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Target Headroom Assessment

Revised Draft Water Resources Management Plan 2024

SES Water

16 August 2023

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1. Introduction and background

As stipulated in the current Water Resources Planning Guideline (WRPG)[1], SES Water is required to include an allowance for the uncertainty around its supply and demand forecasts in its 2024 Water Resources Management Plan (WRMP24). This uncertainty can be determined using risk-based planning tools or it can be determined from a 'target headroom' calculation. A water company's target headroom is defined as 'the minimum buffer that a prudent water company should allow between supply and demand to cater for specified uncertainties (except for those due to outages) in the overall supply demand balance'[2].The purpose of including a target headroom allowance within the supply/demand balance is to include a margin between supply and demand to allow for the risk of variations in the forecast supply/demand balance due to uncertainty in the various components.

The target headroom allowance that SES Water included in its previous two WRMPs is summarised in Table 1-1.

Table 1-1 - SES Water Target Headroom Allowance in previous WRMPs (WRMP14 and WRMP19)

Annual average target headroom (DYAA)	WRMP14		WRMP19	
	2011/12	2039/40	2015/16	2079/80
Risk Percentile (%)	95th	85th	95th	85th
Target Headroom (Ml/d)	5.86	19.82	8.23	12.11
Critical period target headroom (DYCP)	WRMP14		WRMP19	
	2011/12	2039/40	2015/16	2079/80
Risk Percentile (%)	95th	85th	95th	85th
Target Headroom (Ml/d)	20.69	28.12	10.93	15.19

The values in Table 1-1 were based on a Monte Carlo simulation to combine probability distributions for a number of key uncertainty factors, including accuracy of supply and demand data, demand forecast variation and impact of climate change on deployable output (DO). Company headroom allowance values were selected from each distribution at a reducing profile of risk across the 25-year planning horizon. The most appropriate level of headroom uncertainty was considered to be the 95th percentile for the beginning of the planning period, declining to the 85th percentile by the end of the planning period in 2039/40. The WRMP19 assessment predicts uncertainty over a longer planning period up to 2079/80 according to the new guidance[3]. The WRMP14 assessment produced a higher headroom allowance than the WRMP19 assessment. This is because the total headroom allowance in WRMP14 was calculated by summing the uncertainty associated with the individual categories; while the WRMP19 assessment used @Risk (a Monte Carlo simulation software which operates in Microsoft Excel) to sum all the categories within the model runs which resulted in a lower headroom allowance.

The adaptive planning approach adopted by Water Resources South East (WRSE), including SES Water, for WRMP24 allows for uncertainty of certain elements in the supply-demand balance over the planning horizon. Target headroom still forms part of the adaptive planning process but elements of uncertainty are removed from the target headroom value at future adaptive plan branch points to avoid double counting uncertainty during specific adaptive planning situations.

For its draft WRMP24 (published November 2022), SES Water's @Risk target headroom model was not available for update and so WRMP19 target headroom values were used by splitting them into the required WRSE format to allow the adaptive planning approach to be appropriately applied. SES Water's @Risk target headroom model has since been updated for its revised draft WRMP24. Due to the scheduling of WRSE investment modelling and SES Water target headroom model update, the WRSE investment model still uses the WRMP19 values. However, in this report, a comparison of the updated target headroom values is made

[1] Environment Agency, Ofwat and Natural Resources Wales, March 2023. Water resources planning guideline (WRPG). Version 12. Final.
[2] UKWIR, 2002. An Improved Methodology for Assessing Headroom, WR-13.
[3] Environment Agency, June 2016. Estimating impacts of climate change on water supply.

with the WRMP19 values used in the WRSE investment modelling to assess the likelihood of the update significantly affecting the investment model runs.

This report presents the methodology, assumptions and results for both the target headroom used in the WRSE investment model (as per the draft WRMP24) and updated headroom assessment.

2. Target headroom calculation used in WRSE investment modelling

2.1. Components

During March 2022 a request from WRSE was made to all six member water companies to provide a series of target headroom forecasts that could be used by WRSE for adaptive planning investment modelling. The details are covered in the technical note from WRSE entitled '*Target headroom approach for an adaptive plan, Version 1.1, February 2022'*. In addition to this, a request was made to include an allowance for the uncertain impact of the Covid-19 pandemic on demand within the headroom forecasts (note this element was subsequently removed for the modelling for the revised draft WRMP24 as the demand forecast was rebased to include the established Covid-19 effects).

Table 2-1 sets out how the various target headroom components, as defined in UKWIR (2002)[2], which were combined for the various target headroom forecasts requested by WRSE.

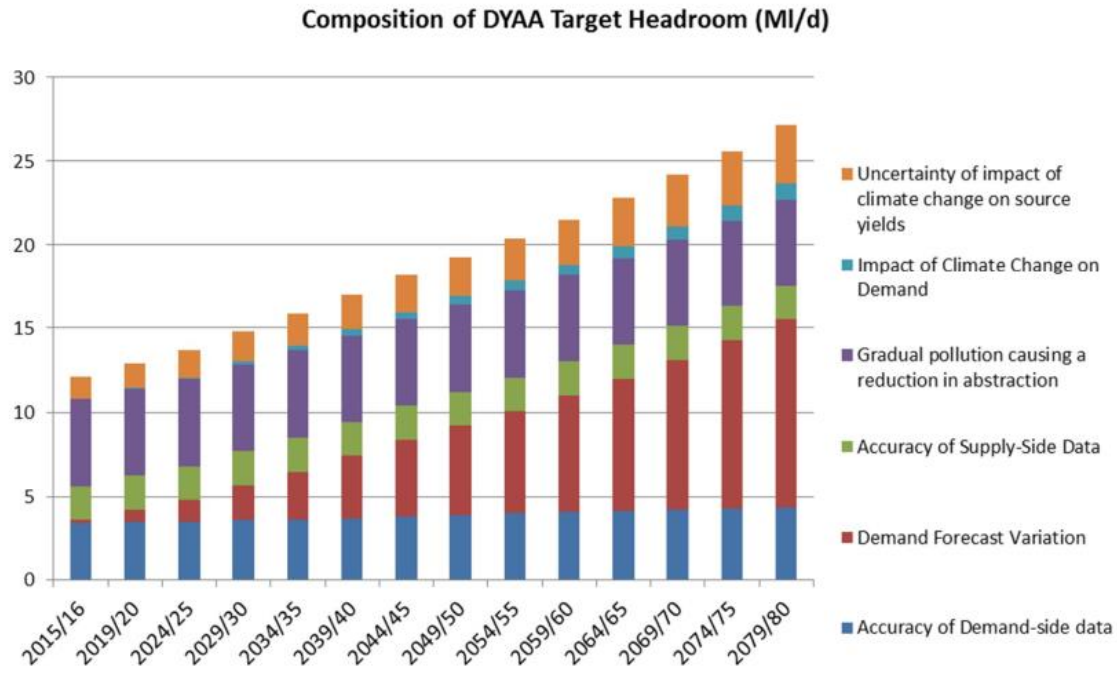
Table 2-1 - WRSE target headroom requirements for adaptive planning

Component	Component description	Full Target Headroom (FTH) profile	Environmental Destination and Growth (EDG) target headroom profile	Environmental Destination, Growth, and Climate change (EDGC) target headroom profile	Interpretation for WRSE requirements
S1	Vulnerable surface water licences	× *	×	×	N/A - not used by SES for WRMP19
S2	Vulnerable groundwater licences	× *	×	×	N/A - not used by SES for WRMP19
S3	Time limited licences	× *	×	×	N/A - not used by SES for WRMP19
S4	Bulk imports	✓	✓	✓	N/A - not used by SES for WRMP19
S5	Gradual pollution of sources causing a reduction in abstraction	✓ **	✓ **	✓ **	Include in all forecasts
S6	Accuracy of supply-side data / overall source yield	✓	✓	✓	Include in all forecasts
S7	Not used	×	×	×	N/A
S8	Uncertainty of impact of climate change on source yields	✓	✓	×	Include in full target headroom (climate change component) and EDG target headroom (climate change component) forecasts
S9	Uncertain output from new resource developments	✓ ***	✓ ***	✓ ***	N/A - final plan only
D1	Accuracy of sub-component data	✓	✓	✓	Include in all forecasts
D2	Demand forecast variation	✓	× ****	× ****	Include in full target headroom (all other components) only
D3	Uncertainty of climate change on demand	✓	✓	×	Include in full target headroom (CC component) and EDG Target headroom (climate change component) forecasts
D4	Uncertain outcome from demand management measures	✓ ***	✓ ***	✓ ***	N/A - final plan only

* Originally included in the UKWIR 2002 methodology but WRPG prevents its inclusion in target headroom as uncertainty around these components is now explicitly listed elsewhere within a water company's adaptive planning supply forecast
** This should be included but only if the deployable output of sources hasn't already been written down in the future due to deteriorating raw water trends
*** This should be based on the schemes selected in the cost-efficient plan
**** D2 – only include non-growth related components for the headroom forecast

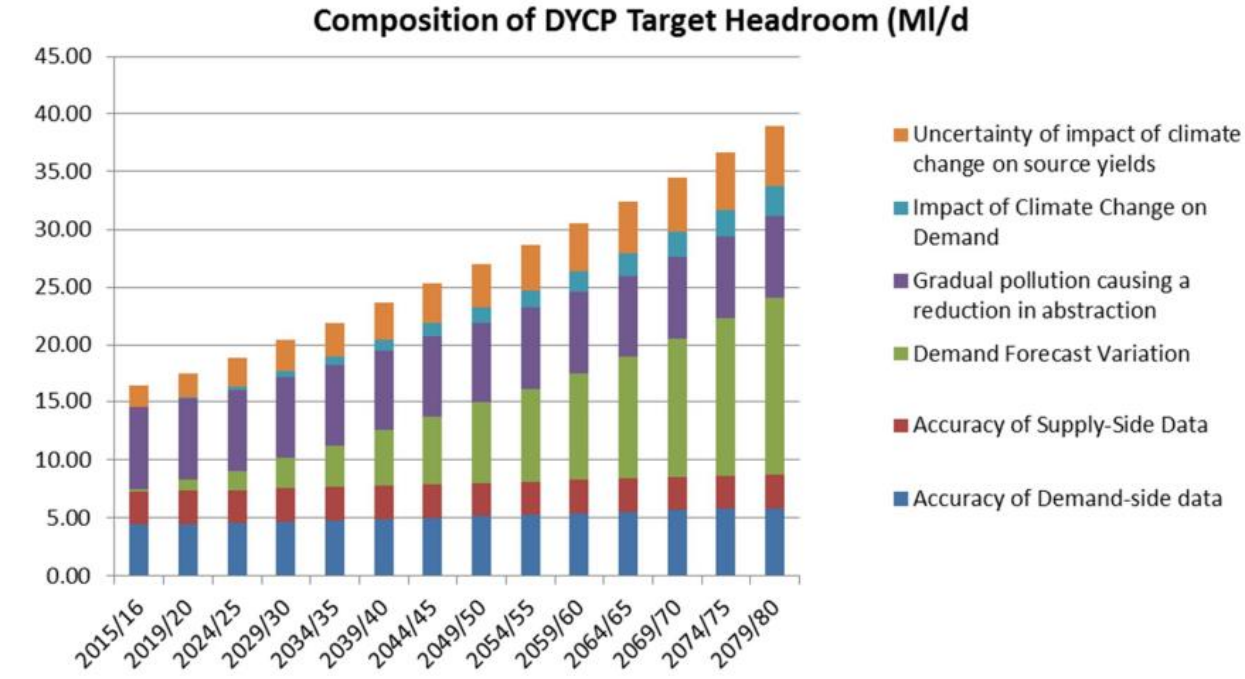
2.2. Method

Due to the reasons stated in Section 1, target headroom values were extracted from two figures contained within Figure 4.4. of Appendix D 'Headroom Assessment' of SES Water's Final 2019 Water Resources Management Plan (WRMP19) report: Composition of Dry Year Annual Average (DYAA) Target Headroom (Ml/d) and the Composition of Dry Year Critical Period (DYCP) Target Headroom (Ml/d). These figures are reproduced here as Figure 2-1 and Figure 2-2 respectively. The scenario selected was the 1:200-year drought event.



Source: Figure 4-2 from SES Water WRMP19, Appendix E

Figure 2-1 - Composition of DYAA Target Headroom (Ml/d)



Source: Figure 4-2 from SES Water WRMP19, Appendix E

Figure 2-2 - Composition of DYCP Target Headroom (Ml/d)

Due to the absence of original source values, the measured values for each component shown on the graphs were extracted and tabulated and subjected to the following process:

- Step 1: Extraction of absolute values from Figure 4.4 WRMP19 Appendix D headroom assessment report.
- Step 2: Calculation of the percentage that each component comprises of overall target headroom value.
- Step 3: Calculation of the percentage that each component comprises of climate change and non-climate change components.
- Step 4: Annual interpolation of percentages between reported 5-year intervals.
- Step 5: Back calculate absolute values for each target headroom component by applying these percentages to total target headroom forecast figures listed in the WRMP19 tables to produce the required WRSE headroom component input format for investment modelling.

Values were fixed beyond the WRMP19 planning horizon 2079/80 in the absence of other information.

The resultant target headroom inputs to the WRSE investment modelling were as illustrated in Figure 2-3 and Figure 2-4.

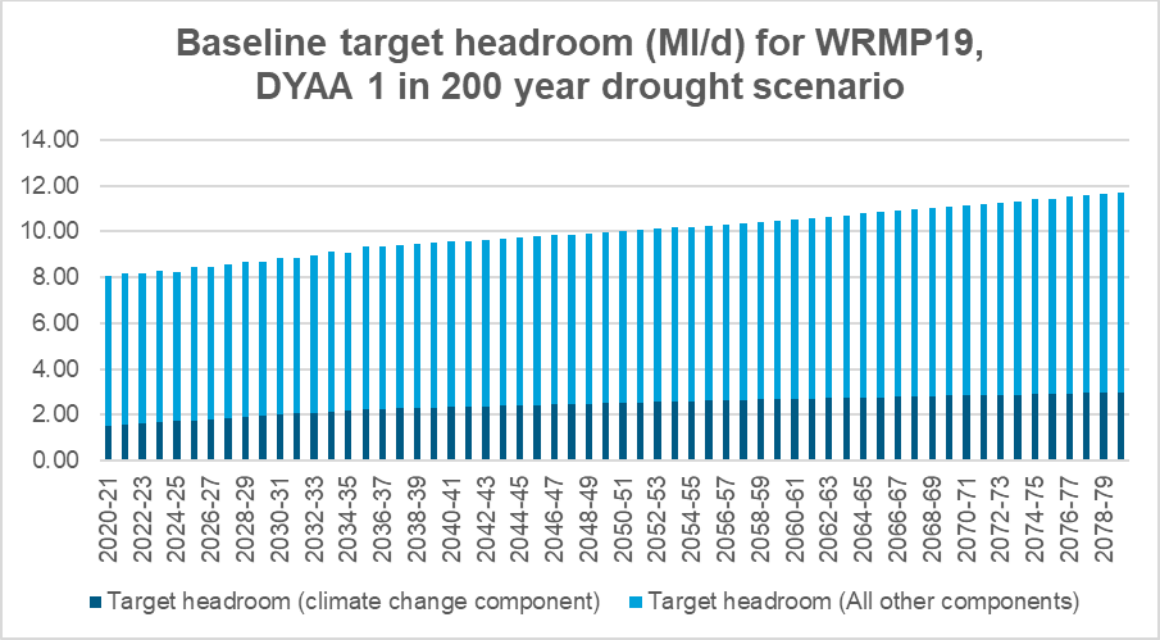


Figure 2-3 – Baseline target headroom forecast for WRMP19 from WRP tables, DYAA 1 in 200 year scenario

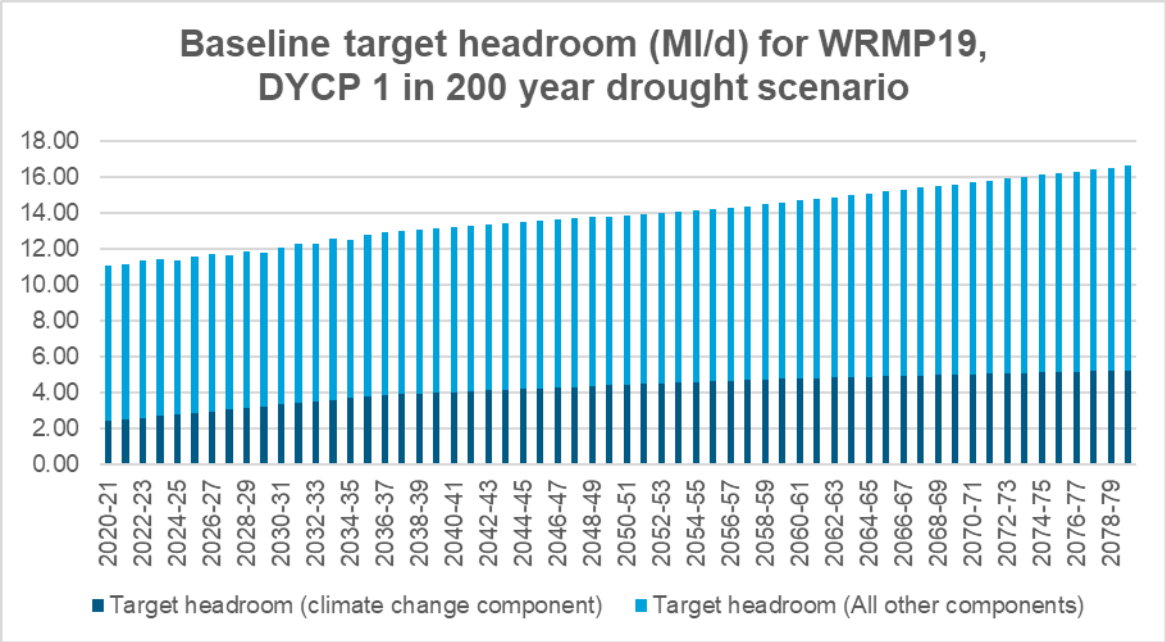


Figure 2-4 - Baseline target headroom forecast for WRMP19 from WRP tables, DYCP 1 in 200 year scenario

2.3. Covid-19 impact calculation

Following discussion with SES Water and some of the other WRSE companies, the following approach was used to generate the Covid-19 uncertainty allowance:

- A reduction in non-household (NHH) demand of 3.5% in 2020/21, scaled linearly to 0% in 2040/41 was applied to the total measured and unmeasured NHH consumption demand forecast for DYAA, DYCP and Normal Year Annual Average (NYAA) (Housing Plan P – baseline). The 3.5% impact was based on a report and analysis undertaken by Artesia[4]. The timescale was based on the approach undertaken by Affinity Water, in the absence of other information. It is understood that different WRSE companies took a variety of approaches due to the uncertainty associated with forecasting this impact.
- An increase in household (HH) demand of 1.5%, also based on information from the Artesia report, scaled linearly to 0% in 2040/41 was applied to the total measured and unmeasured HH consumption demand forecast for DYAA, DYCP and NYAA (Housing Plan P – baseline).
- The sum of these two values was calculated for each year and added to the relevant DYAA, DYCP and NYAA forecast for each WRSE scenario.

