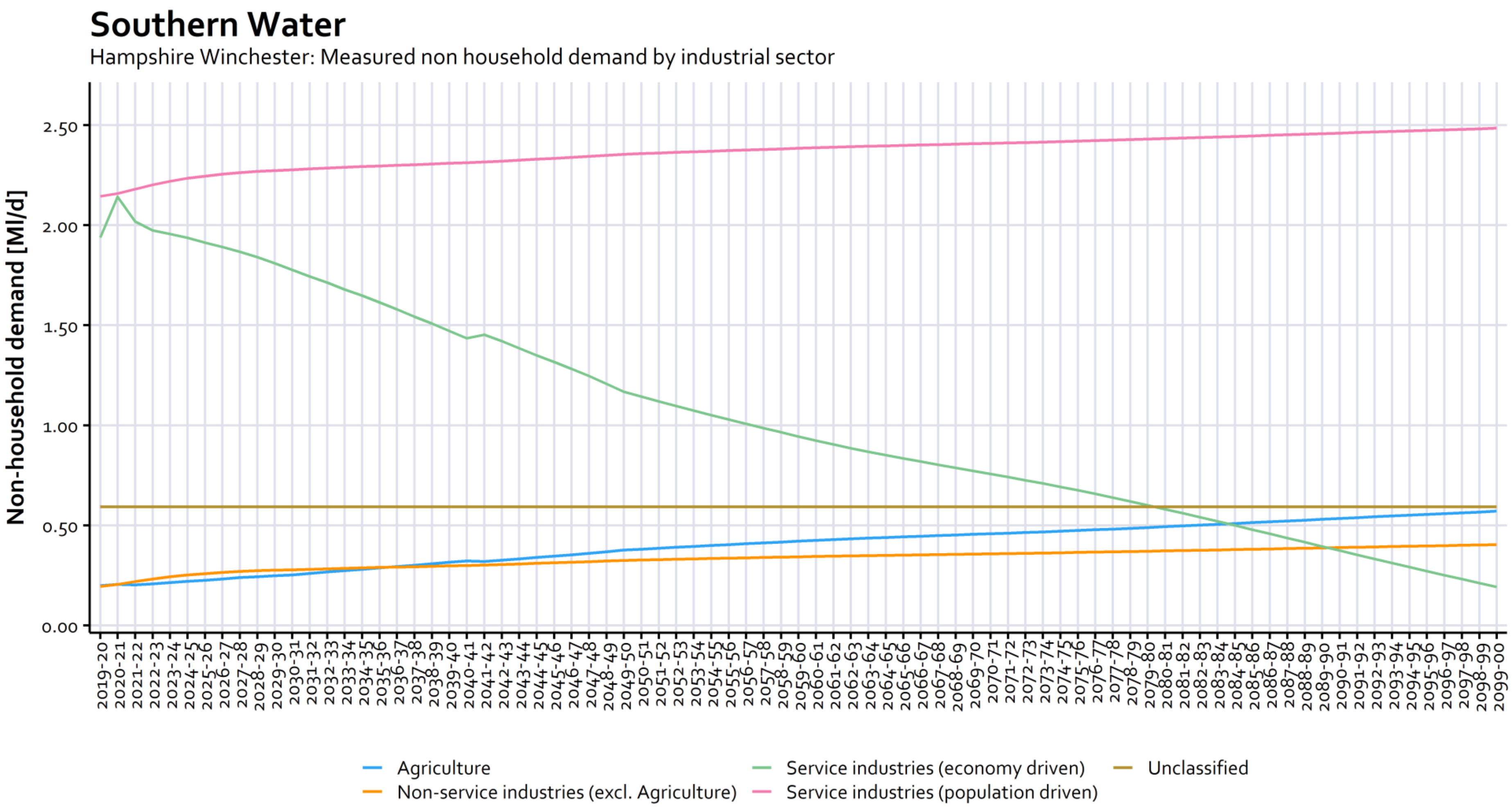

Southern Water
Hampshire Rural: Measured non household demand by industrial sector
Non-household demand [Ml/d]
0.80
0.60
0.40
0.20
0.00
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

