Yorkshire Water
Water Resources Management Plan 2024

January 2025

Security statement

In accordance with Water Resource Management Plan guidelines, this statement certifies that Yorkshire Water's WRMP has been reviewed by our security team. This 'public' version has some information redacted or edited out for reasons of national security.

This document does not contain any commercially sensitive information however, the associated water resource planning tables have some commercially sensitive data redacted as summarised below:

- Title page – Publicly available
- Table 1 – Base year licences – redacted
- Table 2 – WC level data – publicly available
- YWSEST – Publicly available
- YWSGRD – Publicly available
- Table 4 – Options appraisal summary – part redacted
- Table 5 – Option benefits – part redacted
- 5a – 5c – Cost profiles – redacted
- Table 6 – Drought plan links – publicly available
- Table 7 – Adaptive programmes – publicly available
- Table 8 – Business plan links – redacted

Abstract

Our Water Resource Management Plan (WRMP) is a key component of our long-term, strategic planning framework. It sets out how we plan to maintain a safe and reliable water supply to customers over the long term. We are forecasting a supply-demand deficit in the future: This deficit results from the impacts of climate change, population growth, the need to protect the environment and the loss of imported water from a neighbouring water company. We need to take action to ensure resilient water supplies into the future. Our plan to mitigate the deficit is a twin-track approach including demand reduction and increasing available supply. Demand reduction activity includes leakage reduction, smart metering and customer water efficiency.

In respect of supply options, in the early part of our plan (2025-2030) we will make use of new supplies. This includes a new borehole source and associated water treatment works and a scheme to increase the output of an existing borehole site. We have also included plans for changes to existing river abstraction licences in the near term and additional pumping capacity at one of these sites. In the medium term our plans include a new water treatment works and internal water transfer to offset the loss of imported water from outside our region, and a further new borehole to support our grid. To mitigate the future resource reductions associated with the need to protect sensitive river environments our adaptive plans include a transfer from Northumbrian Water and further into the future we include two new additional supply schemes.

For periods of dry weather, we will maintain the actions in our drought plan, but over the lifetime of the plan we will reduce our reliance on these measures moving from the most serious of measures being required once in every 200 years, to the most serious of measures being required once in every 500 years. We reflected on the experiences of the 2018 and 2022 droughts and have made adjustments to our WRMP.

Overview

Our Water Resources Management Plan 2024 (WRMP24) builds on our previous plan (WRMP19) and incorporates new information and the latest methodologies. It shows that the risk of climate change reducing water availability, which was driving a deficit in our WRMP19, still poses a significant threat to our security of supply if we do not act.

Additional risks have been identified in our WRMP24 and these have reshaped our future water resource position. These include future licence changes to protect the environment, an increase in peak demand during dry weather and localised housing growth “hot spots”. Since producing our WRMP19 we have experienced drought events in 2018 and 2022; the second of which is our worst drought since 1995/96. Our WRMP24 is planning for a severe drought risk with a return period of 1 in 500 years. The Covid-19 pandemic in 2020 also led to unprecedented demands that tested our supply system and need to be incorporated into our plans.

A further significant intervention to consider is the decision by our neighbouring company, Severn Trent Water, to cease an existing transfer of raw water it provides to our South Yorkshire area. The transfer is planned to cease by 2035 and we shall invest in an alternative supply so that the loss of the transfer does not impact on our ability to meet our customers’ needs.

Once all the emerging risks and known interventions were incorporated into our forecasts for supply and demand over a 60-year planning period, our WRMP24 indicated, in extreme dry years there is a risk of a supply-demand deficit throughout the planning period (2025 to 2085). Our plan to address this risk is a twin track approach investing in demand reduction and new supplies.

We will continue our WRMP19 plan to reduce demand through increased leakage reduction and we will reduce demand further through smart metering supported by a customer water saving programme. We have set challenging targets for reducing leakage and per capita consumption (customer water use) over the next 25 years. This will reduce average demand in our supply area and reduce our daily average energy consumption used for treating water and pumping to customers. Our aim is also to reduce the volume that we abstract and put into supply from the environment, where we are able to evidence the associated environmental benefits. In doing so we will be required to invest in alternative sustainable water supplies. At the same time, we will invest in new supplies that will be needed during the summer weeks when demand is highest and during drought events when our current sources of supply have reduced availability.

In selecting our preferred plan, we have used a multi criteria approach to produce a best value plan. This approach creates several alternative plans for closing a deficit and scores each plan against metrics that represent a range of key decision-making criteria for meeting water resource planning objectives. The principal objective of our Water Resource Management Plan is to close the supply-demand deficit and provide a sustainable and secure supply of water to our customers. Additional objectives include ensuring costs are efficient and that we maximise the wider benefits of the plan by considering the environmental and social impacts associated with water supply and delivering supply-demand solutions. The objectives are often conflicting, and we must balance the impacts to create a best value plan that may not be optimum for each individual metric but is the most optimal plan when all objectives are considered collectively.

The outcome of our WRMP24 is that we will invest in new technology (smart metering) and further leakage reduction techniques to reduce demand over the long-term. We will also provide our customers with information on how to reduce water consumption in their homes and places of work. During the next five to ten years, we will invest in new supplies including new treatment capacity, new groundwater supplies and an additional internal transfer for offsetting the loss of the import from Severn Trent Water.

Our plan includes various decision points or adaptive pathways in relation to the environment. These include potential near term licence changes to support Water Framework Directive objectives, plus longer-term changes that might be required to support our Environmental Destination. These licence changes, and the solutions to offset them (including a potential import from Northumbrian Water) are considered in the plan.

Although our plan shows a clear need for interventions to maintain our supply-demand balance, there is still significant uncertainty over the scale of the deficit, the benefits that demand reduction activity will achieve and the exact timing of the transfer loss and the licence reductions. New water resource options are subject to planning and environmental consents and further work is required to fully understand their feasibility and reliability. We have therefore created a plan that is flexible to uncertain futures.

The near-term interventions included in our best value plan will improve our resilience to droughts. Over the longer term our plan has several pathways that represent our most likely future scenario and high and low alternatives. Our WRMP24 is an adaptive plan with defined triggers and actions for diverting to an alternative pathway in the future. We may divert to an alternative plan once the risks are certain and we are able to identify with confidence the pathway we are following. This might be if one or more of our preferred options is unsuccessful or if new information on one of the key risks shows we are following a different scenario pathway.

Contents

1 Introduction

This section introduces the principles of water resource planning and describes why we need to prepare a Water Resources Management Plan. It summarises the challenges we face in respect of a resilient water supply in the future and how this has changed since our previous plan, WRMP19.

