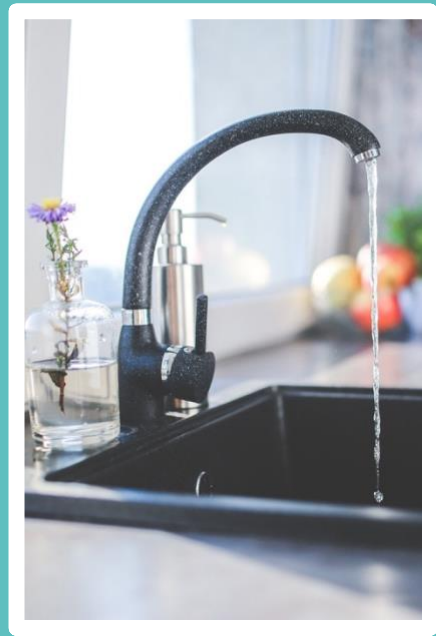

Emerging Regional Plan
Water Resources South East

Annex 1 – The challenge

January 2022 Consultation version

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1. Why do we need to future proof our supplies?

1.1. This section explains the scale of the challenges we are facing, and why we need to future proof our supplies as a result.

National challenges we are planning for

1.2. In 2020 the National Framework looked at the pressures on public water supply nationally, regionally and over time. These included climate change, population growth and the need to increase drought resilience. It provided a preliminary indication of the challenges we could face in providing water supplies in the future. We have set out below what the National Framework told us and then how we went on to develop our own forecasts that differed from those set out in the National Framework.

Public water supply need

1.3. To understand public water supply needs the National Framework for Water Resources utilised the data provided by each water company on water availability in their 2019 WRMPs. This data was aggregated to a regional and national scale and adjusted so that it is comparable across companies. From this data the National Framework provides an understanding of future water needs and what is driving the change in these needs over time. It also provides a comparison of different ways of addressing the need, taking into account the approaches used in WRMPs and alternative scenarios, for example, that achieve more ambitious demand reductions.

1.4. The National Framework also includes an understanding of how much water is used by different sectors and subsectors outside the water industry now, and how that is likely to change in the future. The analysis assumed that actions in the latest round of WRMPs are implemented up to 2025. These include, on a national basis:

- Reducing leakage on average by 19%
- Reducing domestic water consumption on average from 138 l/h/d to 132 l/h/d
- Developing 145 Ml/d of new sources
- Significantly increase resilience to drought

From 2025 it assumes that nothing further is done to meet future water needs to 2050. This allows the Framework to understand the scale of additional capacity required to meet future needs during that period.

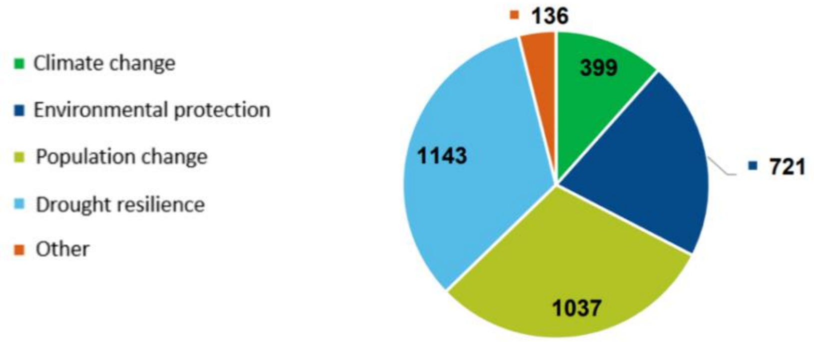
1.5. The National Framework seeks to account for the main pressures on public water supply – climate change, environmental protection, population and increasing drought resilience – but recognises that these have a range of potential impacts. To manage this complexity, their forecast was based on one plausible scenario, considered to represent a reasonable assessment of likely future pressures. This includes:

- Climate impacts taken from WRMPs
- The most ambitious environmental protection scenarios set out in WRMPs
- Increased drought resilience to a 1 in 500 year drought
- High population growth dataset that fits closely with the population data in WRMPs.

1.6. If no action is taken after 2025, the National Framework modelling suggests that England could need up to 3,435 Ml/d by 2050 to meet public water supply needs, with an additional 5,500 to 6,000 Ml/d needed between 2025 and 2100.

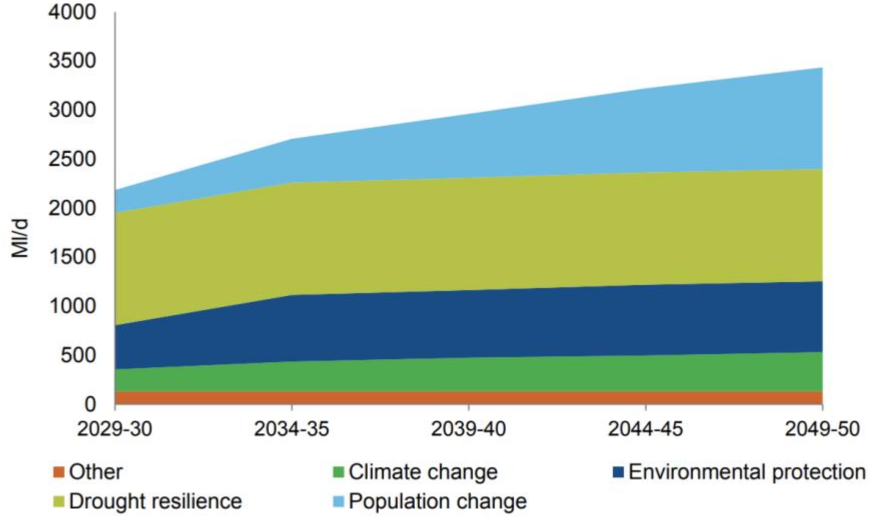
1.7. As shown in Figure 1.1, the need to increase resilience to drought and population growth are the main contributors to water need. Figure 1.2 shows how these drivers develop through the period to 2050. There is an assumption in the National Framework model that there is an immediate need to increase drought resilience, as climate change and population growth develop across the period. In terms of environmental protection, this is considered to develop up to 2035 but then level off. However, it is recognised that this is likely to under-represent the changes needed.

Figure 1.1: Estimate of how much each of the pressures on public water supply is contributing to the potential additional national water need by 2050



Source: National Framework for Water, Environment Agency (2020)

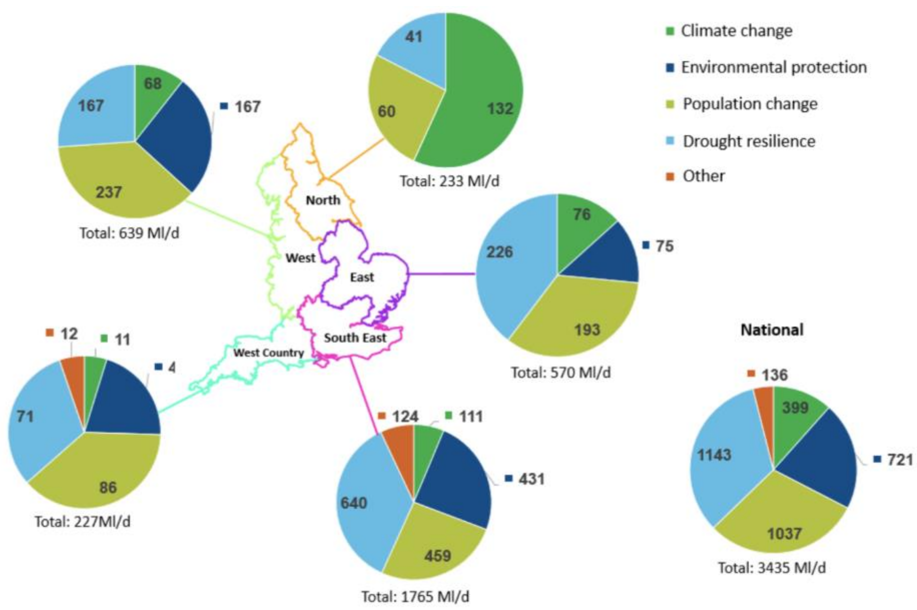
Figure 1.2: The cumulative development of the national additional water need over time in ML/d by driver. (Note this is for a 'do nothing' scenario and therefore excludes actions to meet these pressures.)



Source: National Framework for Water, Environment Agency (2020)

1.8. The regional picture of water need set out in the National Framework provides a stark picture of the pressure facing the South East as shown in Figure 1.3. It estimates that future need for water in the South East could be 1,765Ml/d by 2050, almost half of the water needed nationally. Over a third of this is driven by the need to increase public water supply resilience to droughts, with increased water consumption and protection of the environment also playing a significant part. Deteriorating water quality giving rise to reduced supplies is also another driver.

Figure 1.3: Future pressures on water resources nationally and by region in millions of litres per day (Ml/d) by 2050 assuming no further action is taken from 2025



Source: National Framework for Water, Environment Agency (2020)

1.9. The figures presented in the National Framework provide a starting point, and the Framework signposts the work that the Regional Groups need to do in order to fully understand public water supply needs.

1.10. Our own detailed assessment of future water supply need for the South East is set out in sections 2 to 4 of this Annex.

Non-public water supply need

1.11. The National Framework highlights the necessity to also understand the pressure on water resources from other sectors that are not supplied through water companies. It stresses the need for regional groups to work with these sectors to develop a better understanding of their water needs and explore solutions to meet existing and future demand, as well as protecting the environment.

1.12. The National Framework shows how water is used across England and the sectors that are important for each region. This is shown in Figure 1.4, highlighting for the South East the predominant sectors are industry and agriculture.

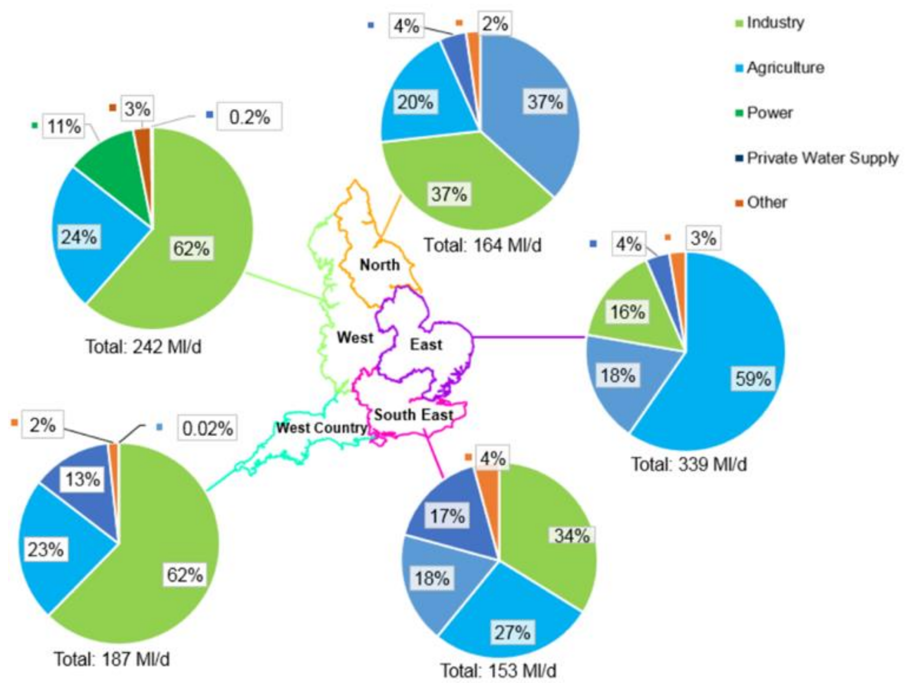
1.13. In comparison to the other regions, the South East has the lowest demand for consumptive water uses. However, our region includes significant trickle irrigation which has historically been exempt from licensing. This includes the rapidly developing soft fruit industry. The National Framework acknowledges that their work does not fully represent these important sectors as they do not feature in historic abstraction records.

1.14. The National Framework challenges us and the other regional groups to gain a better understanding of future demand for non-public water supply. There are sectors that rely on access to water and face many of the same issues as the water companies supplying public water.

1.15. The National Framework provides a preliminary assessment of how water demand may change in the future, examining drivers for, and uncertainties in, water demand outside of the water industry. This focuses on direct abstraction rather than water supplied by water companies. However, the assessment is limited as it does not represent new abstractions emerging in locations where it currently does not take place.

1.16. It is anticipated that estimates of non-public water use will increase in part as a result of some abstractions no longer being exempt from the licensing following regulations introduced by the Water Act 2003. This applies to navigation, minerals (likely to be non-consumptive use) and trickle irrigation.

Figure 1.4: Current consumptive water abstraction outside the water industry across the regional groups.



Source: National Framework for Water, Environment Agency (2020)

1.17. There are many factors that impact demand, including water availability, product market forces, economics, policy and regulation. The National

Framework focused on seven key sectors, that in combination represent in excess of 60% of consumptive freshwater direct abstraction arising from outside the water industry.

1.18. The data from each sector was based on the sources set out in Table 1.1.

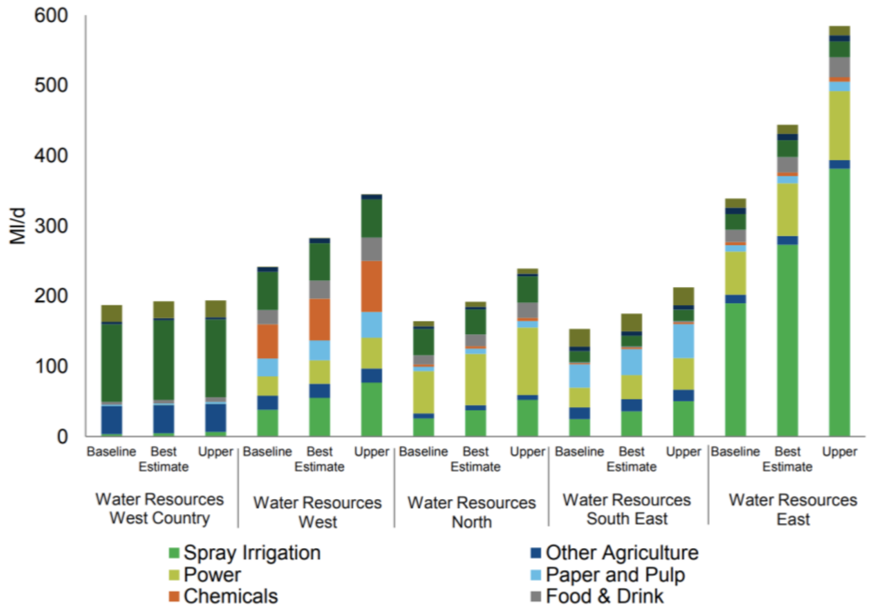
Table 1.1: Data sources for non-public water use

Sector	Data
• spray irrigation • electricity production • paper and pulp • chemicals • food and drink	Based on standard growth rates across England and not adjusted for different regions as limitation on future water use data
• livestock • protected edible crops and ornamental plants	Based on estimates of growth on projections of non-household water use, supplied by water companies in their water resources management plans, as an indicator of how direct abstraction could change.

1.19. Figure 1.5 shows the potential changes in water consumption for different scenarios. The National Framework recognises the limitations of this assessment, signposting the need for further work to fully assess future changes. Using best available information to form estimates, the assessment reflects the uncertainty of how the factors that influence demand may interact. As Figure 1.5 shows, a best estimate and upper range scenario are considered.

1.20. The assessment shows that in all of the sectors examined, the potential increase in demand remains lower than the total volume currently licensed for abstraction nationally. This would appear to indicate that at a national scale these sectors have sufficient water. However, this does not necessarily mean that water is available where it is needed. The assessment does not account for certain abstractions exceeding licence quantities, nor does it consider potential environmental pressures that could be addressed through licence changes. It may not be possible for unused limits on licences to be utilised in the future.

Figure 1.5: Potential range of changes to non-public water supply use to 2050.



Source: National Framework for Water, Environment Agency (2020)

1.21. The National Framework recognises the challenges that planning for non-public water supply brings and highlights the need to be reviewed as regional plans progress. It anticipates that we will work with the business sectors that abstract directly and seek opportunities for collaboration.

What the National Framework concludes

1.22. Of all the regions, the South East faces the greatest pressures on public water supplies. If surplus water can be made available, we will still need to develop options to supply more water, equivalent to all new water resource options and transfers currently selected in company WRMPs, as well as achieving ambitious efficiency reductions. If surplus water cannot be accessed, demand will need to be reduced or further resources developed. The Framework highlights that we must track the progress on demand management as if savings are less than expected, a large shortfall may reduce resilience, limit progress on environmental improvements and lead to more frequent use of drought measures.

How this information has informed this regional plan

1.23. Our own detailed assessment of future water supply need for the South East is set out in sections 2, 3 and 4 of this Annex. As a result of the more detailed work we have undertaken, our own forecasts differ from those in the National Framework, and we have assessed the scale of the challenges we face as being even greater than anticipated in the National Framework. As a result, we have included additional scenarios to consider possible lower impact environmental destinations as well as those in the National Framework.

1.24. Given the scale and complexity of the challenges we are facing in the South East, we have designed a regional planning process that is capable of modelling and assessing many different potential futures, to help us to select a resilient and adaptive best value regional plan.

1.25. The future is uncertain, and we will need to adapt and adjust our proposals over the coming years and decades as part of monitoring and review. However, the regional plan process is specifically designed to facilitate this adaption and change, whilst ensuring that demand management and new resource developments to be implemented in the short term remain as robust choices and decisions whatever future may evolve.

2. Factors affecting future water need for the South East

Supply demand forecasting

2.1. Our regional plan looks ahead to 2100 to understand what the water resource position is likely to be for the region over the next 75 years – considering both public water supplies and the needs of other users – so that the region's water resources can be planned and managed in a more holistic way.

2.2. To this end, we need to set out best estimate predications of the future supply and demand for water, accommodating risks and uncertainties within the different futures we plan for, and from this derive our supply demand balance. Where the demand for water is greater than supply, that indicates we have a deficit in our supply demand balance.

2.3. Demand forecasting is a well-established process that follows regulatory guidance and industry best practice, with three components that, when combined, give us an estimate of the demand that we will need to meet in the future. These components are:

- **Household demand** - this is calculated from population and property forecasts combined with per capita consumption (PCC) and per household consumption (PHC) forecasts
- **Non-household demand** - this is based on a range of factors, including population and properties growth, climate and economic data
- **Leakage** – this includes both distribution network losses (made up of losses from large water mains, service reservoirs, and smaller distribution mains) and customer -side leaks on supply pipes

2.4. Our approach is set out in our Demand Forecast Method Statement which can be found here.

2.5. Supply forecasting involves looking at the water available from existing sources and transfers and then looking at how those sources are affected by factors such as climate change, sustainability reductions, treatment works losses and outage. We have calculated the amount of water that will be available in the future through the following methods:

- **Deployable output** – how we measure supply capability of the water supply system. Our approach to assessing this can be found here.
- **Climate change** – how we determine the impact of climate change on our deployable output. Our approach to assessing this can be found here.
- **Outage** – we have to account for the temporary loss of reliable water due to planned events, such as needing to carry out maintenance at water treatment works, or unplanned events, such as power cuts. We have calculated this using the methods set out here.

2.6. We have utilised a number of tools to further understand and model our supply forecast, including stochastic climate modelling, hydrological modelling and a groundwater framework. The components of our supply forecast are incorporated into our regional simulation model that allows us to assess the supply capabilities of water resource systems, to assess the implications of droughts for customers and the environment, and to examine the impacts that future changes and interventions may have on water resources systems and the environment. Further details of our methods for all these components are included in section 1 of our separate Annex 4, and also in the published method statements on our website.