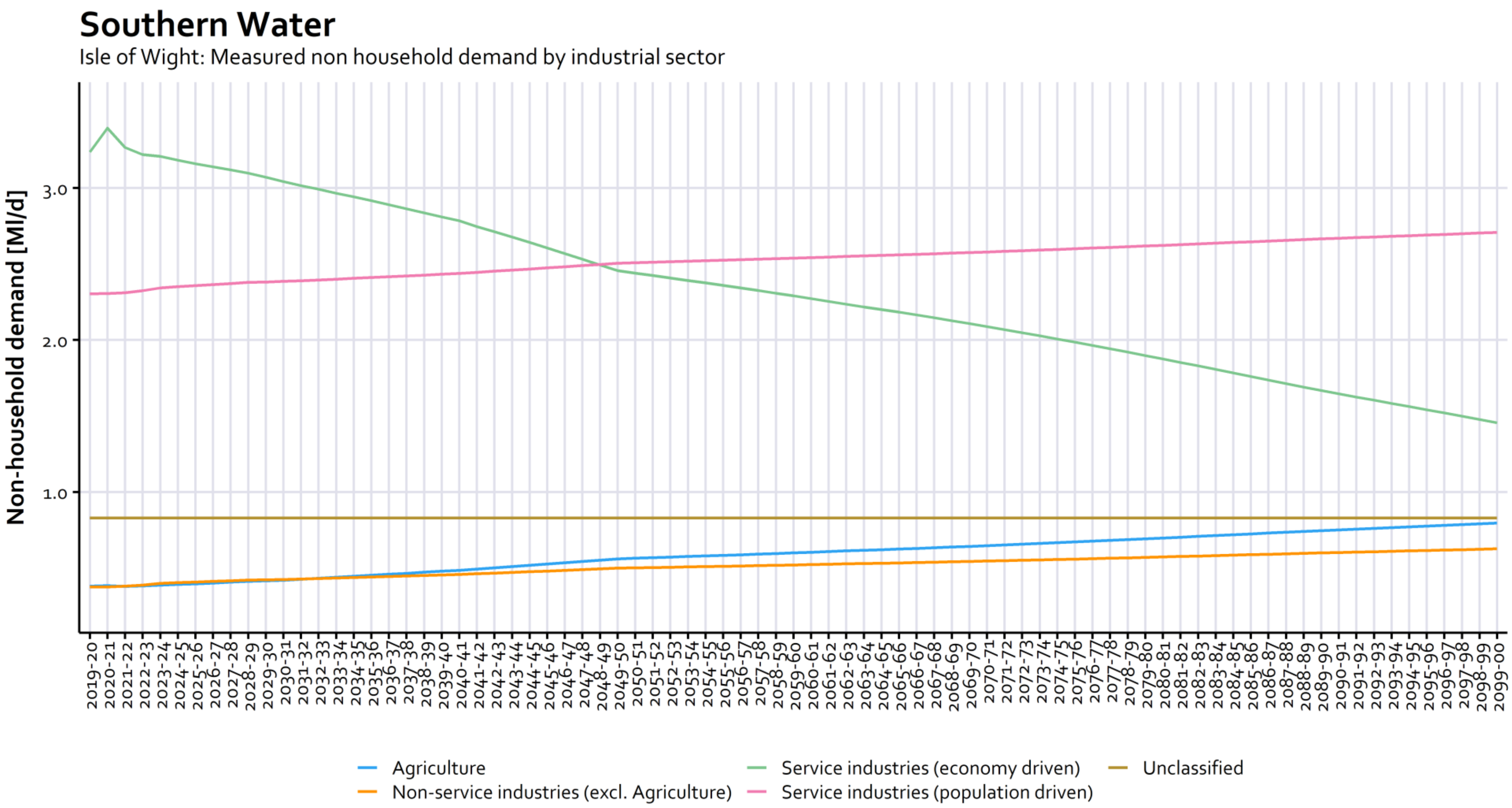
## Southern Water

Hampshire Southampton East: Measured non household demand by industrial sector



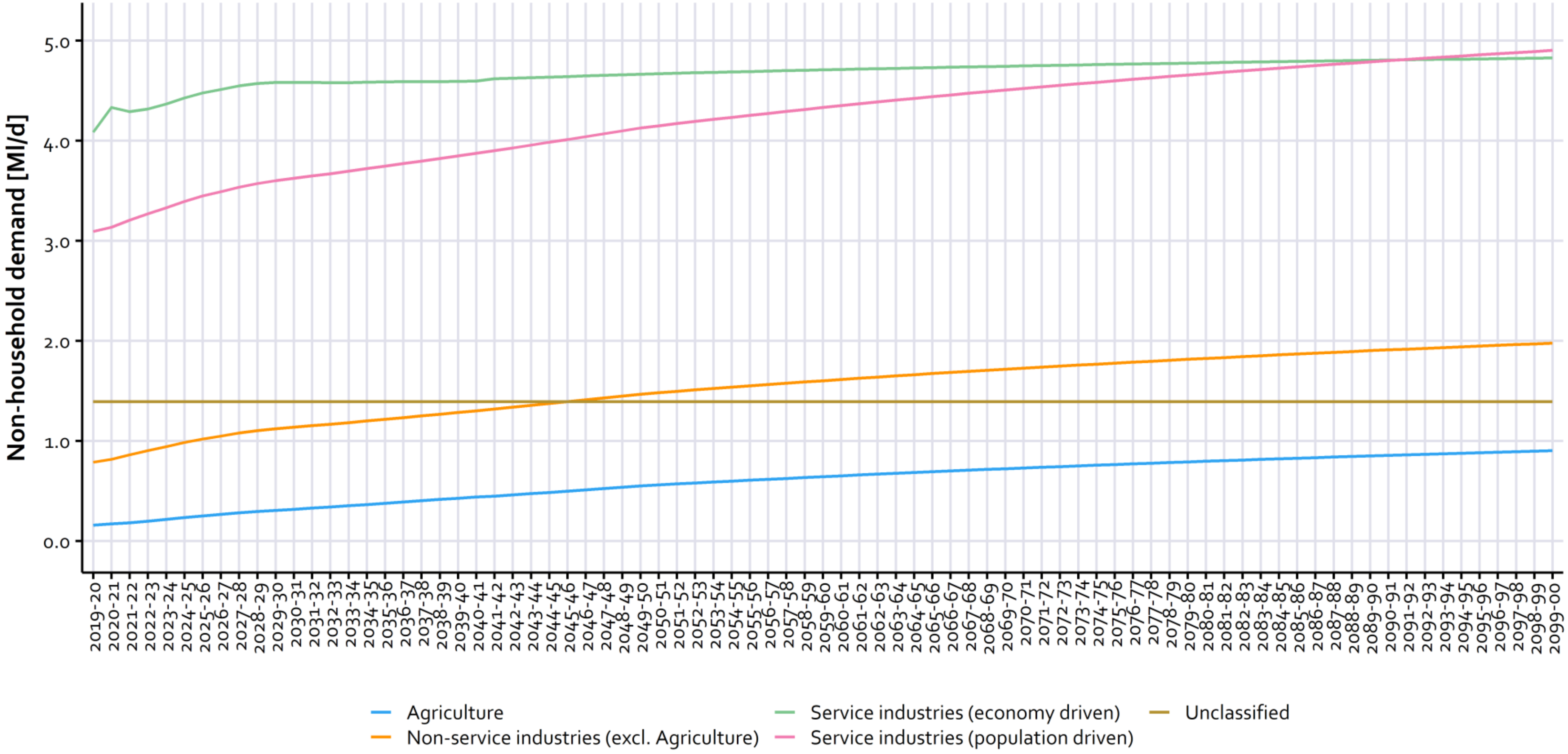

Southern Water
Hampshire Southampton West: Measured non household demand by industrial sector
Non-household demand [Ml/d]
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified


Southern Water
Hampshire Winchester: Measured non household demand by industrial sector
Non-household demand [Ml/d]
0.00
0.50
1.00
1.50
2.00
2.50
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

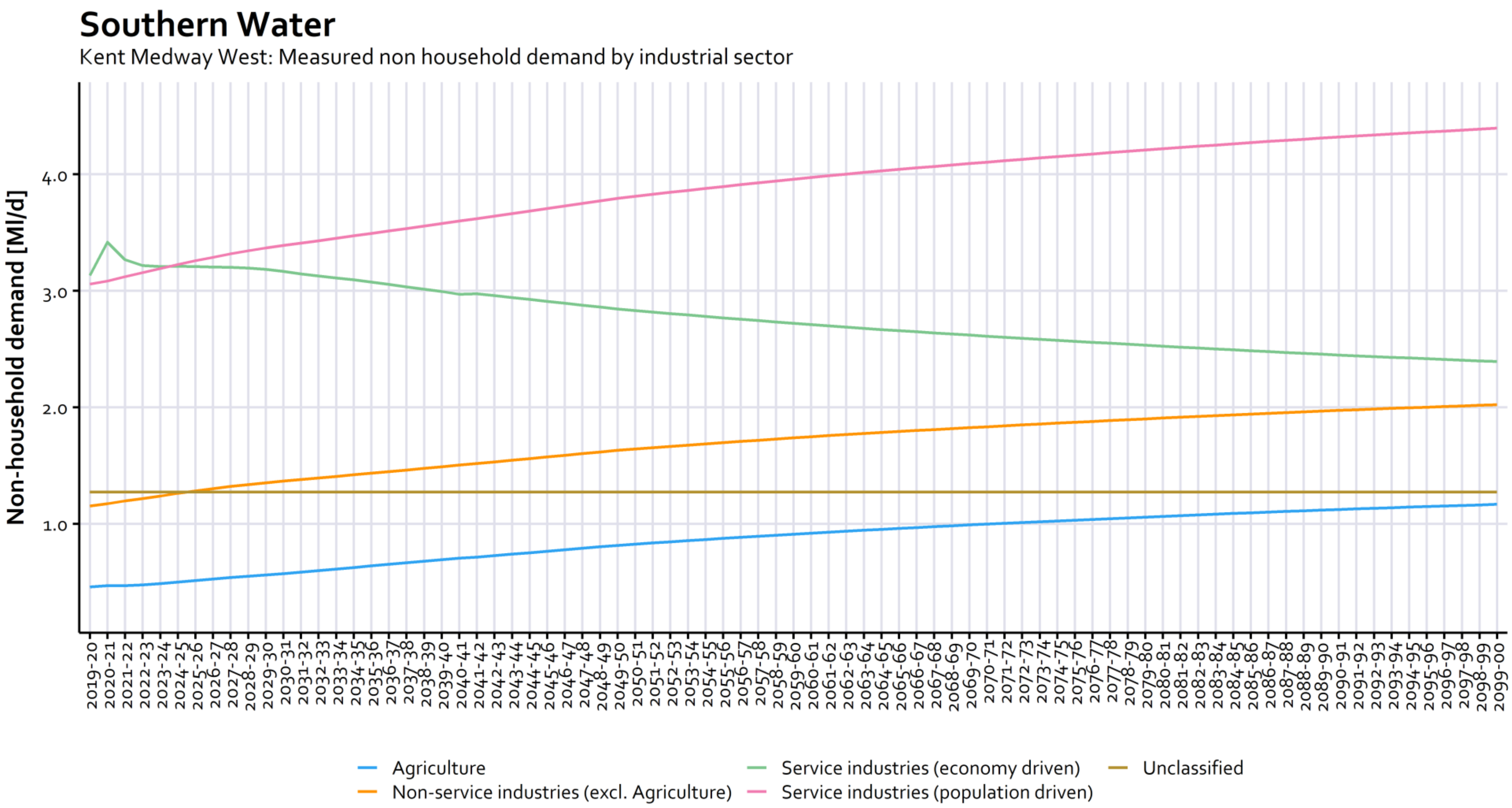

Southern Water
Isle of Wight: Measured non household demand by industrial sector
Non-household demand [Ml/d]
3.0
2.0
1.0
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