1.1 Why do we produce a Water Resources Management Plan?

Our Water Resources Management Plan 2024 (WRMP24) is our strategy for ensuring our customers have a reliable and sustainable supply of high-quality, clean water. The plan prepares us for future challenges such as climate change and population growth, which can put water supply at risk if we do not act. It also considers the environmental impacts of our existing and future water abstraction and identifies where changes are needed to protect and enhance the environment. The output of the plan is an intervention strategy for securing a sustainable water supply over the long term.

Our WRMP24 identifies the future challenges to both meeting customer demand and protecting the environment over a 60-year planning period, from 2025 to 2085. It looks at several future scenarios and identifies the risks of supply not being sufficient to meet future demand. If we do not take action in response to these risks, we could be facing a water supply deficit. We must intervene to remove this risk, whilst ensuring our decisions deliver best value for customers and the environment.

The Water Industry Act (HM Government, 1991) sets a statutory requirement for water companies to produce and publish water resource management plans at least every five years. The government and its regulatory bodies (Environment Agency, Ofwat[1], Drinking Water Inspectorate and RAPID[2]) provide guidelines, expectations, and directions[3] that we must follow. In addition, there are numerous other well documented approaches and best practice guides that help us build individual components of the plan – for example, UKWIR methods for calculating water resources yield, and guidance on how to take a risk-based approach to planning.

We have prepared this plan in accordance with the Water Resources Planning Guideline (WRPG) and supporting documents (Environment Agency, Ofwat and Natural Resources Wales, 2021a), the Water Resources Management Plan (England) Direction 2022 (Defra, 2022a) and Government Expectations for Water Resource Planning (Defra, 2022b). These guidelines and directions define the methods we use for estimating the components of supply and demand to inform our plan as well as key objectives we must incorporate into the outputs of our plan.

Our WRMP24 sets out how we will take a twin track approach to ensure we provide a resilient and sustainable supply of water to our customers. The twin track approach includes both demand management measures (water use reduction) and additional supply schemes (new resources) in our solution for addressing the risks. By reducing demand, we reduce the average volume of water we abstract from the environment daily. By increasing the volume of supply available we are more resilient to periods of increased demand, including droughts. We are also better prepared for licence reductions to protect the environment and to meet the challenges of population growth and seasonal peaks in demand, which demand management alone cannot fully offset.

[1] The Water Services Regulation Authority

[2] Regulators Alliance for Progressing Infrastructure Development

[3] Directions are issued by The Secretary of State for the environment, food and rural affairs (Defra), in exercise of the powers conferred by sections 37A(3)(d) and (7), 37B (11) and 37D (1) of the Water Industry Act 1991(a). The directions are revised with each iteration of the WRMP and the latest directions are The Water Resources Management Plan (England) Direction 2022.

Our demand reduction activity will target our whole supply area to help conserve water and reduce day to day carbon emissions. Our new supply investment will increase drought and non-drought resilience during peak demands and other events (cold weather, outages, critical periods) should we experience temporary system failures. In recent years extreme weather events have created stress on our network and we have maintained supply to our customers. However, these risks are likely to worsen over time and therefore, we must plan timely interventions to avoid supply failure.

Our WRMP24 is a long-term plan that considers the potential risks to available supply and future demand up until 2085. The minimum planning requirement, as directed by regulators, is 25 years from 2025 to 2050. We plan for a 60-year period to ensure an adaptive plan, that is flexible to long term uncertainty Within this, we focus on securing the supply in the first 25 years and putting monitoring and investigation actions in place so that the longer-term risks can be addressed as more information becomes available. The adaptive approach to formulating our plan identifies different intervention or adaptive pathways, alongside triggers for selecting a particular pathway once certainty increases and key decisions can be made. As the plan is revised every five years, this ensures any changes to the components that make up the plan are identified and addressed. Our previous WRMP19 (Yorkshire Water, 2020) covered the period 2020 to 2045 and will be superseded by this new plan once finalised.

1.2 Assurance of our WRMP24

Our WRMP24 has been assured by the Yorkshire Water Board of Directors. The requirement that the Board provide an assurance statement in respect of the Water Resource Management plan to Ofwat and the Environment Agency (EA), is set out in the Water Resource Planning Guidelines (Environment Agency et al, 2021a). The key requirements of the Board assurance are that:

- Obligations have been met in the development of the plan.
- The plan reflects any relevant regional plan, which has been developed in accordance with the national framework and relevant guidance and policy or provides a justification for any differences.
- The plan is an adaptive best value plan for managing and developing water resources, so obligations to supply water and protect the environment can be met and is based on sound and robust evidence relating to costs.
- The assurance statement should be accompanied by a supporting statement detailing how the Board has engaged, overseen and scrutinised all stages of development of the plan and the evidence it has considered in giving its assurance statement.

Completion of the above assurance process, and presentation of relevant papers and information to the Yorkshire Water Board on 20 September 2022 for the draft WRMP and on 27 October 2023 for the revised draft WRMP, has allowed the Board to agree the following assurance statement, which meets the requirements of the Water Resources Planning Guidelines. There were no material changes to our plan as a result of the Defra response to our revised draft WRMP in February 2024 (section 1.6.2), which we responded to in April 2024. Our Board was informed in May 2024 regarding these updates. Our final WRMP reflects this position.

Our Board assurance statement is provided below. The required supporting statement is included as Appendix D to our WRMP. The Yorkshire Water Board makes the following statement:

a) The Board is satisfied that the Yorkshire Water WRMP has met all obligations in its development.
b) The Board is satisfied the plan reflects the Water Resources North Regional Plan and has been developed in accordance with the national framework and relevant guidance and policy.
c) The Board is satisfied the plan is an adaptive best value plan for managing and developing water resources, so obligations to supply water and protect the environment can be met.
d) The Board is satisfied that the adaptive best value plan is based on sound and robust evidence including relating to costs.

1.3 Links with other plans

Our WRMP is developed in conjunction with a number of other frameworks, plans and strategies created by Yorkshire Water and other external bodies, including our regulators. A number of these are described below and integration with regional plans is described in Section 1.4. In addition, we consider interconnections with other plans as part of building the supply and demand components of our WRMP and in formulating the outputs of the plan. For example, local authority plans are used in compiling our demand forecast. External strategies, frameworks and regulatory objectives are considered in our environmental assessment of our supply and demand options (such as Local Nature Recovery Strategies (Defra, 2020), The Draft Environment Bill 2020; State of Natural Capital Annual Report (Natural Capital Committee, 2020), the Water Framework Directive and Regulations (HM Government, 2017), Habitats Regulations Assessment (Council Directive 92/43/EEC); The Conservation of Habitats and Species Regulations 2017 (as amended)(HM Government, 2017b)). A key output of our options appraisal process is our Strategic Environmental Assessment (SEA). As part of our options appraisal, we also carried out a high-level review of water quality risks for our new supply options. Further information is provided in the relevant sections of this WRMP.