2.7. Where we identify deficits, we need to address these through managing and reducing the demand for water and the provision of new water resource supplies. Our water companies have provided us with details of the amount of water (Ml/d benefit) that various water demand and supply options could provide and we have considered these in our emerging draft regional plan.

2.8. Following the Environment Agency's National Framework, we presented an initial projection of the water needed through to 2100 in March 2020[1] and provided an update in February 2021[2]. We have updated those predictions for our emerging plan.

Our main challenges

2.9. The amount of water needed in the future for public water supply (water provided by water companies) is being driven by four main challenges which will mean either less water is available for us to use or more water is needed. They are:

- **Drought resilience** – more water needs to be made available so our supplies last longer during severe drought events, those that occur once in every 500 years, so emergency measures are less likely to be needed.
- **Population growth** – an increase in population means more water is needed to supply customers and businesses
- **Climate change** – will reduce how much water is available from our water sources and when it is available, droughts will also become more common
- **Environmental protection and improvement** – we need to leave more water in the environment, reducing how much water we can take from some of our existing sources

2.10. We look at the first 3 of these factors in this section, and then environmental protection and improvement in section 4.

Drought resilience

2.11. Our March 2020 document setting out our preliminary water resource requirements for the South East[3] was based on planning for a severe drought once in every 500 years and, as a result, boosting the level of resilience of our water supplies. While some stakeholders considered this was unnecessary, there was broader consensus to support this move and since then it has been included as a requirement in the Government's National Infrastructure Strategy[4] and in the WRPG.

2.12. Since our March 2020 document we have carried out detailed work to understand the impact that more severe droughts will have on our water resources. We are considering a range of different rainfall scenarios which include droughts of different durations and intensities so that we understand how much water would be available from our sources under different drought conditions.

2.13. The use of 'stochastic' climate datasets is growing within water resources planning, driven by a need to consider the impact of droughts that have not happened in the past. Historically, water resources planning has been carried out based on assessing supply capability considering only droughts that have happened in the past. This use of the historical record gives climate datasets that water companies, regulators, and stakeholders can be confident in (being based on weather that has happened) but does not allow for a thorough exploration of impacts of droughts that could happen in the future.

2.14. Reliable historical records for rainfall and potential evapotranspiration (PET), which are two of the most important inputs to hydrological models, are generally no more than around 100 years long, and so for companies to confidently assess their supply capability under '1 in 500 year' drought requires a significant amount of statistical analysis of climatic drivers and historical records.

2.15. The use of the term 'stochastic' regarding climate datasets references the nature of rainfall and the way that these datasets are derived. Rainfall cannot be predicted based solely on climatological indicators and rainfall volumes are instead climate-driven, but partially random (i.e. it would not have been possible at the beginning of 1976 to determine how much rain would have fallen that year, or when). The climate datasets are derived using

[1] *https://www.wrse.org.uk/media/anbhm2cb/wrse-future-water-resource-requirements-march-2020-3.pdf*
[2] *https://www.wrse.org.uk/media/3h5p0dzo/future-water-resource-requirements-for-south-east-england-update-2021-final.pdf*
[3] *https://www.wrse.org.uk/media/anbhm2cb/wrse-future-water-resource-requirements-march-2020-3.pdf*
[4] *https://www.gov.uk/government/publications/national-infrastructure-strategy*

relationships between output variables (temperature, rainfall) and climate indicators (e.g. North Atlantic Oscillation (NAO), Sea Surface Temperature (SST)), along with 'random chance', to generate datasets which are statistically consistent with the historical baseline, but which represent different versions of what 'could' have happened.

2.16. The generation of stochastic climate datasets involves a significant amount of complex analysis involving climate science and statistics. For the regional planning process the climate datasets represent a total of 19,200 years of modelled data. This allows us to plan on the basis of not only what we have experienced in the past, but also what we are likely to experience in the future.

2.17. The amount of water we need in the future to provide this increased level of resilience is greater than our original projection because we are considering what a wider range of more severe droughts could mean. The way in which Drought Orders and Drought Permits are used within the plan, to help achieve a higher level of resilience to drought, has been subject to considerable feedback. Some stakeholders are keen to see these tools used to avoid increased investment in new resources while others want their use to be avoided altogether to help protect the environment. Our position is to rely as little as possible on Drought Orders and Drought Permits, particularly in sensitive areas. We have worked with the Environment Agency to review all tools that are currently available to water companies so that we understand the range of environmental risks. We will only include Drought Orders and Drought Permits in our plan which are agreed with the Environment Agency.

2.18. As part of our assessment of alternative water resource programmes we have tested scenarios comparing the cost impact of using or not using Drought Orders and Drought Permits.

2.19. Our assessment has told us that we will need to produce a further 625 million litres per day more water to make our supplies more resilient to severe droughts by 2040.

Population growth

2.20. Our methods for forecasting the future demand for water from a growing population are set out in our Demand Forecast Method Statement[5]. Household demand is calculated from population and property forecasts combined with per capita consumption (PCC) and per household consumption (PHC) forecasts.

Population and property forecasts

2.21. It is recognised that having robust evidence of population growth and changes in demographics is critical to developing a household demand forecast. Using different data sources results in a wide range of results with uncertainty increasing with time.

2.22. The WRPG emphasises the importance of using Local Plans as evidence in deriving a growth forecast and specifies that the forecast 'must not constrain planned growth by local councils and strategic housing developments'. Where an alternative source of data is used, for example beyond the planning period of the Local Plan, or where a Local Plan has not been published, the evidence used should be clearly set out and any assumptions clearly described. We followed this requirement but also considered additional projections to ensure we have included the most likely range of household demand growth up to the end of the century.

2.23. WRSE commissioned Edge Analytics to develop both population and property forecasts for all the WRZs in the region. They used the latest available Local Plan and Office for National Statistics (ONS) trend-based data, as well as other sources including those from the Greater London Authority (GLA). More detail on their methods is available in the report: Population & Property Forecasts - Methodology and Outcomes[6]. A separate forecast for the Oxford-Cambridge (OxCam) area was also produced to assess the

[5] https://www.wrse.org.uk/media/vuwpqxft/method-statement-demand-forecast-august-2021.pdf

[6] https://www.wrse.org.uk/media/isrfvms0/wrse_file_1346_wrse-population-property-forecast-methodology-draft-report.pdf

potential impact of this significant proposed housing plan within our housing growth scenarios.

2.24. From this work we produced forecasts for a wide range of scenarios, by using a combination of trend, housing-led (incorporating housing need, housing requirements and actual planned scenarios) and employment-led forecasts, to account for considerable uncertainty in the projections. Forecasts were produced under 19 main scenarios up to 2050 with three further projections (Principal, High and Low) for each scenario up to 2100. There are therefore 57 projections for each WRZ.

2.25. From the 57 projections (shown in Table 2.1), the minimum and maximum increase in total population at the WRSE level by 2050 are 2% and 26% respectively; the corresponding figures for 2100 are 5% and 52% respectively. A selection of these scenarios is shown graphically in Figure 2.1. The main difference in the Principal, High and Low projections is due to the assumed trajectory post 2050 which is mainly linked to the predicted level of net international migration.

Table 2.1: Range in WRSE Population forecasts

Measure	By 2050	By 2100	Projection
Minimum increase	2%	5%	ONS-18-Low-L
Maximum increase	26.3%	52%	Housing-Need-H
Average increase	17.2%	32.0%	All projections

2.26. Seeking to adopt the same growth forecast and additional growth scenarios across the region was not possible as different factors are driving differences in the upper and lower forecasts in different WRZs and it is important to take these local differences into account.

Figure 2.1: Population growth 2020-2100

2.27. The Housing Plan based projections have been developed using two approaches: a ‘top-down’ approach and a ‘bottom-up’ approach. The ‘top-down’ forecasts allocate growth based on location of existing housing stock, i.e. growth continues in locations where houses have already been built. The ‘bottom-up’ housing plan forecasts take account of areas or sites where housing is identified for delivery in the future, not just where it currently exists. WRSE has adopted ‘bottom-up’ figures for the housing plan values as they represent a more realistic view of the locations of new growth and allocate growth to WRZs more accurately.

2.28. There was also a decision to be made on whether the forecast is based on population or household properties (dwellings). Population growth, particularly household population growth, is likely to be the main driver behind future demand in most WRZs where demand is forecast on a PCC basis rather than a PHC basis. The rate of growth for new properties primarily impacts household occupancy which also has an impact on PCC, since average PCC typically decreases with an increase in average occupancy. Each company has also accounted for hidden and transient populations.

2.29. However, at WRZ level, there is considerable variation around this average with the minimum growth to 2100 ranging from -6% to 13% and the maximum growth from 16% to 46% for the same period. There is also a wide variation on which growth forecast produces the upper and lower boundaries of the range, with two scenarios producing the minimum forecast and five different scenarios providing the maximum forecast across the WRZs.

2.30. Based on data and recommendations from Edge Analytics and the WRPG, WRSE has selected to use the Housing Plan Principal (P) scenario as the baseline growth forecast.

2.31. It is hard, however, to predict exactly when, where and at what rate housing and population growth will happen, so we've looked at six different scenarios to help us develop our household demand forecast. These scenarios are set out in Table 2.2. Within our modelling we have therefore considered alternative forecast scenarios to account for the differences in the upper and lower forecasts between WRZs, as explained in the Edge Analytics report.

Table 2.2: List of growth scenarios per water resource zone

Number	Scenario	Notes
1	Housing-Plan-P (bottom-up)	Baseline Forecast
2	Maximum growth projection	
3	Median growth projection	
4	Minimum growth projection	
5	Completions-5Y-P projection	Unless it is covered by the one of the projections above
6	Housing-Need-H projection	Unless it is covered by one of the projections above

Per Capita/Household Consumption (PCC/PHC)

2.32. The second component of household demand is the level of consumption measured on either a per person (capita) or a per household basis.

2.33. Our method has been aligned with the approach taken on growth, and is based on a bottom-up method consistent with the WRPG that is appropriate to each company - depending on factors such as data availability and metering penetration.

2.34. Through our plan we have sought to align companies' policies, assumptions, assurance and framework for calculating PCC/PHC in order to have a broadly consistent method which is a step change from our previous regional plans.

2.35. The calculation of household demand is based on unconstrained demand (i.e. with no restrictions on water use such has temporary use bans) in a dry year. Restrictions are included in the options appraisal as drought options. This ensures there is no double counting of the benefit of these measures in reducing demand. We have also calculated demand in a 'normal year' for each WRZ.

2.36. Whilst companies have made commitments on reducing PCC in the long term, for the purposes of the baseline forecast only those measures which are in the current period (2020 to 2025), and therefore funded in the Price Review 2019 process, are included. This is consistent with the WRPG. All other potential reductions in PCC are included in the Options Appraisal assessment - as a range of demand management strategies - so that the selection of demand and supply-side options is based on the model outputs.

2.37. One key area which affects demand management is the extent to which external interventions outside of the control of the companies, including changes in government policy, will influence household consumption. This is important as if assumed reductions in consumption are not achieved, this could lead to an increased need for new resources. For example, studies have shown that consumption from white goods would significantly reduce if mandatory water labelling was introduced, and leakage from toilets, which is estimated to occur in around 5% of toilets, could also be minimised if a combination of amendments to current building regulations and practices were introduced. Therefore, whilst some limited interventions are included in our baseline, more ambitious/uncertain levels are in our demand management strategies, including those relying on Government interventions.

Water needed to meet future population growth

2.38. The above forecasts and range of scenarios allow us to project how much water could be needed to meet future population growth. The WRPG requires us to plan for the housing growth set out in local authority housing plans, but we also need to consider other factors including housing completion rates and the impact of net migration, in case the rate of growth is faster or slower than planned. The way people use water because of climate change is also considered.

2.39. The amount of water needed to supply the growing population is higher than we previously projected. The WRPG requires us to use local plan data as the basis of our growth forecast – this is at the higher end of the range of growth scenarios we have produced to date. However, all scenarios are considered within our plan to ensure we can adapt depending on the level of growth that actually occurs.

2.40. In terms of population growth, the projections range from a minimum and maximum increase in total population at the WRSE level by 2050 of 2% and 26% respectively; the corresponding figures for 2100 are 5% and 52% respectively. This means that population growth by 2100 could range from 0.7 million to 9.7 million more people within our region.

2.41. Given the uncertainty in the forecasts, we have considered how population growth could influence the amount of additional water we would need to input into our supplies across a range of adaptive pathways. The additional water we could need is set out in Table 2.3. From 2025 to 2040, when there is greater certainty as to the likely housing growth, our modelling for the emerging regional plan is based on the Housing Plan Principal (P) scenario.

2.42. From 2041 to 2060, where there is some uncertainty, the Housing Plan Principal (P) scenario is our central pathway but there is a high pathway taking maximum population growth and low pathway taking minimum housing growth. From 2061 to 2100, where there is greater uncertainty, we consider further future situations across a range growth scenarios.

2.43. Table 2.3 and Figure 2.2 show we will need to increase water supplies to meet future population growth by 2100 under all future possible situations. With maximum forecast population growth the increase in water could be as much as 1204Ml/d or as little as 38Ml/d with minimum population growth. For the central pathway based on our housing plan projection, we could see the need for 850 Ml/d of additional water by 2100.

Figure 2.2: Forecast increase/decrease from 2026 baseline in required Distribution Input up to 2100 resulting from population growth

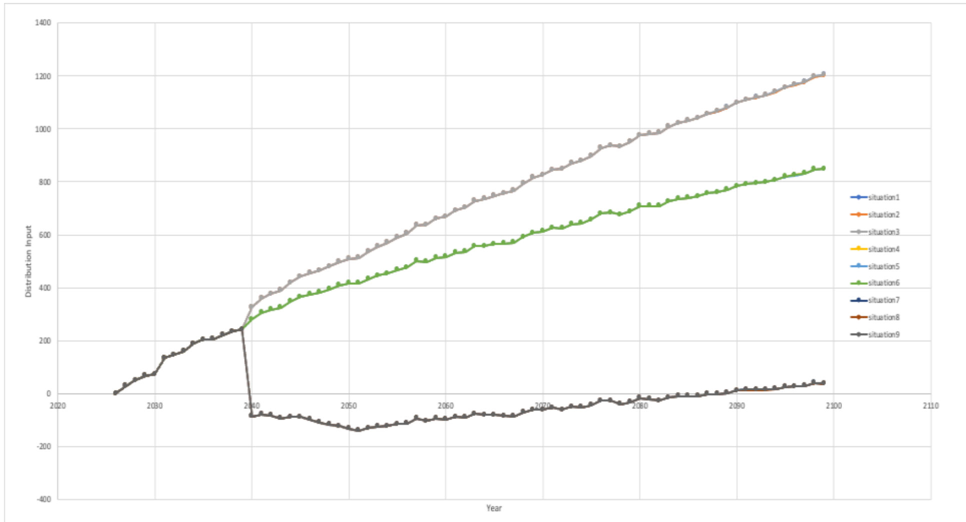


Table 2.3: Change in Distribution Input as a result of forecast population growth

	Distribution Input									
Year >>>>	2026	2040			2050			2100		
Situation	Base year forecast (Ml/d)	Forecast (Ml/d)	Increase from 2026 (Ml/d)	Increase as a % of the 2026	Forecast (Ml/d)	Increase from 2026 (Ml/d)	Increase as a % of the 2026	Forecast (Ml/d)	Increase from 2026 (Ml/d)	Increase as a % of the 2026
1	5,266	5,593	327	6%	5,775	508	10%	6,470	1,204	23%
2	5,266	5,593	327	6%	5,775	508	10%	6,469	1,203	23%
3	5,266	5,593	327	6%	5,775	508	10%	6,470	1,204	23%
4	5,266	5,546	280	5%	5,683	417	8%	6,115	849	16%
5	5,266	5,546	280	5%	5,683	417	8%	6,115	848	16%
6	5,266	5,546	280	5%	5,683	417	8%	6,115	849	16%
7	5,266	5,179	-87	-2%	5,134	-133	-3%	5,304	38	1%
8	5,266	5,179	-87	-2%	5,134	-133	-3%	5,303	37	1%
9	5,266	5,179	-87	-2%	5,134	-133	-3%	5,304	38	1%

2.44. Note that there are three sets of forecasts in Table 2.3, one as the basis for situations 1 to 3, one for situations 4 to 6, and one for situations 7 to 9. Figure 2.2 shows how Distribution Input could increase/decrease over the period up to 2100 across the 9 situations. There is little variation between the scenarios 1-3, 4-6 and 7-9, hence only three core pathways are shown. Further explanation of the use of these 9 situations in our adaptive planning is provided in section 5 of this Annex.

Climate Change

2.45. The process we have followed to calculate the impact climate change could have on the amount of water that is available in the future is set out in our Climate Change – Supply Side Method Statement[7].

2.46. We need to ensure that we include an appropriate allowance for the impact that climate change will have on supply capabilities in the period up to 2100.

[7] *https://www.wrse.org.uk/media/4midbziv/method-statement-climate-change-august-2021.pdf*

2.47. For WRMP19, water companies carried out the most comprehensive supply-side climate change assessment ever undertaken by the UK water industry. However, since these analyses have been conducted, the underlying data that was used has been updated, with the 'UKCP09' climate change projections being replaced with 'UKCP18' projections. Data from UKCP18[8] provides the most up to date climate change projections available for the UK, using the best climate models from the UK and around the world, and provides several datasets which can be used by the water industry to determine the range of outcomes that climate change may result in.

2.48. The Environment Agency has released new draft guidance associated with assessment of supply-side climate change impacts to incorporate guidance on using UKCP18 projections and on how to account for climate change impacts when considering '1 in 500-year' drought.

2.49. We have thoroughly explored the implications of this guidance to incorporate climate change in our Regional System Simulator model (see our separate Annex 4 for further detail on our model). This considers the impact of climate change on deployable output, that is the supply capability of a water supply system.

2.50. We developed new climate data sets to support our water resource planning. These provide a set of 400 time series for each location for the assessment of climatological drought risk across England and Wales for a baseline climate without climate change. The same stochastic model is now applied to all five regions of England and Wales and is an improved model compared to previous assessments for WRMP19. Within each region these data sets are spatially and temporally coherent, providing plausible scenarios of a wide range of possible drought conditions. This data provides inputs to hydrological, groundwater and water resources systems models for the assessment of baseline deployable outputs and risks of very low rainfall over durations from 3 months to several years. Further information can be found in the Regional Climate Data Tools Report (July 2020)[9].

2.51. Our assessment tells us that climate change is expected to make droughts more serious and common in the future. This is because we are likely to see lower rainfall levels during hotter, drier summers so less water will be available in the sources we rely upon for our supplies. The impact that climate change will have is uncertain. The extent of future climate change is as yet unknown and dependent on human actions now and in the future. Even if we were to know the level of future emissions, the impact that this would have on our supplies is still uncertain. As such we have included 28 climate change scenarios in our planning (see Climate Change – Supply Side Method Statement for more details[10]).

2.52. As with population growth, given the uncertainty in the forecasts, we have considered how climate change could impact our supplies across a range of adaptive pathways. The additional water we could need is set out in Table 2.4. For our emerging regional plan, up to 2060, we utilise the median forecast. From 2061 to 2100, where this is greater uncertainty a range of climate change scenarios is considered including median, upper and lower quartile climate change scenarios.

2.53. As evidenced by Table 2.4, by 2100 the median climate change impact could result in the need for an additional 230Ml/d of water being required.