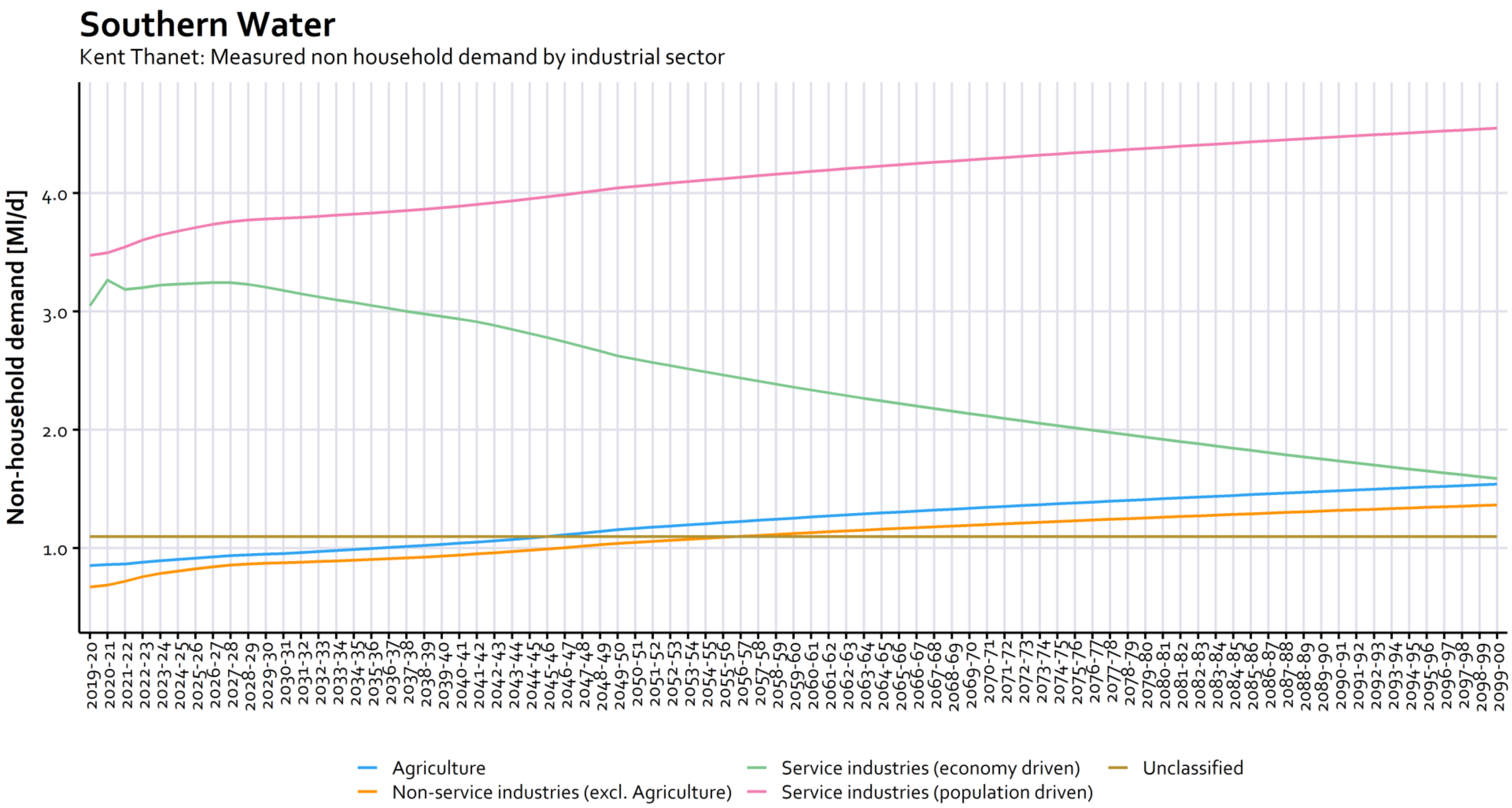
## Southern Water

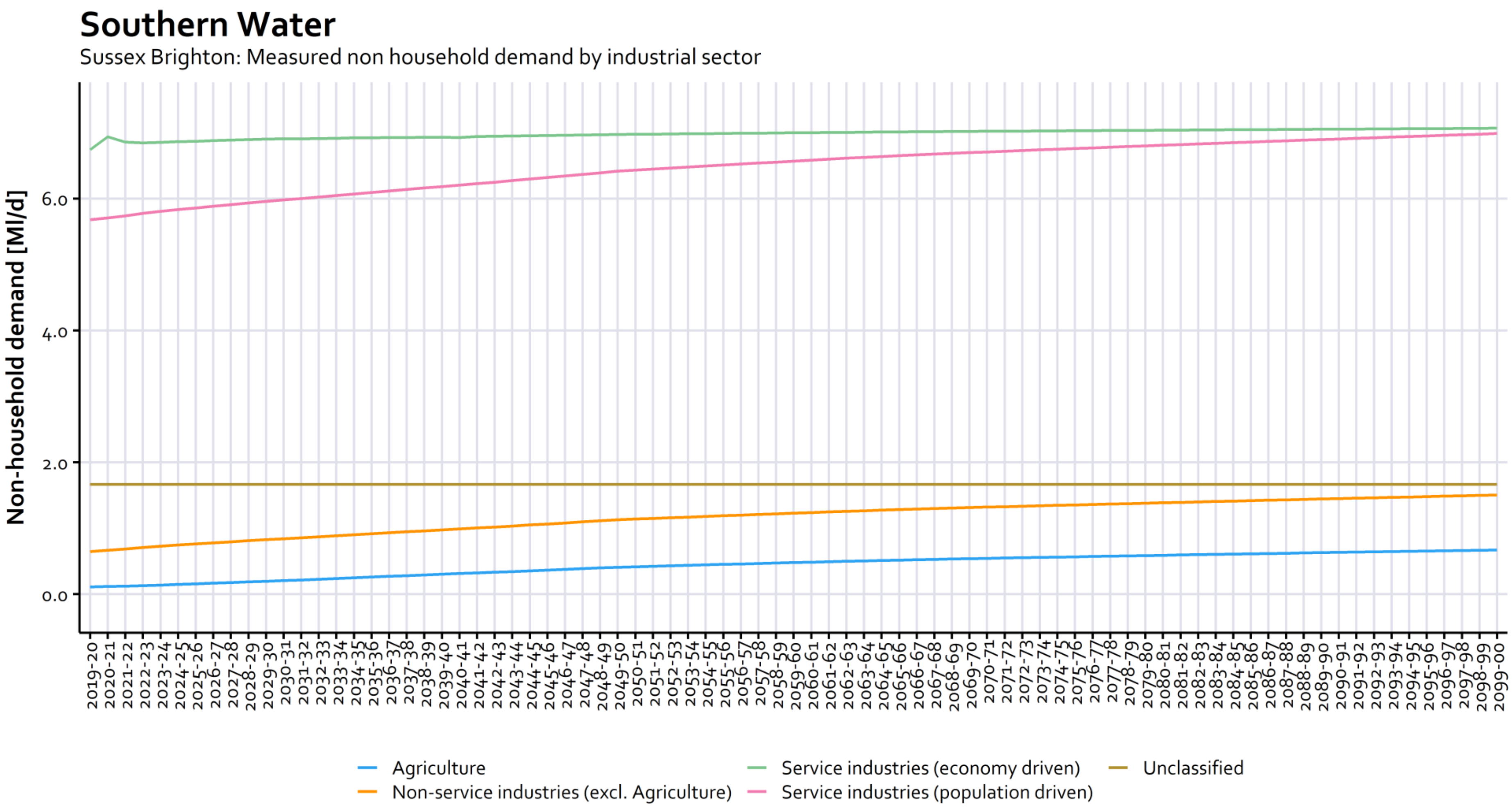
Kent Medway East: Measured non household demand by industrial sector