1.3.1 Government's 25-year Environment Plan[4]

This plan sets out the government's goals for improving the environment, within a generation, and leaving it in a better state than found. The objectives include 'improving at least three quarters of our waters to be close to their natural state as soon as is practicable'. Water companies have a key part to play in achieving this and Water Resources North (WReN) has included the 25-year Environment Plan ambition as a key objective, which our WRMP will help to achieve. The Government's Environmental Improvement Plan (Defra, 2023)[5] provides an update on the progress against the interim and long-term targets underpinning the 25-year Environment Plan.

Our WRMP will contribute through using a best value plan approach, setting targets to reduce demand, and meeting our environmental destination. As we progress to delivering of our plan, we will aim to support nature recovery and deliver net gain for the environment.

1.3.2 The Yorkshire Water Drought Plan

Our Drought Plan (Yorkshire Water, 2022b) complements our WRMP by setting out the actions we take when our area is approaching or in a drought. It describes how we enhance available supplies, manage customer demand, and minimise the environmental impacts of our drought actions. The actions are linked to our levels of service for temporary use bans, drought permits or orders for increasing supplies or an essential use ban and for emergency drought actions (level 4 restrictions, for example, rota cuts). Our WRMP aims to ensure our levels of service can be maintained or improved. WRMP24 shows we are not currently operating to the level of service for level 4 actions we stated in our drought plan. It sets out our plan to achieve this by no later than 2039.

1.3.3 The Yorkshire Water Business Plan

We submit business plans to Ofwat every five years as part of a 'price review'. These plans set out what we plan to deliver for customers and the environment. They include our planned expenditure for the next five years whilst looking further ahead to consider how the future influences our plans today. Our draft business plan (Yorkshire Water, 2023a) for the Price Review 2024 (PR24) was submitted to Ofwat on 2 October 2023. Our WRMP24, once finalised, will align with our PR24 business plan, and set performance commitments related to the delivery of the WRMP and achieving the Government's 25-year Environment Plan.

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[4] 'A Green Future: Our 25 Year Plan to Improve the Environment' (Defra, 2018)

[5] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1168372/environmental-improvement-plan-2023.pdf

1.3.4 The Yorkshire Water Drainage and Wastewater Management Plan

Our Drainage and Wastewater Management Plan 'DWMP' (Yorkshire Water, 2023b) is a key component of our PR24 Business Plan. It is a new strategic planning framework requirement for PR24. It is a collaborative long-term strategic plan highlighting the needs and requirements of drainage, wastewater, and environmental water quality for the next 25 years and beyond. Our DWMP will identify changes in levels of risk to the core services we provide across a range of time horizons. By exploring different time horizons, we will identify and anticipate risks arising from climate change and population growth and the effects these may have on the levels of service we provide. The DWMP will consider all aspects of our wastewater networks (foul, combined and surface water), our wastewater treatment works, the interconnecting drainage systems from other risk management authorities, such as local authorities and the EA and how these impact our environment, including discharges to rivers, streams and other waterbodies.

Similar to the WRMP, the DWMP incorporates future pressures on water supply and demand due to predicted changes to the climate. It also looks at future changes in population, housing, water use and metering trends in Yorkshire. The WRMP and DWMP follow the same time horizons and principles, to ensure resilient water and wastewater services now and in the future. Where appropriate, it is important that the two are considered together and complement each other when making business decisions. Whilst efforts have been made to align the data and processes utilised within our WRMP and DWMP differing timescales and requirements, including regulatory guidance, have meant this has not always been possible. At this stage there are no direct linkages between the interventions we plan to carry out in our WRMP and our DWMP, although there are important implications to consider in respect of customers' water consumption and disposal. In the future there will be potential to explore options that would result in direct alignment of the DWMP and the WRMP, such as the use of grey water or effluent reuse to offset potable water demand.

1.3.5 River Basin Management Plans

River Basin Management Plans 'RBMP's' (Environment Agency, 2022) describe the challenges that threaten the water environment and how these challenges can be managed and funded. The plans are based upon a detailed analysis of the pressures on the water bodies within the river basin district and an assessment of their impacts. They set out the environmental objectives for the water bodies and a summary of the programme of measures that will be taken to achieve them.

The WRPG states that water companies must take account of the requirements of the Water Framework Directive (WFD) regulations when considering the preferred plan, including objectives outlined in the RBMPs. A WFD Compliance Assessment has therefore been carried out to inform the Strategic Environmental Assessment associated with WRMP24 and assess the impact of the best value plan on WFD requirements, including the RBMP objectives.

In more general terms, our WRMP24 will contribute to the objectives of the RBMP by ensuring a sustainable set of options to maintain water supply into the future, supporting customers to use less water and preventing deterioration of the environment in line with the requirements of the Water Industry National Environment Programme (WINEP) (Defra, 2022d) and Environmental Destination (Environment Agency, 2020b).

We have described our approach to resilience in Section 3.6, and this includes our approach to catchment resilience and catchment-based solutions. Historically the focus of our catchment approach has been on improving water quality. While that remains the primary objective of this activity, the multiple benefits of such programmes, including flood mitigation, biodiversity and carbon sequestration, are increasingly recognised as equally important. In addition, we have been collaborating with the Environment Agency and United Utilities, to create a national framework to help inform the use of water supply reservoirs to help mitigate flood risk, building on our experience at Hebden Bridge in Calderdale. This framework is looking to set out how such schemes may be considered in the future and how the important, but sometimes conflicting, requirements of water resources and flood risk reduction can be appropriately balanced.

1.4 How Water Resources North has shaped our WRMP24

Yorkshire Water is part of the Water Resources North (WReN) Regional Planning Group, of which there are five nationally. WReN was assembled to oversee water resources planning at a regional scale for Yorkshire and the North East of England. The WReN regional group members include stakeholders with an interest in water resources in our region, including energy providers, agriculture, navigation, industry, water companies and representatives from key groups and trusts. Yorkshire Water is producing the first WReN Regional Plan in partnership with Northumbrian Water, Hartlepool Water and the regional group members. Regional water resource plans provide a process for water companies to plan for the long-term in collaboration with other abstractors in the same region. They aim to address the future water resource demands of both the water users and the environment for 25 years or more. This includes improving resilience to drought and contributing to national resilience through bulk transfers between regions, if these prove to be best value solutions.