[8] https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/download-data

[9] https://www.wrse.org.uk/media/ok1mtsoq/wrse_file_1338_regional-climate-data-tools.pdf

[10] https://www.wrse.org.uk/media/4midbziv/method-statement-climate-change-august-2021.pdf

Table 2.4: Impact of climate change on the supply forecast

	Impact of climate change on the supply forecast									
Year >>>>	**2026**	**2040**			**2060**			**2100**		
Situation	**Base year forecast (Ml/d)**	**Forecast (Ml/d)**	**Increase from 2026 median impact (Ml/d)**	**Increase as a % of the 2026 median impact**	**Forecast (Ml/d)**	**Increase from 2026 median impact (Ml/d)**	**Increase as a % of the 2026 median impact**	**Forecast (Ml/d)**	**Increase from 2026 median impact (Ml/d)**	**Increase as a % of the 2026 median impact**
Maximum cc impact	-212	-337	-243	259%	-475	-382	408%	-743	-649	693%
Upper quartile (cc06)	-139	-216	-122	130%	-306	-213	227%	-480	-386	412%
Median cc impact	-94	-144	-50	54%	-206	-112	120%	-324	-230	246%
Lower quartile (cc07)	-57	-83	11	-11%	-120	-27	28%	-190	-97	103%
Minimum cc impact	82	133	227	-242%	183	276	-295%	281	375	-400%

2.54. As noted above, for our emerging regional plan, up to 2060, we utilise the median forecast. From 2061 to 2100, where this is greater uncertainty a range of climate change scenarios is considered including median, upper quartile (cc06) and lower quartile (cc07) climate change scenarios.

3. The need to protect and improve the environment

Our approach

3.1. Our past approach to protecting the environment has been focused on what improvements are required in the next 5 to 15 years to deliver the improvements set out in the WINEP. Typically, this programme delivers schemes and seeks to investigate potential issues which might then feed into the next round of water company business plans.

3.2. The WINEP provides the actions required in the short-term to be compliant with environmental legislation. The process does not currently lend itself to considering a more collective longer-term approach as the approach doesn't account for potential landscape changes or the impact climate change might have on the availability of water in the future. For this reason, there is a need to use other approaches to provide the additional information required.

3.3. We have therefore developed an environmental ambition method to establish a series of alternative 'futures' which can be used to derive an adaptive regional plan and hence identify a series of pathways towards these different outcomes. Our approach has allowed us to map out issues and identify opportunities and schemes to deliver water resource and water quality benefits that can be put forward to the water companies and other sectors to improve the resilience of the environment against future scenarios.

3.4. Just as we take account of future population growth, the development of the environmental ambition allows us to take account of the future requirements of the environment; this allows more robust plans to be constructed. This is a step change in approach from previous plans. The current plan includes a series of three different scenarios that anticipate future levels of environmental protection, these all include greater levels of protection than current levels, which will help to move towards planning for proactive protection rather than retrospective remediation.

3.5. This new approach for regional planning was set out in the National Framework document and has evolved, as we have developed our plan. Our approach has sought to integrate existing, well-established process, with other indicators to provide a better longer-term view of the potential requirements of the environment. The approach has sought to blend these various approaches together, in order to generate plausible scenarios into the future to ensure the catchments are protected.

3.6. The Environment Agency (EA) has recently completed a longer-term environmental water needs assessment as part of the Water Resources National Framework, establishing the potential licence reductions required by 2050 to meet the Environmental Flow Indicators(EFI) so that a good ecological status is achieved or maintained. We have used this work to inform the environmental scenarios in our emerging plan.

3.7. The EFI is defined by an Abstraction Sensitivity Band (ASB) allocated to each waterbody. Four scenarios have been analysed:

- **Business as usual** (BAU): the same percentage of natural flows for the environment that currently applies continues for the future. Uneconomic waterbodies, where reducing abstraction would imply a significant investment, were initially discarded. However, an additional scenario (BAU+) including them has been subsequently incorporated.
- **Enhance**: a greater environmental protection for protected areas and Sites of Special Scientific Interest (SSSI) rivers and wetlands, and principal salmon and chalk rivers is achieved by applying the most restrictive ASB.
- **Adapt**: same ASB as BAU but a recovery to a lower standard in some heavily modified waterbodies is assumed.
- **Combine**: balances a greater environmental protection for protected areas, SSSI rivers and wetlands and principal salmon and chalk rivers with a view that good status (as defined under the Water Framework

Directive) cannot be achieved everywhere in a shifting climate. Hence, adopts the Enhance ASB with a lower recovery to the EFI in some heavily modified waterbodies.

3.8. In all cases, flow balance evolves as a proportion of natural flows as these are changed by the impacts of climate change.

3.9. We have analysed the impact of these scenarios on the supply-demand balance of our region's water resource zones by establishing the potential changes to deployable output to feed into the investment model.

3.10. Tables 3.1 and 3.2 present the modelled reductions in public water supply licences and abstractions respectively to fulfil the objectives of the different scenarios. The largest proposed reduction in abstraction corresponds to Thames Water followed by Affinity. Moving from the BAU scenario to the Enhance scenario would increase the reduction of abstraction required by 60% although there are differences between water companies, with Thames Water for instance only experiencing an increase in reduction of 14%.

Table 3.1: Required licence reductions in Ml/d by company and scenario

Water company	Current licences	BAU	ADAPT	BAU+	COMBINE	ENHANCE
Affinity Water	988	-275	-421	-426	-504	-511
Portsmouth Water	302	-84	-133	-134	-142	-143
South East Water	825	-232	-376	-377	-416	-414
Southern Water	1179	-320	-640	-645	-695	-698
SES Water	402	-12	-99	-101	-99	-99
Thames Water	4190	-824	-878	-939	-960	-1019
Other	93	-17	-41	-42	-46	-47
Total	**7979**	**-1765**	**-2587**	**-2664**	**-2862**	**-2931**

Table 3.2: Required abstraction reductions in Ml/d by company and scenario

Sector	Predicted abstraction	BAU	ADAPT	BAU+	COMBINE	ENHANCE
Affinity Water	732	-171	-250	-255	-275	-282
Portsmouth Water	154	-12	-42	-42	-48	-48
South East Water	430	-66	-154	-156	-161	-162
Southern Water	578	-78	-176	-181	-210	-213
SES Water	228	-3	-10	-12	-10	-12
Thames Water	2915	-448	-453	-512	-454	-510
Other	49	-5	-24	-24	-24	-24
Total	**5086**	**-783**	**-1109**	**-1181**	**-1183**	**-1251**

3.11. The largest reduction would be concentrated in the London, Colne and Upper Lee catchments areas (see Figure 3.1).

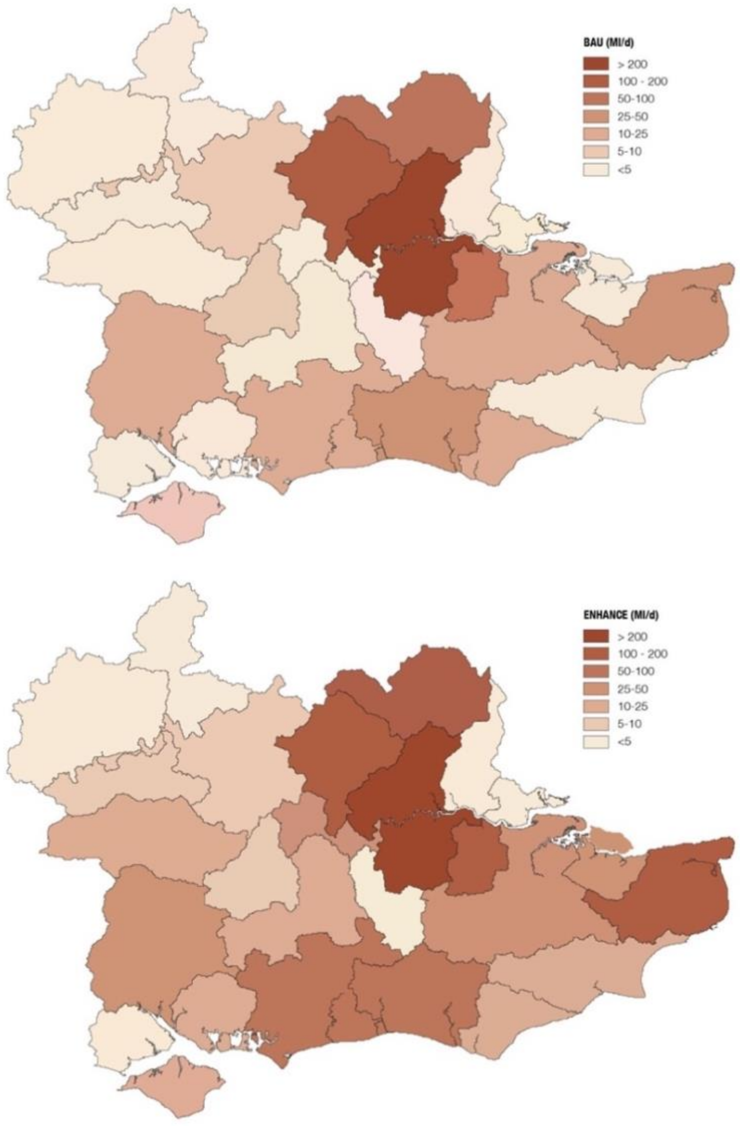
Our forecast

3.12. We now understand the impact the different scenarios will have on abstraction across the region and have used the WRSE investment model to identify the solutions that could make up the overall shortfall in water supplies that will occur, by when and at what cost to customers. This has helped us to determine the amount and phasing of any investment over the lifetime of the plan, and identify our environmental challenges.

3.13. Our plan approach allows us to adapt and respond to different scenarios in the future once we have greater certainty. As set out in Table 3.3, we have considered what the impact on water resources in the region would be from applying the BAU+ and Enhance scenarios. We have also introduced two further scenarios – Alternative and Central - based on the water companies' own investigations and assessments and developed in consultation with the Environment Agency.

3.14. We have used this range of scenarios to forecast how much additional water may be needed to replace unsustainable abstraction beyond 2025 (not including those already included in the WINEP).

Figure 3.1: Distribution and scale of required reductions in abstractions



Source: Mott MacDonald based on EA data

3.15. From the period 2025 to 2040, our emerging regional plan is based upon the Central forecast which we consider best reflects the level of environmental challenge and improvement that can be achieved within this period. From 2041 to 2060, our central path continues to be the Central forecast, but we consider our higher and lower paths respectively, the Enhance and Alternative scenarios. From 2061 to 2100 we continue to consider the Central, Enhance and Alternative scenarios across the nine pathways.

3.16. Overall, our emerging regional plan is showing us that the amount of water lost through abstraction reductions will increase significantly compared to previous WRMPs and mark a step-change in the level of environmental improvement that water companies are expected to deliver. We will continue to work on the levels of environmental improvement being considered in the regional plan through collaboration with companies and the Environment Agency as we develop our draft regional plan and beyond.

Table 3.3: Impact of environmental improvements on the supply forecast

	Impact of environmental improvements on the supply forecast									
Year >>>>	**2026**	**2040**			**2060**			**2100**		
Situation	**Base year forecast (Ml/d)**	**Forecast (Ml/d)**	**Increase from 2026 (Ml/d)**	**Increase as a % of the 2026**	**Forecast (Ml/d)**	**Increase from 2040 (Ml/d)**	**Increase as a % of the 2040**	**Forecast (Ml/d)**	**Increase from 2060 (Ml/d)**	**Increase as a % of the 2060**
Alternative (ADO)	0	-315	-315		-466	-151	48%	-466	0	0%
BAU+ (2050 Linear ADO)	0	-469	-469		-1121	-653	139%	-1121	0	0%
Central (ADO)	0	-305	-305		-498	-194	64%	-498	0	0%
Enhance (Linear ADO)	0	-507	-507		-1203	-696	137%	-1203	0	0%

4. Understanding the needs of other sectors

Our multi-sector approach

4.1. For the first time we are considering the future needs of sectors that have their own water supplies through our emerging regional plan. Details of our approach is set out in our multi-sector method statement[11].

4.2. To develop a regional assessment of the future water requirements we have sought to understand how much water is required for the public water supply system and the other sectors over the planning period, and how much water will be available from the environment to support these requirements. The difference between the requirements and the availability provides an indication of the scale of the challenge in the future.

4.3. To support our work, we have established a multi-sector stakeholder group. This comprises representatives from the multi-sector which is defined as the industries which have a licence, or an equivalent legal permission, to abstract water from the environment in order to support their manufacturing or specific activity requirements.

4.4. Just like the water industry, these multi-sector groups in the South East of England abstract water from the environment. The National Framework set out the volumes of water that are currently abstracted through a number, but not all, of these abstractions. It has been assumed that the current abstraction rates that have been reported through the abstraction returns represent the current requirements of the industries. However, these abstractions do not represent all the abstractions in a catchment. Industries such as trickle irrigators and navigation authorities, such as the Canals and Rivers Trust also abstract water from the environment; they are not currently included in the National Framework Assessment report. Therefore, the volumes of water reported in the National Framework underestimate the amount of water, outside public water supply, that is currently abstracted each day and how much extra water may be needed in the future.

4.5. Building on the work undertaken for the National Framework, we have updated the forecasts by working with the key sectors and using information from non-household demand forecasts to understand the range of potential future requirements for each sector in the region.

4.6. The current water requirement of the other sectors is based on abstraction returns and the voluntary returns of those who are currently exempt. Some of these abstractors exempt from licensing will be brought under the abstraction licence regime in the future, this includes sectors and organisations such as the Canal and River Trust and trickle irrigation users.

4.7. The anticipated growth rates of these sectors have been moderated, where possible, with the non-household growth forecast methodology used by water companies that provide public water supplies. Where these forecasts do not exist then additional expert advice has been sought through the WRSE multi-sector group.

4.8. Through the process above (set out in more detail in our Method Statement) and by working with the multi-sector group, we have generated a series of future requirements for the key sectors in the region.

4.9. Typically, these other sectors' availability of water during extreme drought or low flow events has been assessed through a vulnerability assessment using the river flow and groundwater levels based on the stochastic sequences[12]. If the water available for the individual sources is insufficient to meet the current and or future requirements of a particular sector then an assessment of the shortfall between the requirement and the availability has been undertaken and calculated as the net additional water required for the sector. This net additional water requirement for the sector has been calculated and aggregated with the net requirements for other sectors and assigned to the appropriate water resource zone.

[11] *https://www.wrse.org.uk/media/3rxnyout/method-statement-multi-sector-approach-nov-2021.pdf*

[12] *https://www.wrse.org.uk/media/v3op3gqf/method-statement-stochastic-datasets-august-2021.pdf*

4.10. The requirements of each water resource zone have been taken into the investment model which has been used to help determine a suitable portfolio of options, including multi-sector options, that will meet the requirements of the sectors but also improve the overall resilience of the environment and non-public water supply sector.

4.11. As well as looking at demand within these sectors, we have also looked at the potential availability of water from their own abstractions.

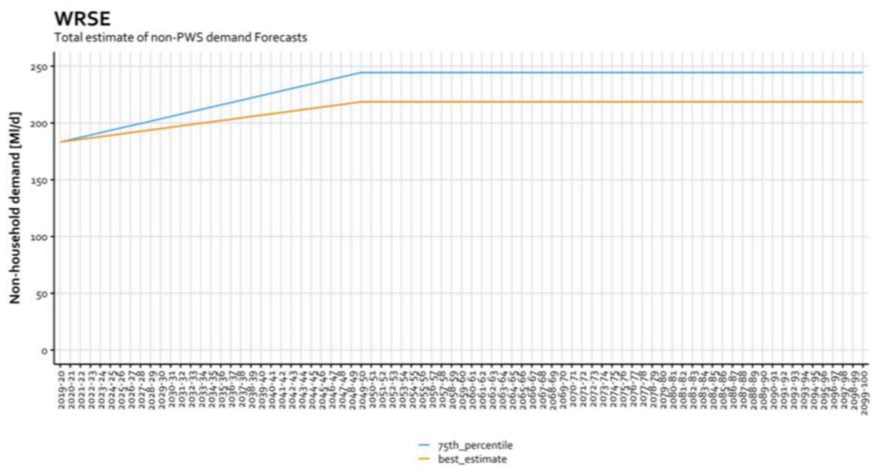
4.12. From the assessment of future needs and the availability of water we have been able to define a range of future requirements. Within the assessment we have undertaken, an iterative process to establish the future resilience that each sector wants to achieve, has included a consideration of the costs associated with achieving different levels of resilience.

Non-household demand from non-public water supply

4.13. As set out above, forecasting demand from the non-public water supply sector is considerably more challenging given the lack of data. Whilst the impact on overall demand is relatively small, at a current level of around 150 million litres per day in comparison to an overall demand of up to 6 billion litres per day in the public water supply (PWS) sector, the WRSE member companies are working together with the Environment Agency and other stakeholders to better understand the locations and volumes associated with non-public consumptive abstraction of water, and in particular any future changes to permitted direct abstraction. We are also working to identify if abstractors are more likely to use public supplies in future, for example due to climate change.

4.14. Taking forward the work started by Defra and the Environment Agency, we classified abstractions into sectors such as spray irrigation and power generation. The forecast is shown in Figure 4.1.

Figure 4.1: Non-public water supply forecast



4.15. By 2025, the start of our planning period, we expect other sectors to be using 190 million litres per day. By 2050 this is projected to increase to 278 million litres per day. Beyond 2050 the needs of other users are less clear. Table 4.1 below shows projected demand in the future if we follow a linear trend through to 2100.

4.16. We have worked with the other sectors to understand their future water needs. The sectors that have projected an increase in their future water needs are paper and pulp, and energy. An increase in water needed for wetlands has also been identified and is included within the 'other' category. The Canal and River Trust (CRT) currently uses 414 Ml/day of water and has 350 trading arrangements in place. This water is non-consumptive and CRT did not identify additional water requirements as navigation would be prohibited in extreme drought events.

4.17. We requested that stakeholders identify any specific water needs through our Engagement HQ website and this led to some specific point needs being identified related to canal water supply (not managed by the CRT), paper and pulp, conservation and agriculture. These needs, totalling 70Ml/d, are considered additional to the projections set out in Table 4.1 below.

4.18. Not all the additional water needed by other sectors needs to be found through the regional plan, as some can be capable of being met through the use of existing licences and by using water more efficiently by other sectors. Our draft regional plan will consider how to make these sectors more resilient to drought and other events, so their supplies are less likely to fail. This could require additional water to be identified in the regional plan than currently shown in our emerging plan and delivered through options that benefit multiple parties.

4.19. We will continue to work with the multi-sector stakeholder group to improve understanding of the requirements of these sectors over the planning horizon.

Table 4.1: The future needs of other sectors in the South East using a linear trend forecast (Ml/day)

Sector	2025	2030	2040	2050	2070	2100
Agriculture (non spray irrigation)	16.16	16.28	16.52	16.77	17.26	18.00
Spray irrigation	29.07	31.01	34.95	38.89	46.74	58.53
Horticulture including trickle irrigation	32.01	33.73	38.04	42.35	50.63	63.16
Chemicals	1.81	1.87	2.00	2.13	2.39	2.77
Food and drink	0.70	0.72	0.78	0.84	0.95	1.11
Minerals and extraction	1.79	1.77	1.72	1.67	1.58	1.44
Navigation	0.01	0.01	0.01	0.01	0.01	0.01
Paper and Pulp	33.02	53.67	54.96	56.26	58.85	62.73
Power	29.23	68.00	68.00	68.00	68.00	68.00
Other	45.75	51.65	51.44	51.24	50.83	50.23
Total	**189.54**	**258.70**	**268.43**	**278.15**	**297.23**	**325.98**

5. How we are planning for an uncertain future - our adaptive plan

5.1. Water resource plans have traditionally always considered a range of potential futures, but the published WRMPs identified a single forecast future which formed the basis for identifying the proposals necessary to balance customer demand and available supplies. This 'central forecast' included 'headroom' (an allowance for uncertainty and risk) and was used as the basis for the whole of the plan period (normally a 25 year period).