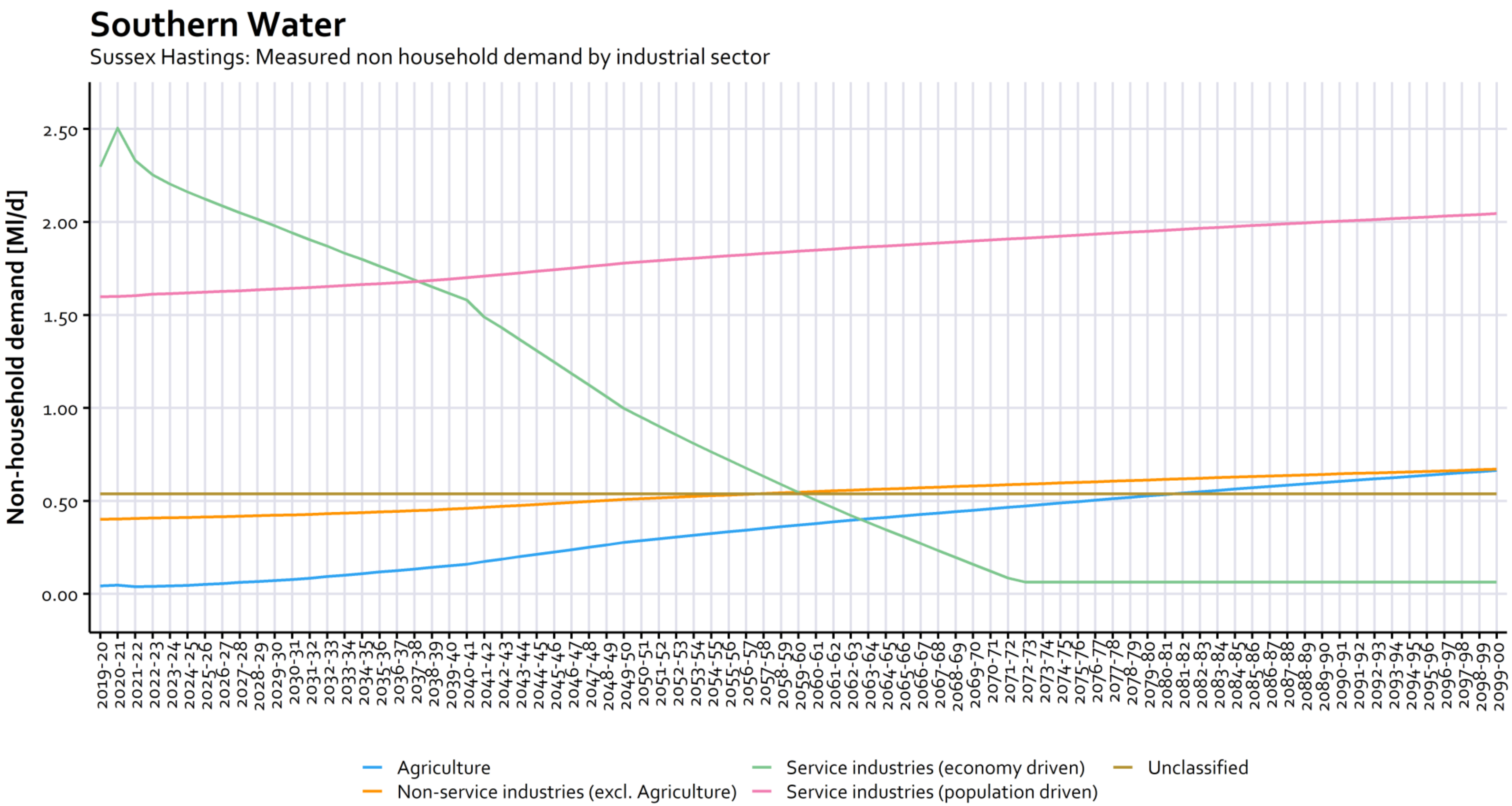



Southern Water
Kent Medway West: Measured non household demand by industrial sector
Non-household demand [Ml/d]
4.0
3.0
2.0
1.0
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified


Southern Water
Kent Thanet: Measured non household demand by industrial sector
Non-household demand [Ml/d]
4.0
3.0
2.0
1.0
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