The WReN Regional Plan is available on the WReN webpage via this link https://www.waterresourcesnorth.org/.

Further information on the Government's requirements of regional plans can be found via this link: https://www.gov.uk/government/publications/meeting-our-future-water-needs-a-nationalframework-for-water-resources.

1.4.1 National Framework for Water Resources

In 2020 the Environment Agency published a policy paper '*Meeting our future water needs: a national framework for water resources*' setting out actions and ambitions for meeting the needs of all water users and for restoring, protecting and improving the water environment. The actions included a requirement for each of the five regional groups to produce an overarching Regional Plan for their area that would inform water companies' Water Resources Management Plans. The Regional Plan objectives, as set out in the National Framework, include:

- Reduce demand to an average 110 litres of water per person per day by 2050 and drive down water use across all sectors,
- Halve leakage rates by 2050, compared to 2017/18 levels[6],
- Develop new supplies such as reservoirs, water reuse schemes and desalination plants as well as innovative cross-sector options that bring broader benefits,
- Move water to where it is needed through more transfers of different scales and lengths,
- Increase resilience to drought so that restrictions such as rota cuts and standpipes are needed no more than once every 500 years on average by the 2030s,
- Reduce the use of drought measures that have an impact on the environment,
- Proactively enhance the environment and increase ambition, particularly for protected and other sensitive species / habitats (also referred to as 'Environmental Destination').

Our WRMP24 has been developed in parallel to the WReN Regional Plan and the above objectives have been considered in our decision making at both a regional and company level to form our best value plan. The impacts of the Regional Plan on our WRMP24 are described in the relevant sections. The final solution of our plan is aligned with the WReN Regional Plan solution. We will continue to incorporate the National Framework objectives into future iterations of both plans as further information becomes available.

[6] https://www.water.org.uk/wp-content/uploads/2018 /11/Letter-to-the-SoS-18.10.18.pdf

1.4.2 Regional Plan reconciliation process

A key component during the development of the regional plans was the reconciliation process, which was devised to ensure alignment of strategic resource options between regional planning groups. Strategic resource options (SROs) are options that have been taken forward through the RAPID[7] gated process and may be developed further than WRMP level options at this stage due to the requirements of that process. They can be collaborations between multiple water companies and /or other sectors. Three reconciliation exercises have been completed. In advance of the draft plan Reconciliation 1 took place in two phases during Autumn 2021 (to inform the emerging regional plan), with Reconciliation 2 taking place in spring 2022. In advance of the revised draft WRMP24 submission in October 2023 regions undertook a further round of reconciliation known as Reconciliation 3.

As the regional plans and WRMPs were developed and supply-demand surplus and deficit information became available, the regional groups were able to create solutions that included bulk transfer options based on the needs and transfer capacity of each region. At each reconciliation phase, regions tested the impact that transfer positions (as a donor or recipient) had on their plans. They also considered how the reconciliation position could change under different supply-demand balance scenarios to test the resilience of the position. The output of the reconciliation process was an agreed transfer position across the regions that would feed into each of the company WRMPs.

1.4.3 Regional Plan reconciliation process in practice for WReN

WReN's transfer options included potential exports to Water Resources West (WRW) that could be provided by either YW or Northumbrian Water. During the reconciliation process these options were not selected as part of WRW's solution in either its core plan or any adaptive pathways. However, it was identified by phase 3 of the reconciliation process (Reconciliation 2) that the existing transfer between WReN and WRW would cease (which was affirmed in Reconciliation 3, with the transfer ceasing under all pathways). This is a key strategic import to the YW supply area and the risk it creates and the solution to remove the risk are addressed as part of our WRMP24. WReN's transfer options included potential exports to WRW. During the reconciliation process these options were not selected as part of WRW's solution in either its core plan or any adaptive pathways.

The other potential for a regional transfer between WReN and a neighbouring region is with Water Resources East (WRE). However, although options for a WReN (YW) to WRE (Anglian Water) transfer were identified, they were not classed as feasible. At the draft plan stage, although Anglian Water had a deficit in its WRMP24, the area of need was not geographically close to the YW supply area but was much further south. A bulk transfer solution was therefore considered infeasible on cost grounds (both construction and operation), due to the distances involved. As we progressed through the reconciliation stages it also became apparent that YW's supply–demand balance risks meant that any trades with Anglian Water were limited by the future water availability. However, subsequently Anglian Water have confirmed that there are deficits in their revised draft plan closer to the Yorkshire area; therefore, further exploration of trading opportunities will be needed in WRMP29.

1.4.4 Environmental Destination

The National Framework (Environment Agency, 2020) sets out the concept of 'Environmental Destination', which requires regional groups to explore and plan for potential changes in abstraction that ensure the water environment is sufficiently protected in the long-term. This is in addition to short-term changes in abstraction to ensure sustainable abstraction under existing statutory requirements. The WRPG (Environment Agency, Ofwat and Natural Resources Wales, 2021) require water companies to reflect both the short and long-term changes in abstraction (as set out in the regional plans) in their WRMPs.

[7] Regulators' Alliance for Progressing Infrastructure Development

1.4.5 Strategic Resource Options

In developing our first Regional Plan we have identified that significant new supply infrastructure may be required, including inter-company water transfers and new water sources. To accelerate the development and implementation (where required) of these solutions we have proposed a portfolio of SROs to RAPID as part of our PR24 business plan submission. This will ensure these strategically important supply-side solutions are accelerated, delivered at an appropriate pace and quality to meet the region's long-term water needs. Our proposed PR24 SRO programme includes the development of an inter-company transfer from Northumbrian Water which would be supported by Kielder Reservoir.

1.4.6 The future of the Severn Trent Water transfer to Yorkshire Water

The most significant impact of the regional reconciliation process on WReN is the future of an existing transfer from Severn Trent Water's (STW) Upper Derwent Valley reservoirs in WRW to YW. The transfer agreement is in place until 2084 and includes a clause for either party to terminate the agreement in 2035, provided noticed is given no later than 2030.

YW and STW were jointly developing an SRO that would increase the reservoir capacity in the Upper Derwent Valley. However, following concerns by regulators and stakeholders on the impacts of the reservoir expansion scheme, STW has now confirmed that it will not progress any further with this option. In an update to its draft WRMP, STW has also confirmed that cessation of the existing transfer will be included in its preferred plan for WRMP24.