5.2. The range of potential futures and challenges that we face is significant, and this requires a different approach.

Problem characterisation

5.3. Water resources planning uses a risk-based planning approach. The tools you develop and methods you employ to identify an overall best value solution should be commensurate with the risks in your planning area. In order to establish the level of risk, we have taken the base data we have gathered and carried out an assessment known as problem characterisation.

5.4. Problem characterisation enables us to examine the severity of any potential planning problems and the potential complexity of solution to those problems at WRZ-level. By combining these elements, we can establish an overall High, Medium, Low risk level for each zone, and go on to consider which tools are fit for purpose to meet those risks.

5.5. There are a range of risk levels identified at individual WRZ level. We consider that taken together at a regional scale, the overall risk for the South East of England to be high.

5.6. The UKWIR Decision Making Process guidance describes decision-making tools and supporting methods available from the simple to the complex, cost-based to full multi-metric, system simulated adaptive planning. With WRSE assessing its level of risk as high, UKWIR Guidance recommends that we consider the use of extended or complex risk-based techniques to enable a thorough analysis of the planning problem. The decision support tools we have developed are specifically designed to respond to this.

5.7. A detailed explanation of how we are developing our regional plan is set out in our separate Annex 4.

5.8. Set out below is an explanation of our adaptive planning approach.

Adaptive planning overview

5.9. WRSE has chosen to develop an adaptive plan as a result, which means the options that are ultimately chosen will be the ones that best meet a wide range of possible futures. This adaptive planning approach is promoted by the National Framework and the WRPG.

5.10. The options identified for development in the first fifteen years of the plan (to 2040) in particular, need to be the optimum schemes capable of meeting the full range of potential futures the region faces to 2060, and on to 2100.

5.11. We do this through a five step process:

- Step 1 – Define possible futures – population growth, climate change, environmental ambition
- Step 2 – Generate futures – combining the scenarios and creating a spread of possible future supply-demand balances
- Step 3 – Choose single pathways for the investment model
- Steps 4 and 5 – choose branched pathways (decision trees) that enable the plan to adapt at pre-determined points.

Defining possible future scenarios

5.12. Sections 1 to 4 of this Annex have set out the range of information gathered and generated as part of the preparation of the emerging regional plan. This includes information on a wide range of factors affecting future supplies and resource demands, including population growth, climate change and environmental policies and aspirations.

5.13. From the information gathering and data generation we have undertaken, we have devised:

- 6 different population growth scenarios
- 28 climate change scenarios, and
- 5 different environmental scenarios

5.14. We clearly do not know how these different scenarios may combine in the future, and there is therefore considerable uncertainty and a wide range of potential future challenges that we need to plan for. We will continue to monitor and update these scenarios over future iterations of the regional plan, but we need to plan now for the full range of potential futures we face. This will enable us to ensure that we maintain sufficiently resilient public water supplies for customers and multi-sector users, in an environmentally acceptable and responsible way.

Generating futures from these scenarios

5.15. To ensure that the full range of potential future challenges is planned for, we combine the 6 population growth, 28 climate change and 5 environmental scenarios together in differing combinations.

5.16. This results in a total of 870 different potential future water requirements, covering the full range of challenges that we face. Whilst these 870 futures are formed from different combinations of the individual scenarios, these individual combinations can give very similar results to other futures.

5.17. We plot each of these 870 futures under each of our four planning scenarios to demonstrate how, without any proposals we may make in the regional plan, the forecast deficits in available supplies change over time, under each of the potential futures. The range between the forecasts is significant, covering approximately 3,200Ml/d.

5.18. These plots cover the different planning scenarios required under the WRPG – Normal Year Annual Average (NYAA), Dry Year Annual Average (DYAA), Dry Year Critical Period (DYCP), and for different drought conditions - 1:100 year, and given the need to increase resilience to more severe droughts for the regional plan, the 1:500 year drought. Further information on these is set out on Sections 5.46 to 5.56 of this Annex.

5.19. Plots for the whole of the South East region are shown for each of the planning scenarios in Figures 5.1 to 5.4.

5.20. The plots show in graphical format the wide range of potential impacts on the supply demand balance under the 870 potential futures. Each of the plots, although different, is consistent in what it shows – as in the early part of the planning period the lines are relatively closely grouped, as there is less variability in the forecasts in the short term. However, by the middle of the planning period the spread between the lines increases, as the range of potential futures, and the corresponding impacts on the supply demand balance increases. By the end of the planning period the range between the most challenging and least challenging future is very significant, amounting to thousands of megalitres a day difference between the forecast futures.

5.21. It is therefore not only the magnitude of the individual potential future challenges, but also the range between them and how this could change over time, which drives investment choices in the regional plan.

5.22. The regional plan investment model is used to develop plans which can cater for the full range of futures over the whole of the planning period. This is achieved by selecting single pathways from the 870 available (example shown as the yellow line in the figures below).

Figure 5.1: Normal Year Annual Average (NYAA) plot of potential futures

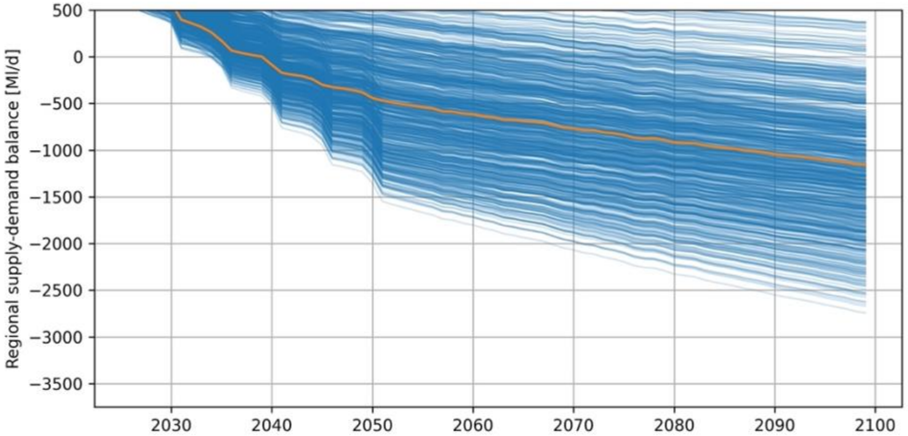


Figure 5.2: 1:100 Dry Year Annual Average (DYAA) plot of potential futures

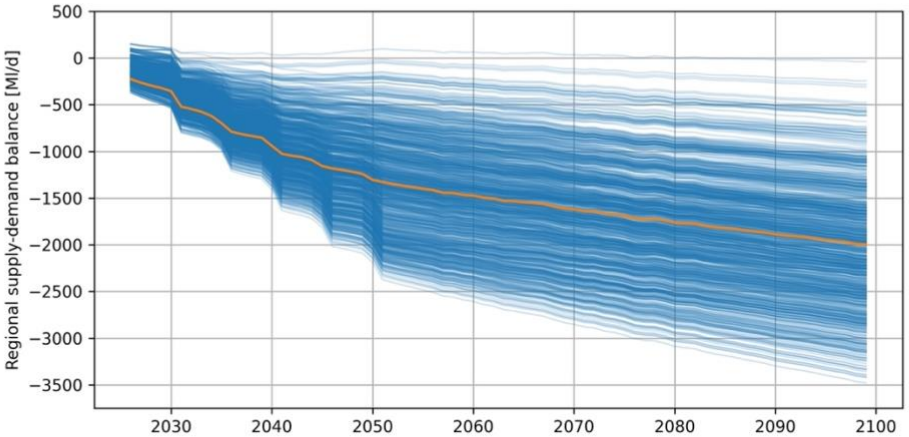


Figure 5.3: 1:500 Dry Year Critical Period (DYCP) plot of potential futures

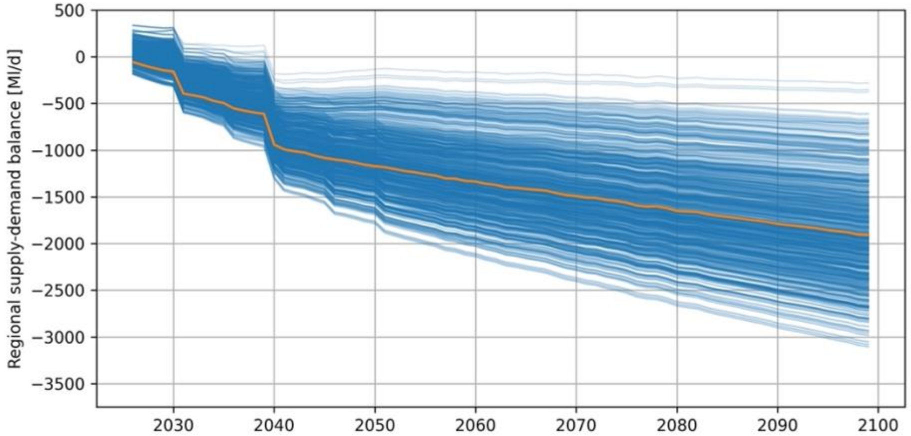
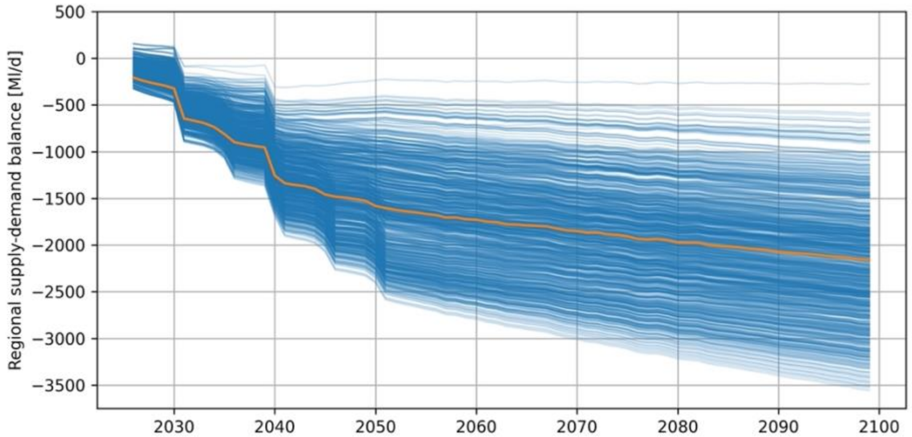


Figure 5.4: 1:500 Dry Year Annual Average (DYAA) plot of potential futures



5.23. The model ensures that options selected are adaptable to different futures, and so investment decisions are made on a 'least regrets' basis – i.e. the model initially selects options which are needed to meet initial challenges, without precluding being able to meet challenges later on'. This is in line with the WRPG and Ofwat's approach to long-term strategy development.

5.24. A wide range of interventions are selected in the regional plan from saving water, trading, multisector, within region transfers, recycling water, inter-regional transfers as well as developing reservoirs.

5.25. We can use the investment model runs to identify differentials between the branches, including how the types of solutions and schemes that the model selects changes, as the scale of future challenges increases.

Choose single pathways for the investment model

5.26. Each of the selected single pathways is input to the investment model which is run to allow it to select the optimal least cost water resource programme for each pathway. This is the combination of demand management strategies and new resource development options that provide the required amount of water for the least investment.

5.27. A series of model runs are undertaken for different single pathways, demonstrating how the selection of options would change over time, according to the scale of the challenges that it is being asked to solve for each pathway. The greater the challenge, the greater the level of demand management and new resource development the model must select as a result. We have completed hundreds of single pathway investment model runs. These have demonstrated some clear core solutions and several solutions which are dependent on key policies or scheme costs and benefits.

5.28. Single pathway runs are helpful for explanatory purposes, but they do not generate efficient plans across a wide range of challenges. Typically, they produce efficient plans for the situation that is being tested, but soon become inefficient or inadequate plans when considering a more diverse and wider set of challenges; hence the need to use adaptive plans for situations which are quite diverse in their nature.

Choose branched pathways (decision trees) for the investment model

5.29. The single pathway runs and the key policy decision points allow us to construct the adaptive plan branches. The branch points are fixed to provide key decision points for the regional plan. The plan sets out the investments required each year to meet the challenges in the branches (each branch represents a more challenging position).

5.30. For WRSE these branch points have been set at 2040 (drought resilience policy) and 2060 (environmental ambition). In this way, the model is being focused on achieving the WRSE key policy objectives by fixed points in time, but there remains flexibility in the model to choose different combinations of options to achieve them. 15 years has been used before the first branch point as this represents the lead time for larger strategic schemes – decisions need to be made now if they are to be available within that period.

5.31. For the first 15 years, from 2025 to 2040, we have chosen the pathway (the root branch) which is most likely, based on the current available evidence, from the range of combined population growth, climate change and environmental scenarios. Options selected in this root branch up to 2040 are the optimum (least cost) required to meet all of the branches beyond 2040. Uncertainty in this period is included within target headroom.

5.32. These investment decisions are resilient to whichever of the pathways are selected – so called 'no regret' decisions. The supply requirements in the first 15 years of the plan are significantly affected by the timing of achieving certain polices, for leakage reduction; drought resilience, water efficiency, bulk supplies and preparation for the final decision on the regional environmental destination drive the choices in the first 15 years of the plan. **The plan is policy driven in the initial 15 year period.**

5.33. From 2040, the plan splits into three alternative pathways that cover a wider range of scenarios to 2060. This gives us confidence that the options chosen in the first 15 years are the right ones for the future, and show us when we might need to move to a different pathway and what options would then be required. The choice of how much and how fast the implementation of the environmental destination is delivered is key to selecting which branch of the regional plan is followed after 2040, and so the three branches to 2060 represent increasingly challenging circumstances as we meet the range of various environmental ambitions. **The plan is driven by choices in the 2040-2060 period.**

5.34. From 2060 to 2100 the three potential plan pathways split again, representing 9 potential futures over that period, covering a wide range of potential future challenges that we expect to face. From 2060 onwards, the plan is being driven by the longer-term forecasts following the different policies being implemented in the previous 35 years. There are a considerable range of uncertainties in the forecasts, and the final set of 9 branches to 2100 set out the additional investments needed as a result. **The plan is driven by these uncertainties in the 2060-2100 period.**

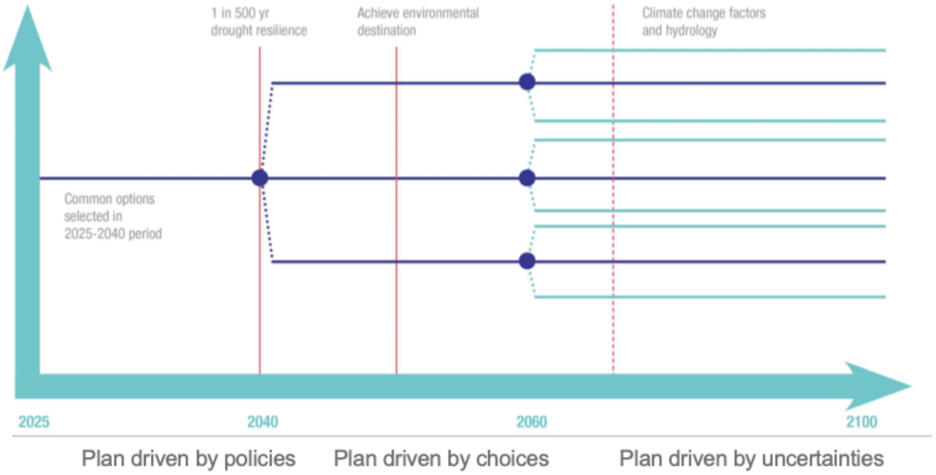
5.35. This is illustrated in Figure 5.5.

Our selected pathways (decision tree) for the investment model

5.36. Our choices for the first single pathway to 2040, the three branches to 2040 and the nine branches to 2100 have been influenced by the policy and other requirements that we are planning to meet, and the range of challenges and futures we need to plan for. In this way, the model is being focused on achieving the WRSE key policy objectives by fixed points in time, but there remains flexibility in the model to choose different combinations of options to achieve them.

5.37. WRSE recognises the significance of the decision making around these pathways and branches, as ultimately this drives the selection of options in the investment modelling. However, the investment model optimises option selection to generate an adaptive investment plan across the range of future situations. The selection of the root and branches is to ensure that the plan can adapt to the full range of potential challenges in the region in the future.

Figure 5.5: Illustration of model pathways



5.38. The future challenges have been generated by combining different discrete forecasts of growth, climate change and environmental ambition together. This combination of the discrete forecasts set out a wide range of supply demand balances, over 870 for each planning scenario.

5.39. These combinations of discrete forecasts describe the overall supply demand balances. Whilst each pathway is described by a combination of discrete forecasts, many of the pathways are remarkably similar. What this means is that whilst a single pathway or branch has been selected, there are several other combinations of forecasts that could produce a similar supply demand balance to the one described in the plan. It should also be noted that the environmental ambition scenarios not only describe the outcome associated with a particular scenario, but each scenario will have an associated implementation profile. For the emerging plan we have assumed that implementation of environmental ambition will take place over numerous years.

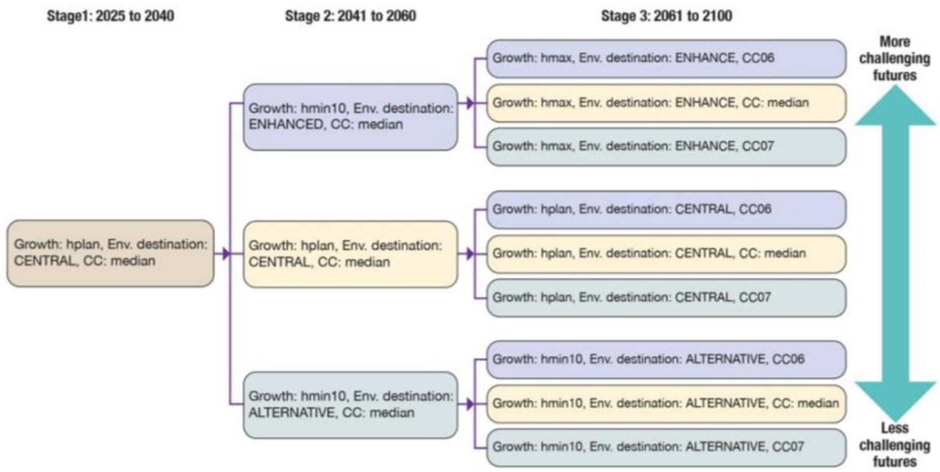
5.40. WRSE has undertaken investment model runs using various iterations of branches and trees, to determine what it considers to be the most appropriate to select as the basis for the regional plan. These have been tested and assessed by the individual companies, and with the environmental regulators, which is particularly relevant given the degree of influence that the selected level of environmental ambition has on the regional plan.

5.41. This testing and review process has been undertaken on an iterative basis, enabling the impacts on investment model option selection to be understood at each stage of the process. From this work, WRSE has been able to assess the scale of supply demand balance deficits arising from some of the more challenging climate change, population growth and environmental destination scenarios. For the more extreme scenarios, this includes testing the extent to which there are sufficient options available to overcome supply demand deficits, and/or whether some options considered to be potentially environmentally damaging have to be selected, in order to meet the scale of deficit forecast.

5.42. Arising from all of this work, WRSE has selected a 'root and branch' tree as the base forecast for its regional plan investment modelling. This incorporates what WRSE considers to be the most likely range of environmental futures that the region is facing, as illustrated in Figure 5.6.