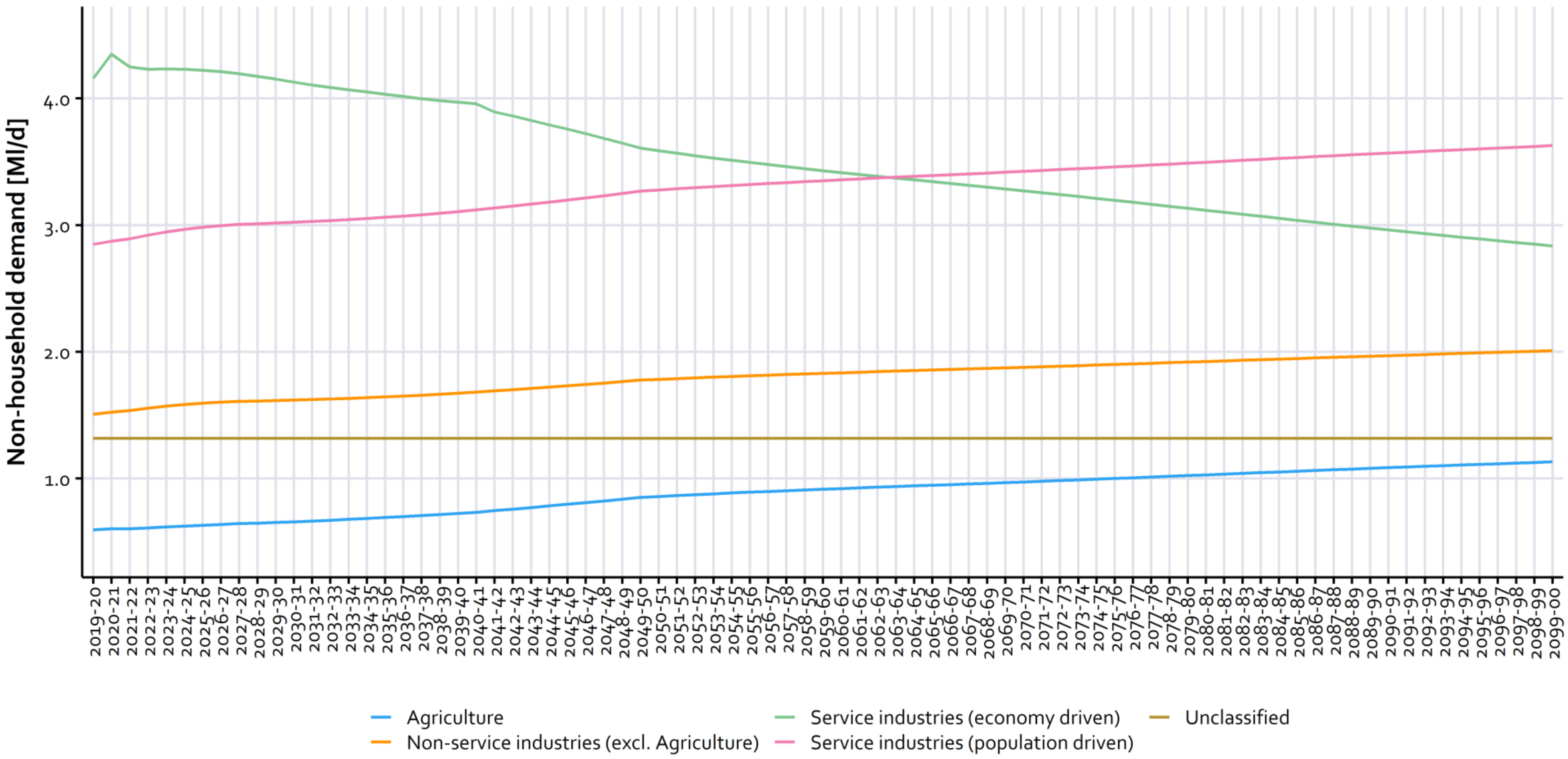

Southern Water
Sussex Brighton: Measured non household demand by industrial sector
Non-household demand [Ml/d]
0.0
2.0
4.0
6.0
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

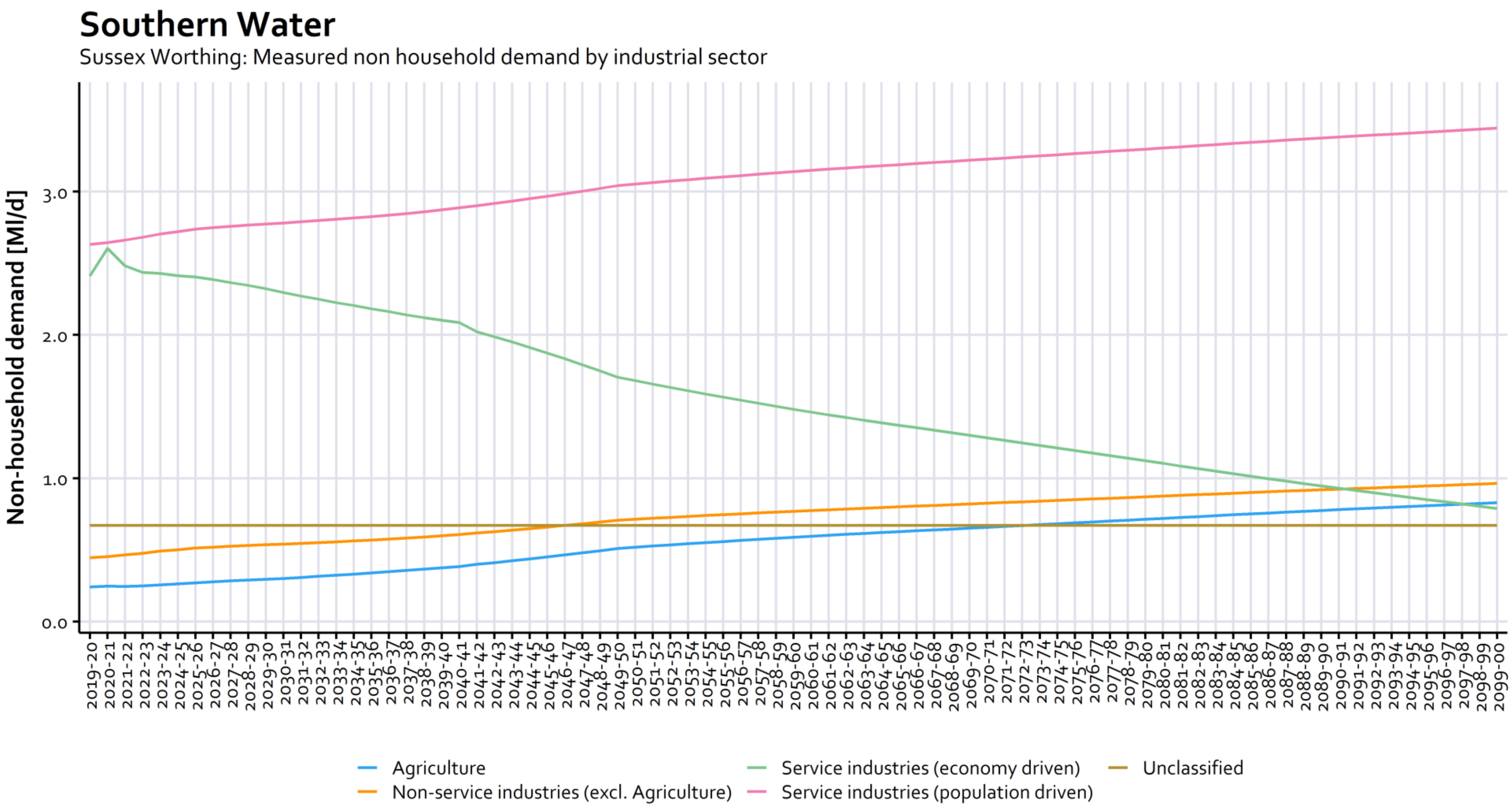

Southern Water
Sussex Hastings: Measured non household demand by industrial sector
Non-household demand [Ml/d]
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

## Southern Water

Sussex North: Measured non household demand by industrial sector




Southern Water
Sussex Worthing: Measured non household demand by industrial sector
Non-household demand [Ml/d]
0.0
1.0
2.0
3.0
2019-20
2099-00
Agriculture
Non-service industries (excl. Agriculture)
Service industries (economy driven)
Service industries (population driven)
Unclassified

## MLR model metrics

Note:

- A great improvement in modelling has been observed including a high population-density flag for three WRZs: Hmpshire Southampton East, Sussex Brighton, and Kent Medway East.
- The UK gridded population based on Census 2011 and Land Cover Map 2015 from CEH was used to derive population density for each WRZ.
- The use of the population density indicator improved the estimates, but not as much as the high-density flag, which could still bring benefit to the models.
- This suggests that there are additional factors that characterise theaw three WRZs.
- Both the high-density flag and the population density are therefore used for the models.
- The Unclassified sector has been forecasted as constant, keeping the base year value steady.

The result in the case of Southern Water NHH consumption MLR model is reported in the following tables.

**MLR model summary for the industry group "agriculture"**

| term | estimate | std.error | p.value |
|---|---|---|---|
| (Intercept) | 0.19 | 0.11 | 0.0749 |
| mosl | 0.034 | 0.013 | 0.0094 |
| employment | -0.0047 | 0.0024 | 0.0532 |
| population | 0.0000013 | 0.0000001 | 0 |
| pop_density | -0.000096 | 0.000014 | 0 |
| highdensity | -0.25 | 0.027 | 0 |

**MLR model summary for the industry group "nonservice"**

| term | estimate | std.error | p.value |
|---|---|---|---|
| (Intercept) | -0.096 | 0.037 | 0.0109 |
| mosl | 0.097 | 0.039 | 0.0137 |
| population | 0.0000033 | 0.00000025 | 0 |
| pop_density | -0.00021 | 0.000043 | 0 |

**MLR model summary for the industry group "serviceeconomy"**

| term | estimate | std.error | p.value |
|---|---|---|---|
| (Intercept) | 0.57 | 0.68 | 0.4085 |
| mosl | 0.35 | 0.093 | 0.0003 |
| population | 0.000008 | 0.00000032 | 0 |
| GVA | -0.0000051 | 0.0000045 | 0.2675 |

**MLR model summary for the industry group "servicepopulation"**

| term | estimate | std.error | p.value |
|---|---|---|---|
| (Intercept) | -0.098 | 0.093 | 0.2932 |
| employment | 0.00001 | 0.000018 | 0.5782 |
| population | 0.0000049 | 0.00000038 | 0 |
| mosl | 0.25 | 0.056 | 0 |
| pop_density | 0.00025 | 0.000061 | 0.0001 |

## Calibration factors

The calibration factors for Southern Water are reported below.