Therefore, we have aligned our plan with this outcome and because the transfer is a critical source of supply to the South Yorkshire area our plan must include a new source of supply to this area to offset the loss of the transfer by 2035.

1.5 WRMP24 engagement

Our WRMP defines our strategy for maintaining water supply for the long term. It includes supply and demand initiatives that will require funding and will impact across a broad range of criteria. The outputs of the plan impact on our customers, the environment and other water users in Yorkshire. It is therefore important that others are given the opportunity to influence our plan and that regulators are kept updated with the key components as they are developed. Our WRMP24 has been developed in parallel to the WReN Regional Plan. The cross sectoral and customer engagement carried out for the Regional Plan has fed into our WRMP24 and has been considered in forming our solution for this round of planning.

1.5.1 Pre-consultation on our WRMP24

In addition to the WReN engagement, we have carried out a pre-consultation of our WRMP24. We wrote to statutory and non-statutory consultees, including new appointments and variations, and retailers, in March 2022 notifying them of the formal consultation to be held later in the year and providing them with a summary of the emerging plan. We have also met with the Environment Agency, Drinking Water Inspectorate and Ofwat to discuss the plan as it emerged and seek feedback.

We have also met with regional stakeholders including the Yorkshire Leaders Board, a network of Yorkshire's Council and Mayoral Authority leaders, to brief them on the emerging plan themes and the consultation process, and to open up discussions around how closer working with local Yorkshire Water Draft WRMP24 authority partners may help to deliver water resources related activity (such as building standards for new homes).

In addition, we have met several times with the Yorkshire Hub group, which brings together all of the Catchment Hosts across Yorkshire, which includes local Rivers Trusts, the Yorkshire Wildlife Trust and other partners leading the Catchment Based Approach (CaBA) in our region. As well as engaging with this overarching group that covers our whole region, we have also held more detailed discussions with individual catchment groups where requested and also where there are specific issues where more detailed consultation is valuable: For example, with the Yorkshire Wildlife Trust as hosts of the Hull and East Riding Catchment Partnership, to discuss how we can support delivery of the CaBA's Chalk Stream Restoration Strategy that was published in 2021.

We are also engaging directly with retailers as we go through the PR24 process, including WRMP. At PR19, wholesalers engaged with retailers individually. The feedback from retailers was that this was inefficient, and the engagement was often on the same topics, with retailers providing repeated feedback to multiple wholesalers. The engagement was often not focussed on market outcomes and instead more on individual wholesaler outcomes.

The ask from retailers for PR24 was to join up the engagement, in a more co-ordinated way that allows for central themes and issues to be debated and solutions considered in a central forum rather than in individual company silos. With this in mind, wholesalers, Market Operator of England's Non Household Water Market (abbreviated to MOSL), retailers and the UK Water Retail Council (UKWRC) have come together to create a market PR24 forum, and we are engaging through that forum on matters related to PR24 and other plans including WRMP. Through this forum, we know that issues that are of particular interest to retailers at this stage include wholesaler service incentivisation, smart meters and water efficiency. As part of our WRMP24 pre-consultation we sent a survey to retailers in our supply area to ask how they would prefer to deliver water efficiency to non-household water users. This showed there was a willingness for collaborative projects to be carried out between wholesalers and retailers. However, retailers did not consider it the role of the wholesaler to offer services direct to non-household customers.

1.5.2 What have we done to inform our WRMP?

WRMP24 marks a 'step change' in water resources planning, not just for Yorkshire Water but for the whole of England and Wales. Water company WRMPs now sit within the broader context of the National Framework for Water Resources and five Regional Plans, and this includes new long-term ambitions for reductions in abstraction, which have been termed as 'Environmental Destination', as well as challenging expectations for demand management and leakage reduction. New data about the potential impacts of climate change has altered our view of the future risk to supplies. Covid-19 lockdowns have changed demand patterns and we continue to see the impact of this even as society has reopened. In Yorkshire, droughts in 2018 and 2022 – the second of which is our worst drought since 1995/96 – have led to new learning about our drought resilience and the need for continued investment to maintain resilience into the future. All these factors mean that our WRMP24 will be substantially different to previous recent WRMPs.

To help us understand future demand for water, we update our forecasts for both household and non-household water use for each iteration of our WRMP. For WRMP24 we have combined updated information on population growth and housing developments with other factors that influence customer water use, such as meter uptake and technology changes. This data has been put into a new household consumption model, and both dry year and Covid-19 impacts have been applied.

We have also considered policy requirements for demand reduction and how we can achieve the National Framework objectives. This includes continuing to plan for further reductions in leakage, as well as understanding how we can work in partnership with others, including the Government, to deliver on ambitious expectations for reductions in per capita consumption.

On the supply side, we have worked closely with the Environment Agency to understand where environmental pressures may reduce the amount of water available to us in the future. For WRMP24 this has included ensuring that the new, longer term, potential reductions in water availability – 'Environmental Destination' as described through the National Framework and reflected into the WReN Regional Plan – have been considered in developing the adaptive pathways in our WRMP.

We have also updated our assessment of the impact of our changing climate on water resources, using stochastic data to model our deployable output with UKCP18 climate change model projections[8] informing our assessment of the risk of climate change to future supply.

We have considered how water quality may change in the future, and how we will need to invest in a range of solutions to ensure that we do not compromise on the quality of water supplied to customers. We continue to grow our industry-leading programme of work with landowners, land managers and the agriculture sector to enhance the resilience of our raw water sources, both in terms of volume and water quality, recognising that working with these sectors to promote more sustainable land management practices not only benefits our water resources resilience but also provides other benefits such as increased retention of floodwaters, enhanced biodiversity, carbon capture and more (economically) sustainable farming businesses.

In developing our plan, we have thought about how as a company we impact on Yorkshire's environment, its economy, and people as we carry out our activities. As well as talking to our customers to find out their priorities, we have engaged expert assistance to provide us with the latest understanding of the challenges that we face.