This Covid-19 impact was removed from the uncertainty allowance for the revised draft WRMP24 as the demand forecast was rebased to 2021/22 and included the impacts of Covid-19 which were considered to permanent thereafter.

2.4. Results

The results were provided to WRSE in the WRSE Data Landing Platform spreadsheet template within a copy entitled “DLP input template for Demand Forecasts and Headroom_values only - _v2_040520221”[5] and are shown graphically in Figure 2-5 to Figure 2 -13 on the following pages. The three WRSE scenarios all show different trends:

[4] Artesia (2021). The impact of COVID-19 on water consumption during February to October 2020 – Final report. Project reference 2463, report number AR1403.

[5] https://atkins.sharepoint.com/:x:/r/sites/SESWaterWRSupport/Shared%20Documents/General/Headroom/Issued%20by%20Atkins%20to%20SES%20Water/DLP%20input%20template%20for%20Demand%20Forecasts%20and%20Headroom_values%20only%20-%20_v2_040520221.xlsx?d=w02e8108ed9c642e3bbacd98ba0d7af46&csf=1&web=1&e=vbdDby

- The FTH (Full Target Headroom) profile shows a decline up to 2039/40 due to the declining impacts of Covid-19 on demand, and then an increase to 2079/80 predominantly due to uncertainty associated with the demand forecast. From 2079/80 to 2099/2100 it is assumed to remain constant in the absence of an updated baseline target headroom forecast.
- For the EDG (Environmental Destination and Growth) scenario, target headroom declines until 2039/40 due to the declining impacts of Covid-19 on demand, and then stays relatively constant overall as the uncertainty associated with the demand forecast is removed, although the climate change component increases gradually over time as uncertainty in the impacts of climate change on supply and demand are included in this forecast.
- For the EDGC (Environmental Destination, Growth, and Climate change) scenario, as with the other two scenarios, target headroom declines until 2039/40 due to the declining impacts of Covid-19 on demand. Following this there is a more gradual decline until 2079/80 because demand forecast uncertainty and impacts of climate change on supply and demand are excluded, but accuracy of supply and demand-side data components are included, which are forecast to decline over this timeframe within the WRMP19 forecast. As before, from 2079/80 to 2099/2100 the forecast is assumed to remain constant in the absence of an updated baseline target headroom forecast.

Following provision of the headroom profiles to WRSE for the draft WRMP24, it was noted that Covid-19 impacts were included in the 'climate change only' component forecasts (in addition to the non-climate change forecasts), resulting in potential double counting if these are added together. This was a relatively small component of target headroom (0.67 Ml/d versus total of 8-11 Ml/d depending on the planning scenario in 2025/26, with declining impacts up until 2040 and zero beyond this) and was corrected for the revised draft WRMP24 forecasts provided to WRSE for investment modelling.

Target headroom results for draft WRMP WRSE scenarios

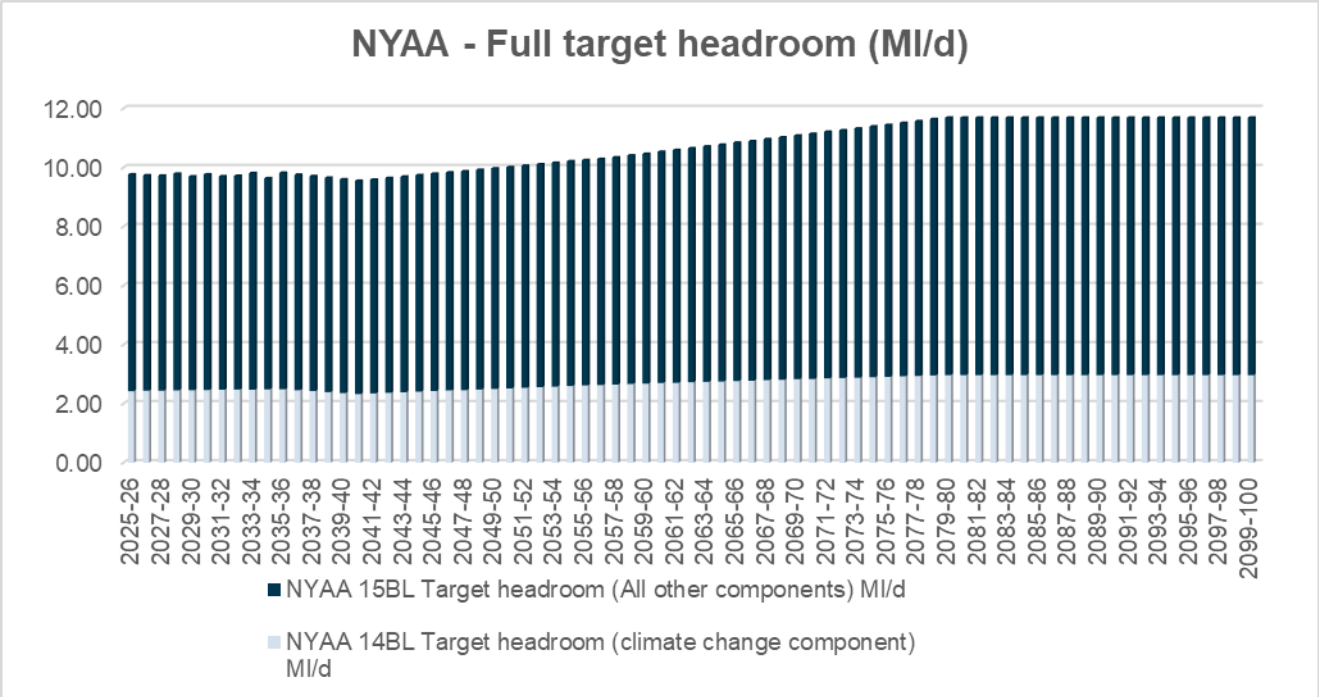


Figure 2-5 - Target headroom results for draft WRMP WRSE (NYAA FTH)

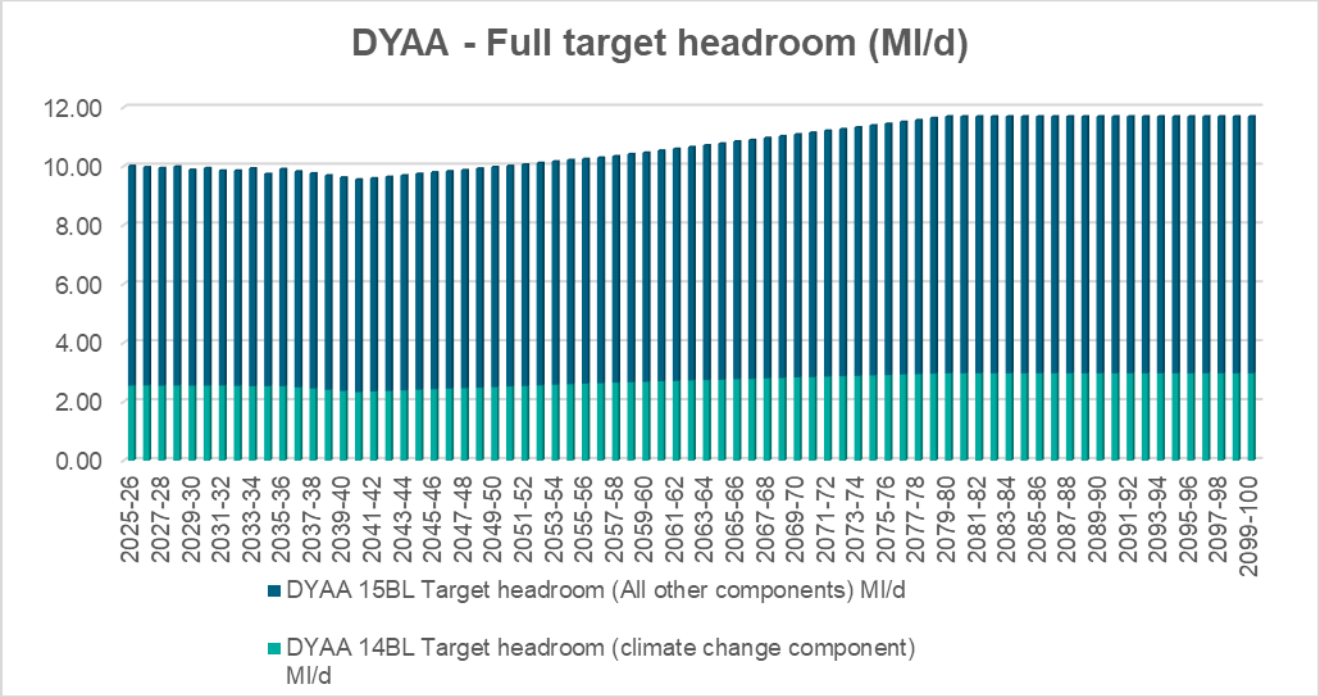


Figure 2-6 - Target headroom results for draft WRMP WRSE (DYAA FTH)

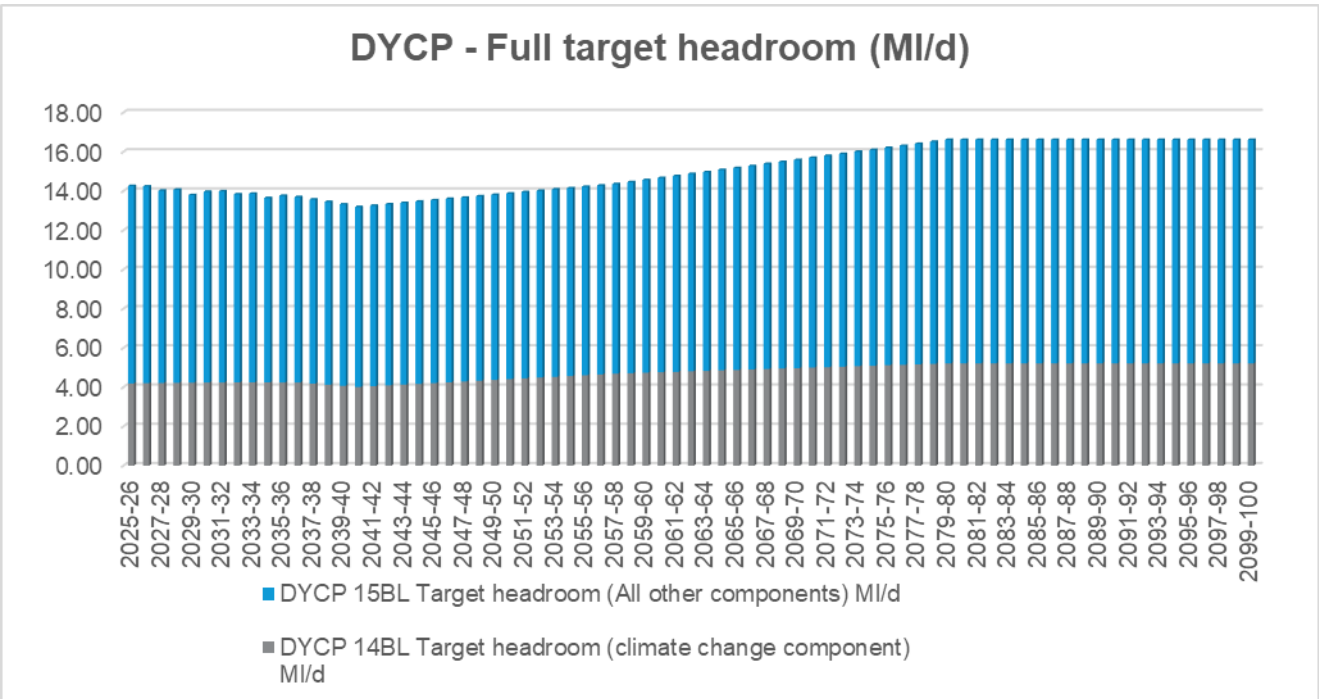


Figure 2-7 - Target headroom results for draft WRMP WRSE (DYCP FTH)

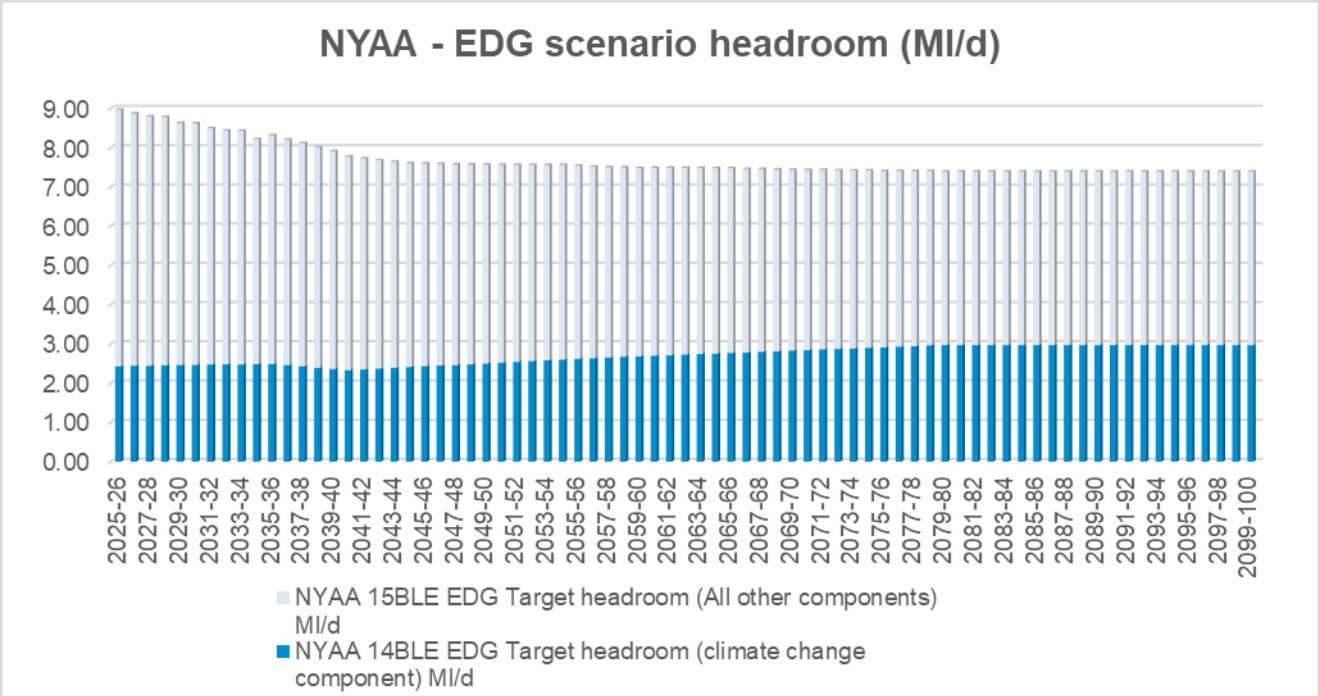


Figure 2-8 - Target headroom results for draft WRMP WRSE (NYAA EDG)