5.43. The root branch (2025-2040) has been based on the housing plan growth (compliant with guidance), median climate change and a glidepath of environmental ambition that allows implementation of abstraction reductions over the interim years before finalising the future environmental outcomes in the next set of branches. This generates a root branch which is central to the range of challenges that we could experience in the south east in the future, and is one that we consider is the most appropriate and a robust basis for our emerging plan.

Figure 5.6 Illustration of scenarios underpinning selected root and branch



5.44. The next three branches seek to cover the range of potential environmental ambition. The enhance and BAU+ scenarios, which are derived from the National Framework scenarios, have the greatest impact on the supply forecasts. These therefore define the most challenging scenarios along with the maximum housing growth scenario and median climate change impacts. The central branch continues with the root branch scenario whilst the least challenging branch uses a low growth forecast, a lower regional environmental ambition forecast (alternative) and medium climate change. These three branches help define the range of potential challenges that the region could experience in the future.

5.45. The final set of branches focus on how climate change could continue to impact of the future availability of water. Like the other branches we have selected a range of scenarios to characterise the potential spread of future challenges, whilst trying to avoid planning for the absolute extremes of the combinations of discrete scenarios. Inspection of this root and branch construction show a good range of coverage of the potential futures. This ensures that these branches are realistic and reasonable alternatives that characterise the range of potential challenges in the future. Likewise, based on this root and branch tree, the adaptive plan can adapt in the future by ensuring the choices that are made at the beginning of the plan can also be effective for the challenges in the future.

What these selected pathways mean for the supply demand balance

5.46. We produce supply demand balance plots for the selected root and branches, at individual WRZ level, which can be aggregated at Company and regional level. These plots identify how the scale of supply demand balance challenges change, according to the different branches in the selected tree, from the more challenging to less challenging futures that we face.

5.47. These plots cover the different planning scenarios required under the WRPG – Normal Year Annual Average (NYAA), Dry Year Annual Average (DYAA), Dry year Critical Period (DYCP), and for different drought conditions - 1:100 year, and importantly for the regional plan given the need to increase resilience to more severe droughts, the 1:500 year drought. Plots can be provided at WRZ, company and regional level. When selecting schemes to solve for the future challenges all four planning scenarios, normal year to severe droughts are used to when selecting options to ensure that the solutions selected can meet the anticipated deficits across all the scenarios to provide more efficient solutions. The four planning scenarios also provide utilisation profiles across the full planning challenge rather than a utilisation profile focussed on the severe drought only.

5.48. We have provided forecast summaries below at the regional level for each of these planning scenarios. These highlight that the South East region is facing significant reductions in the supply demand balance because of the potential futures we face. The plots show how the reductions change under the differing roots and branches, for each of the NYAA, 1:100 DYAA, 1:500 DYCP and 1:500 DYAA planning scenarios. These are the forecast deficits which the investment model is seeking to derive the optimum solution for. In total there are 148 planning problems across the South East that the investment model seeks solutions to for every year of the planning horizon. So, in a 75 year plan there is a total of 11,100 supply demand balance problems which are solved.

Normal Year Annual Average (NYAA)

5.49. As the name suggests this planning scenario represents the supply demand balances expected to be seen in the future depending on climate change, population growth and environmental ambition. The normal year represents an event which should occur, on average, every other year. This planning scenario is used to ensure that the solutions selected in the regional plan can contribute to the challenges the region faces in a normal year as well the more severe droughts. This scenario also indicates how much a solution would be utilised under these more extreme

5.50. As can be seen from the plot in Figure 5.7, under NYAA the region starts in surplus but is forecast to be in deficit by 2040 under the more challenging futures, with deficits forecast to increase to 2,500Ml/d by 2100 under the most challenging future.

Figure 5.7: Supply demand balance plot for South East region under NYAA

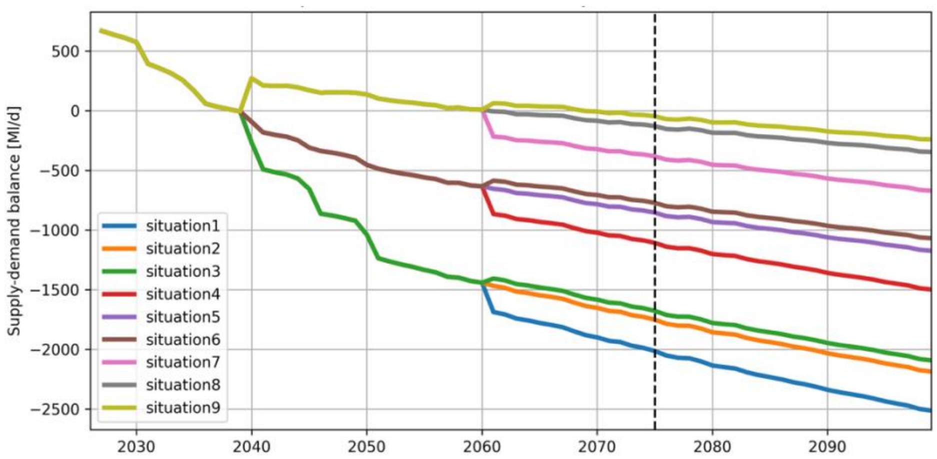


Table 5.1: Supply demand balance for South East region under NYAA

	2026	2039	2040	2060	2061	2074	2099
Sit 1*	708.99	1.01	-259.27	-1414.58	-1661.49	-1961.06	-2486.94
Sit 2	708.99	1.01	-259.27	-1414.58	-1442.06	-1701.46	-2160.10
Sit 3	708.99	1.01	-259.27	-1414.58	-1380.62	-1628.77	-2065.77
Sit 4	708.99	1.01	-86.59	-616.42	-849.12	-1069.38	-1481.05
Sit 5	708.99	1.01	-86.59	-616.42	-637.54	-819.07	-1156.24
Sit 6	708.99	1.01	-86.59	-616.42	-569.08	-738.07	-1051.12
Sit 7	708.99	1.01	278.33	20.48	-206.29	-355.28	-659.01
Sit 8	708.99	1.01	278.33	20.48	5.30	-104.97	-334.20
Sit 9	708.99	1.01	278.33	20.48	73.75	-23.97	-229.09

*Sit = situation

Dry Year Annual Average (DYAA) 1:100

5.51. The dry year annual average planning scenario represents an event which would be experienced once in a hundred years and is similar to some of the historic droughts experienced. The root and branches in the figure below are derived from the same combination of discrete forecasts that are used across all of the planning scenarios. Figure 5.8 shows the range of planning challenges we would expect.

5.52. Table 5.2 summarises the potential deficits that could occur across the South East given the discrete combinations of the growth, climate change and environmental ambition. These challenges are more severe than the normal year planning challenge but not as severe as the 1:500 year planning challenges. In the most challenging situation (situation 1) the anticipated deficits by the turn of the century could be as great as -3200 Ml/d, whilst the least challenging situation (situation 9) could experience supply shortfalls as much as -1100 Ml/d by the turn of the century.

Figure 5.8: Supply demand balance plot for South East region under DYAA 1:100 drought

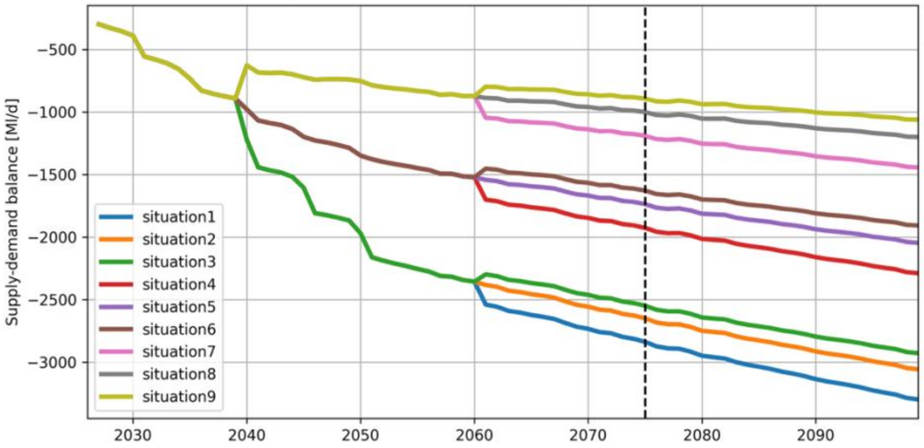


Table 5.2: Supply demand balance for South East region under DYAA 1:100

	2026	2039	2040	2060	2061	2074	2099
Sit 1	-257.9	-884.4	-1212.3	-2328.8	-2512.5	-2785.8	-3271.1
Sit 2	-257.9	-884.4	-1212.3	-2328.8	-2355.1	-2599.7	-3029.5
Sit 3	-257.9	-884.4	-1212.3	-2328.8	-2270.6	-2500.3	-2900.6
Sit 4	-257.9	-884.4	-971.5	-1503.8	-1683.2	-1888.4	-2270.8
Sit 5	-257.9	-884.4	-971.5	-1503.8	-1524.6	-1700.7	-2027.8
Sit 6	-257.9	-884.4	-971.5	-1503.8	-1434.5	-1594.2	-1889.5
Sit 7	-257.9	-884.4	-619.6	-861.1	-1034.2	-1164.0	-1431.3
Sit 8	-257.9	-884.4	-619.6	-861.1	-875.6	-976.4	-1187.8
Sit 9	-257.9	-884.4	-619.6	-861.1	-785.5	-869.8	-1049.5

Dry Year Critical Period (DYCP) 1:500

5.53. The 1:500 year planning scenarios represent the new drought resilience standards across the region. There are two 1:500 year planning scenarios that we look at the annual average scenario and the peak summer demand scenarios. These droughts provide a far greater challenge that the normal year planning scenarios.

5.54. As can be seen from Table 5.3 and the plot in Figure 5.9, under 1:500 DYCP the range of deficits could be as little as -834 Ml/d to as much as -2800 Ml/d. This planning scenario is unique, in so much that you would normally expect to see greater deficits in the critical peak time than in the annual average condition. The reason why this is not the case comes down to how the environmental ambition scenarios typically have a far bigger impact on the annual average figures, as they curb the total amount of water abstracted over the year rather than the amount of water that is abstracted to meet summer peak demand for water. If the abstraction scenarios change and are deemed to affect the peak summer abstraction as much as the annual abstraction, then the deficits would increase across the region.

Figure 5.9: Supply demand balance plot for South East region under DYCP 1:500 drought

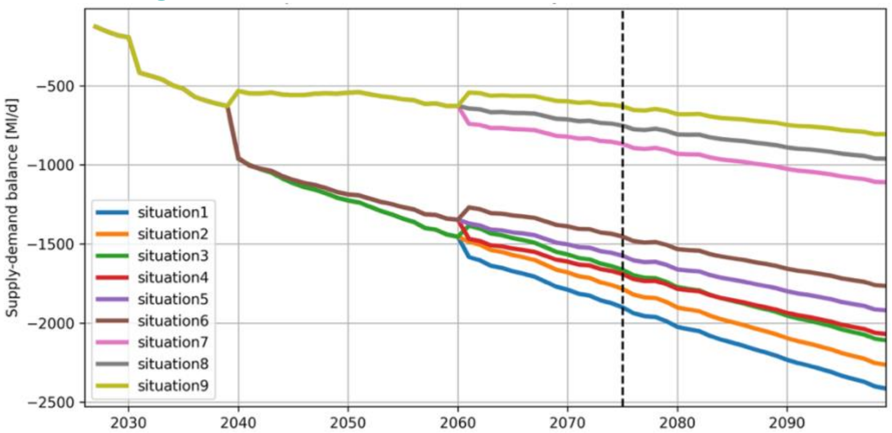


Table 5.3: Supply demand balance for South East region under DYCP 1:500

	2026	2039	2040	2060	2061	2074	2099
Sit 1	-89.2	-645.7	-1135.8	-1883.9	-2011.9	-2303.7	-2842.4
Sit 2	-89.2	-645.7	-1135.8	-1883.9	-1914.9	-2188.9	-2693.4
Sit 3	-89.2	-645.7	-1135.8	-1883.9	-1813.9	-2069.4	-2538.2
Sit 4	-89.2	-645.7	-974.2	-1369.5	-1490.4	-1693.6	-2091.8
Sit 5	-89.2	-645.7	-974.2	-1369.5	-1393.4	-1578.8	-1942.8
Sit 6	-89.2	-645.7	-974.2	-1369.5	-1292.4	-1459.3	-1787.7
Sit 7	-89.2	-645.7	-550.5	-656.3	-769.8	-883.3	-1138.9
Sit 8	-89.2	-645.7	-550.5	-656.3	-672.8	-768.5	-989.9
Sit 9	-89.2	-645.7	-550.5	-656.3	-571.8	-649.0	-834.8

Dry Year Annual Average (DYAA) 1:500

5.55. The 1:500 year DYAA planning challenge is the most severe in the region and is a key driver for future interventions in the South East. In this planning scenario the full extent of the abstraction restrictions impact on the sources and the future availability of sources.

5.56. 2040 is the date we have set for meeting the 1:500 requirement, and as can be seen from Table 5.4 and the plot in Figure 5.10, the ranges of challenges in the region can vary from –1200 Ml/d to over –3300 Ml/d. Not only are the magnitude of the challenges significant, so is the range that the regional plan must be able to adapt to, ensuring that the options selected in the core branch are able to put in place schemes that work well across the range of future challenges.

Figure 5.10: Supply demand balance plot for South East region under DYAA 1:500 drought

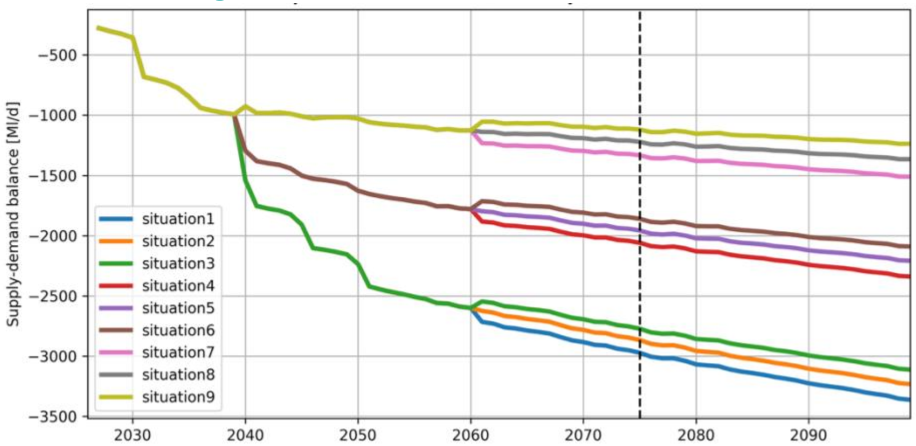


Table 5.4: Supply demand balance for South East region under DYAA 1:500

	2026	2039	2040	2060	2061	2074	2099
Sit 1	-239.9	-986.0	-1531.5	-2571.7	-2687.3	-2922.4	-3334.0
Sit 2	-239.9	-986.0	-1531.5	-2571.7	-2596.3	-2817.6	-3203.8
Sit 3	-239.9	-986.0	-1531.5	-2571.7	-2517.8	-2724.8	-3084.1
Sit 4	-239.9	-986.0	-1287.3	-1759.8	-1863.8	-2024.0	-2320.2
Sit 5	-239.9	-986.0	-1287.3	-1759.8	-1778.4	-1923.1	-2189.3
Sit 6	-239.9	-986.0	-1287.3	-1759.8	-1694.7	-1827.3	-2070.7
Sit 7	-239.9	-986.0	-918.4	-1112.9	-1219.4	-1308.7	-1497.4
Sit 8	-239.9	-986.0	-918.4	-1112.9	-1125.2	-1197.8	-1352.7
Sit 9	-239.9	-986.0	-918.4	-1112.9	-1041.5	-1098.0	-1224.1

How the scale of supply demand balance deficit influences option selection

5.57. The scale of solutions and the types of options selected by the investment model increases, according to the scale of future challenge that the model is seeking to overcome. The model has to select a larger basket of options to meet the more challenging futures ,and given the scale of deficits under those futures there are relatively few large scale options available to meet those deficits.

5.58. Figure 5.11 illustrates the scale in terms of volume and thus the contribution to meeting the supply demand balance deficit under situation (branch) 9, the least challenging future.

5.59. This shows that under the less challenging futures, the contribution of demand management to meeting the supply demand balance is significant, at 61% of volume. We have commented on risks and uncertainties, including in relation to demand management in our separate Annex 4.

5.60. Figure 5.12, in comparison, illustrates that under the more challenging futures (when the scale of deficit to be met in terms of volume is significantly greater) the contribution from demand management is proportionally less as there are simply not enough demand management options available.

5.61. One of the key drivers of the supply demand deficits over the period to 2050 is the level of environmental ambition that we are planning to achieve. In simple terms, the higher the level of environmental ambition, the greater the impact on existing supplies and the greater the impact on potential future options too.

5.62. The investment model runs are necessarily complex, and take a long time to complete, as they are seeking to complete a series of interlinked calculations at the same time. Each model run is seeking to select the optimum (least cost) choice of options necessary to solve the supply demand balance deficits in each WRZ, in each year, throughout the planning period.