1.5.3 What are our customers telling us?

Customer engagement for our WRMP24 started early, as part of our work through the WReN Regional Plan, and in partnership with Northumbrian Water and Hartlepool Water. The WReN engagement built on the significant work that all companies had carried out for PR19, in recognition that our understanding of, and the evidence based for, customer preferences and opinions is not starting from 'zero'. The key conclusions take from research carried out to inform PR19 were:

- A reliable supply of safe drinking water is a top priority across the Water Resources North region. However, affordability considerations lead to a preference for maintaining and protecting existing performance; where there is willingness to pay for improvements, water service tends to be lower valued than wastewater driven issues.
- When considering water resource themes, reducing leakage and environmental improvements are generally seen as more important than level of service (for example, customer use restrictions). Level of service is typically seen as a low priority, although this may in part be caused by the infrequency of experiencing such events; the duration of events (when they occur) is probably more important than the frequency.
- Whilst customers are supportive of improvements in a number of areas particularly around leakage, consumption, meeting public water supply reliability needs, and the environment, in a number of other areas (for example, drought resilience) they would only support meeting minimum levels or regulatory standards.

Building on the existing knowledge from previous research, YW, Northumbrian Water and Hartlepool Water collaborated to carry out further customer research at the Water Resources North regional scale. This comprised deliberative research across 16 representative customer groups, each meeting twice over a period of a week. These groups were made up of a mix of existing household customers, future customers and citizens, as well as a range of non-household customers. The non-household sessions were held with a mixture of water dependent businesses (for example, farmers) and non-water dependent businesses. Whilst this type of approach typically engages a lower number of customers than quantitative survey approaches, it benefits from a much greater dialogue and opportunity for those involved to really understand the nuances of water resources management. This allows for more informed feedback on customer priorities for future plans, especially where topics are relatively complex or multi-faceted.

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

Although the research was carried out at a WReN regional level, it was completed in such a way as to allow disaggregation of the research results by water company, allowing each of the water companies to understand the preferences of their own customers, within the overarching WReN picture.

The key focus areas for the research were:

- Defining a 'best value plan' (linked to Regional Plan and WRMP objectives and metrics)
- Environmental Destination
- Water trading
- Opinions on option types

When exploring best-value planning, the research identified themes that were consistent with PR19 research outcomes. In terms of objectives, the strongest level of support was for 'creating a plan that is affordable and sustainable over the long term', 'meeting future public water supply drought resilience' and 'contributing to the Government's ambition in the 25-year Environmental Plan'.

With regards to the plan metrics, customers were asked to rank these in order of importance. This highlighted that leakage, drought resilience (reliable supplies) and cost (affordability) have the strongest customer focus, with a range of environmental and social considerations (and per capita consumption) sitting in the mid rank. Of particular importance was the fact that customers did not place great importance on option deliverability, or on option type, indicating that achieving the desired outcome is more important than how those outcomes are achieved.

The following more general key messages were also taken from this engagement:

Overall, the following key messages were observed:

- Customers, citizens and non-household customers are unaware of current or potential water scarcity within the WReN region.
- WReN WRMP objectives gained support, although a focus on education was something that was felt to be missing potentially.
- Customers, citizens and non-household customers were open to the idea of water trading as long as there were no adverse effects on their supply, and recipient companies do not use it as the 'easy option' which could lead to greater inefficiencies (proxy for leakage).
- Timescales for targets were perceived as being too far in the future. Customers want to see shorter timelines (5-10 years) even if this is progress against a long-term goal.
- Given the importance of water resources and improving the environment, there was a general willingness to pay a small increase in bills for investment against targets as long water companies are transparent about this.
- Support was also evident for the environmental ambition, with the general consensus being that abstraction should be reduced and also be the last resort.

Since the WReN customer engagement work was completed, we have carried out further research with YW's customers to help inform our approach to PR24 and long-term strategies including WRMP24. The most recent results from this research were made available in September 2022 and they are broadly consistent with what customers told us through the WReN engagement programme. Specifically:

- The research highlights that customers consider that the highest priority for YW remains 'providing a continuous supply of water that is safe to drink', just as it was when this research was carried out in 2017. 'Keeping bills affordable for all' was second in importance for the majority of customers which is a significant change from the 2017 study. Additionally, once again, customers see the importance of YW 'preventing sewage entering homes and businesses'.

- Customers also place a high level of importance on YW protecting water quality and water bodies in the wider environment. Specifically, preventing pollution from sewage pipes, reducing the release of untreated sewage mixed with rainwater and ensuring water is treated to a high standard to protect rivers and beaches are all priorities identified as being of above average importance to both household and non-household customers.
- Previously, these were some of the priorities that customers are most likely to say they would be willing to pay more to fund. However, a key theme throughout all stages of the research was the 'cost of living crisis' and it is very clear that both household and non-household customers anticipate challenging financial times in the near future.

Our WRMP24 takes on board the research that we have undertaken and the priorities that customers have identified, notably in how we have developed the metrics that we have used for our best value planning process. WRMP24 describes how we will ensure that we continue to have sufficient water to supply our customers, in the face of climate change, population growth and environmental pressures. This plan ensures that we will continue to provide our customers with a secure water supply that meets demand both now and in the future.

Full details of our engagement with customers for WReN's Regional Plan and, by extension, WRMP24 are provided in WReN Regional Plan Appendix 7[9] and provided in Appendix H.

1.5.4 What are our regulators telling us?

There have been some notable shifts in the regulatory environment for water resources since our last plan at WRMP19. Some of the key changes have been:

- The Environment Agency's publication of the National Framework for Water Resources, in March 2020, which set out expectations for long term water resources planning by building on previous national work including the Water Resources Long Term Planning Framework (Water UK, 2016), and 'Preparing for a drier future' (National Infrastructure Commission, 2018).
- The emergence of a new layer of regional water resources planning, in response to expectations set out in the National Framework. Yorkshire Water is a part of WReN, one of five new regional groups.
- The formation of RAPID, created at PR19 to bring together water regulators across England and Wales to help drive investment in key Strategic Resource Options (SROs). In support of the RAPID framework, Yorkshire Water had been developing a new SRO - the Upper Derwent Valley Reservoir Expansion scheme – in partnership with Severn Trent Water. However, due to concerns over potential environmental and heritage impacts, this solution will not progress any further as an SRO. Instead, the SRO will be rescoped to focus on the development of alternative supply-side solutions in South Yorkshire. Since the submission of the revised draft WRMP24 in October 2023, we have been working with RAPID, Northumbrian Water and United Utilities to develop a new SRO for Kielder Reservoir in Northumbrian Water's supply area. The SRO would explore the potential to optimise the use of this underutilised water source to provide value to both customers and the environment.
- The publication of the 25 Year Environment Plan (Defra, 2018) and subsequent passing of the Environment Act (HM Government, 2021) which will lead to long term targets to be set across a range of areas including water, and also allows for collaboration between water companies over water resources planning to be more formalised through the regional planning process. Targets of particular relevance to the WRMP, as informed by the 25 year plan and latterly the Environmental Improvement Plan (Defra, 2023), include those in relation to water demand and leakage reduction.