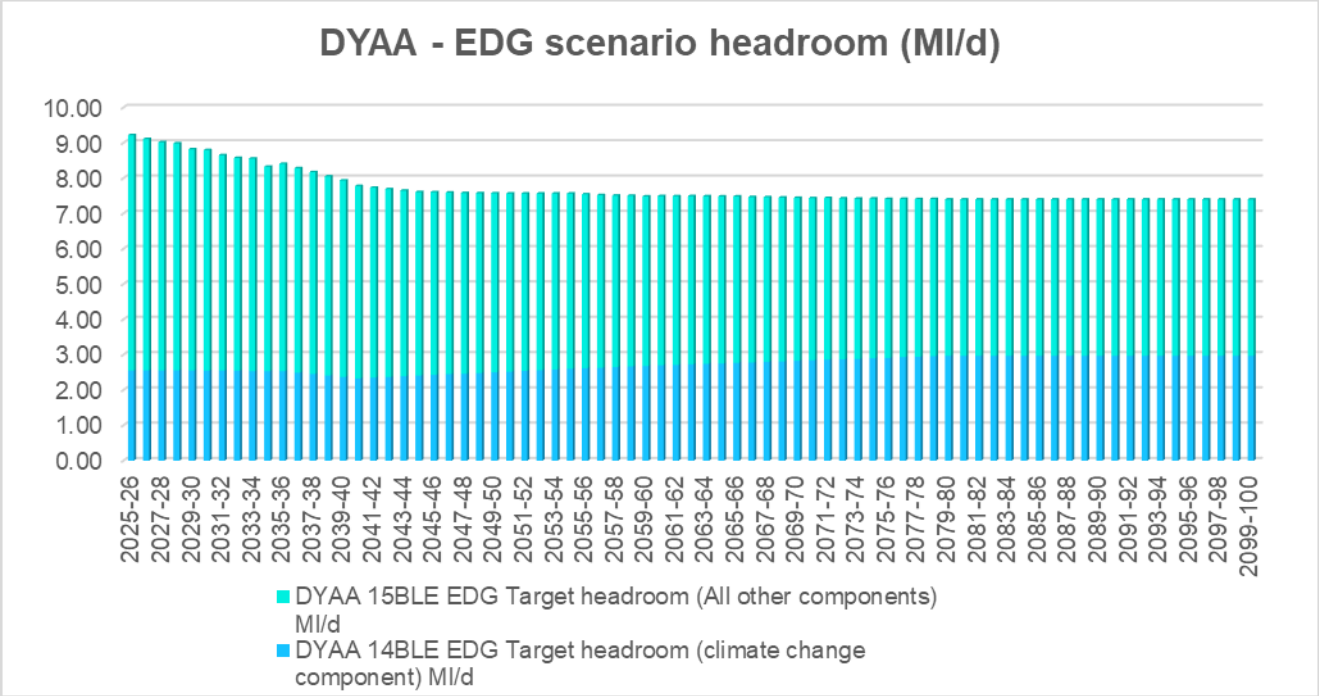


Figure 2-9 - Target headroom results for draft WRMP WRSE (NYAA EDG)

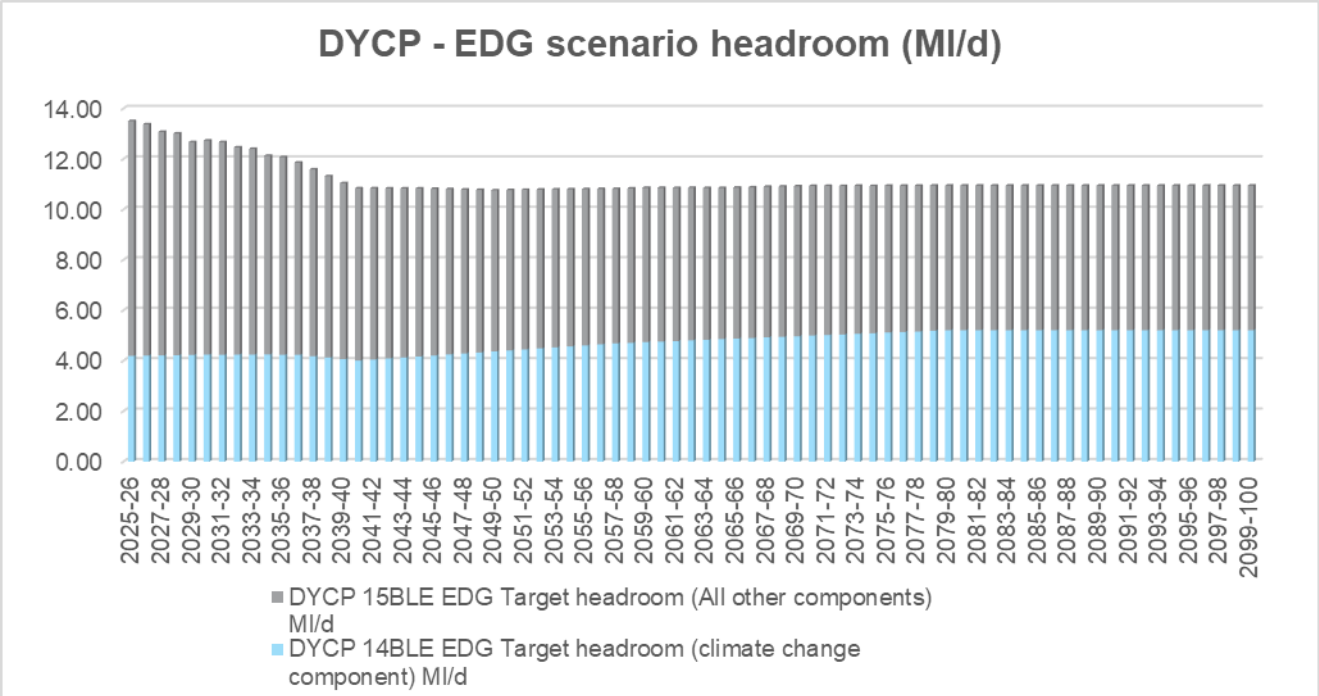


Figure 2-10 - Target headroom results for draft WRMP WRSE (DYCP EDG)

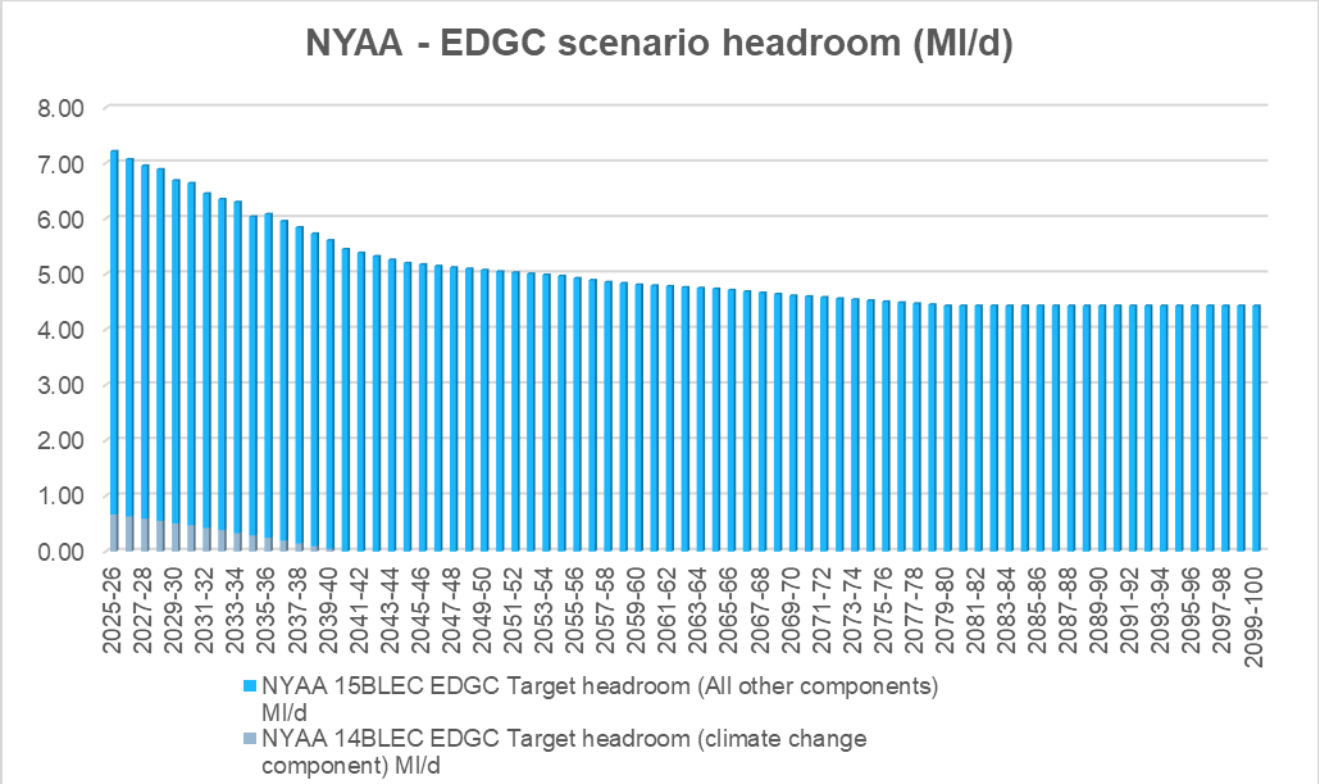


Figure 2-11 - Target headroom results for draft WRMP WRSE (NYAA EDGC)

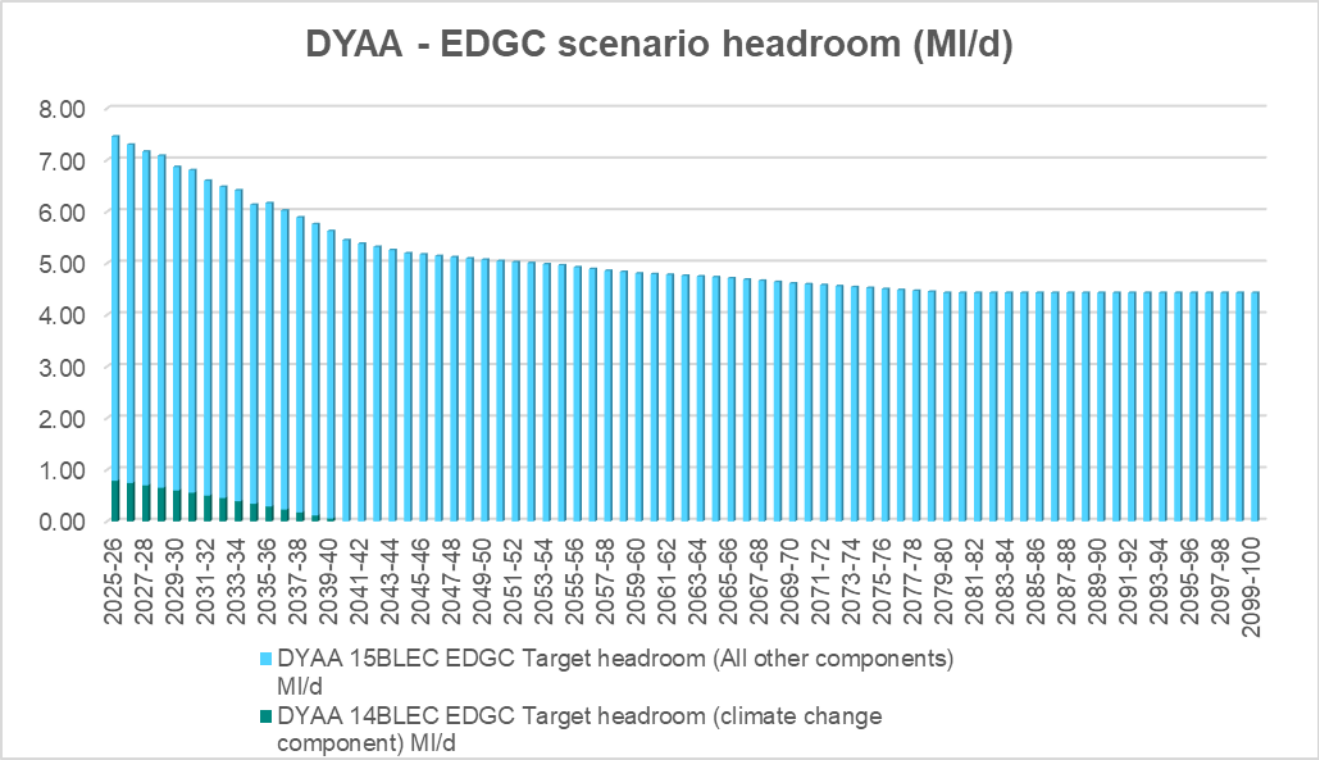


Figure 2-12 - Target headroom results for draft WRMP WRSE (DYAA EDGC)

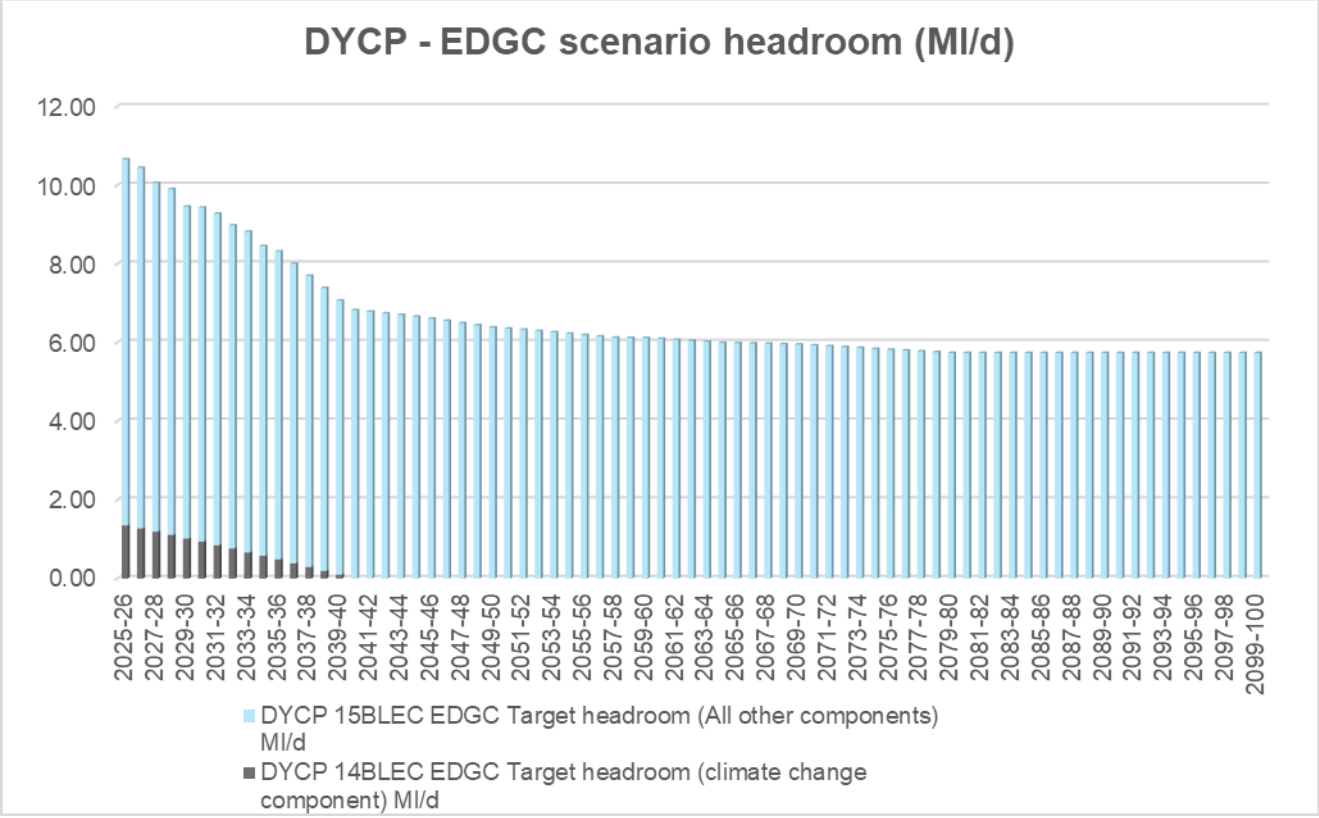


Figure 2 -13 - Target headroom results for draft WRMP WRSE (DYCP EDGC)

3. Recalculation of target headroom for revised draft WRMP24

3.1. Objectives of headroom update

The objective for updating the headroom assessment was to calculate target headroom value distributions, for each period in the planning horizon until 2100, and for each planning scenario, to cover the various uncertainties inherent within the future supply/demand balance. Headroom allowance values can then be determined from the distribution for each period at an appropriate level of risk. This analysis has been undertaken by updating SES Water's existing Monte Carlo simulation headroom model.

This modelling update:

- Assesses the risks and uncertainties which apply to the components of SES Water's supply/demand balance, through consideration of relevant information;
- Develops suitable probability distributions to represent each relevant uncertainty factor;
- Combines the individual probability distributions into a single distribution representing SES Water's headroom uncertainty for each year in the planning horizon; and
- Determines headroom allowance profiles, by selecting values from the combined headroom uncertainty distributions at appropriate levels of risk across the planning horizon.

3.2. Headroom assessment methodology

One of the suitable methods for calculating target headroom listed by the current WRPG[1] is: UKWIR, 2002. An Improved Methodology for Assessing Headroom'.

This methodology was the basis of SES Water's target headroom calculation for its recent WRMPs and is also the basis for the WRMP24 but it is combined with WRSE's adaptive planning approach. In the UKWIR (2002) approach, a probability distribution is assigned to each individual risk or uncertainty factor within the supply/demand balance, based on known data and other relevant information. These probability distributions are then combined using the statistical technique of Monte Carlo simulation, which iteratively takes random samples from each distribution and sums them according to specified rules. The summed result of each iteration then forms a point on the curve of the combined distribution; by sampling the distributions over a large number of iterations it is then possible to build up a probability distribution to represent the overall risk or uncertainty of all factors taken together.

The Monte Carlo simulation software @RISK was used for the analysis, which operates in conjunction with the Microsoft Excel spreadsheet package. Due to the random nature of the Monte Carlo simulation technique, it is not possible to guarantee that identical results will be generated each time the same simulation is run. However, by selecting a suitably large number of iterations for the simulation, to give an acceptable mean standard error for the simulation results, it is possible to obtain repeatable results to an acceptable level of accuracy. For WRMP19 and for this WRMP24 headroom assessment update, 10,000 iterations were used to obtain consistent results.