Figure 5.11: Illustration of option type by volume for situation 9 (least challenging future) in 2075

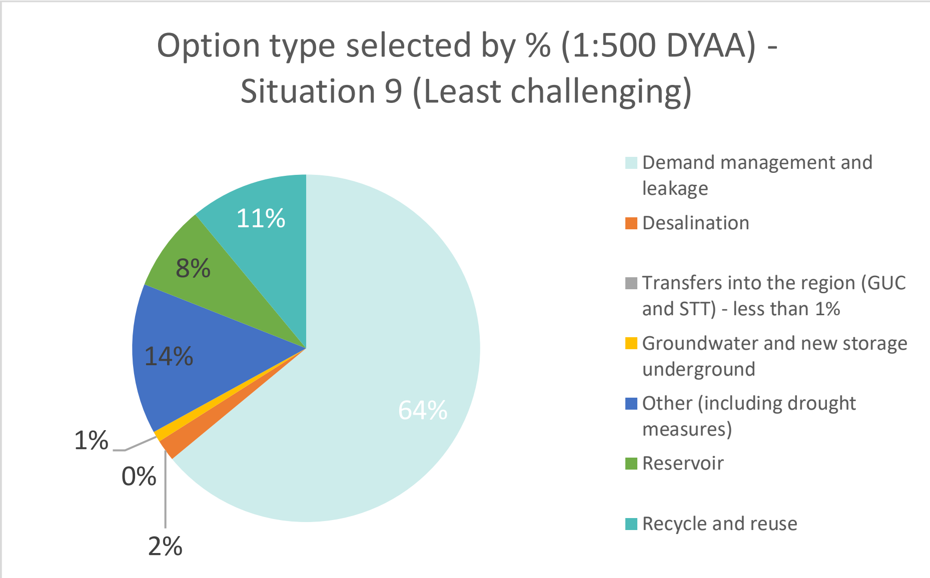
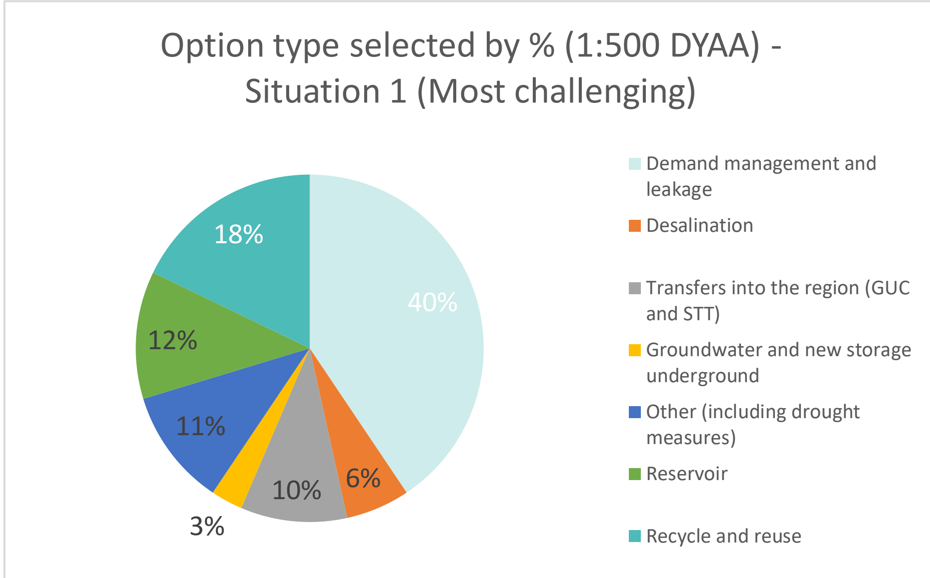


Figure 5.12: Illustration of option type by volume for situation 1 (most challenging future) in 2075



How model outputs are presented

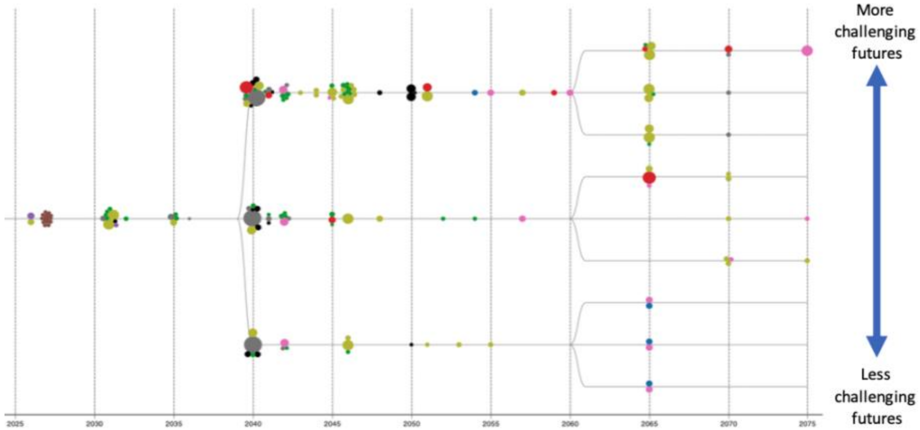
5.63. Model outputs are provided in a series of ways, both in tabular and graphical format, through the use of visualisation tools. These tools enable highly complex and lengthy sets of data generated by the model to be more easily understood and interpreted by the water resources modelling teams working for WRSE, and by the individual companies and stakeholders. These outputs allow WRSE to check and verify results from the model runs, to test and understand what is driving individual option selection, and (later in the process) to undertake a series of best value and sensitivity runs and assessment. These can be used to effectively 'switch off' sets of options, or individual options, to see what the model would select instead.

5.64. One visualisation tool output is the production of root and branch diagrams, similar to the supply demand balance plots illustrated above, but populated with the options selected by the investment model. These plots identify the individual options selected in each year of the planning period under each root and branch. Plots can be produced for each WRZ, by Company and for the South East region as a whole, for each of the NYAA, DYCP and DYAA planning scenarios.

5.65. An example root and branch plot for the 1:500 yr. planning scenario is shown in Figure 5.13. This is a representative plot and does not illustrate the final model outputs. Each of the dots in the plot represents an option selected by the model, the larger the dot, the larger the volume of water (deployable output) that the option provides. The different colours represent different options types, e.g. demand management options are a different colour from transfer options or water reuse options.

5.66. Figure 5.13 shows an illustration of options selected for the root branch for the first 15 years of the planning period – these are the most critical for the regional plan as these are the options that will need to be progressed and implemented in the relatively short-term, through individual Company WRMPs and other programmes in order to meet the short-term supply demand deficits. As the branches diverge in 2040, and again in 2060, Figure 5.13 demonstrates quite clearly (and unsurprisingly) that as the scale of the supply demand deficit increases, under the more challenging futures, a greater number of options are selected – shown in the higher branches of the plot.

Figure 5.13: Example root and branch investment model plot from visualisation tool



5.67. Other visualisation tool outputs include "sankey plots' which provide an illustration for how the supply demand balance for the region as a whole, individual company or WRZ will change during the planning period. The plot shows the amount of water available for use (WAFU) at the start of the planning period and then can be used to layer on the contribution of water from the individual options selected by the investment model year by year through the planning period. An example of a plot at the start and end of the planning period is provided in Figure 5.14 and Figure 5.15 below as an illustration. Note that these are representative plots and do not illustrate the final model outputs.

5.68. The visualisation tool also provides tabular data for each model run, including on cost, environmental metrics including SEA, natural capital and biodiversity net gain, and on core reliability, adaptability and evolvability metrics. WRSE and the individual companies can use these tables to better understand and differentiate between the individual model run outputs.

Figure 5.14: Example Sankey plot of investment model outputs from visualisation tool (start of planning period)

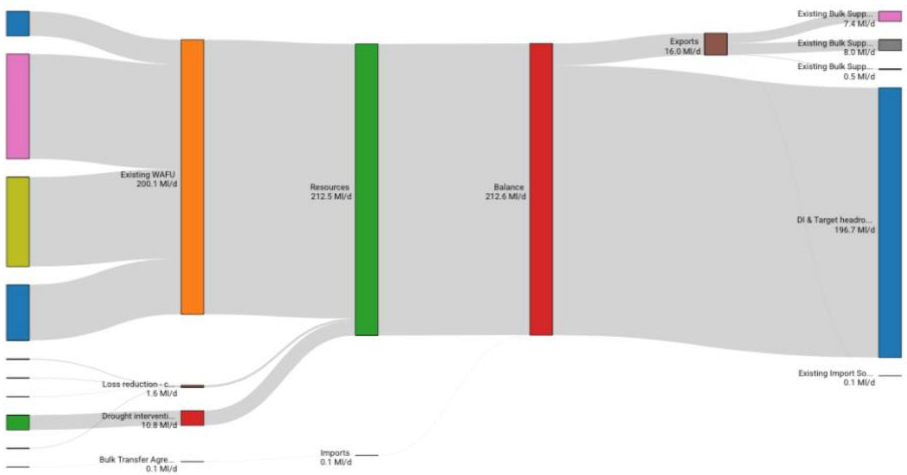
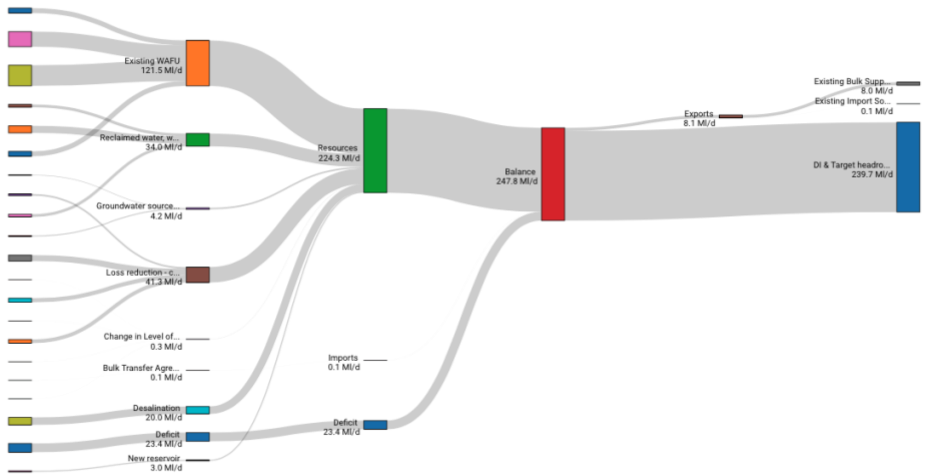


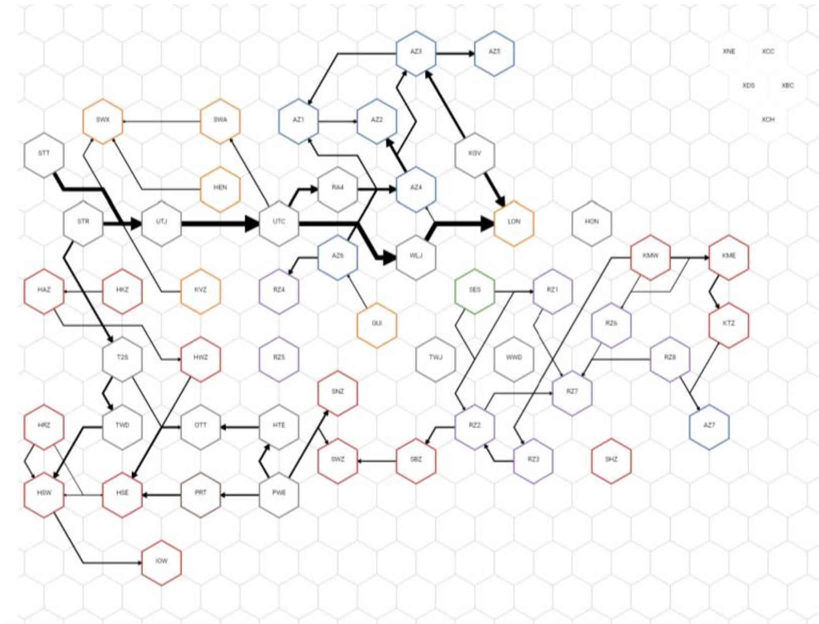
Figure 5.15: Example Sankey plot of investment model outputs from visualisation tool (end of planning period)



5.69. The visualisation tools available to WRSE also include the ability to plot transfer diagrams highlighting how the number and type of transfers selected within the region change over time. These diagrams (see example in Figure 5.16) help us to see how connectivity changes over time across the region under different model runs.

5.70. Through using these combination of tools, WRSE and the individual companies are able to interrogate and understand the model runs in selecting the most appropriate basis for the emerging regional plan.

Figure 5.16: Example plot of investment model transfer options from visualisation tool



Regional reconciliation

Overview

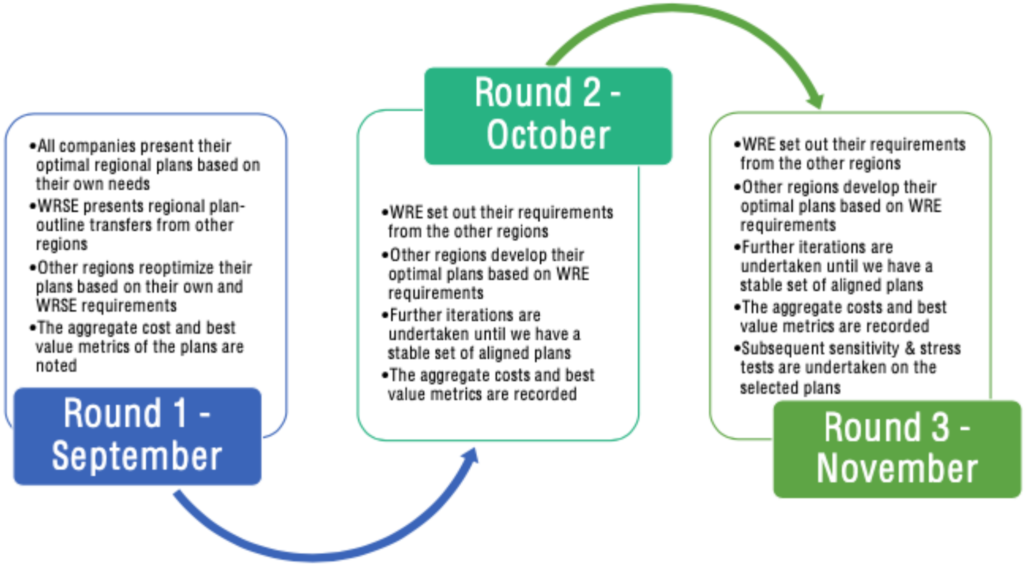
5.71. WRSE is one of five regions preparing their own regional plan (see Figure 5.17). Given the existing and potential future inter-connections between regions, and the key role which sharing resources across regional boundaries plays in water resources planning there has been a high degree of regional collaboration.

5.72. For WRSE, key regional interfaces are with West Country, East and West regions, although there has been close working and collaboration across all regions through regional working groups.

Figure 5.17: The five water resources planning regions

5.73. A key aspect of the regional collaboration has been to share information on available options and on the outputs of the individual regional modelling work. This focuses on existing and potential inter-regional transfers, to ensure that the various transfers align in individual regional plans both in terms of volumes and dates. A series of regional reconciliation rounds were agreed to take place through Autumn 2021, as illustrated in Figure 5.18.

Figure 5.18: Autumn 2021 Regional reconciliation rounds



Regional reconciliation outcomes

5.74. WRSE has presented its investment model run outputs to the other regions as part of the reconciliation process, to test and verify the extent to which potential transfers into the South East region from other regions are expected to be available under the planning scenarios.

5.75. The expectation at the outset of this process was that regional imports could potentially play a key role in meeting some of the scale of challenges that the South East region is facing.

5.76. The regional reconciliation process has enabled the regions to test this against consistent planning scenarios, including what effect achieving higher levels of resilience (1:500), population growth and climate change, and importantly differing levels of environmental destination, has on the future availability of water to transfer to other regions.

5.77. The outcomes of this work have shown that under the more challenging futures, rather than having plentiful supplies of water to potentially transfer to the South East region, other regions are themselves facing significant water resource deficits. The greater the future scale of challenges that the regions plan for, the lower the level of potential future inter-regional transfers that results.

5.78. We have undertaken a number of iterations of our investment modelling as we have worked through the regional reconciliation process. The resulting outputs, in the form of our adaptive regional plan are based on the most likely availability of resources from other regions at this point in time. We have summarised the regional reconciliation outcomes in a Regional Reconciliation Report attached as Appendix 1.

5.79. Following consultation on our emerging regional plan there will be a further round of regional reconciliation, ahead of our draft regional plan in summer 2022. We have commented further relating to ongoing regional reconciliation in our separate Annex 4.

Presentation of our cost efficient emerging regional plan

5.80. The outcome of the technical work described in this section is the selection and presentation of what is currently our cost efficient emerging regional plan. More details on the proposals in this emerging plan are presented in separate Annexes 2 and 3, and more information on how we are developing our plan in separate Annex 4.

5.81. Under a 'traditional' water resources plan, the least cost plan can be presented as the preferred plan. However, WRSE is preparing a regional plan which will, when fully drafted, be a 'best value plan', in accordance with the National Planning Framework and the WRPG. The 'cost efficient' emerging regional plan which we are consulting on in early 2022 represents the current position at the time of consultation. A cost efficient planning process assesses all options which meet both company and WRSE feasibility threshold against whole life delivery costs including the cost of carbon. The resulting plan therefore represents the lowest programme costs to deliver requires policy outcomes and core strategic objectives. A cost efficient plan does not include, in its selection process, other benefits, additional value and/or wider objectives.

5.82. The (cost efficient) emerging plan will be used as a benchmark to understand cost and value when we are developing our 'best value' plans in the next stage of the process in 2022, ready for our draft regional plan to be published in summer/autumn 2022.

5.83. Over the coming months we will develop a number of *alternative* water resource programmes, all of which produce the water needed so we can compare them to see their cost, and measure the wider benefits they deliver. We have worked with customers and stakeholders to develop a set of best value objectives that are represented by a range of criteria and metrics that deliver the benefits they want to see. We also asked customers which of the criteria were most important so we'll use their feedback to help us identify our preferred programme for our best value plan.

5.84. The opportunity to deliver additional value may be limited when we try to solve the more extreme future scenarios, this is because there are fewer choices to be made between options as so much additional water is needed. However, we expect our best value assessment to have more of an impact on the options that are chosen in the less challenge pathways of our adaptive plan.

5.85. The programmes will be shortlisted and stress tested to see how well they will perform in different future scenarios and against a range of environmental and resilience measures. We've also developed a simulation model of the region's water network to check that the options work well together and provide water where and when it is needed.

5.86. This will enable us to choose the preferred water resource programme that forms the basis of the draft 'Best Value' regional plan that will be used to inform the six water companies' draft WRMPs that will be published for consultation later this year.

Appendix 1: Regional Reconciliation Process Report Version 7

Regional Reconcilliation Process

Version 7

Title	Method Statement: Regional Plan Reconciliation
Last updated	January 2022
Version	7
History of Changes made to this version	This technical report is based on the PowerPoint slides circulated to the Regional Co-ordination group in July 2019, November 2019, April 2020, November 2020. It also encompasses the methodologies derived through the All Company Working Group; Environment Agency , NRW and members of the Regional Co-ordination Group. Version 6 contains an update to chapter 7 outlining the stress testing approach.
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Approved by	Water Resources East: Geoff Darch, Ben Fitzsimons Water Resources West: Richard Blackwell, Marcus 0'Kane West Country Water Resources: Robert Scarrott Water Resources North: Granville Davies Water Resources South East: Meyrick Gough

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1 Executive Summary

1.1 Following the publication of the National Infrastructure Commission report: Preparing for a drier future, the National Framework group was commissioned and three new regional groups were established[1]. These groups complemented the existing regional groups: Water Resources East and Water Resources South East.

1.2 The purpose of these strategic regional groups is to assess the future water requirements of their region and to set out a plan showing how these requirements could be met. These requirements cover the environment, public water supply and non-public water supply.

1.3 An early indication of the extent of these requirements was set out in the Environment Agency report *Meeting our future water needs: a national framework for water resources*. Immediately following this publication each of the regions published their regional perspective of their future resource requirements. These publications were in March 2020 and February 2021. Further updates to these estimates were produced for regulators and for sharing between regions[2] at the end of August 2021, marking the beginning of the reconciliation process.

1.4 Each of these regional assessments set out their key challenges for water in the future which range from an increasing need to support population growth; a requirement to protect the environment; a growing need to become more resilient as well as the essential ability for these plans to adapt to the challenges from climate change.

1.5 In February 2019 Ofwat also published their draft determinations of companies' business plans. This key publication put forward a series of specific strategic resource options that needed to be investigated and designed further. The scale of these schemes was nationally significant as they provided a means of moving water across the country and between regions. These strategic resource options are referred to as SRO's. The funding for these schemes was maintained in the final determinations for the companies.

1.6 Each SRO scheme is being developed through a structured, gated process using a set of consistent methodologies that have been developed by the All Company Working Group (ACWG). The gated process has been clearly set out in the Ofwat publications and the process is overseen by the Regulatory Alliance for Progressing Infrastructure Development (RAPID).

1.7 In addition to the SRO process other potential future options for the environment, other sectors and water companies are also being investigated and developed and these could also feature in regional plans as potential solutions to meet the challenges in the future.

1.8 The development of the regional plans, the SRO schemes and the construction of the company Water Resource Management Plans (WRMP) is an integrated process with exchanges of information flowing back and forth between these planning processes.

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[1] Water Resources North, Water Resources West and West Country Water Resources

[2] Whilst materials at this stage may have been shared more widely in some cases, the pre-reconciliation outputs in August 2021 were not a public document or submission as such.

1.9 Just as the various planning processes are linked it is also critical to ensure that the regional plans are also linked and integrated as each plan will seek to construct a series of best value plans based on the requirements of their region as well as potentially providing support to or from a neighbouring region. Therefore, each plan will need to be reconciled with the other regions.