**Calibration factors for the considered WRZs.**

| wrz | industry_grouping | factor1 | factor2 |
|---|---|---|---|
| Hampshire Andover | agriculture | -0.014 | 2.069 |
| Hampshire Andover | nonservice | -0.017 | 2.069 |
| Hampshire Andover | serviceeconomy | -0.069 | 2.069 |
| Hampshire Andover | servicepopulation | -0.109 | 2.069 |
| Hampshire Andover | unclassified | -0.470 | 2.069 |
| Hampshire Kingsclere | agriculture | 0.027 | 2.580 |
| Hampshire Kingsclere | nonservice | -0.016 | 2.580 |
| Hampshire Kingsclere | serviceeconomy | -0.181 | 2.580 |
| Hampshire Kingsclere | servicepopulation | -0.237 | 2.580 |
| Hampshire Kingsclere | unclassified | -0.273 | 2.580 |
| Hampshire Rural | agriculture | 0.021 | 2.432 |
| Hampshire Rural | nonservice | -0.038 | 2.432 |
| Hampshire Rural | serviceeconomy | -0.074 | 2.432 |
| Hampshire Rural | servicepopulation | -0.150 | 2.432 |
| Hampshire Rural | unclassified | -0.330 | 2.432 |
| Hampshire Southampton East | agriculture | -0.071 | 1.660 |
| Hampshire Southampton East | nonservice | 0.527 | 1.660 |
| Hampshire Southampton East | serviceeconomy | 0.525 | 1.660 |

| wrz | industry_grouping | factor1 | factor2 |
|---|---|---|---|
| Hampshire Southampton East | servicepopulation | 1.184 | 1.660 |
| Hampshire Southampton East | unclassified | -0.772 | 1.660 |
| Hampshire Southampton West | agriculture | -0.114 | 1.867 |
| Hampshire Southampton West | nonservice | 0.413 | 1.867 |
| Hampshire Southampton West | serviceeconomy | 0.172 | 1.867 |
| Hampshire Southampton West | servicepopulation | 0.010 | 1.867 |
| Hampshire Southampton West | unclassified | -0.782 | 1.867 |
| Hampshire Winchester | agriculture | 0.011 | 2.084 |
| Hampshire Winchester | nonservice | -0.096 | 2.084 |
| Hampshire Winchester | serviceeconomy | 0.276 | 2.084 |
| Hampshire Winchester | servicepopulation | 0.391 | 2.084 |
| Hampshire Winchester | unclassified | -0.349 | 2.084 |
| Isle of Wight | agriculture | 0.061 | 1.776 |
| Isle of Wight | nonservice | -0.159 | 1.776 |
| Isle of Wight | serviceeconomy | 0.633 | 1.776 |
| Isle of Wight | servicepopulation | 0.284 | 1.776 |
| Isle of Wight | unclassified | -0.554 | 1.776 |
| Kent Medway East | agriculture | 0.023 | 2.033 |
| Kent Medway East | nonservice | -0.395 | 2.033 |
| Kent Medway East | serviceeconomy | -0.616 | 2.033 |
| Kent Medway East | servicepopulation | -0.583 | 2.033 |
| Kent Medway East | unclassified | -1.435 | 2.033 |
| Kent Medway West | agriculture | 0.012 | 2.807 |

| wrz | industry_grouping | factor1 | factor2 |
|---|---|---|---|
| Kent Medway West | nonservice | 0.030 | 2.807 |
| Kent Medway West | serviceeconomy | -0.350 | 2.807 |
| Kent Medway West | servicepopulation | -0.207 | 2.807 |
| Kent Medway West | unclassified | -0.870 | 2.807 |
| Kent Thanet | agriculture | 0.195 | 2.125 |
| Kent Thanet | nonservice | -0.208 | 2.125 |
| Kent Thanet | serviceeconomy | -0.206 | 2.125 |
| Kent Thanet | servicepopulation | 0.317 | 2.125 |
| Kent Thanet | unclassified | -0.848 | 2.125 |
| Sussex Brighton | agriculture | 0.053 | 1.806 |
| Sussex Brighton | nonservice | -0.343 | 1.806 |
| Sussex Brighton | serviceeconomy | 0.744 | 1.806 |
| Sussex Brighton | servicepopulation | 0.539 | 1.806 |
| Sussex Brighton | unclassified | -1.763 | 1.806 |
| Sussex Hastings | agriculture | -0.067 | 2.390 |
| Sussex Hastings | nonservice | -0.035 | 2.390 |
| Sussex Hastings | serviceeconomy | 0.033 | 2.390 |
| Sussex Hastings | servicepopulation | -0.260 | 2.390 |
| Sussex Hastings | unclassified | -0.709 | 2.390 |
| Sussex North | agriculture | 0.013 | 1.736 |
| Sussex North | nonservice | 0.050 | 1.736 |
| Sussex North | serviceeconomy | 0.166 | 1.736 |
| Sussex North | servicepopulation | 0.014 | 1.736 |

| wrz | industry_grouping | factor1 | factor2 |
|---|---|---|---|
| Sussex North | unclassified | -0.933 | 1.736 |
| Sussex Worthing | agriculture | 0.040 | 1.968 |
| Sussex Worthing | nonservice | -0.012 | 1.968 |
| Sussex Worthing | serviceeconomy | -0.343 | 1.968 |
| Sussex Worthing | servicepopulation | -0.244 | 1.968 |
| Sussex Worthing | unclassified | -1.261 | 1.968 |

# 5. Annex 7e: NHH Demand Forecast Update

# Southern Water Non-Household Forecast Update

| | | | |
|---|---|---|---|
| **Project no.:** | 2631 | **Date:** | 18/07/2023 |
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| **Reviewed by:** | Joe Cahill, Sarah Rogerson | **Reference:** | AR1528 |

## 1 Introduction

This technical note covers changes made to the Southern Water non-household consumption forecasting, as an update from the forecasts provided in 2020. This involves updates to demographics and historical consumption datasets, which are then applied to existing MLR models.

One of the primary drivers of this piece of work is due to several large-scale events (Covid-19 pandemic, Brexit, and the war in Ukraine) that have impacted the socio-economic situation in the United Kingdom, resulting in significant changes in economic and employment forecasts, as well as non-household water consumption through changing consumer behaviours.

The original process consisted of the training of an MLR model to predict NHH consumption trends using a combination of population, employment, economic and consumption metrics, as well as a MOSL flag for consumption data source. Central, upper and lower scenarios were also modelled to provide an understanding of the uncertainty bands around the prediction levels depending on future events.

Properties are classified using the government SIC codes, which are mapping up to one of five industry groups: Agriculture, non-service, service (economy-driven), service (population-driven) and unclassified. Each of these industry groups has an MLR model, which is then calibrated to base-year consumption from the latest annual review (AR) data.