Since WRMP19 the headroom calculation has been undertaken on the basis of a single company-wide WRZ.

Two planning scenarios have been considered in the WRMP24 target headroom assessment update, as follows:

- Dry Year Annual Average demand paired with 1 in 500-year return period Minimum Resource Deployable Output (MDO). The calculation of MDO is described in Appendices A and B of the revised draft WRMP24.
- Dry Year Critical Period demand paired with 1 in 500-year return period Peak Deployable Output (PDO). The calculation of PDO is described in Appendices A and B of the revised draft WRMP24.

Key areas of future risk and uncertainty relevant to SES Water's future supply/demand balance were identified in the WRMP19 headroom calculation which included a review of relevant data, DO assessments, demand forecasts, water quality data and other relevant information. A brief note of the key assumptions and proposed probability distributions was then drawn up and agreed as the basis for the headroom analysis. The types of uncertainty, relating to both supply and demand factors, as specified in the UKWIR methodology are shown in Table 3-1. These uncertainties, along with the assumptions adopted for the headroom calculation, are discussed further in Section 4.

Table 3-1 - Headroom Uncertainty Factors

Factor	Name
S1	Vulnerable Surface water licences
S2	Vulnerable Groundwater licences
S3	Time Limited Licences
S4	Bulk Imports
S5	Gradual Pollution
S6	Accuracy of Supply-Side Data
S8	Impact of Climate Change on Deployable Output
S9	New Sources
D1	Accuracy of Sub-component Demand Data
D2	Demand Forecast Variation
D3	Impact of Climate Change on Demand
D4	Demand Management Measures

The @Risk methodology used in the WRMP19 headroom assessment has been adopted for the WRMP24 update, however the WRMP24 update uses revised input data (e.g. DO and demand), as discussed in Section 4. Furthermore, in the WRMP24 update SES Water has separated out target headroom forecasts for use in adaptive planning into the three profiles:

1. FTH including all uncertainties (including demand growth and climate change)
2. EDG branches which should exclude any environmental destination[6] and demand growth related components from headroom to avoid double counting for this in WRSE modelling
3. EDGC branches which should exclude any environmental destination[6] and growth and climate change related components from headroom to avoid double counting for this in WRSE modelling

In order to incorporate the adaptive planning profiles, three headroom models are required under each DYAA and DYCP scenario (i.e. a total of six models):

- For the full target headroom DYAA and DYCP models, with the exception of S9 and D4 (which are considered separately in the Final Plan Target Headroom and are considered as part of the WRSE adaptive planning process) all WRSE listed 'S' and 'D' components have been included.
- For the EDG target headroom DYAA and DYCP models, (population) growth related impacts on demand[7] have been removed to avoid double counting in WRSE modelling.
- For the EDGC target headroom DYAA and DYCP models, both (population) growth related impacts on demand and climate change impacts on supply and demand are removed to avoid double counting in WRSE modelling.

The headroom components included in each profile are outlined in Table 3-2 and the adaptive planning supply/demand profiling upon which they are based is illustrated schematically in Figure 3-1.

[6] Environmental Destination components are not relevant to the headroom calculation in this instance as S1, S2 and S3 are not used in the calculation. Environmental Destination uncertainty is dealt with through alternative adaptive planning pathways.
[7] Note there are no growth impacts on supply

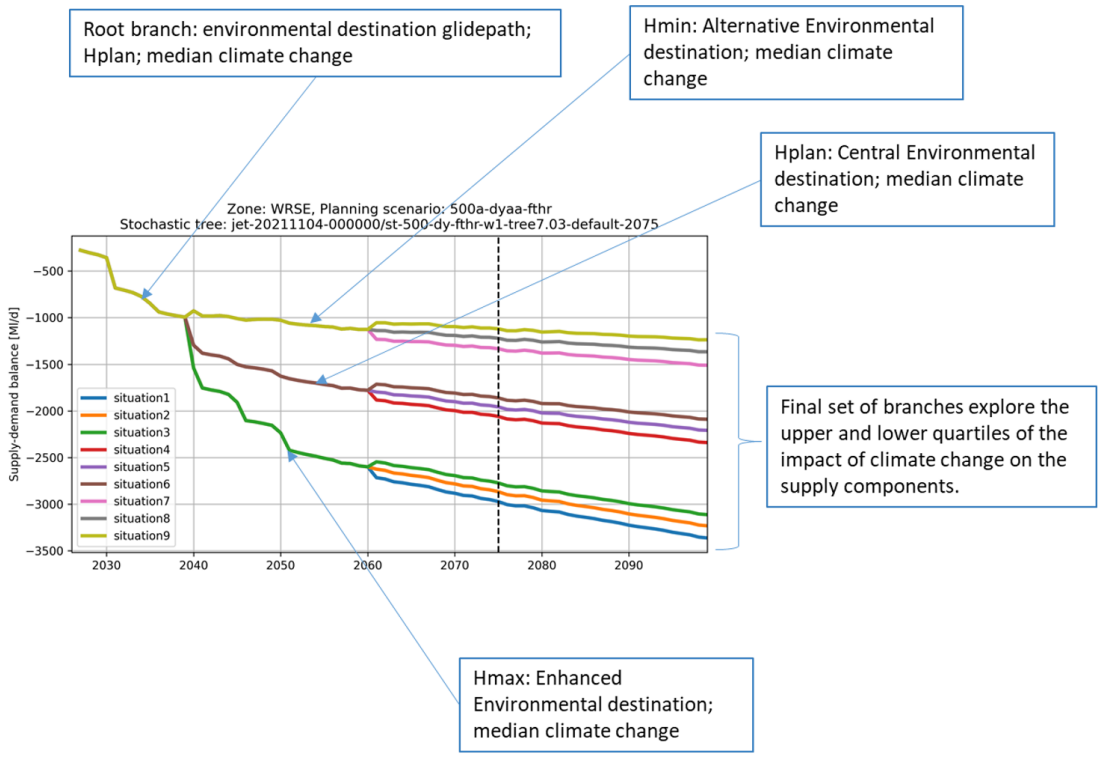


Figure 3-1 - WRSE illustration of supply-demand adaptive planning situation branches

Table 3-2 - Target headroom components included in adaptive planning profile

Component	FTH profile	EDG target headroom profile	EDGC target headroom profile	Comment regarding WRMP24
S1 – Vulnerable surface water licences	× *	×	×	N/A - not used by SES for WRMP24
S2 – Vulnerable groundwater licences	× *	×	×	N/A - not used by SES for WRMP24
S3 - Time limited licences	× *	×	×	N/A - not used by SES for WRMP24
S4 - Bulk imports	✓	✓	✓	N/A - not used by SES for WRMP24
S5 - Gradual pollution causing a reduction in abstraction	✓ **	✓ **	✓ **	Included in all forecasts
S6 - Accuracy of supply-side data	✓	✓	✓	Included in all forecasts
S8 - Uncertainty of impact of climate change on source yield	✓	✓	×	Included in full target headroom (climate change component) and EDG target headroom (climate change component) forecasts
S9 - Uncertain output from new resource developments	✓ ***	✓ ***	✓ ***	N/A - final plan only (addressed by WRSE adaptive plan)
D1 - Accuracy of subcomponent data	✓	✓	✓	Included in all forecasts
D2 - Demand forecast variation	✓	× ****	× ****	Included in full target headroom (all other components) only
D3 - Uncertainty of impact of climate change on demand	✓	✓	×	Included in full target headroom (CC component) and EDG Target headroom (climate change component) forecasts
D4 – Uncertain outcome from demand management measure	✓ ***	✓ ***	✓ ***	N/A - final plan only (addressed by WRSE adaptive plan)

** Originally included in the UKWIR 2002 methodology but WRPG prevents its inclusion in target headroom as uncertainty around these components is now explicitly listed elsewhere within a water company's adaptive planning supply forecast*

*** This should be included but only if the deployable output of sources hasn't already been written down in the future due to deteriorating raw water trends*

**** This should be based on the schemes selected in the cost-efficient plan*

***** D2 – only include non-growth related components for the headroom forecast*

4. Headroom assumptions

4.1. Headroom assumptions

The assumptions used to inform this headroom analysis along with assumptions made for the headroom analysis are summarised in Table 4-1 and are discussed further in the following sections.

The 1 in 500-year DO values were used (for both DYAA-MDO and DYCP-PDO scenarios) for assessment of the supply side components of target headroom. Individual source DOs (required for S5 and S6 components) were scaled proportionally to the total company DO (required for S8) to ensure DO values were consistent throughout the headroom model[8]. Therefore the tables detailing uncertainty probability distributions in the following sections pertain to the scaled DOs.

[8] Note that total company MDO and PDO are not just the sum of the individual source DOs. PyWR modelling of the conjunctive system demonstrated lower total MDO and PDO suggesting that infrastructure constraints within the supply network (e.g. pipe capacity, network pressures etc) limit the ability to deploy the total sum of source DOs.

Table 4-1 - Summary of assumptions informing the headroom analysis

Component	Assumptions
S1 – Vulnerable surface water licences	Excluded from analysis - current WRPG precludes this component from the headroom calculation.
S2 – Vulnerable groundwater licences	Excluded from analysis - current WRPG precludes this component from the headroom calculation.
S3 - Time limited licences	WRPG precludes this from the headroom analysis.
S4 - Bulk imports	No bulk imports therefore not included in the analysis.
S5 - Gradual pollution causing a reduction in abstraction	Unconfined Chalk - Triangular distribution with a maximum of 3% probability of zonal loss of DO per AMP period, best estimate of 2% and minimum of 0%. Greensand – Triangular distribution with a maximum loss of 5% of the aquifer group DO per AMP period, minimum loss of 0% and best estimate of 3% ADO per AMP period. Surface water – 2.5% zonal loss of DO as maximum per AMP, best estimate is 1.5% of zonal DO and minimum of 0%. Confined Chalk – Triangular distribution with a maximum of 1% probability of zonal loss of DO per AMP period, best estimate of 0.5% and minimum of 0%.
S6 - Accuracy of supply-side data	**S6/1 - Uncertainty for yields constrained by pump capacity** Not included **S6/2 - Meter uncertainty for licence critical sources** 95% probability that the reading is within ± 5 **S6/3 - Uncertainty for aquifer constrained groundwater sources** 95% probability that the reading is within ± 5 **S6/4 - Uncertainty for climate and catchment characteristics affecting surface waters** 95% probability that the reading is within ± 10
S8 - Uncertainty of impact of climate change on source yield	Triangular distribution with upper and lower bounds of the impact of climate on supply, and the best estimate is the difference between the two
S9 - Uncertain output from new resource developments	Total combined volumetric uncertainty of options as defined in the investment model which provides each feasible option with a ± uncertainty range is used to define the bounds of the triangular distribution. These are only included after WRSE investment modelling for any identified options.
D1 - Accuracy of subcomponent data	95% probability that the reading is within ± 3%
D2 - Demand forecast variation	Forecast demand scenario starting with zero variation in first year, leading linearly to ±10% in 2100. Triangular distribution using the central demand forecast, lower demand forecast and higher demand forecast to determine the min, most likely and max uncertainty range
D3 - Uncertainty of impact of climate change on demand	Triangular distribution using the 50th percentile climate change scenario (most likely), 10th percentile climate change scenario (low climate change) and the 90th percentile climate change projections (high climate change) to determine the min, most likely and max uncertainty range.
D4 – Uncertain outcome from demand management measure	As in S9.

4.1.1. S1 Vulnerable Surface water licences

This component relates to the uncertainty associated with concerns over the sustainability of surface water abstractions at the licensed rate(s) and the likelihood that the licence will be revoked, reduced or otherwise modified. However, the current WRPG states that water companies should not include any target headroom allowance for uncertainty related to sustainability changes to permanent licences, as the Environment Agency will work with them to ensure that these do not impact your security of supply. Therefore risk/uncertainty allowance for this factor was excluded from this target headroom assessment.

4.1.2. S2 Vulnerable Groundwater licences

This component relates to the uncertainty associated with concerns over the sustainability of groundwater abstractions at the licensed rate(s) and the likelihood that the licence will be revoked, reduced or otherwise modified. However, the current WRPG states that water companies should not include any target headroom allowance for uncertainty related to sustainability changes to permanent licences, as the Environment Agency will work with them to ensure that these do not impact the security of supply. Therefore risk/uncertainty allowance for this factor was excluded from this target headroom assessment.

4.1.3. S3 Time Limited Licences

The current WRPG states that no allowance for uncertainty relating to the non-renewal of time limited licences should be included in the target headroom calculation. This factor was therefore excluded from the headroom analysis.

4.1.4. S4 Bulk imports

SES Water only has one bulk import agreement which is with Thames Water Utilities (TWU) for up to 13.6 Ml/d from Merton Pumping Station. However, as TWU cannot guarantee this during a drought period it is not included in SES Water's baseline supply assessment nor is it included in the headroom calculation.

4.1.5. S5 Gradual pollution

This category of the assessment considers the vulnerability of sources to gradual pollution. Some of the factors considered were whether the aquifer is confined or unconfined, as unconfined aquifers are more vulnerable to pollution, whether there are any sources of either point or diffuse pollution near the abstraction sites and the treatment capability for these potential sources of pollution, whether there has been historical loss of DO due to a pollution/contamination event at the sites, and whether there are observed water quality trends. Three areas were identified as risk of gradual pollution:

- The sources in the unconfined chalk are at risk from cryptosporidium and nitrate pollution. Although there is some treatment in place to remove pollutants, there is a suspicion that the water quality is likely to deteriorate further in the near future. To represent this uncertainty, a triangular distribution has been used with a maximum of 3% probability of zonal loss of DO per AMP period, best estimate of 2% and minimum of 0%.
- Lower Greensand sources are vulnerable to pollution from local landfill sites and have a history of contamination. In order to represent uncertainty associate with these sources, a triangular distribution has been used with a maximum loss of 5% of the aquifer group DO per AMP period, minimum loss of 0% and best estimate of 3% per AMP period.
- There is concern that the water quality in Bough Beech Reservoir is likely to deteriorate as a result of increased use of pesticides, and potential cryptosporidium contamination. Although treatment is in place to deal with this, effective pesticide treatment has a number of dependencies and therefore some risk still remains. This is represented by a triangular distribution assuming a maximum zonal loss of 2.5% per AMP, a best estimate of 1.5% loss of zonal DO and a minimum loss of 0%.
- The confined chalk is considered to be at a low risk of contamination therefore a triangular distribution with a maximum loss of 1% of the aquifer group DO per AMP period, minimum loss of 0% and best estimate of 0.5% per AMP period, has been used to represent the uncertainty.

The uncertainties used for this category are summarised in Table 4-2 below.

Table 4-2 - S5 headroom uncertainty probability distribution summary data

	Uncertainty range (MDO)			Uncertainty range (PDO)		
	Maximum (Ml/d)	Best (Ml/d)	Minimum (Ml/d)	Maximum (Ml/d)	Best (Ml/d)	Minimum (Ml/d)
Unconfined Chalk	3.76	2.51	0.00	4.08	2.72	0.00
Lower Greensand sources	1.68	1.01	0.00	1.32	0.79	0.00
Bough Beech	0.41	0.25	0.00	0.41	0.24	0.00
Confined Chalk	0.08	0.04	0.00	0.10	0.05	0.00

4.1.6. S6 Accuracy of supply side data

S6/1: Uncertainty for yields constrained by pump capacity

SES Water groundwater DO assessments use actual pumping rates rather than nominal pumping capacities; hence this component does not apply.

S6/2 Meter uncertainty for licence critical sources

It is assumed that all sources are subject to meter uncertainty. A ± 5% uncertainty allowance has therefore been included in this analysis with a 95% probability that the value is within this range. A normal probability distribution has been adopted to represent the range of uncertainty, around a mean of 0 Ml/d as shown in Table 4-3.

S6/3 Uncertainty for aquifer constrained groundwater sources

A ± 5% uncertainty allowance has been included in this analysis with a 95% probability that the value is within this range. A normal probability distribution has been adopted to represent the range of uncertainty, around a mean of 0 Ml/d as shown in Table 4-3.

S6/4Uncertainty for climate and catchment characteristics affecting surface waters

Uncertainty around the accuracy of river flow measurements associated with Bough Beech has been included in this assessment. The UKWIR, 2002 guidance[9] suggests that an accuracy of ± 10% should be assumed for catchments/sources with long records and/or where the catchments are large. A ± 10% uncertainty allowance has therefore been chosen for Bough Beech, with a 95% probability that the value is within this range. A normal probability distribution has been adopted to represent the range of uncertainty, around a mean of 0 Ml/d. This is shown in Table 4-3.