[9] https://www.waterresourcesnorth.org/our-region/wren-regional-draft-plan/

Alongside the above changes to the regulatory environment for water resources planning, Defra and regulators have also published a series of documents setting out guidance and expectations for the next round of water resources planning. In summary, these set out expectations to secure the long-term resilience of water supplies because of climate change and an increasing population. There is a stronger focus on environmental protection at PR24, particularly in respect of long term 'Environmental Destination'. Expectations around trading between companies, ambitious reductions also been clearly articulated by Government, Defra, and regulators in the run up to WRMP24.

Creating tomorrow, together (Ofwat, 2021) sets out Ofwat's draft proposed methodology for PR24 and was published for consultation in July 2022. The draft methodology identified four key ambitions for PR24: focussing on the long term with stronger adaptive planning; delivering greater environmental and social value; reflecting a clearer understanding of customers and communities; and driving improvements through efficiency and innovation.

In relation to Ofwat's expectations on planning for the long term, the regulator also *published PR24 and beyond*: *Final guidance on long-term delivery strategies* (Ofwat, 2022). This set out how Ofwat expected companies to set PR24 business planning decisions within the context of a long-term delivery strategy, with Regional Plans and WRMPs being some of the key inputs to a company's long-term strategy (alongside other plans such as Drainage and Wastewater Management Plans, the Water Industry National Environment Plan, for example).

Adaptive planning is expected to be 'at the heart of the long-term delivery strategy'. Notably, this guidance also set out the need to test strategies against 'common reference scenarios', specifically high and low climate change trajectories, slow and fast technological development, high and low demand forecasts, and high and low reductions in abstraction. Companies are also encouraged to test against wider scenarios where these may be local or company specific. Use of these 'common reference scenarios' is a key aspect of the scenario testing and adaptive planning approach that we have taken to WRMP24.

The *Government's strategic priorities and objectives for Ofwat* (Defra, 2022b) sets out Defra's strategic priorities for Ofwat and the water industry as:

- Protect and enhance the environment by challenging water companies to improve day-to-day environmental performance;
- Deliver a resilient water sector by planning, investing and operating water and wastewater services to secure customer needs now and into the future, whilst delivering value to customers, the environment and wider society over the long term;
- Serve and protect customers to provide a fairer service for all;
- Use markets to deliver for customers where appropriate.

The *Guidance Note*: *Long term planning for the quality of drinking water supplies* (Drinking Water Inspectorate, 2022) requires our WRMP24 to take account of all statutory drinking water quality obligations, and to include plans to meet their statutory obligations in full. The Drinking Water Inspectorate has also published supplementary guidance for water companies, in the form of Guidance Note: Resilience of water supplies in water resource planning (Drinking Water Inspectorate, 2021). This provides further "guidance on the resilience of water supplies in water resource planning, with emphasis on the consideration of impacts on drinking water quality when planning for sufficiency of supplies and development of water resource schemes, including the development of SROs being managed by RAPID."

The Water Industry Strategic Environmental Requirements (WISER) publication, published in May 2022, sets out the Environment Agency's and Natural England's three main objectives for water companies for PR24 and the period 2025 to 2030. These objectives are: a thriving natural environment; expected performance and compliance, and resilience for the environment and customers.

Relevant to water resources planning, key expectations relate to:

- catchment actions to protect and enhance water quality;
- achieving long term Environmental Destination – particularly in relation to protected sites – whilst accounting for predicted climate change impacts;
- supporting healthy and resilient fish stocks by improving abstractions;
- managing and mitigating risks from Invasive Non Native Species (INNS);
- supporting the 25 Year Environment Plan and the Environment Act 2021 in relation to issues such as Local Nature Recovery Strategies and biodiversity;
- compliance with permits;
- delivering enhanced environmental resilience to support resilience services, including climate change adaptation, use of nature-based solutions, and working towards net zero;
- specific ambitions for resilience in water resources planning including the need to be resilient to a 1 in 500 year drought, keeping drought plans up to date, reducing demand and leakage and ensuring alignment between Regional Plans, company WRMPs, and PR24 business plan submissions.

In September 2022, Defra launched a consultation on mandatory water efficiency labelling for water using products. The consultation sets out proposals to use an international standard to guide labelling products such as taps, showers, toilets, dishwashers and washing machines, in a similar way to the energy efficiency labelling that has been in place for many years. Yorkshire Water has welcomed this development and is a strong supporter of product labelling to help customers make informed choices. Previous research (by the Energy Savings Trust) has suggested that such a scheme, linked also to building regulations and minimum standards, would be the most cost-effective approach for delivery water efficiency savings, and we consider it to be a critical action in supporting achievement of the ambitious demand reductions set out in the National Framework for Water Resources and reflected into Regional Plans and WRMPs.

Our WRMP24 has addressed the priorities of the Government and our regulators to ensure we can continue to meet the needs of people, businesses, and the environment of Yorkshire.

1.6 WRMP24 public consultation

Our draft WRMP24 was submitted to Defra on 3 October 2022 and was available for public consultation for 14 weeks from 18 November 2022 to 24 February 2023. Key areas of our draft WRMP24 on which we sought the views of our customers and stakeholders, were:

- **Plan objectives**
  Determine the level of support for the objectives identified in the plan and understand if there are any further objectives that should be included.
- **Levels of service**
  We sought views on our proposed levels of service for drought resilience, including how quickly we should aim to meet the Government's target for 1 in 500-year levels of drought resilience. We sought to understand customer support for the need to make changes to our final plan to support future resilience.
- **Policy requirements for demand reduction**
  Our WRMP sets out policy objectives on demand reduction that reflect the National Framework for Water Resources, Government expectations and Environment Agency guidelines – we sought views on these policies including a 50% leakage reduction by 2050 and a per capita consumption of 110 l/h/d by 2050.

- **Uncertainty, risk, and relative cost**
  We sought views on the levels of certainty associated with proposed solution types and the associated relative costs Use scenario-based propositions to assess preferences.
- **Range of options considered to address the supply-demand deficit**
  We sought views on the range and appropriateness of demand options. We explored support for some specific policy areas including the Government's proposed scheme for water efficiency labelling and potential YW policy to install a meter on 'change in occupancy', that is, when a new customer moves into a house that was previously unmetered. We sought views on the range of supply options and any other options that could be considered.
- **Metrics for assessing the best value plan**
  We sought views on the levels of support for the proposed metrics asking whether any other metrics that should be included.
- **Preferred plan**
  We sought views on the levels of support for the preferred plan. We sought opinions of preferred approach to specific requirements such as replacement of the Severn Trent Water import. We sought views on the levels of support of the longer-term investment for the transfer of water from Northumbrian Water.