This piece of work takes the existing models and applies them to updated data from several data sources, to provide an understanding of how the changing socio-economic climate in the UK has impacted NHH consumption forecasts. Updated factors were initially intended to be GVA (economic), employment, consumption (AR) and population datasets, although GVA and population weren't used in the final forecast update. The forecasted consumption is then adjusted to the upper and lower scenarios, by the same factors as in the previous forecasts, rather than re-modelling scenarios.

# 2 Data Updates

## 2.1 Oxford Economics

The models used Gross Value Added (GVA) and employment forecasts from Oxford Economics (OE) through to 2040. A data update was purchased from Oxford Economics, with the intention of using this to update non-household property forecasts with the latest available data by SIC group, this is particularly important to understand how the economic landscape of the UK is forecasted to change post-Brexit, post-covid and with additional factors such as the war in Ukraine.

Upon our initial QA checks upon receipt of this data, it was clear that there were significant changes to the economic forecast, not only looking ahead, but also historically. This causes significant issues as the models are trained on specific data, and this data needs to be consistent for an updated forecast to be calculated. Figure 1 shows the differences in GVA forecast after the data updates. There are historical changes in all SIC groups, but most notably in groups C and E.


**Figure 1 - Updated vs Original Oxford Economics forecast by SIC group**

After further analysis and discussion with OE, the following conclusions were reached as to what could have changed historical data:

1. The original dataset was set to 2016 £s, whereas the new data uses 2019 £s, meaning inflation will have adjusted the numbers.

2. A larger effect will be coming from the fact that the ONS made methodological changes to their GVA calculations in 2021 (back casted for all previous years), which OE then incorporated into their models.

Due to point 2, and after performing some sensitivity analysis on the effects of these changes, it was decided that it wouldn't be possible to use updated economic data for this forecast update.

There were no issues noted with the OE employment data.

## 2.2 Consumption Data

Additional AR consumption data was provided for AR21 and AR22 at WRZ-level, this is used to create calibration factors for the model consumption.

## 2.3 Population data

WRZ-level population data is used as an explanatory variable in the models, but due to lack of data availability, existing population data was used as before.

# 3 Results

The updated datasets and forecasts show the sharp downwards spike in consumption due to the Covid-19 pandemic and resulting step-change in the base year consumption. Under almost all aggregations, there is considerable downwards movement in the position of the forecasts.

The outputs are provided in three different aggregations: company, industry group and WRZ. Tabular and visual outputs for each of these are shown below. Within these aggregations, the most notable (relative) changes within a group are as follows:

- WRZ-level
    - Kent Thanet has a 19% drop in forecast consumption.
    - Hampshire Rural has an 16% drop in forecast consumption.
    - Hampshire Winchester has a 16% drop in forecast consumption.
- Industry-level
    - Service-population has an 14% drop in forecast consumption.
    - Non-service has a 13% drop in forecast consumption.
    - Service-economy has an 13% drop in forecast consumption.
- SWS company has an 13% drop in forecast consumption.

No groupings show an increase in forecast consumption.

# 4 Outputs

Table 1, ordered by largest reduction in consumption, shows how much each group within each aggregation has changed with the updated forecasts.

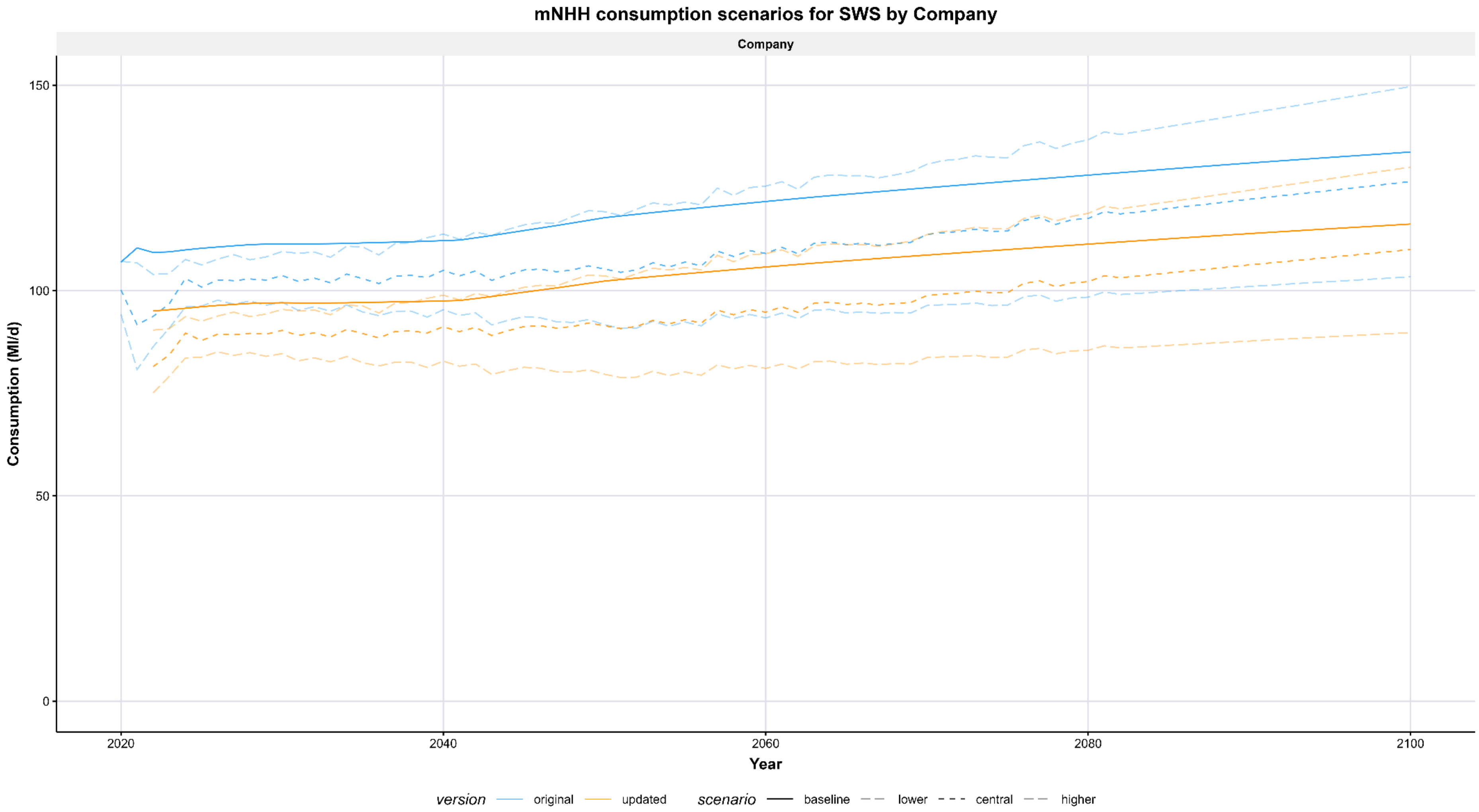
**Table 1 - Change in average (across timeseries) consumption forecast by groupings**