[9] UKWIR, 2002. An Improved Methodology for Assessing Headroom

Table 4-3 - S6 headroom uncertainty probability distribution summary data

	Uncertainty Range (MDO)					Uncertainty Range (PDO)				
Source Name	MDO (Ml/d)	Proportionally reduced MDO (Ml/d)	Min (Ml/d)	Max (Ml/d)	STDEV (Ml/d)	PDO (Ml/d)	Proportionally reduced PDO (Ml/d)	Min (Ml/d)	Max (Ml/d)	STDEV (Ml/d)
Cheam	8.18	7.51	-0.38	0.38	0.19	10.42	7.31	-0.37	0.37	0.19
Cheam Park	1.04	0.96	-0.05	0.05	0.02	1.14	0.80	-0.04	0.04	0.02
Nonsuch Park	5.00	4.59	-0.23	0.23	0.12	12.00	8.42	-0.42	0.42	0.21
Sutton	8.35	7.67	-0.38	0.38	0.20	11.90	8.35	-0.42	0.42	0.21
Sutton Ct Rd	0.63	0.58	-0.03	0.03	0.01	1.13	0.79	-0.04	0.04	0.02
Hackbridge & Goatbridge	8.57	7.87	-0.39	0.39	0.20	13.87	9.73	-0.49	0.49	0.25
Oaks	3.50	3.21	-0.16	0.16	0.08	7.40	5.19	-0.26	0.26	0.13
Holly Lane	5.74	5.27	-0.26	0.26	0.13	6.50	4.56	-0.23	0.23	0.12
Woodmansterne	13.59	12.48	-0.62	0.62	0.32	14.51	10.18	-0.51	0.51	0.26
Smitham	5.68	5.22	-0.26	0.26	0.13	5.68	3.98	-0.20	0.20	0.10
Kenley	17.74	16.29	-0.81	0.81	0.42	22.08	15.49	-0.77	0.77	0.40
Purley	5.05	4.64	-0.23	0.23	0.12	19.20	13.47	-0.67	0.67	0.34
Outwood Lane	3.02	2.77	-0.14	0.14	0.07	3.02	2.12	-0.11	0.11	0.05
Elmer & Young St	14.25	13.09	-0.65	0.65	0.33	17.05	11.96	-0.60	0.60	0.31
Leatherhead	27.92	25.64	-1.28	1.28	0.65	40.91	28.70	-1.43	1.43	0.73
Dorking	11.82	10.85	-0.54	0.54	0.28	11.82	8.29	-0.41	0.41	0.21
Clifton's Lane	0.88	0.81	-0.04	0.04	0.02	1.12	0.79	-0.04	0.04	0.02
Warwick Wold	3.22	2.96	-0.15	0.15	0.08	3.22	2.26	-0.11	0.11	0.06
Brewer Street	2.41	2.21	-0.11	0.11	0.06	2.42	1.70	-0.08	0.08	0.04
Bletchingley	2.02	1.86	-0.09	0.09	0.05	2.02	1.42	-0.07	0.07	0.04
North Park	3.50	3.21	-0.16	0.16	0.08	3.50	2.46	-0.12	0.12	0.06
Godstone	2.48	2.28	-0.11	0.11	0.06	2.48	1.74	-0.09	0.09	0.04
Flower Lane A&B	2.00	1.84	-0.09	0.09	0.05	2.37	1.66	-0.08	0.08	0.04
Flower Lane C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Green	2.18	2.00	-0.10	0.10	0.05	2.18	1.53	-0.08	0.08	0.04
Westwood	2.59	2.38	-0.12	0.12	0.06	3.08	2.16	-0.11	0.11	0.06
Bough Beech	18.00	16.53	-1.65	1.65	0.41	23.20	16.27	-1.63	1.63	0.41
Springclose Lane	2.00	1.84	n/a yield constrained by pump capacity			2.00	1.40	n/a yield constrained by pump capacity		
Langley Park	1.90	1.74				1.90	1.33			
Woodcote	3.50	3.21				4.60	3.23			
Chipstead	1.00	0.92				1.64	1.15			
Fetcham Springs	8.33	7.65				10.83	7.60			
Buckland	1.40	1.29				1.40	0.98			
Water Lane	2.00	1.84				2.00	1.40			

4.1.7. S8 Impact of Climate Change on Deployable Output

The minimum, mean and maximum climate change impacts on DO for the 2080s were calculated from PyWR modelling[10]. These values were then used in this assessment to determine the uncertainties using a triangular

[10] PyWR, SES Supply Forecast, 2020

distribution to represent the potential variation from the most likely impacts if either the low or high impacts were to apply. The parameters of each triangular distribution were therefore calculated as follows:

Minimum = Low – most likely in Ml/d (a negative value)

Most Likely = 0 (i.e. zero uncertainty)

Maximum = High – most likely forecast in Ml/d (a positive value)

The minimum and maximum values are shown in Table 4-4; however the most likely is not shown as it is zero for both scenarios across all the years.

S8 was not included for the EDGC adaptive planning profile.

Table 4-4 - S8 headroom uncertainty probability distribution summary data

	Uncertainty range DYAA (Ml/d)		Uncertainty range DYCP (Ml/d)	
AMP	Min	Max	Min	Max
2024/25	-2.35	4.99	-2.68	4.67
2029/30	-2.69	5.71	-3.06	5.34
2034/35	-3.02	6.42	-3.45	6.01
2039/40	-3.36	7.13	-3.83	6.68
2044/45	-3.69	7.84	-4.21	7.35
2049/50	-4.03	8.56	-4.59	8.01
2054/55	-4.36	9.27	-4.98	8.68
2059/60	-4.70	9.98	-5.36	9.35
2064/65	-5.03	10.70	-5.74	10.02
2069/70	-5.37	11.41	-6.13	10.69
2074/75	-5.71	12.12	-6.51	11.35
2079/80	-6.04	12.84	-6.89	12.02
2084/85	-6.38	13.55	-7.27	12.69
2089/90	-6.71	14.26	-7.66	13.36
2094/95	-7.05	14.98	-8.04	14.02
2099/100	-7.32	15.55	-8.35	14.56

4.1.8. S9 New Sources

This has not been included at this stage. Uncertainty around new supply options is considered outside the target headroom calculation by the WRSE adaptive planning process.

4.1.9. D1 Accuracy of sub-component demand data

D1 is based upon the uncertainty in the accuracy of the Distribution Input (DI) meters. DI comprises a number of components as outlined in Table 4-5.

In the WRMP24 update, the uncertainty in the accuracy of the DI has been applied differently for the three adaptive planning profiles. To avoid double counting of growth-related uncertainty (which are instead included in the adaptive planning branches), the demand estimates removed growth related components for the EDG and EDGC profiles (see Table 4-5).

Table 4-5 - Distribution input components

Component of DI	Growth component
Measured Non Household - Consumption	×
Unmeasured Non Household - Consumption	×
Measured Household - Consumption	✓
Unmeasured Household - Consumption	✓
Water Taken Unbilled	×
Distribution System Operational Use	×
Measured Non Household - USPL	×
Unmeasured Non Household - USPL	×
Measured Household - USPL	×
Unmeasured Household - USPL	×
Void Properties - USPL	×
Distribution Losses	×

An allowance of ± 3% has been included to represent the uncertainty in the accuracy of distribution input (DI) meters, with a 95% probability that the value is within this range[11]. A normal probability distribution has been adopted to represent the range of uncertainty, around a mean of 0 Ml/d as shown in Table 4-6 (FTH profile) and Table 4-7 (EDG and EDGC profile). It should be noted that these meters are typically located at the point of distribution and are not the same as those used to measure abstraction, so this avoids double-counting with factor S6/2 (see Section 4.1.6).

The difference between DI for DYAA and DYCP is due to variance in measured and unmeasured household consumption (growth related components) therefore the average demand for the non-growth related components (shown in Table 4-7) is equal for both DYAA and DYCP.

[11] Note that the 95% probability that the reading is within ± 3% was calculated using the lower demand forecast variation rather than the central demand forecast variation in error. As the difference between using the lower and central estimates is a maximum of 0.73 Ml/d in 2100 (7.27-6.54 = 0.73 Ml/d) (DYCP FTH profile), this has been deemed to have a minor impact and has not been corrected in this version. However, it is recommended this is adjusted for the next target headroom update .

Table 4-6 - D1 headroom uncertainty probability distribution summary data (FTH profile)

AMP	Uncertainty range DYAA (Ml/d)				Uncertainty range DYCP (Ml/d)			
	Average demand	Min	Max	STDEV	Average demand	Min	Max	STDEV
2024/25	161.65	4.83	-4.83	2.46	203.46	6.08	-6.08	3.10
2029/30	161.76	4.80	-4.80	2.45	205.25	6.09	-6.09	3.11
2034/35	164.43	4.85	-4.85	2.47	209.92	6.19	-6.19	3.16
2039/40	167.66	4.91	-4.91	2.51	215.14	6.31	-6.31	3.22
2044/45	170.45	4.96	-4.96	2.53	219.99	6.41	-6.41	3.27
2049/50	173.56	5.02	-5.02	2.56	225.32	6.52	-6.52	3.32
2054/55	174.75	5.02	-5.02	2.56	227.77	6.54	-6.54	3.34
2059/60	175.44	5.01	-5.01	2.55	229.54	6.55	-6.55	3.34
2064/65	176.00	4.99	-4.99	2.55	231.11	6.55	-6.55	3.34
2069/70	176.62	4.97	-4.97	2.54	232.69	6.55	-6.55	3.34
2074/75	176.83	4.94	-4.94	2.52	233.85	6.54	-6.54	3.34
2079/80	177.39	4.93	-4.93	2.51	235.40	6.54	-6.54	3.34
2084/85	178.23	4.92	-4.92	2.51	237.29	6.54	-6.54	3.34
2089/90	178.94	4.90	-4.90	2.50	239.05	6.55	-6.55	3.34
2094/95	179.55	4.88	-4.88	2.49	240.69	6.54	-6.54	3.34
2099/100	180.13	4.86	-4.86	2.48	242.26	6.54	-6.54	3.34

Table 4-7 - D1 headroom uncertainty probability distribution summary data (EDG and EDGC profiles)

AMP	Average demand (excluding growth related components) (Ml/d)	Min (Ml/d)	Max (Ml/d)	STDEV (Ml/d)
2024/25	50.37	1.51	-1.51	0.77
2029/30	48.21	1.43	-1.43	0.73
2034/35	47.86	1.41	-1.41	0.72
2039/40	48.17	1.41	-1.41	0.72
2044/45	47.95	1.40	-1.40	0.71
2049/50	47.76	1.38	-1.38	0.70
2054/55	48.07	1.38	-1.38	0.70
2059/60	48.29	1.38	-1.38	0.70
2064/65	48.55	1.38	-1.38	0.70
2069/70	48.98	1.38	-1.38	0.70
2074/75	49.01	1.37	-1.37	0.70
2079/80	49.33	1.37	-1.37	0.70
2084/85	49.78	1.37	-1.37	0.70
2089/90	50.09	1.37	-1.37	0.70
2094/95	50.33	1.37	-1.37	0.70
2099/100	50.64	1.37	-1.37	0.70

4.1.10. D2 Demand forecast variation

A triangular distribution has been used to express the probability distribution, starting with zero forecast variation in 2021/22 and leading linearly to an assumed error of ±10% at the end of the planning period. The Min and Max values are shown in Table 4-8 (FTH profile) and Table 4-9 (EDG and EDGC profile); however the most likely is not shown as it is zero for both scenarios across all the years.

Table 4-8 - D2 headroom uncertainty probability distribution summary data (FTH)

AMP	Uncertainty range DYAA (Ml/d)			Uncertainty range DYCP (Ml/d)		
	Average demand	Min	Max	Average demand	Min	Max
2024/25	161.65	-0.62	0.62	203.46	-0.78	0.78
2029/30	161.76	-1.66	1.66	205.25	-2.11	2.11
2034/35	164.43	-2.74	2.74	209.92	-3.50	3.50
2039/40	167.66	-3.87	3.87	215.14	-4.96	4.96
2044/45	170.45	-5.03	5.03	219.99	-6.49	6.49
2049/50	173.56	-6.23	6.23	225.32	-8.09	8.09
2054/55	174.75	-7.39	7.39	227.77	-9.64	9.64
2059/60	175.44	-8.55	8.55	229.54	-11.18	11.18
2064/65	176.00	-9.70	9.70	231.11	-12.74	12.74
2069/70	176.62	-10.87	10.87	232.69	-14.32	14.32
2074/75	176.83	-12.02	12.02	233.85	-15.89	15.89
2079/80	177.39	-13.19	13.19	235.40	-17.50	17.50
2084/85	178.23	-14.40	14.40	237.29	-19.17	19.17
2089/90	178.94	-15.60	15.60	239.05	-20.84	20.84
2094/95	179.55	-16.80	16.80	240.69	-22.53	22.53
2099/100	180.13	-18.01	18.01	242.26	-24.23	24.23

Table 4-9 - D2 headroom uncertainty probability distribution summary data (EDG and EDGC)

AMP	Average demand (excluding growth related components) (Ml/d)	Min (Ml/d)	Max (Ml/d)
2024/25	50.37	-0.19	0.19
2029/30	48.21	-0.49	0.49
2034/35	47.86	-0.80	0.80
2039/40	48.17	-1.11	1.11
2044/45	47.95	-1.41	1.41
2049/50	47.76	-1.71	1.71
2054/55	48.07	-2.03	2.03
2059/60	48.29	-2.35	2.35
2064/65	48.55	-2.68	2.68
2069/70	48.98	-3.01	3.01
2074/75	49.01	-3.33	3.33
2079/80	49.33	-3.67	3.67
2084/85	49.78	-4.02	4.02
2089/90	50.09	-4.37	4.37
2094/95	50.33	-4.71	4.71
2099/100	50.64	-5.06	5.06

4.1.11. D3 Impact of climate change on demand

In order to incorporate the demand forecast scenarios into factor D3 of the headroom allowance, a triangular distribution has been adopted to represent the potential variation from the 'most likely' climate change demand forecast (50th percentile scenario) if either the 'No Climate Change' or 'High Climate Change' scenario (90th percentile) were to apply. This is illustrated schematically in Figure 4-1.

The parameters of each triangular distribution were therefore calculated as follows:

Minimum = No Climate Change – Most Likely forecast in Ml/d (a negative value)

Most Likely = 0 (i.e. zero uncertainty)

Maximum = High – Most Likely forecast in Ml/d (a positive value)

The triangular distributions for both scenarios considered in this analysis across the planning horizon to 2099/100 are shown in Table 4-10. The most likely values are not shown as they are zero for both scenarios across all the years.

D3 was not included for the EDGC adaptive planning profile.

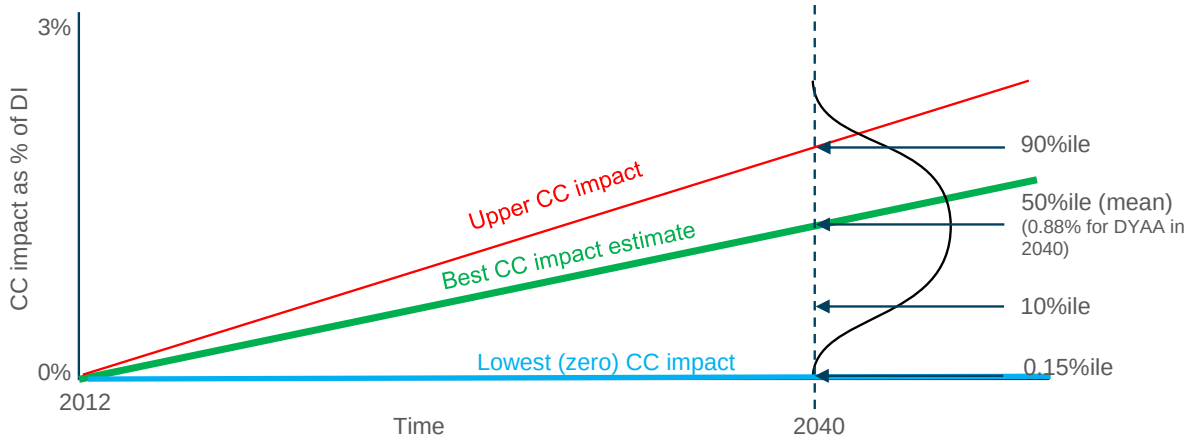


Figure 4-1 – Climate change impact schematic

Table 4-10 - D3 headroom uncertainty probability distribution summary data

AMP	Uncertainty range DYAA (Ml/d)		Uncertainty range DYCP (Ml/d)	
	Min	Max	Min	Max
2024/25	-0.21	0.21	-0.27	0.27
2029/30	-0.29	0.29	-0.38	0.38
2034/35	-0.37	0.37	-0.48	0.48
2039/40	-0.45	0.45	-0.58	0.58
2044/45	-0.53	0.53	-0.69	0.69
2049/50	-0.61	0.61	-0.79	0.79
2054/55	-0.69	0.69	-0.90	0.90
2059/60	-0.77	0.77	-1.00	1.00
2064/65	-0.85	0.85	-1.11	1.11
2069/70	-0.93	0.93	-1.21	1.21
2074/75	-1.01	1.01	-1.31	1.31
2079/80	-1.09	1.09	-1.42	1.42
2084/85	-1.17	1.17	-1.52	1.52
2089/90	-1.25	1.25	-1.63	1.63
2094/95	-1.33	1.33	-1.73	1.73
2099/100	-1.41	1.41	-1.84	1.84

4.1.12. D4 Demand Management Measures

This has not been included at this stage. Uncertainty around new demand management options is considered outside the target headroom calculation by the WRSE adaptive planning process.

4.2. Relationship between headroom components

Interdependencies between uncertainty factors have been incorporated within the Monte Carlo analysis. Interdependency is where the sampled value of one probability distribution is not completely independent of the value of another, i.e. there is some relationship between the two variables. The only interdependency identified in this assessment is between the impact of climate change on deployable output and on demand, i.e. the greater the increase in demand due to climate change, the greater the reduction in deployable output (both of which impacts have a positive effect on the calculated headroom allowance). This has been modelled by setting a positive correlation between the probability distribution functions for factor S8 and factor D3 respectively, in each year across the planning horizon.