1.10 During October to December 2020 the regulators and regions undertook a series of workshops to determine what should be aligned between the regional plans[3]. This process identified that the alignment of the inter-regional schemes was the key focus of the plans.

1.11 The process for integrating the regional plans together is referred to as regional reconciliation process and the purpose of this report is to describe the approach used to reconcile SRO (or other relevant strategic transfer) schemes and plans with each other during the period from September to December 2021.

1.12 The conclusion from the reconciliation process was to set out an agreed set of inter-regional transfers, backed by supply options, which seek to support each of the emerging regional plans in meeting their challenges.

1.13 For some regions the reconciled solution was confirmed that a transfer between the two regions was optimal. For other regions the process highlighted that some transfers between the regions were not possible, based on the information currently available.

1.14 The reconciliation process also showed an alternative alignment of the regional plans and demonstrated that some existing assets and non-SRO schemes are critical to a number of regions when they develop their future plans.

1.15 The document sets out the approach followed, the reconciliation tables that was concluded between the regions and the results of the sensitivity runs. It is unlikely that this will be the only time that we undertake this process. It is expected that following the consultation on the emerging regional plans a further stage of reconciliation will be required.

[3] RCG Alignment Project Report V0.pdf

2 Introduction

2.1 In January 2022 each of the five regional groups will consult on their individual emerging plans[4] setting out the combination of policies and interventions which are best suited to meet the range of challenges and outcomes required for their region. These consultations will reflect the work that they have been able to undertake at this point in the process, but they will set out some choices with an aim to obtain feedback from stakeholders and customers.

2.2 Each region faces a range of different challenges over the next 25 to 60 years, and beyond. These vary in magnitude, uncertainty, and spatial distribution across their regions as improved resilience requirements; different climatic change patterns; growth projections and environmental requirements contribute to a greater need for water in the future.

2.3 Each regional group is developing a plan to meet their specific requirements. For some regions, these requirements could be met through local or regional solutions. However, more resilient, or cost-effective solutions might be developed by considering transfers between regions. It is important to compare these various plans to understand which combination of solutions provide the overall best solution for the regions.

2.4 Therefore, regardless of how a regional plan is formed it is important to understand how each of the plans will interact with each other to meet their needs and collectively meet the future requirements for England and parts of Wales (as WRW regional plans will still need to ensure consumer/environment needs are met there).

2.5 The initial estimates for England have been based on the company plans and an estimation of the requirements of other sectors. These requirements were set out in two key national publications by the NIC and the National Framework Group[5] (Table 1). It is worth noting though that by the time the regional plans are published in January 2022 these requirements will have been superseded as several key forecasts and environmental requirements will have been updated.

Table 1: Future water requirements for England by 2050

Organisation	Volume of water required
National Infrastructure Commission	4,000 million litres per day (Ml/d)
Environment Agency	3,435 million litres per day (Ml/d)

[4] National Framework Senior Steering Group: Papers 11 & 17.

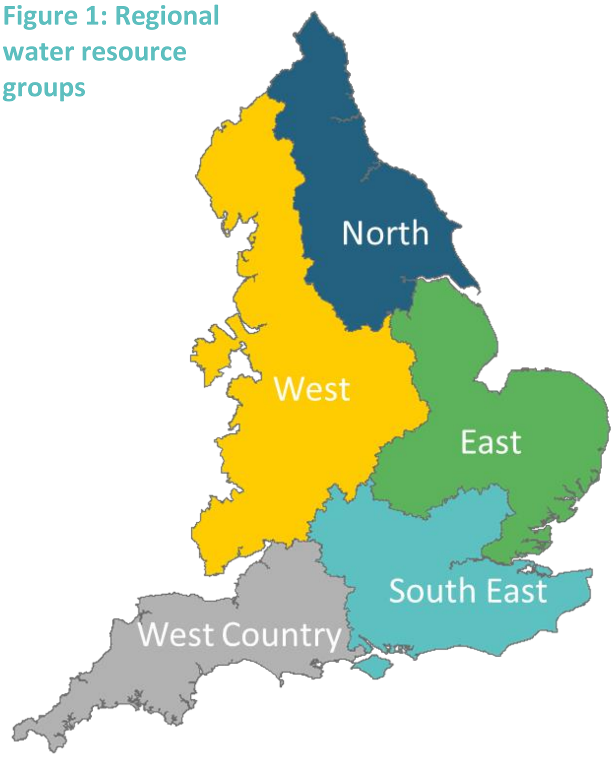
[5] NIC: Preparing for a drier future – 25th April 2018; Environment Agency: Meeting our future water needs: a national framework for water resources.

2.6 This report sets out the process that was discussed at the regional co-ordination group in July 2019; November 2019 and April 2020. The approach has also been discussed at the All Company Working Group (ACWG) which is formed of the group of companies working on the Strategic Resource Options (SRO) set out in the Final PR19 Determination by OFWAT.

3 Regional planning

3.1 There are five regional groups established which cover England and a small area in Wales. These regions are shown in figure 1. The five regions are: Water Resources North (WReN); Water Resources West (WRW); Water Resources East (WRE); West Country Water Resources Group (WCWRG) and Water Resources South East (WRSE).

Figure 1: Regional water resource groups



3.2 The latest guidance[6] from the EA, NRW and Ofwat has set out that If you are a water company in Wales and have a resource zone within England, you should include it within the appropriate regional plan.

3.3 Where you have a resource zone bordering England and Wales, which is important for cross-border shared supplies, you may also include these in the relevant regional plan. You should discuss which resource zones should be used to inform a regional plan with the regional group, regulators, and the Welsh Government.

3.4 Your Water Resources Management Plan (WRMP) should reflect the regional plan in respect to these resource zones. In addition, you should refer to the Welsh Government guiding principles in respect to these resource zones. There is no current requirement from Welsh Government for regional plans to be produced in Wales.

3.5 Each region has a different set of challenges to overcome in the future. These were set out in their initial resource position statements published in March 2020. Most regions will experience deficit conditions at some point in the future, however, there are enough options both within a region and across regions to meet these future challenges.

3.6 In deriving a regional plan, it is important to determine which combination and schedule of options provide the best value solution for the region.

[6] EA Water Resource Planning Guidance, February 2021

3.7 Best value can be derived in a variety of ways, including the approach which is set out in the UKWIR methodology[7] and the WRPG best value text[4]. Whichever approach is used it is for the region to decide and set out, in a clear and transparent way, what is meant by best value for their plan and which metrics it will use in undertaking this assessment. These metrics are critical for the reconciliation process and were agreed and defined by each of the regional groups before the reconciliation process began at the end of August 2021. This ensured that the plans that were considered during the reconciliation process were not subject to further changes during the reconciliation process. An Excel workbook[8] contains a template for these criteria for each region.

3.8 Each region will present their best value plans to their boards for sign off. The sign off process will vary with each region and the number of plans they will be presented with will also vary. For example, WRSE have several plans that are signed off, these being: the draft plan for reconciliation; the draft plan for consultation; the revised draft plan for incorporation in the company own WRMPs and the final regional plan. Each region will set out their own approach for signing off their regional plan.

3.9 When a scheme crosses regional boundaries, it is critical that it is represented in the donor and recipient regions' plans in a clear and coherent way such that the schemes are reconciled between the plans. The reconciliation of plans is not a new problem for the water industry and has in the past and can be, in the future, resolved through the generation of draft plans and iterative synchronisation of schemes which feature in both sets of plans. The process will usually start with one plan deriving the requirement for additional resources and neighbouring plans determining whether they can provide all or part of that resource at the timescales required.

3.10 Typically, scheme reconciliation problems have been confined to neighbouring companies where one company has a resource deficit, and a neighbouring company could generate additional resources which when combined with the other options produces a best value plan for both companies. For WRMP24 the reconciliation process has become more complex as there needs to be national reconciliation within and between the five regions.

4 The process of reconciling the plans

4.1 Each region has a different set of challenges to overcome in the future . These challenges were set out in their initial resource position statements published in March 2020. Inevitably during this planning horizon, most of the regions will encounter some form of water resource deficits in the future if they do not put in place a range of scheduled solutions. However, when considering these future options there might be a potential to develop solutions within a region that can not only meet their requirements but provide some water to a neighbouring region. By doing so, this could provide a better overall solution for customers and the environment.

[7] Deriving a best value water resources management plan; Report Ref No: 20/WR/02/14
[8] Microsoft Excel Workbook: Regional_Best_Value_Criteria&score.xlsx

4.2 These types of opportunities need to be explored in a structured approach to determine what is the overall best set of strategic solutions for the regions. The proposed reconciliation approach sets out this process.

4.3 The reconciliation process uses an iterative, cascade approach to derive an overall set of regional reconciled plans. Thereby keeping the regionally agreed approaches intact but ensuring a strategic overview of the resource solutions being selected. This cascade approach relies on comparing different sets of plans together to determine which are the better sets of solutions.

4.4 To compare the benefits of an integrated regional approach with a within-region only set of solutions, the process begins with all the regions deriving their own regional optimum plans based on solutions located within their own region. This could include options for new bulk supply transfers between companies within the same region. If there is an existing bulk supply contract between two companies in different neighbouring regions these would be included in the within-region plan.

4.5 To derive a set of reconciled regional plans a cascade optimisation approach was used. This approach requires one region (initiator region) to start the process off by deriving a best value plan to meet its own future requirements using set of interventions which include options both within and outside the regional geographical boundary. For example, for WRSE, Severn Thames transfer and Transfers from Anglian Water are considered alongside with other regional solutions such as leakage reduction, demand management and resource developments.

4.6 Those regions which border the initiator region (primary suppliers) can then test how the transfer option impacts their own best value optimum regional plan using their defined methodologies and based on their own regional resource requirements and the requirements of the other initiator region. The final step in the cascade process requires those regions who are neither the initiator region or the primary supply regions to complete their regional plan based on their resource requirements and those from the primary suppliers (if any).

4.7 These collective steps form one iterative step.

4.8 Following the first iteration of the cascade process a check needs to be undertaken to ensure that the transfers between the regions can be achieved both from a timing perspective and a volumetric perspective. E.g., WRSE might require 300 Ml/d from WRW by 2035. WRW might not be able to meet this requirement by 2035, but they could provide 90 Ml/d by 2035, a further 64 Ml/d by 2040 and an additional 150 Ml/d by 2050. If the proposed solutions in the plans cannot be met, then another iteration of the plans is required noting any constraints that were established in the first phase of the iteration.

4.9 The iterative process continues until an agreed set of plans can be established which meets the needs of all the regions. I.e. the regions produce their best value plan given the requirements of the lead region for this iteration. At this point no more iterations are undertaken and the first round of iterations are completed. A note of the cost and the best value plan scores for each of the regions. Likewise, the transfers between the regions (existing and future) are recorded in the inter-regional transfer template spreadsheet.

4.10 The next round of the regional cascade optimisation process is then undertaken with another region acting as the initiator region and a new set of primary and secondary suppliers. At the end of this round another set of scores and costs are recorded in the relevant spreadsheets.

4.11 Following an agreed set of rounds a review is undertaken to determine which schedule, size and combination of inter-regional schemes provide the overall best set of regional plans. These plans are then stress tested to see what would happen if a scheme were: delayed and cannot achieve its benefit date; cannot supply the volume of water and cost more than anticipated.

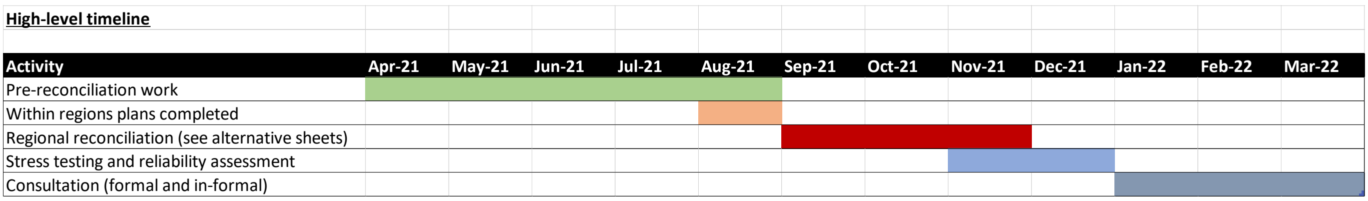
4.12 Based on this combined information the potential best set of regional plans was discussed and agreed on through consultation with the regional boards during November/December 2021 to reach an agreed position to allow the regions to inform their wider consultation in January 2022.

5 The reconciliation process timeline

5.1 The overall reconciliation process is a simple approach to compare intra and inter-regional schemes on a like for like basis to derive a regional plan. Scheme reconciliation is based on deriving and comparing regional plans with each other through a series of reconciliation planning rounds to establish a synchronised set of inter-regional solutions across all the plans.

5.2 During this process the regulators participated to allow them to comment on each stage of the iteration process. Whilst it is recognised that their participation cannot compromise future regulatory positions, their participation was important to flag up any potential issues which they believe would not meet government policies or legal constraints.

5.3 To ensure that the correct information is available for the synchronisation of the various steps for the process a timeline was established. This is set out in the diagram below:



5.4 The first key milestone date was the derivation of the baseline regional plan which sets out a regional best value plan based on the challenges the region faces and using potential within region solutions and contracted transfers between companies who are in different regions. This baseline plan is key to for comparative purposes later to help quantify the benefits arising from the inter-regional transfers.

5.5 Two rounds of reconciliation were undertaken, the two regions who initiated this process were: WRSE and WRE. The result of this process was an agreed set of transfers between the regions, which are captured in the regional transfer spreadsheet.

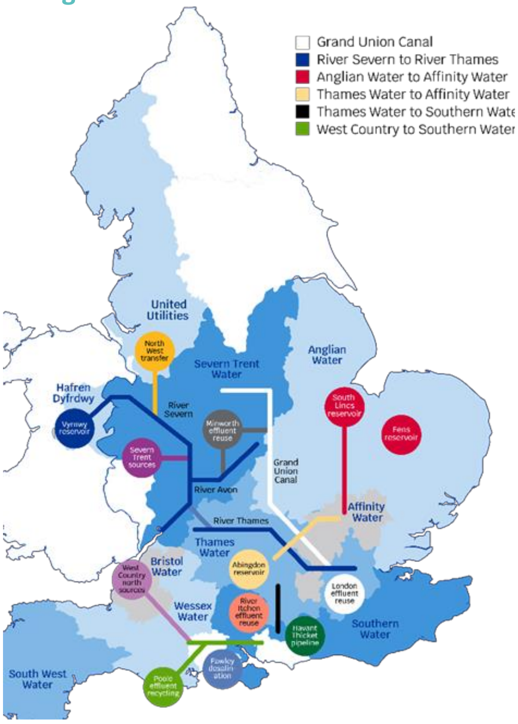
5.6 Following the reconciliation process the regions will undertake a consultation on their emerging regional plan in January 2022. If a material change to their regional plan occurs because of the consultation process on the emerging plans then an additional reconciliation process, before the autumn 2022 versions of regional plans (where relevant) and WRMPs are published, to ensure overall alignment of the plans. The extent of any further reconciliation depends on whether a strategic scheme(s) design had to change. If the material changes are associated with local schemes and the proposed changes to these schemes do not affect the identified inter-regional schemes, then the plans would not need to be reconciled.

6 Consistency of scheme costs and benefits

6.1 The purpose of the reconciliation process is to ensure that any interregional schemes that are selected are clearly visible in both regional plans and are developed in a timely manner. This either means that a scheme is developed in a co-ordinated manner between the two regions, or the scheme is developed in a phased way in a region to meet its own immediate needs and those need of a neighbouring region in the future.

6.2 Whilst each region has many different options available to it to meet its own requirements, a set of strategic resource options are being developed across several regions to generate and potential transfer resources across the country. These there are shown in figure 2.

Figure 2: SRO schemes



6.3 Each of the SRO schemes have submitted their initial, gate 1, findings to RAPID for their appraisal. To drive consistency across key parts of these schemes the group of companies who are developing the options have formed a working group. The All Company Working Group (ACWG) represents those companies who are investigating and developing each of the SRO schemes. Four methodologies have been developed through this working group to provide consistency on: costing schemes; environmentally appraised; checked for water quality implications and their deployable outputs.

6.4 These ACWG methods are in line with Water Resource Management Plan guidance and are designed to provide additional technical guidance how to undertake some of these detailed assessments. These methodologies are being applied across the various SRO schemes and allow comparisons between the SRO schemes to be undertaken in a consistent way, which is key for the reconciliation process. These methods are used in conjunction with the WRPG, which was published in February 2021, this guidance includes what is expected for all options appraisals.

6.5 All the methodologies have been through a sign off process through the All Company Working Group (ACWG). These methodologies have also been commented on by RAPID and updates to the methodologies have been made where appropriate.

6.6 Ultimately, the demonstration of 'best value' will be done using a combination of the different cost / benefit criteria being used by each of the regions. These criteria differ between regions to reflect the concerns and priorities of their specific regional stakeholders. However, the net change in the combined regional metrics will be used to demonstrate whether the SROs or other transfer options provide a better value outcome than just relying on within-region solutions.

7 The reconciled plans

7.1 As discussed earlier the regional reconciliation process undertook two rounds of assessment. The first round used WRSE as the primary draw for water from the other regions and the second round was triggered by WRE's requirements for water.

7.2 The WRSE Reconciliation of the regional plans considered drawing water from WRW, a western route for water into the region. WRE reconciliation considered drawing water in from WRSE, due to a lack of resources in the region, which is an eastern route.

7.3 The two reconciliation rounds consisted of: round 1 outlined WRSE's requirements and those from the other regions and round 2 outlined WRE's requirements and those of the other regions. The choice of the better strategy is based on the best value metrics and costs.

7.4 Before the beginning of the two rounds of the reconciliation process each of the regions provided and updated position on the regional surpluses which are published in the consultation documents. Typically these updated resource positions demonstrated that all of the regions will go into deficit unless a range of interventions were developed.

7.5 These interventions always included further measures to reduce consumption and leakage (government policy demand management and leakage reductions were included in the pre-reconciliation baselines). Following these interventions most of the regions required further interventions still to be developed. These additional interventions were not just to help the regional deficits but also a potential option to help move water from one region to the next.

7.6 Two different aligned plans have emerged through the reconciliation process. The first-round plan included developing a new set of transfers from WRW whilst maintaining the current supply, to Affinity, from Grafham Water reservoir to its resource zone. In the second round WRE, who are not able or required to export further water from their region, looked to see what would happen if Affinity reduced their existing abstraction from Grafham Water.

7.7 The reconciliation rounds also highlighted several other transfers which are or could be impacted by the updated resource positions within each of the regions.

7.8 The outcome of the reconciliation process is set out in the reconciliation table below. Each round of the reconciliation process considered each of these routes. The two rounds of reconciliation the regions have agreed which configuration of regional alignment provides a preferred emerging alignment of the reconciliation process are shown in the table below. This showed that the western route of the reconciliation was the overall preferred reconciliation. Therefore, at this point the regional reconciliation process has concluded that it is better overall for the existing export to the WRSE region to continue, this will be reviewed in the next regional reconciliation process.

7.9 Whilst the BVP metrics from the regions were close, the cost differential played the biggest deciding factor. The final alignment of the regional plans, which will be used for the consultation on the emerging plans, was based on the alignment of the plans from round 1 which WRSE initiated.