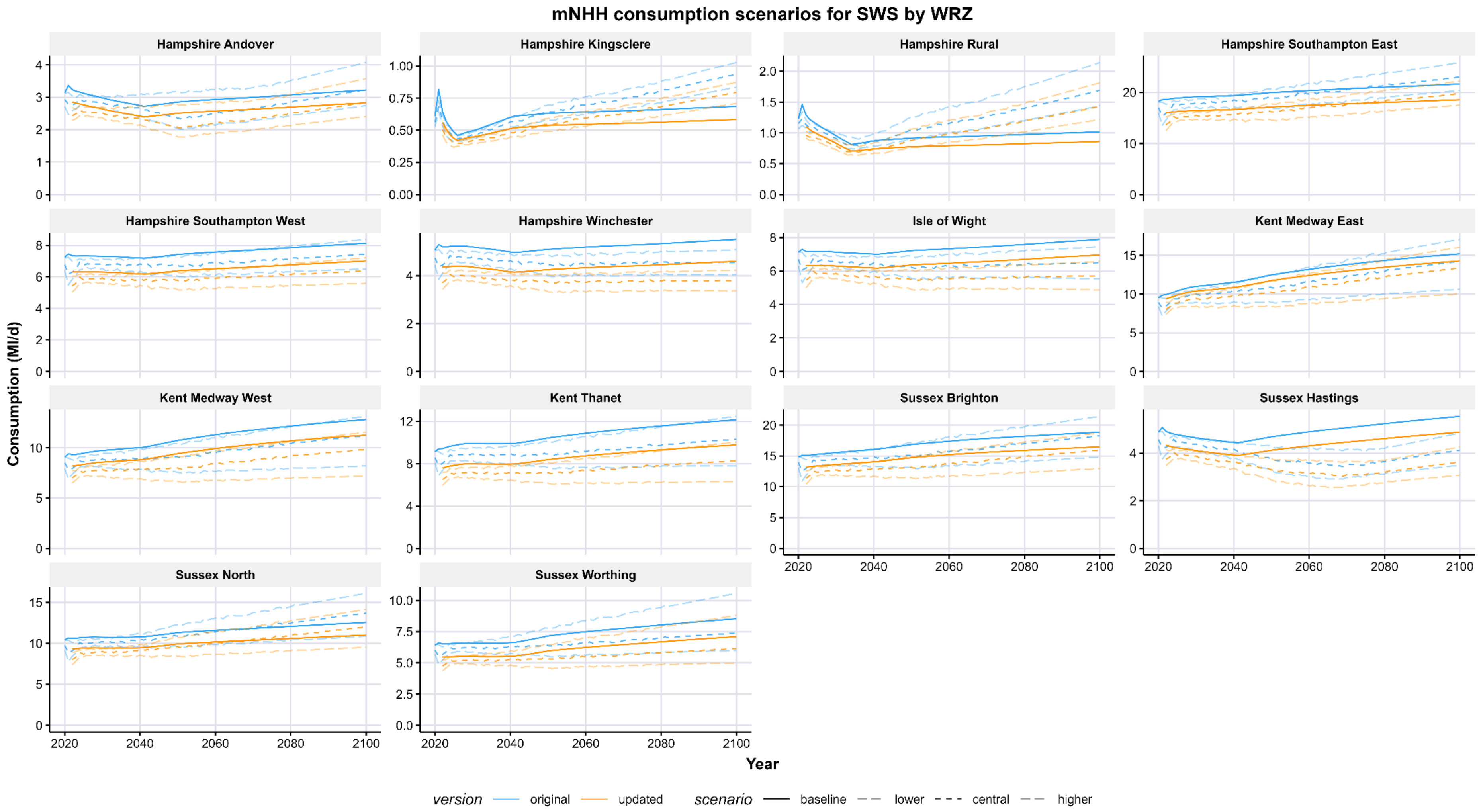
| Meter Status | Area | Sector | Grouping Type | Original (ml/d) | Updated (ml/d) | Raw Change (ml/d) | Change (%) |
|---|---|---|---|---|---|---|---|
| measured | Kent Thanet | Measured | WRZ | 10.8 | 8.74 | -2.08 | -19% |
| measured | Hampshire Rural | Measured | WRZ | 0.969 | 0.817 | -0.152 | -16% |
| measured | Hampshire Winchester | Measured | WRZ | 5.23 | 4.37 | -0.862 | -16% |
| measured | Sussex Worthing | Measured | WRZ | 7.43 | 6.21 | -1.22 | -16% |
| measured | Hampshire Kingsclere | Measured | WRZ | 0.625 | 0.534 | -0.0911 | -15% |
| measured | Company | Service industries (population driven) | Industry Grouping | 43 | 37.2 | -5.84 | -14% |
| measured | Hampshire Southampton East | Measured | WRZ | 20.2 | 17.4 | -2.81 | -14% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| measured | Hampshire Southampton West | Measured | WRZ | 7.6 | 6.55 | -1.05 | -14% |
| measured | Company | Company | Company | 121 | 105 | -15.5 | -13% |
| measured | Company | Non-service industries (excl. Agriculture) | Industry Grouping | 14.7 | 12.8 | -1.9 | -13% |
| measured | Company | Service industries (economy driven) | Industry Grouping | 43.6 | 37.7 | -5.83 | -13% |
| measured | Hampshire Andover | Measured | WRZ | 2.99 | 2.63 | -0.367 | -12% |
| measured | Isle of Wight | Measured | WRZ | 7.37 | 6.51 | -0.863 | -12% |
| measured | Kent Medway West | Measured | WRZ | 11.2 | 9.85 | -1.31 | -12% |
| measured | Sussex Brighton | Measured | WRZ | 17.1 | 15.1 | -2.1 | -12% |
| measured | Sussex Hastings | Measured | WRZ | 4.96 | 4.37 | -0.593 | -12% |
| measured | Sussex North | Measured | WRZ | 11.5 | 10.1 | -1.38 | -12% |
| measured | Company | Agriculture | Industry Grouping | 6.17 | 5.5 | -0.676 | -11% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| measured | Company | Unclassified | Industry Grouping | 13.6 | 12.3 | -1.31 | -10% |
| measured | Kent Medway East | Measured | WRZ | 12.9 | 12.3 | -0.68 | -5% |


mNHH consumption scenarios for SWS by Company
Company
Consumption (Ml/d)
150
100
50
0
2020
2040
2060
2080
2100
Year
version original updated
scenario baseline lower central higher


mNHH consumption scenarios for SWS by WRZ
Hampshire Andover
Hampshire Kingsclere
Hampshire Rural
Hampshire Southampton East
Hampshire Southampton West
Hampshire Winchester
Isle of Wight
Kent Medway East
Kent Medway West
Kent Thanet
Sussex Brighton
Sussex Hastings
Sussex North
Sussex Worthing
Consumption (Ml/d)
Year
version original updated
scenario baseline lower central higher

# 5 Conclusions and Recommendations

Overall, there is seen to be a significant decline in NHH consumption forecasts. This is primarily driven by the lower base-year consumption caused by the drop during the covid-19 pandemic, alongside changing employment forecasts in the Oxford Economics datasets.

A positive result of this update is the fact that almost all the updated baseline forecasts are contained within the scenario bounds from the original forecast. This shows that the original scenarios sufficiently accounted for potential variations in the forecasts due to unknown changes.

Our primary recommendations would be to carry out a re-modelling process using the latest available GVA data, as the data update wasn't able to be used due to changes in the underlying method of deriving this metric. This means a true understanding of how the economic forecasts have changed since 2020 are limited to just the employment forecasts. Updated population data should also be used.

We also recommend re-modelling and redefining the scenarios that are used, to ensure that they are in-line with the latest socio-economic changes and providing uncertainty bounding around the baseline models with additional context around the economic uncertainty from the data sources.

# 6 Appendix

## 6.1 SIC group to industry group mapping

| sic_code_group | industry_grouping |
|---|---|
| A | agriculture |
| B | nonservice |
| C | nonservice |
| D | nonservice |
| E | nonservice |
| F | nonservice |
| G | serviceeconomy |
| H | serviceeconomy |
| I | serviceeconomy |
| J | serviceeconomy |
| K | serviceeconomy |
| L | serviceeconomy |
| M | serviceeconomy |
| N | serviceeconomy |
| O | servicepopulation |
| P | servicepopulation |
| Q | servicepopulation |
| R | servicepopulation |

| | |
|---|---|
| S | servicepopulation |
| T | servicepopulation |
| U | unclassified |