4.3. Summary of key changes from WRMP19

The WRMP19 target headroom assessment used DO values for both the 1:200 year event and the worst drought on historic record (WDHR). In this update for WRMP24, 1:500 year DO values were used as required in the current WRPG[1]. As outlined in Section 4.1, individual source DOs were scaled proportionally to the total company 1:500 year DO as assessed in the 2020 PyWR supply forecast.

The 2020 PyWR supply forecast was also used to determine the climate change impacts for the S8 component. The forecast outlined upper, central and lower climate change impacts up to 2070. These were linearly interpolated from zero in 1990 (the end of the UKCP18[12] 1961-90 baseline) and extrapolated to 2099/2100 for the headroom assessment.

[12] UK Climate Projections 2018

Values for demand components were also updated using the SES Water Household Consumption Forecast (HHCF) model (v4.19.2). This model provided DI values for D1 and D2. D3 climate change demand impact uncertainty was also determined using outputs from the HHCF model, these were linearly interpolated from 2012 to 2040 and then extrapolated to 2099/2100 for the headroom assessment.

Following calculation of target headroom, it was established that a small error had been introduced into the calculation. In extracting the values from the demand forecast model for the DI value used in the head room calculation, the 'volume of consumption due to climate change' had been added as an additional component to the other genuine components that make up DI. However, this is actually double counting as the climate change uplift has already been applied to those components and that 'volume of consumption due to climate change' is not an additional element, it is the volume of the calculated consumption that can be attributed to climate change.

This has been corrected in demand forecast HHCF model versions 4.20.2 and 4.20.3 but not in time for use in the target headroom model update. Depending on which metering penetration (and DYCP climate change correction) model is selected, this leads to a DI being too high by c. 0.4 Ml/d (2024/25) to 3.7 Ml/d (2099/00) under DYAA and c. 0.6 Ml/d (2024/25) to 13.5 Ml/d (2099/00) under DYCP. Given that the target headroom calculation applies relatively small uncertainty percentages to the DI values, this error is expected to result in very small, insignificant differences, particularly early in the planning horizon. However, this error should be corrected in any future target headroom iterations.

5. Results

5.1. @Risk outputs

The results of the assessment for the 1:500 year event at 2099/2100 are summarised in Table 4-1 below (the full results from the @RISK spreadsheet are contained in Appendix A).

Table 5-1 - Target headroom (Ml/d) at 2099/2100 – 1:500 year event

Scenario	Adaptive planning profile	Probability (%)								
		55	60	65	70	75	80	85*	90	95**
DYAA (Ml/d)	FTH	7.19	8.37	9.65	10.96	12.49	14.01	15.81	18.07	21.49
	EDG	6.45	7.19	7.97	8.80	9.75	10.76	11.99	13.50	15.57
	EDGC	3.58	3.94	4.28	4.65	5.02	5.50	5.98	6.62	7.50
DYCP (Ml/d)	FTH	6.78	8.23	9.80	11.60	13.39	15.34	17.66	20.50	24.68
	EDG	5.79	6.53	7.38	8.25	9.12	10.17	11.32	12.72	14.57
	EDGC	3.57	3.90	4.28	4.63	5.03	5.50	6.04	6.72	7.59

* Risk Percentile to be used at the end of the forecast
** Risk Percentile to be used at the start of the planning period

The risk glidepath was adopted from WRMP19 with the level of acceptable risk was determined to be 95% in the beginning of the planning period, falling to 85% at the end of the planning period. Based upon WRMP19, a 95% risk level has been applied to 2020-2045, the uncertainty values are then interpolated to the 90% risk level at 2065 and then interpolated from 90% risk level at 2065 to 85% risk level at 2100. This was considered to be most appropriate in order to ensure the headroom is not so large that it drives unnecessary expenditure, and not too small that it leaves the possibility that the planned level of service cannot be met. A higher level of risk is more acceptable in the future than in the early years because as time progresses, the uncertainties for which headroom allows reduce and there is more time to adapt to any changes. This is in line with the Environment Agency's WRPG[1] which promotes the use of a glide path approach.

Figure 5-1 below summarises how the headroom uncertainty varies over time in the FTH profile for each scenario as well as the target headroom based on the acceptable level of risk over the planning period (figures for the EDG and EDGC profile can be found in Appendix B). It can be seen that generally the uncertainty increases with time; however the glide path reflects the changing risk profile over time.

Note that in the headroom profiles, there is an initial spike in headroom uncertainty from 2020 to 2022. This is as a result of these values being based upon historical data and therefore not calculated by the same method as in subsequent years.

The relative contribution of the different components of the target headroom assessment is shown for the FTH profile for each scenario in Figure 5-1 below. It should be noted that the sum of the different categories in Figure 5-2 does not match the target headroom as shown in Figure 5-1. This is because the sum of the individual categories does not provide a statistically correct percentile impact for the overall target headroom. The sum of all these components' results is greater than the overall target headroom result, because statistically, the probability of all components experiencing the same percentile impact simultaneously is much smaller than a single headroom component experiencing a particular percentile impact. By using @Risk to sum all the categories within the model runs, the sums are done during each iteration of the model and therefore the target headroom allowance is lower than the sum of the individual categories.

The contribution of "accuracy of demand and supply side data" and "gradual pollution of sources" is relatively constant throughout the planning period. The uncertainties associated with the impact of climate change on source yields and demand, as well the demand forecast variation increase across the planning period, with the latter contributing the most to uncertainty by the end of the planning period.

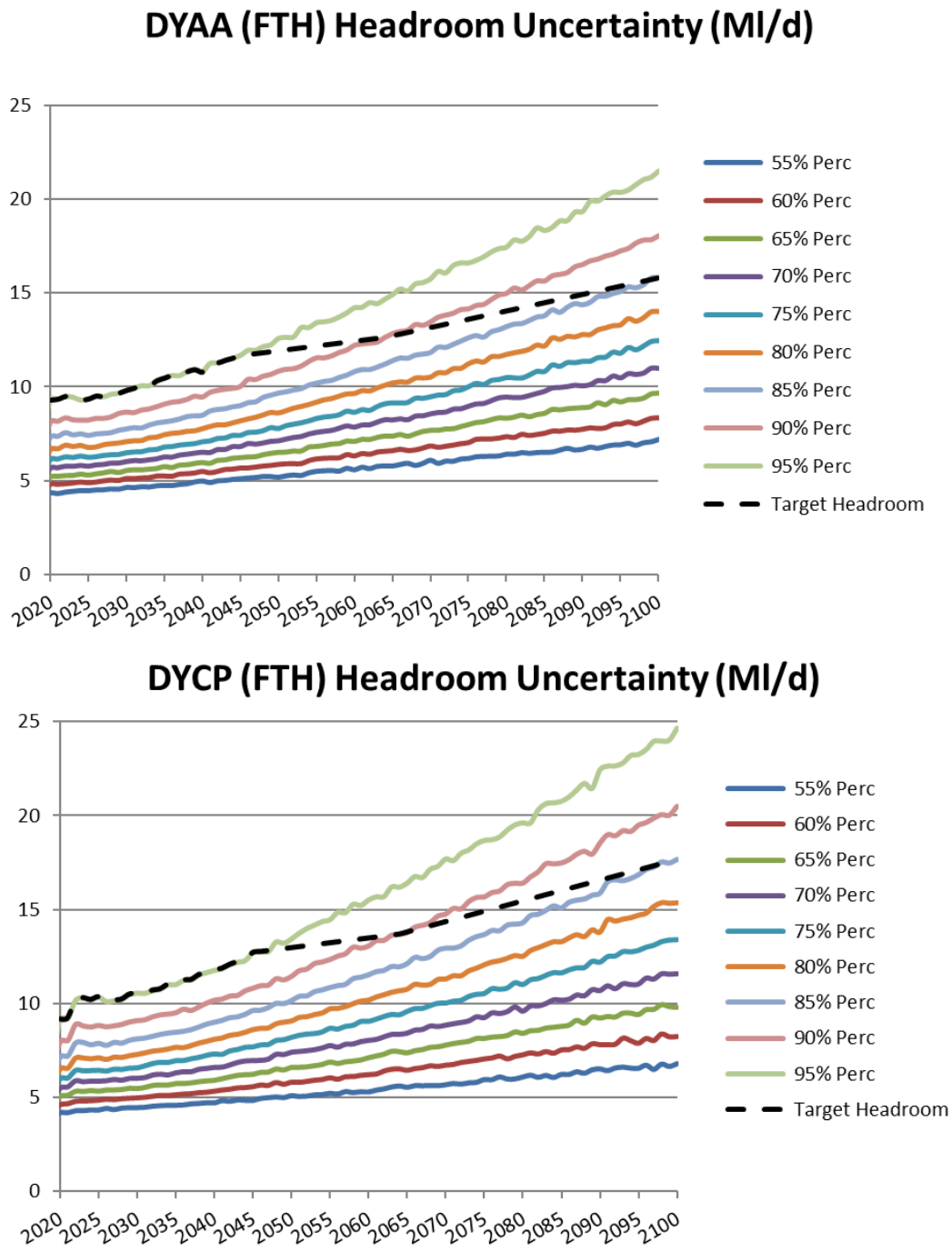


Figure 5-1 - Headroom uncertainty and varying risk percentiles (FTH profile)

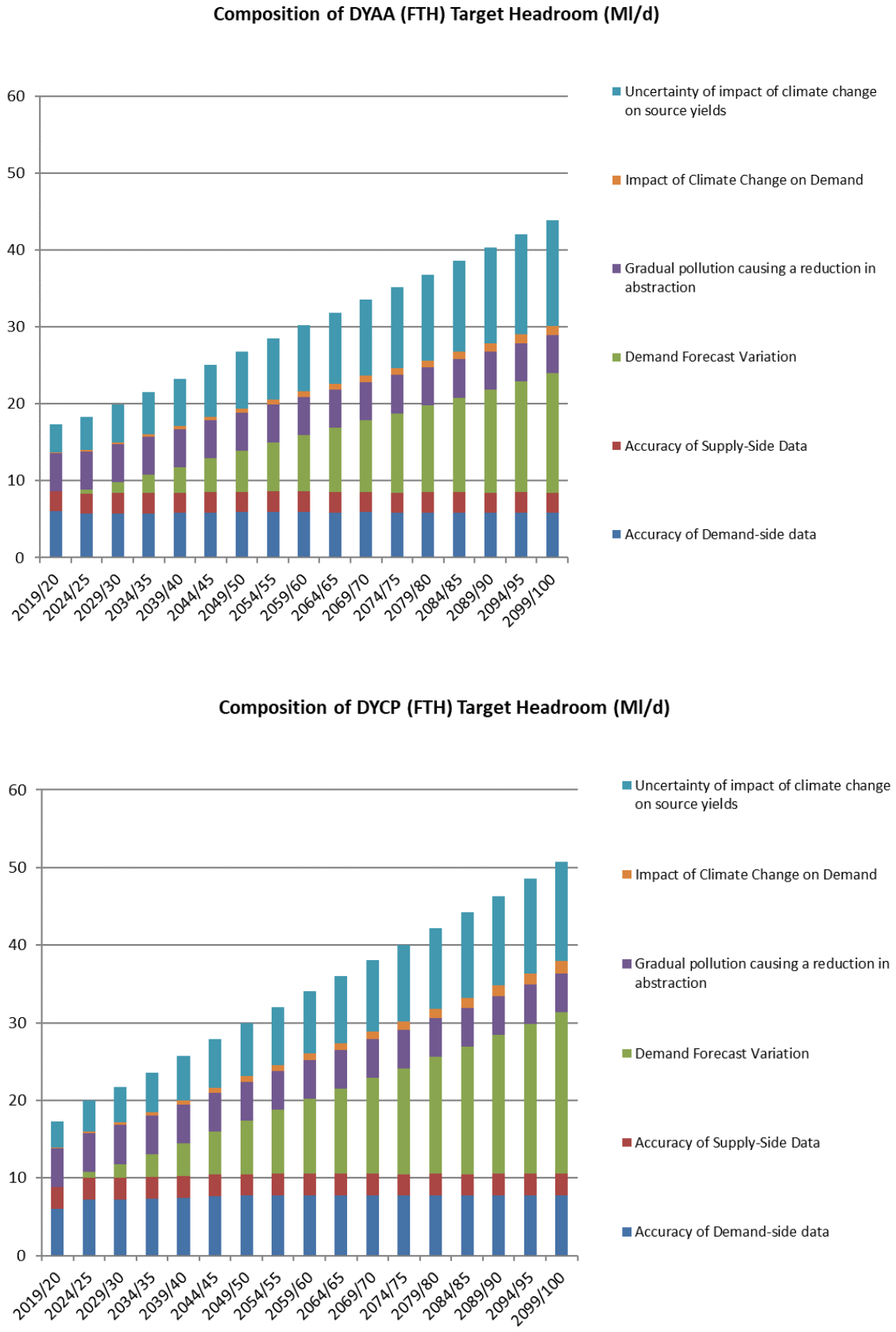


Figure 5-2 - Relative contribution of the different categories to the target headroom

5.2. Combined adaptive planning profile

As noted in Section 1, due to the timing of headroom model update and WRSE investment modelling, the latter includes WRMP19 target headroom values profiled as a combination of FTH, EDG and EDGC. However, this combined profile has been updated for future model runs following the same approach. These updated combined profiles are shown in Figure 5-3, where the FTH profile is applied up until 2040, the EDG profile applied from 2040 – 2060 and the EDGC profile applied from 2060 onwards. The full combined profiles can be found in **Error! Reference source not found.**.

It is noted that using the risk glidepath with the combined profile produces a headroom uncertainty that reduces from 2045 onwards (when an 85% risk is applied). As the EDG profile removes uncertainty associated with growth and the EDGC profile then further removes uncertainty related to climate change.

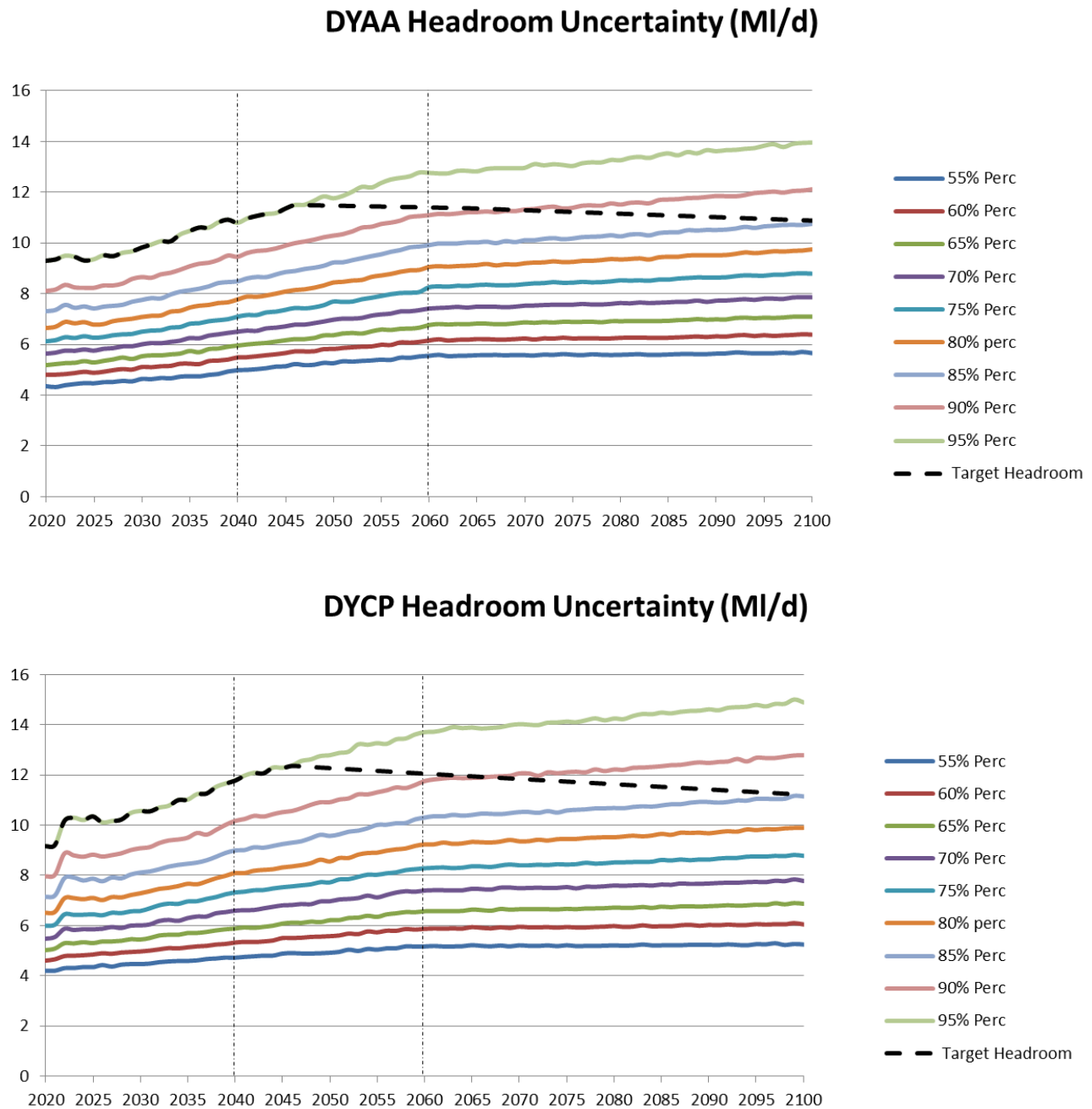


Figure 5-3 - Headroom uncertainty and varying risk percentiles (combined adaptive planning profile)

5.3. Comparison of WRMP24 and WRMP19

As the WRMP24 WRSE investment modelling utilised WRMP19 target headroom values and was completed before the recent WRMP24 target headroom update values were available, the most recent calculation of target headroom has been compared with that used in the investment modelling to assess whether the change is likely to have significantly impacted option selection.