7.10 The final alignment table is shown below in Table 2

Resource zone and water company area of proposed scheme (source of abstraction)	Potential resource zones or regions that could benefit or receive water from scheme	Option Name	In-region or inter-regional option?	Type of option	Proposed scheme development history	Reconciliation stress test assessment	Reconciliation outcome and current status of scheme selection	Earliest year of Ml/d benefit available	Indicative year of option selection	Maximum capacity or yield of option in Ml/d
Severn Trent Strategic Grid	Thames Water (SWOX, London), Affinity Water and potentially others in WRSE and WCWR	Severn Trent Sources (Netheridge and Mythe)	Inter-regional option from WRW to WRSE (primarily) and WCRW (as adaptation)	Effluent re-use (Netheridge) and partial source re-deployment (Mythe)	Strategic Resource Option under development through the RAPID gated process	Following the update of scheme information in November the Netheridge scheme still gets selected but the Mythe does not. The Netheridge scheme are always selected in the more challenging situations in the south east of England.	Included in the reconciled plan to meet the needs of WRSE, and potential adaptation into WCWR noted. Reconciliation assessment accounts for consequential cost to Severn Trent Water being reflected in prices to WRSE companies.	2030	2040 (Netheridge)	35 Ml/d (Netheridge) and 15 Ml/d (Mythe)
Severn Trent Strategic Grid	Thames Water (SWOX, London), Affinity Water and potentially others in WRSE and WCWR	Minworth	Inter-regional option from WRW to WRSE (primarily) and WCRW (as adaptation)	Effluent re-use	Strategic Resource Option under development through the RAPID gated process	Minworth gets selected for both STT and the GUC transfer. These schemes are always selected in the more challenging situations in the south east of England. In the middle to lower branches these schemes aren't selected. If Minworth could only support one of the two transfer routes then the transfer route to GUC would be the referred route.	Included in the reconciled plan to meet the needs of WRSE, and potential adaptation into WCWR noted. Reconciliation assessment accounts for consequential cost to Severn Trent Water being reflected in prices to WRSE companies.	2035	2044 (via STT) and 2049 (50 Ml/d via GUC) and 2060 (further 50 Ml/d via GUC)	115 Ml/d (via STT) and 100 Ml/d (via GUC)
United Utilities Strategic Zone	Severn Trent, Thames Water (SWOX, London), Affinity Water and potentially others in WRSE (Southern), WCWR (Bristol and Wessex) and WRW (South Staffs)	North West Transfer (Vyrnwy Aqueduct and United Utilities Sources)	Both in-region option and Inter-regional option from WRW to WRSE (primarily) and WCRW (as adaptation)	Partial source re-deployment (Vyrnwy) enabled by network enhancement and new sources	Strategic Resource Option under development through the RAPID gated process	The Vyrnwy options usually gets selected in all of the scenarios that we have tested. Typically these schemes are always selected in the more challenging situations in the south east of England. It is only in the middle to lower branches in which the schemes are not selected.	Included in the reconciled plan to meet the needs of WRW, WRSE, and potential adaptation into WCWR noted. Reconciliation assessment accounts for consequential cost to United Utilities being be reflected in prices to WRSE companies.	2030	2040 (75 Ml/d to Severn Trent) and 2041 (50 Ml/d to WRSE) and 2051 (further 25 Ml/d to WRSE) and 2055 (further 20 Ml/d to WRSE) and 2056 (further 10 Ml/d to WRSE) and 2065 (further 25 Ml/d to WRSE, via Shrewsbury) (Note dates and volumes refer to water made available by the scheme in the River Severn Uplands.)	180 Ml/d via Vyrnwy Reservoir and 25 Ml/d via Shrewsbury = 205 Ml/d total
Severn Trent Strategic Grid and United Utilities Strategic Zone	Thames Water (SWOX, London), Affinity Water and potentially others in WRSE	Severn Thames Transfer (STT)	Inter-regional option from WRW to WRSE	New raw water transfer using rivers and pipeline or canal	Strategic Resource Option under development through the RAPID gated process	The Severn Thames Transfer is selected as one of the many solutions in the south east of England. This enabling scheme is usually configured with support options. This scheme is always selected in the more challenging situations in the south east of England.	500 Ml/d transfer included in the reconciled plan to meet the needs of WRSE. Linked to supporting options: Severn Trent Sources, Minworth and North West Transfer (Vyrnwy Aqueduct and UU Sources) and benefits from unsupported abstraction from the River Severn.	2033	2040	500 Ml/d
Severn Trent Strategic Grid	Affinity Water	Grand Union Canal (GUC)	Inter-regional option from WRW to WRSE	New raw water transfer using canal	Strategic Resource Option under development through the RAPID gated process	The Minworth / Grand Union canal option is selected across a number of the more challenging situations in the regional plan. These schemes were also selected in the stress tests.	100 Ml/d transfer included in the reconciled plan to meet the needs of WRSE. Linked to Minworth supporting option.	2034	2049 (50 Ml/d) and 2060 (further 50 Ml/d)	100 Ml/d
Anglian Water East Lincolnshire	Anglian Water Ruthamford North and Ruthamford South; Affinity Water	South Lincolnshire Reservoir	Inter-regional option from WRE to WRSE	New reservoir	Strategic Resource Option under development through the RAPID gated process	Not available in stress test due to conclusions of reconciliation	Selected as an in-region option only; in development as Gate 2 solution	2035-36	2035-36	150 Ml/d
Anglian Water Fenland	Anglian Water WRZs in Cambridgeshire and Norfolk; Cambridge Water	Fens Reservoir	In-region option	New reservoir	Strategic Resource Option under development through the RAPID gated process	In scenarios with larger deficits in WRE the option is selected at a larger size.	In development as Gate 2 solution	2035-36	2035-36	99 Ml/d
Anglian Water Ruthamford South	Anglian Water Ruthamford South; Affinity Water	Grafham Water	Inter-regional option from WRE to/from WRSE	Transfer	n/a	Not available in stress test due to conclusions of reconciliation	Options to either increase or reduce transfers from WRE to WRSE were investigated. The reconciled plan includes continuation of the existing transfer volumes. The impact of a 40 Ml/d reduction in the transfer had approximately double the cost impact on WRSE compared to WRE.	2025-6	n/a	40 Ml/d
Severn Trent Strategic Grid	Yorkshire Water Grid	Cease existing Derwent Valley Transfer	Inter-regional option to stop existing transfer from WRW to WReN regional group	Stop existing transfer	Operational since early 1900s	The transfer is included in the reconciled plan. Stress testing considered loss of this existing transfer which could cause in 2050 a deficit in Yorkshire Water Grid of around 40 Ml/d under average baseline conditions (with the deficit up to 58 Ml/d under the adverse scenario). Transfer loss impacts on the supply integrity and cause deficit in a specific part of Yorkshire Water Grid, requiring significant in-company investment for Yorkshire Water / WReN. Based on initial work completed at this stage, Yorkshire Water has estimated, at a high level, that the loss of the Derwent could result in costs of the order of £200m to develop and construction options to offset the lost water in YW's operating area.	Severn Trent could benefit from reducing this existing transfer from 2035 onwards, however this would cause significant new options to be developed in Yorkshire Water's area. Recognising this impact the option to cease the trade is not included in the reconciled plan which instead includes continuation of this transfer, enabled by the Derwent Valley Storage Increase option.	N/A existing	N/A existing (contractually existing transfer ends 2084, but with potential for break from 2035)	40 MLX/d annual average, but 68Ml/d actual max
Severn Trent Strategic Grid	Severn Trent Strategic Grid and Yorkshire Water Grid (Maintains existing transfer benefit if retained)	Derwent Valley Storage Increase	In-region option, which also allows existing inter-regional Derwent Valley Transfer to continue	Reservoir enlargement	Strategic Resource Option under development through the RAPID gated process.	If this option were not available this would impact the ability to continue with the Derwent Valley Transfer above.	Included in the reconciled plan to allow Derwent Valley Transfer to continue and therefore avoid the need to develop options in Yorkshire Water's area as well as meet needs in Severn Trent. Avoids deterioration of several Best Value Plan metrics in WReN area, including significant capital, operational and opportunity cost associated with alternative solutions for Yorkshire Water.	2040	2040	80 Ml/d

Resource zone and water company area of proposed scheme (source of abstraction)	Potential resource zones or regions that could benefit or receive water from scheme	Option Name	In-region or inter-regional option?	Type of option	Proposed scheme development history	Reconciliation stress test assessment	Reconciliation outcome and current status of scheme selection	Earliest year of Ml/d benefit available	Indicative year of option selection	Maximum capacity or yield of option in Ml/d
Severn Trent Strategic Grid and United Utilities Strategic Zone	Bristol Water and Wessex Water	River Severn to West Country Transfer	Inter-regional option from WRW to WCWR	Enhance existing canal transfer to Bristol.	New scheme identified through regional planning. United Utilities to Bristol was identified at WRMP19. Linked to Severn Thames Transfer Strategic Resource Option under development through the RAPID gated process.	Robust option. Water could be used when not needed by other regions. Increases local resilience in Bristol and Bath towns	Not selected in reconciled plan, but benefits recognised as an adaptation pathway from 2040 onwards. Also note potential added resilience benefits if the connection is available, due to lower correlation of drought events across regions compared to within regions.	2030	N/A	35 Ml/d
Bristol Water	Bristol Water and Wessex Water	Cheddar 2	In-region option for WCWR	New reservoir	Strategic Resource Option under development through the RAPID gated process, has been a feasible option in previous WRMP submissions.	Robust to a reasonable range of stresses and is selected in moderate and/or more challenging adaptive pathways	Lower value option that is likely to only be needed in the more extreme adaptive pathways of the regional plan and/or WRMP24	2030	2030-2040	16 Ml/d (treated water), 65 Ml/d (raw water)
Bristol Water	Bristol Water supply area, wider WCWR region and configuration options to export to WRSE in the future	Mendip quarries raw water reservoir	In-region option for WCWR, with option for inter-regional connection with WRSE in the future	New reservoir	Strategic Resource Option under development, New feasible option for WRMP24	Robust to a reasonable range of stresses and is selected in the preferred adaptive pathway	Feasible, cost-beneficial and likely to be preferred option for WRMP24	2049-50	2049-50	90 Ml/d
Bournemouth Water	Bournemouth Water, Wessex Water	Poole Effluent Re-use	In-region	Effluent Re-use	Strategic Resource Option under development through the RAPID gated process.	Robust option. Water would be used in all scenarios.	Feasible and cost-beneficial. Has the potential for significant improvement in overall catchment operation. Water would be used to offset sustainability reductions on the Hampshire Avon. Also has the added environmental benefit of reducing nutrient load into Poole Harbour. Opportunity to offset an existing large industrial potable supply but analysis needed to understand the feasibility.	2030	2035	30 Ml/d
Thames Water	Thames Water - Affinity Water (Potentially others that extract from the Thames)	SESRO (Abingdon)	In region option for WRSE	New Reservoir	Strategic Resource Option under development through the RAPID gated process	This option is consistently selected across all WRSE situations. This scheme is also selected in stress test model runs.	Included in the reconciled plan to meet the needs of WRSE.	2037	2040	293 Ml/d
Thames Water	Thames water London (WLJ,KGV)	London Reuse - Mogden	In region option for WRSE	Effluent Re-use	Strategic Resource Option under development through the RAPID gated process.	London-Reuse Mogden option is selected across a number of the more challenging situations in the regional plan. These schemes were also selected in the stress tests.	Included in the reconciled plan to meet the needs of WRSE.	2031	2065	100 Ml/d
Thames Water	Thames water London (WLJ,KGV)	Direct river abstraction - Teddington	In region option for WRSE	DRA	Strategic Resource Option under development through the RAPID gated process.	Teddington DRA option is selected n the most challenging situation in the regional plan. These schemes were also selected in the stress tests.	Included in the reconciled plan to meet the needs of WRSE.	2034	2045	50 Ml/d
Thames Water	Thames water London (WLJ,KGV)	London Reuse - Beckton	In region option for WRSE	Effluent Re-use	Strategic Resource Option under development through the RAPID gated process.	The core London-Reuse Beckton is selected across all situations. The Enhanced Beckton 50Ml/d options are also used in all options. The Enhanced Beckton 100Ml/d options is only selected in the most challenging situation. These schemes were also selected in the stress tests.	Included in the reconciled plan to meet the needs of WRSE.	2031 Beckton 2034 Beckton Enhanced 100Ml/d 2034 Beckton Enhanced 50Ml/d	2031 Beckton 2046 Beckton Enhanced 50Ml/d 2051 Beckton Enhanced 100Ml/d	Beckton 95Ml/d Beckton Enhanced + 50Ml/d Beckton Enhanced + 100Ml/d
Portsmouth Water	Southern Water	SWS Havant Thicket Raw Water Transfer	In region option for WRSE	Raw water transfer	Strategic Resource Option under development through the RAPID gated process.	Not included in stress testing as the reservoir now has planning permission so is more likely to be constructed.	Not included in reconciled plan	2027	n/a	Multiple options ranging from 90-190Ml/d
Southern water	Portsmouth Water	SWS Water Recycling	In region option for WRSE	Reclaimed water, water re-use, effluent re-use	Strategic Resource Option under development through the RAPID gated process.	This option is consistently selected across all WRSE situations. This scheme is also selected in stress test model runs.	Included in the reconciled plan to meet the needs of WRSE.	2027	2031	90Ml/d
Southern water	Southern Water	SWS Water Desalination	In region option for WRSE	Desalination	Strategic Resource Option under development through the RAPID gated process.	Not included in stress testing following the announcement that the Fawley desalination plant is no longer a feasible option following the gate 1 review.	Not included in reconciled plan	2026	n/a	Multiple options ranging from 40-200Ml/d
Thames water	Affinity Water	T2AT	In region option for WRSE	Raw water transfer	Strategic Resource Option under development through the RAPID gated process.	Not included in stress testing exercise for the regional reconciliation process but will be completed for the within region stress testing	Not included in reconciled plan	2034	n/a	Multiple options ranging from 50-100Ml/d
Thames water	Southern Water	T2ST	In region option for WRSE	Raw water transfer	Strategic Resource Option under development through the RAPID gated process.	Not included in stress testing exercise for the regional reconciliation process but will be completed for the within region stress testing	Not included in reconciled plan	2030	n/a	Multiple options ranging from 24-200Ml/d

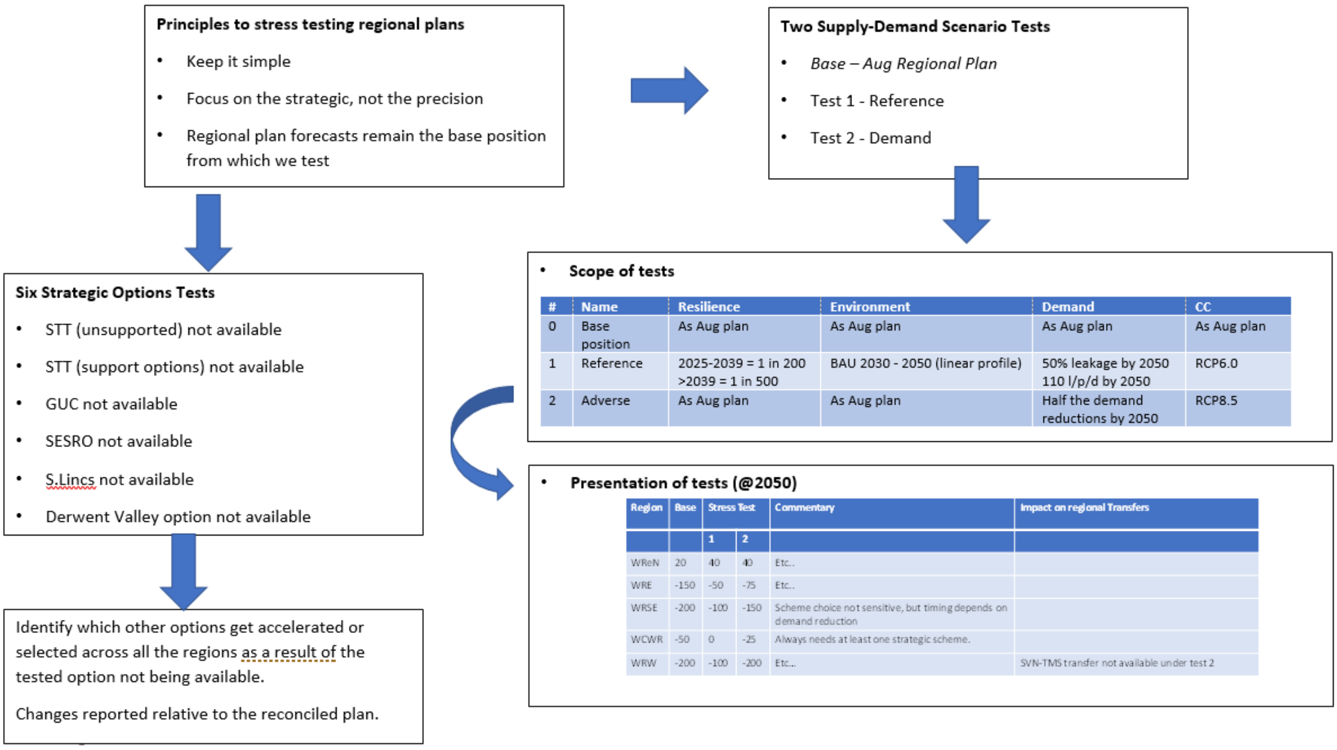
Table 2 Reconciliation alignment table

8 Stress testing

8.1 The purpose of stress testing is to show what happens and how well prepared a plan is when certain stressors are introduced. Stress testing the Regional Plans is recommended for two reasons:

- To give confidence – how far do assumptions in the forecasts each region has produced need to change to get a different answer?
- To support the consultation – what questions we might want to ask and show links between regions and schemes

8.2 The approach undertaken is set out below. Two types were undertaken during the stress test process: the first was to exclude certain schemes, and the second was to stress test the supply demand balance in each region through the reduced benefits from demand management and leakage reduction schemes.



8.3 RCG has undertaken two stress tests relating to the supply-demand balance:

- A reference scenario - that has common assumptions on resilience, climate change, environmental needs, demand and environment
- An adverse scenario - that shows the impact of reduced demand savings and worse climate change

8.4 The stress tests highlight whether different scheme choices are stable, which they were within the range that they were tested.

8.5 A further stress test has been conducted to explore the criticality and sensitivity of selecting options. This has been done by forcing an assumption that particular options are not available for selection. Therefore, we have explored the impact on the region that benefits from the option and any knock-on consequences to the other regions through transfers. Changes are reported relative to the reconciled plan. For example, we identify which other options get accelerated or selected across all the regions due to the tested option not being available.

8.6 A summary of the scenarios assessed and the implications for each region can be found in Table 2 under the headings “Reconciliation stress test assessment” and “Reconciliation outcome and current status of scheme selection”

9 Summary

9.1 The cascade reconciliation methodology sets out an approach to reconcile the regional plans. The approach utilises each of the regions’ own planning processes in a co-ordinated and phased approach to ensure we have a coherent set of core plans.

9.2 The timeline for completing this reconciliation process was three months. Two rounds of reconciliation were required.

9.3 To complete the cascade reconciliation process each region developed a regional baseline plan based on its own requirements over the planning horizon. This baseline regional plan was used for comparative purposes with other subsequent plans.

9.4 To determine the overall best combination of regional plans each region also developed an agreed set of best value metrics that it used for evaluating its plan. These metrics were used to understand the overall best set of reconciled plans.

9.5 Key to this process was ensuring that each of the SRO schemes have costs and benefits associated with them. The ACWG methodologies have set out a series of technical approaches to ensure consistency of some key metrics for comparative purposes.

9.6 The final set of regional reconciled plans have been signed off / approved for consultation purposes by each of the regional boards A further round of reconciliation may be required in April 2022.