The WRMP24 target headroom was assessed for the 1:500 year event scenario, whereas WRMP19 assessed target headroom for the 1:200 year and WDHR scenarios. Therefore, while direct comparisons between WRMP24 and WRMP19 headroom assessments cannot be made, the results from WRMP19 and WRMP24 headroom assessments are presented in Table 5-2 to give an indication of the overall magnitude of change.

Table 5-3 outlines the individual supply and demand components in WRMP19 (1:200 year (full target headroom)) and WRMP24 (1:500 year (full target headroom))[13]. It should be noted that total headroom is calculated using @Risk, and therefore is not equal to the sum of the individual components.

In the WRMP19 assessment the company wide DO was taken as a sum of individual source 1:200 year event DOs, producing a 206.49 Ml/d MDO and 287.04 Ml/d PDO. In contrast, WRMP24 used 1:500 year event company-wide DOs of 183.20 Ml/d MDO and 188.40 Ml/d PDO (discussed in Section 4.3). As a result, the supply side components S5 and S6 of the WRMP19 1:200 year headroom assessment (FTH) produced a higher headroom allowance than the updated WRMP24 1:500 year headroom assessment (FTH), as shown in Table 5-3. However, despite the smaller DOs in WRMP24, the uncertainty of climate change on demand (S8) is having a greater impact in WRMP24, resulting in an overall higher supply-side headroom value in 2074/75 for both DYAA and DYCP.

The difference between values used in the WRSE investment modelling (WRMP19 1:200) and the update (WRMP24 1:500) at reference points 2024/25 and 2074/75 is +1.1 Ml/d (13% increase) and +2.2 Ml/d (19% increase) in DYAA target headroom respectively. The updated target headroom values represent 6% of total Distribution Input (161.7 Ml/d) in 2024/25 and 8% of total Distribution Input (176.8 Ml/d) in 2074/75. The differences in target headroom represent less than 2% of total DYAA Distribution Input.

The difference between values used in the WRSE investment modelling (WRMP19 1:200) and the update (WRMP24 1:500) at reference points 2024/25 and 2074/75 is -1.0 Ml/d (9% decrease) and -1.2 Ml/d (7% decrease) in DYCP target headroom respectively. The updated target headroom values represent 5% of total Distribution Input (203.5 Ml/d) in 2024/25 and 6% of total Distribution Input (233.6 Ml/d) in 2074/75. The differences in target headroom represent less than 1% of total DYCP Distribution Input.

It is evident that the target headroom update for WRMP24 has resulted in small absolute and percentage changes from the WRMP19 values that were used in the WRSE baseline investment modelling and it is considered unlikely that these changes would have a substantial impact on option selection. The impact is likely to be limited to minor changes in when rather than if an option gets selected. Nevertheless, the updated target headroom values should be used for any suites of future investment model runs.

As discussed in Section 5.2, the use of the combined adaptive planning profiles reduces the overall headroom uncertainty as uncertainty relating to growth and climate change is removed at different points throughout the planning period. These uncertainties can then be considered explicitly in different WRSE investment model adaptive planning pathways.

[13] Note that the WRMP24 demand side headroom components (both DYAA and DYCP) will actually be slightly smaller due to the double counting of the climate change element in Distribution Input calculation (as discussed in Section 4.3).

Table 5-2 - SES Water Target Headroom Allowance comparison between WRMP19 and WRMP24 at reference points 2024/25 and 2074/75

Scenario			Year	Target Headroom (Ml/d)
Worst drought in historic record (full target headroom)	WRMP19	DYAA	2024/25	8.48
			2074/75	11.74
		DYCP	2024/25	11.16
			2074/75	14.77
1:200 year (full target headroom)	WRMP19	DYAA	2024/25	8.25
			2074/75	11.39
		DYCP	2024/25	11.37
			2074/75	16.10
1:500 year (full target headroom)	WRMP24	DYAA	2024/25	9.35
			2074/75	13.61
		DYCP	2024/25	10.35
			2074/75	14.90
1:500 year (combined adaptive planning profile)	WRMP24	DYAA	2024/25	9.35
			2074/75	11.21
		DYCP	2024/25	10.35
			2074/75	11.74

Table 5-3 - SES Water Target Headroom Allowance comparison of individual headroom components between WRMP19 and WRMP24 at reference points 2024/25 and 2074/75

	WRMP19 1:200 year (full target headroom) (Ml/d)				WRMP24 1:500 year (full target headroom) (Ml/d)			
	DYAA		DYCP		DYAA		DYCP	
	2024/25	2074/75	2024/25	2074/75	2024/25	2074/75	2024/25	2074/75
Total headroom	**8.25**	**11.06**	**11.37**	**15.60**	**9.35**	**12.61**	**10.35**	**13.66**
Supply side total	**6.57**	**6.24**	**9.29**	**8.89**	**7.53**	**9.79**	**7.44**	**9.22**
Gradual pollution causing a reduction in abstraction (S5)	5.16	4.67	7.03	6.39	4.58	4.14	4.60	4.19
Accuracy of demand-side data (S6)	2.01	1.27	2.87	1.81	1.86	1.18	1.94	1.23
Uncertainty of climate change on demand (S8)	1.60	2.08	2.46	3.32	3.43	6.33	3.17	5.77
Demand side total	**3.63**	**7.12**	**4.76**	**9.91**	**4.07**	**6.01**	**5.13**	**7.90**
Accuracy of demand-side data (D1)	3.51	2.70	4.58	3.63	4.04	2.61	5.10	3.46
Demand forecast variation (D2)	1.27	6.58	1.68	9.03	0.43	5.43	0.53	7.19
Impact of climate change on demand (D3)	0.11	0.62	0.30	1.59	0.14	0.46	0.19	0.59

6. Conclusions

A headroom assessment for SES Water's dWRMP24 submission has been prepared. Although the formal planning horizon ends in 2074/75, the assessment has been extended to 2099/100, and has adopted the latest guidance provided by the Environment Agency and WRSE.

In general, the assumptions made for WRMP14 and WRMP19 have been followed through with this assessment. Changes from previous WRMPs include:

- The WRMP24 target headroom assessment used DO values for the 1:500 year event scenario (previous assessments used WDHR and/or 1:200 year event scenario).
- Individual source DOs were scaled proportionally to the total company 1:500 year DO
- Input data into the headroom assessment was updated using the 2020 PyWR supply forecast and the SES Water HHCF model (v4.19.2).
- The WRMP24 provides target headroom forecasts for three adaptive planning profiles (FTH, EDG and EDGC)

As in WRMP19, a glidepath approach has been adopted, whereby the level of acceptable risk is maintained at 95% for the next AMP period, reducing to 85% at the end of the planning period. This is in line with the latest Environment Agency guidance.

From Section 5.3, it is evident that the target headroom update for WRMP24 has resulted in small absolute and percentage changes from the WRMP19 values that were used in the WRSE baseline investment modelling and it is considered unlikely that these changes would have a substantial impact on option selection. The impact is likely to be limited to minor changes in when, rather than if, an option gets selected. Nevertheless, the updated target headroom values should be used for any suites of future investment model runs.

7. Recommendations

As indicated in Section 4.3, since the target headroom model update, DI values have been updated to remove the double counting of climate change effects and although these updated DI values (from demand forecast model v4.19.1.1) were used in the baseline WRSE investment model runs, these changes are not reflected in the target headroom values. This DI update had a small impact (0.4 – 0.6 Ml/d) on DI at the start of the planning period (2024/25) rising 3.7 to 13.5 Ml/d by 2099/00. Therefore, changes to target headroom, components of which include small percentages of DI, will be very small and extremely unlikely to have a material impact on WRMP24 option selection, particularly early in the planning horizon. However, for the next target headroom update, the revised DI values should be utilised.

As noted in Section 4.1.9 when calculating the D1 component, the 95% probability that the reading is within ± 3% was calculated using the lower demand forecast variation rather than the central demand forecast variation in error. It is recommended this is adjusted for the next target headroom update.

Appendices

Appendix A. @Risk Spreadsheet Outputs

A.1. DYAA Headroom Allowance by Probability (FTH)

Units: Ml/d

Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section 5.

Year	Probability (%)								
	55	60	65	70	75	80	85	90	95
2019/20	4.37	4.79	5.20	5.64	6.13	6.65	7.32	8.10	9.29
2024/25	4.48	4.88	5.30	5.76	6.27	6.78	7.43	8.22	9.35
2029/30	4.66	5.11	5.55	6.01	6.51	7.09	7.76	8.65	9.81
2034/35	4.76	5.24	5.76	6.26	6.82	7.46	8.14	9.08	10.47
2039/40	5.00	5.49	5.97	6.51	7.10	7.78	8.49	9.45	10.79
2044/45	5.11	5.67	6.23	6.81	7.44	8.19	9.00	10.02	11.67
2049/50	5.19	5.87	6.51	7.12	7.80	8.61	9.67	10.83	12.57
2054/55	5.50	6.16	6.82	7.56	8.34	9.19	10.20	11.54	13.41
2059/60	5.59	6.33	7.09	7.84	8.67	9.65	10.81	12.21	14.21
2064/65	5.79	6.61	7.37	8.22	9.17	10.21	11.39	12.84	14.90
2069/70	6.09	6.86	7.68	8.55	9.50	10.52	11.82	13.46	15.74
2074/75	6.18	7.04	7.98	8.95	10.03	11.23	12.61	14.16	16.59
2079/80	6.41	7.36	8.32	9.44	10.52	11.73	13.20	14.99	17.43
2084/85	6.51	7.54	8.58	9.75	10.85	12.17	13.78	15.65	18.31
2089/90	6.67	7.76	8.88	10.03	11.39	12.78	14.35	16.53	19.33
2094/95	6.90	8.04	9.19	10.46	11.82	13.30	15.06	17.26	20.34
2099/100	7.19	8.37	9.65	10.96	12.49	14.01	15.81	18.07	21.49

A.2. DYAA Headroom Allowance by Probability (EDG)

Units: Ml/d

Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section 5.

Year	Probability (%)								
	55	60	65	70	75	80	85	90	95
2019/20	4.20	4.49	4.81	5.12	5.41	5.76	6.20	6.73	7.50
2024/25	4.37	4.65	4.92	5.24	5.60	6.00	6.46	7.05	7.88
2029/30	4.47	4.81	5.12	5.47	5.85	6.28	6.77	7.37	8.24
2034/35	4.61	4.96	5.32	5.69	6.12	6.55	7.09	7.74	8.69
2039/40	4.70	5.09	5.47	5.91	6.36	6.85	7.45	8.13	9.13
2044/45	4.86	5.26	5.68	6.12	6.62	7.16	7.81	8.57	9.69
2049/50	4.98	5.42	5.88	6.38	6.95	7.52	8.18	8.97	10.10
2054/55	5.12	5.59	6.10	6.59	7.17	7.80	8.50	9.43	10.70
2059/60	5.27	5.76	6.28	6.82	7.51	8.13	8.86	9.78	11.10
2064/65	5.40	5.91	6.45	7.06	7.70	8.42	9.30	10.31	11.68
2069/70	5.52	6.06	6.73	7.33	8.03	8.82	9.67	10.82	12.29
2074/75	5.71	6.31	6.93	7.60	8.31	9.15	10.02	11.17	12.71
2079/80	5.84	6.46	7.10	7.82	8.61	9.49	10.55	11.76	13.42
2084/85	5.93	6.66	7.38	8.13	8.99	9.87	10.90	12.07	13.75
2089/90	6.15	6.81	7.50	8.27	9.11	10.07	11.16	12.54	14.49
2094/95	6.20	7.00	7.71	8.54	9.40	10.42	11.61	13.08	14.95
2099/100	6.45	7.19	7.97	8.80	9.75	10.76	11.99	13.50	15.57

A.3. DYAA Headroom Allowance by Probability (EDGC)

Units: Ml/d

Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section .5.

Year	Probability (%)								
	55	60	65	70	75	80	85	90	95
2019/20	3.47	3.66	3.89	4.13	4.37	4.63	4.97	5.37	5.98
2024/25	3.45	3.66	3.87	4.09	4.33	4.59	4.91	5.28	5.89
2029/30	3.45	3.65	3.85	4.10	4.33	4.61	4.92	5.30	5.81
2034/35	3.49	3.70	3.90	4.12	4.35	4.62	4.94	5.30	5.90
2039/40	3.47	3.68	3.90	4.14	4.39	4.66	4.98	5.38	5.99
2044/45	3.46	3.69	3.91	4.15	4.40	4.69	5.00	5.41	6.00
2049/50	3.46	3.67	3.91	4.17	4.43	4.70	5.04	5.44	6.05
2054/55	3.48	3.70	3.92	4.16	4.45	4.74	5.11	5.54	6.17
2059/60	3.47	3.70	3.95	4.21	4.49	4.81	5.14	5.60	6.30
2064/65	3.50	3.76	4.01	4.29	4.58	4.88	5.25	5.72	6.36
2069/70	3.50	3.79	4.06	4.32	4.62	4.95	5.34	5.82	6.50
2074/75	3.52	3.78	4.08	4.36	4.67	5.01	5.41	5.89	6.57
2079/80	3.51	3.81	4.10	4.43	4.77	5.10	5.49	6.02	6.80
2084/85	3.52	3.81	4.12	4.45	4.79	5.21	5.64	6.22	7.07
2089/90	3.56	3.87	4.18	4.52	4.87	5.27	5.74	6.36	7.15
2094/95	3.57	3.92	4.24	4.60	4.95	5.38	5.88	6.50	7.37
2099/100	3.58	3.94	4.28	4.65	5.02	5.50	5.98	6.62	7.50

A.4. DYCP Headroom Allowance by Probability (FTH)

Units: Ml/d

Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section 5.

Year	Probability (%)								
	55	60	65	70	75	80	85	90	95
2019/20	4.19	4.59	5.03	5.47	5.99	6.51	7.13	7.95	9.16
2024/25	4.33	4.83	5.31	5.85	6.44	7.11	7.86	8.81	10.35
2029/30	4.46	4.95	5.45	6.01	6.58	7.29	8.10	9.07	10.56
2034/35	4.58	5.12	5.71	6.30	6.96	7.67	8.45	9.49	11.01
2039/40	4.71	5.31	5.89	6.59	7.31	8.09	8.98	10.16	11.78
2044/45	4.84	5.55	6.21	6.95	7.69	8.61	9.61	10.80	12.70
2049/50	5.09	5.79	6.58	7.40	8.20	9.07	10.14	11.43	13.45
2054/55	5.21	6.03	6.87	7.76	8.68	9.71	10.84	12.33	14.48
2059/60	5.29	6.20	7.10	8.04	9.05	10.17	11.52	13.05	15.53
2064/65	5.53	6.43	7.36	8.42	9.57	10.76	12.11	13.77	16.42
2069/70	5.67	6.70	7.78	8.85	10.02	11.30	12.93	14.76	17.71
2074/75	5.94	7.04	8.14	9.25	10.53	12.05	13.66	15.67	18.70
2079/80	6.08	7.25	8.41	9.60	11.00	12.50	14.29	16.41	19.64
2084/85	6.22	7.52	8.78	10.19	11.63	13.27	15.08	17.48	20.79
2089/90	6.51	7.80	9.23	10.70	12.19	13.79	15.86	18.54	22.46
2094/95	6.54	7.87	9.41	11.05	12.82	14.68	16.85	19.50	23.29
2099/100	6.78	8.23	9.80	11.60	13.39	15.34	17.66	20.50	24.68

A.5. DYCP Headroom Allowance by Probability (EDG)

Units: Ml/d

Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section 5.

Year	Probability (%)								
	55	60	65	70	75	80	85	90	95
2019/20	4.04	4.32	4.59	4.89	5.22	5.61	6.03	6.59	7.37
2024/25	4.16	4.45	4.74	5.06	5.40	5.79	6.25	6.81	7.63
2029/30	4.26	4.56	4.89	5.23	5.63	6.05	6.55	7.13	8.03
2034/35	4.36	4.68	5.03	5.40	5.79	6.22	6.76	7.43	8.33
2039/40	4.43	4.81	5.19	5.61	6.06	6.56	7.13	7.81	8.71
2044/45	4.59	4.99	5.39	5.82	6.26	6.78	7.39	8.16	9.22
2049/50	4.63	5.07	5.52	5.99	6.46	7.01	7.71	8.56	9.72
2054/55	4.75	5.22	5.65	6.14	6.76	7.37	8.16	8.95	10.20
2059/60	4.87	5.36	5.88	6.41	7.02	7.69	8.44	9.40	10.64
2064/65	4.97	5.49	6.06	6.64	7.23	7.92	8.72	9.76	11.19
2069/70	5.05	5.64	6.22	6.84	7.53	8.27	9.14	10.22	11.70
2074/75	5.29	5.85	6.42	7.04	7.74	8.52	9.40	10.54	12.07
2079/80	5.33	5.92	6.58	7.29	8.04	8.91	9.91	11.04	12.67
2084/85	5.45	6.06	6.77	7.48	8.27	9.11	10.28	11.51	13.21
2089/90	5.60	6.28	6.96	7.71	8.53	9.48	10.51	11.79	13.61
2094/95	5.61	6.30	7.01	7.83	8.79	9.80	10.93	12.41	14.24
2099/100	5.79	6.53	7.38	8.25	9.12	10.17	11.32	12.72	14.57

A.6. DYCP Headroom Allowance by Probability (EDGC)

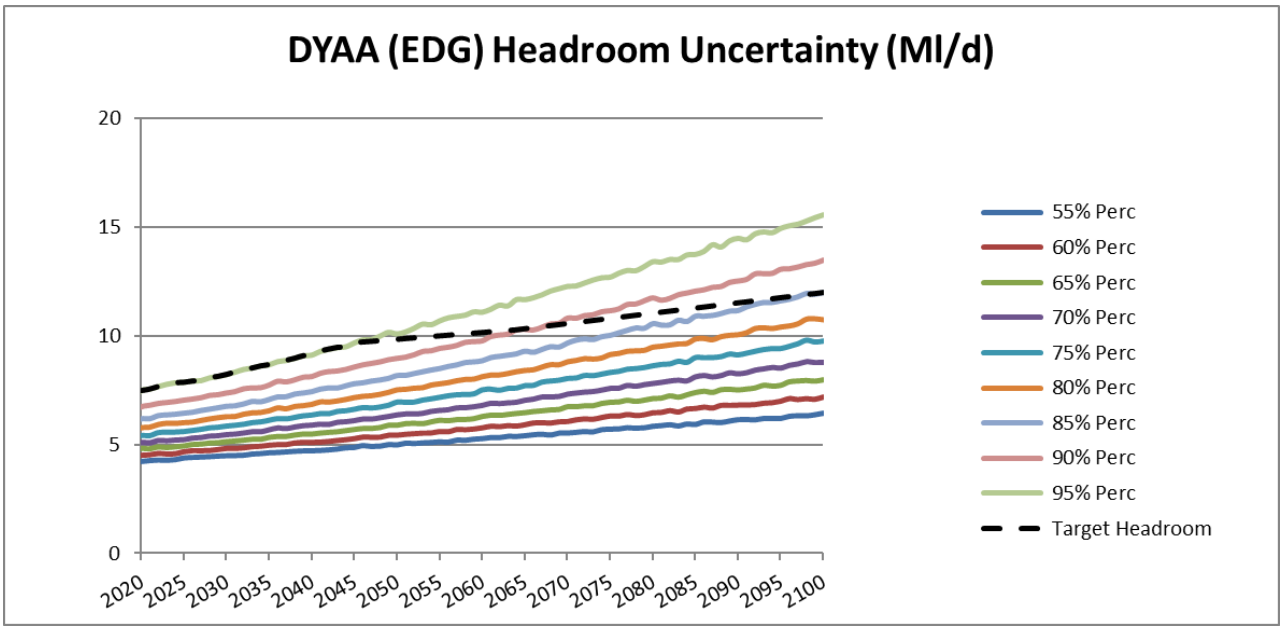
Units: Ml/d

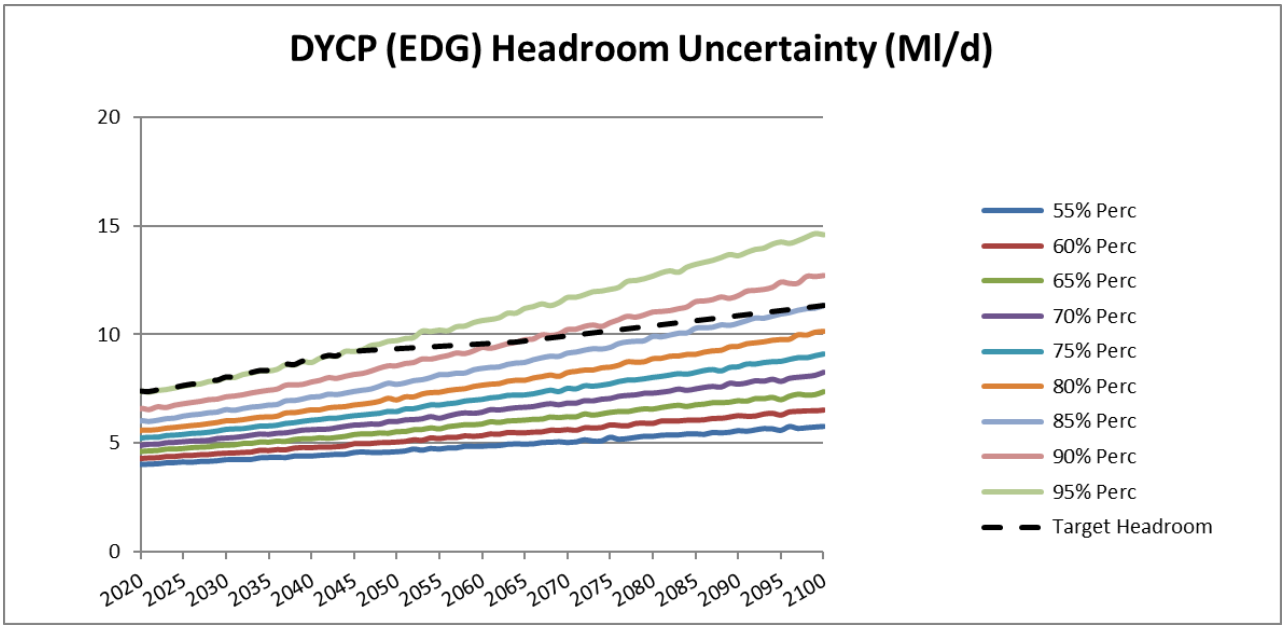
Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section 5.

Year	Probability (%)								
	55	60	65	70	75	80	85	90	95
2019/20	3.48	3.69	3.91	4.14	4.40	4.67	5.02	5.45	6.02
2024/25	3.47	3.69	3.90	4.12	4.39	4.65	4.96	5.36	5.90
2029/30	3.44	3.66	3.88	4.13	4.39	4.68	5.02	5.39	5.95
2034/35	3.45	3.66	3.89	4.13	4.38	4.64	4.99	5.36	5.94
2039/40	3.47	3.68	3.92	4.18	4.42	4.71	5.03	5.41	6.03
2044/45	3.48	3.70	3.92	4.17	4.44	4.73	5.08	5.52	6.10
2049/50	3.48	3.70	3.93	4.20	4.46	4.75	5.09	5.55	6.19
2054/55	3.48	3.71	3.96	4.23	4.49	4.80	5.18	5.63	6.27
2059/60	3.49	3.73	3.99	4.25	4.54	4.85	5.23	5.69	6.32
2064/65	3.54	3.80	4.05	4.32	4.61	4.94	5.33	5.76	6.45
2069/70	3.54	3.81	4.07	4.34	4.65	4.97	5.40	5.93	6.60
2074/75	3.54	3.80	4.08	4.39	4.68	5.06	5.48	6.00	6.71
2079/80	3.53	3.84	4.13	4.45	4.77	5.13	5.54	6.08	6.83
2084/85	3.53	3.83	4.17	4.49	4.87	5.26	5.70	6.26	7.05
2089/90	3.56	3.88	4.19	4.53	4.88	5.28	5.77	6.39	7.18
2094/95	3.58	3.92	4.25	4.60	5.00	5.41	5.92	6.55	7.33
2099/100	3.57	3.90	4.28	4.63	5.03	5.50	6.04	6.72	7.59

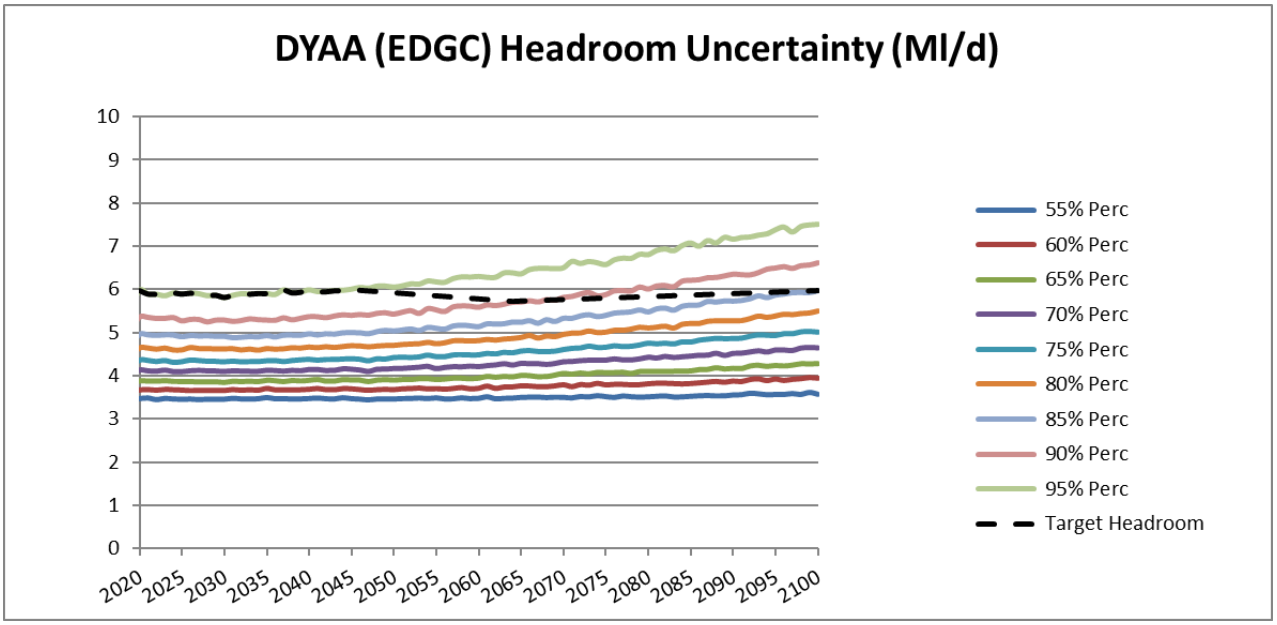
Appendix B. EDG and EDGC figures

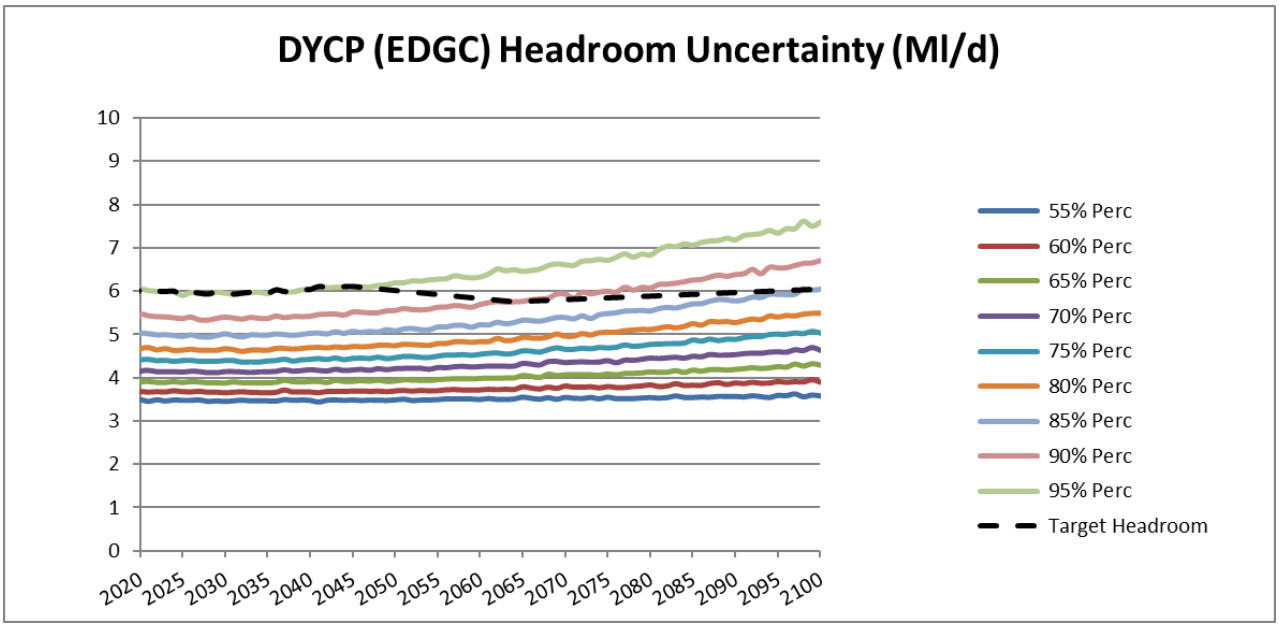
B.1. Headroom uncertainty and varying risk percentiles (EDG profile)





B.2. Headroom uncertainty and varying risk (EDGC profile)





Appendix C. Combined adaptive planning profiles

C.1. DYAA Headroom Allowance by Probability (Combined planning profile)

Units: Ml/d

Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section 5.

	Probability	95%				90%				85%			
Adaptive planning profile		FTH	EDG	EDGC	Combined	FTH	EDG	EDGC	Combined	FTH	EDG	EDGC	Combined
AMP	2019/20	9.29	7.50	5.98	9.29	8.10	6.73	5.37	8.10	7.32	6.20	4.97	7.32
	2024/25	9.35	7.88	5.89	9.35	8.22	7.05	5.28	8.22	7.43	6.46	4.91	7.43
	2029/30	9.81	8.24	5.81	9.81	8.65	7.37	5.30	8.65	7.76	6.77	4.92	7.76
	2034/35	10.47	8.69	5.90	10.47	9.08	7.74	5.30	9.08	8.14	7.09	4.94	8.14
	2039/40	10.79	9.13	5.99	10.79	9.45	8.13	5.38	9.45	8.49	7.45	4.98	8.49
	2044/45	11.67	9.69	6.00	11.35	10.02	8.57	5.41	9.89	9.00	7.81	5.00	8.85
	2049/50	12.57	10.10	6.05	11.76	10.83	8.97	5.44	10.29	9.67	8.18	5.04	9.23
	2054/55	13.41	10.70	6.17	12.36	11.54	9.43	5.54	10.75	10.20	8.50	5.11	9.55
	2059/60	14.21	11.10	6.30	12.76	12.21	9.78	5.60	11.10	10.81	8.86	5.14	9.91
	2064/65	14.90	11.68	6.36	12.82	12.84	10.31	5.72	11.22	11.39	9.30	5.25	10.01
	2069/70	15.74	12.29	6.50	12.96	13.46	10.82	5.82	11.33	11.82	9.67	5.34	10.10
	2074/75	16.59	12.71	6.57	13.03	14.16	11.17	5.89	11.39	12.61	10.02	5.41	10.17
	2079/80	17.43	13.42	6.80	13.26	14.99	11.76	6.02	11.52	13.20	10.55	5.49	10.25
	2084/85	18.31	13.75	7.07	13.53	15.65	12.07	6.22	11.72	13.78	10.90	5.64	10.41
	2089/90	19.33	14.49	7.15	13.62	16.53	12.54	6.36	11.86	14.35	11.16	5.74	10.50
	2094/95	20.34	14.95	7.37	13.83	17.26	13.08	6.50	12.00	15.06	11.61	5.88	10.64
	2099/100	21.49	15.57	7.50	13.96	18.07	13.50	6.62	12.12	15.81	11.99	5.98	10.74

C.2. DYCP Headroom Allowance by Probability (Combined planning profile)

Units: Ml/d

Cells highlighted in blue based on the applied probability using the risk glidepath, as discussed in Section 5.

	Probability	95%				90%				85%			
	Adaptive planning profile	FTH	EDG	EDGC	Combined	FTH	EDG	EDGC	Combined	FTH	EDG	EDGC	Combined
AMP	2019/20	9.16	7.37	5.69	9.16	7.95	6.59	5.16	7.95	7.13	6.03	4.81	7.13
	2024/25	10.35	7.63	5.99	10.35	8.81	6.81	5.38	8.81	7.86	6.25	4.99	7.86
	2029/30	10.56	8.03	5.97	10.56	9.07	7.13	5.37	9.07	8.10	6.55	4.98	8.10
	2034/35	11.01	8.33	5.97	11.01	9.49	7.43	5.37	9.49	8.45	6.76	4.99	8.45
	2039/40	11.78	8.71	6.03	11.78	10.16	7.81	5.41	10.16	8.98	7.13	5.01	8.98
	2044/45	12.70	9.22	6.09	12.28	10.80	8.16	5.44	10.51	9.61	7.39	5.03	9.24
	2049/50	13.45	9.72	6.14	12.78	11.43	8.56	5.54	10.91	10.14	7.71	5.11	9.56
	2054/55	14.48	10.20	6.26	13.26	12.33	8.95	5.58	11.30	10.84	8.16	5.11	10.01
	2059/60	15.53	10.64	6.31	13.70	13.05	9.40	5.63	11.75	11.52	8.44	5.17	10.30
	2064/65	16.42	11.19	6.49	13.89	13.77	9.76	5.75	11.88	12.11	8.72	5.28	10.40
	2069/70	17.71	11.70	6.63	14.02	14.76	10.22	5.93	12.06	12.93	9.14	5.40	10.52
	2074/75	18.70	12.07	6.73	14.12	15.67	10.54	5.98	12.11	13.66	9.40	5.46	10.58
	2079/80	19.64	12.67	6.85	14.25	16.41	11.04	6.09	12.21	14.29	9.91	5.56	10.68
	2084/85	20.79	13.21	7.09	14.48	17.48	11.51	6.22	12.35	15.08	10.28	5.66	10.78
	2089/90	22.46	13.61	7.22	14.61	18.54	11.79	6.35	12.47	15.86	10.51	5.80	10.92
	2094/95	23.29	14.24	7.39	14.79	19.50	12.41	6.56	12.69	16.85	10.93	5.93	11.05
	2099/100	24.68	14.57	7.49	14.89	20.50	12.72	6.66	12.79	17.66	11.32	6.02	11.14

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