In response to the WRMP24 consultation we received engagement from a broad and varied set of stakeholders, often with multiple areas of interest across the themes in our plan. We had representations from 19 (including non-household) statutory and non-statutory consultees and from one member of the public. We also received 12 responses to our online survey, 246 responses through our 'Your Water' Community survey and focus group sessions.

We compiled the representations received together with our reply to each individual feedback point into a Statement of Response, which was published on our website on 31 July 2023. In response to the feedback we received, we have made several changes to our plan, and these are reflected in this document. A summary of these changes is presented in the section below.

1.6.1 Summary of changes made after the draft plan consultation

We have carefully considered each of the comments made in representations and we accounted for them in our final plan. The main feedback themes and the changes we have made in response to feedback are summarised in the table below.

Table 1-1: Key changes to our final WRMP24 in response to public consultation feedback.

Key feedback theme	Feedback summary	Changes in our final WRMP24
Demand Management	It was clear from consultation that demand management is a priority for most of our stakeholders. The EA gave direction that further work was required to demonstrate compliance with the guidance with respect to our leakage plan. We committed to carrying out significant further work on the leakage, per capita consumption (PCC) and non-household demand reduction options and this work has been completed.	The **demand management strategy** targets for leakage and PCC have remained the same (50% leakage reduction, 110 l/h/d PCC by 2050). We are also including initiatives to support the business demand reduction to achieve the interim target for a 9% reduction in non-household use by 2038. We will continue to review and develop non-household options for consideration in the next iteration of our plan and to build a strategy to achieve the 15% reduction by 2050. This target was introduced late in the process, and we did not include initiatives other than smart metering costs in the draft plan, hence options will be expanded. Overall, the demand interventions remain largely consistent with the draft plan. There is, however, a shift in the balance to increased smart metering and additional activity required for water efficiency

		measures as outlined. The trajectory for reaching these targets has been re-modelled. This is to enable better optimisation and greater granularity of benefit, cost and intervention type in the WRMP.
The Environment and Environmental Assessment	A number of comments were received from stakeholders relating to the environmental aspects of our plan. Some of these requested further clarity on such things as the spatial extent of Strategic Environmental Assessment (SEA) area, and the assumptions and limitations concerning mitigation measures. Others were concerned with the environmental issues at a more strategic level.	Where further clarity has been requested, the SEA Environmental report has been updated, as detailed to consider representations. We are aware of the limitations of the inter-cumulative assessment at the draft WRMP stage. When submitting the draft WRMP we did not have visibility of the plans from neighbouring water companies or regional groups. However, now these have been published we will be updating the SEA: We will address any evidence gaps where we can and put proposals in place where this may not be possible in the timeframe for this plan. We have been, and still are, actively engaging with the other water companies/regional groups to agree a way forward in regard to assessing the in-combination effects of projects. Future work will include more detailed environmental assessments at scheme level as part of the implementation of the selected option.
Timing of Key Projects	A key driver for investment in our plan is the River Derwent abstraction reduction. Representations from the Environment Agency and Natural England questioned the timing of the River Derwent abstractions reductions. They suggested that the licence reduction date of 2050 was too far in the future. Ensure alignment of transfers and options with adjacent companies and/or regions.	The date for this has since been brought forward to 2040 which also aligns with the Regional Plan and the NWL WRMP24 (where the abstraction reduction triggers broader WRMP options). This date is subject to further investigations and options appraisal to determine if the revised date and solution is both deliverable and best value. In addition, since the draft WRMP24 submission it has been confirmed that the AMP7 Strategic Resource Option to raise the reservoir levels in the Derwent Valley is no longer a valid option. Without the reservoir scheme, Severn Trent must terminate the existing transfer to meet its own WRMP24 needs. This is in accordance with the bulk transfer agreement that states if notice is provided in 2030 the bulk transfer of water from Severn Trent to YW can cease in 2035. To offset this loss, we must start to implement a 'backfill option' well in advance of the notice period and the delivery programme has been brought forward as part of the final WRMP24 plan.
Options Development	We received feedback that our draft WRMP24 contained a limited number of supply options and that we should review the timing of these and associated risk for delivery.	In response we are reviewing all options and where appropriate revising delivery dates. We will carry out further options identification for appraisal in WRMP29 to assess a wider range of alternatives to the options in WRMP24. We can confirm that this work will be timed to be available based on the need drivers, availability of the WINEP studies and the regulatory process for funding additional options (RAPID). We will include additional information in our WRMP24 adaptive plan monitoring.

In addition to the changes outlined in the table above in response to the feedback received, there have been some other changes that emerged due to external factors. In summary:

- The baseline supply demand balance deficit has increased since the draft plan, from an average of 105 Ml/d to 135Ml/d. This net 30Ml/d increased deficit is largely due to adjustments to the water balance which have mainly affected the process losses value but there have also been positive adjustments in deployable output and outage allowance.
- We have also replaced our 'WRAPsim' supply model with a 'PyWR' model and recreated the WRMP24 baseline supply scenarios. This has resulted in an increase (non-material) in the Grid SWZ deployable output volume. The PyWR model allows us to model the stochastic inflows better, as it can accommodate large datasets.
- There have been changes to our options costs. The demand options cost increases are largely due to the increase in numbers of smart meters required and the inclusion of non-household water efficiency schemes to achieve the interim 9% reduction by 2037 (excluding growth). Further work to review and develop our plan to meet the 15% reduction by 2050 will be complete for the next iteration of our plan. The supply options cost increases reflect our review of the need for early planning costs for schemes to support progress on both groundwater and strategic options. This is to close the deficit in the short term and drive towards an increased drought resilience level by 2039.
- The demand options have been reprofiled to update for cost assumptions and to align where feasible with the Government's Environmental Improvement Plan demand reduction targets for 2050, including the interim targets. A non-household demand strategy has also been created and included in the preferred plan.
- Since the draft WRMP24 submission it has been confirmed that the AMP7 SRO to increase the reservoir capacity in the Derwent Valley and support South Yorkshire is no longer a valid option. Severn Trent Water have confirmed they will terminate the existing transfer to meet their own WRMP24 needs. This is in accordance with the bulk transfer agreement that states if notice is provided in 2030 the bulk transfer of water from Severn Trent Water to YW can cease in 2035. To offset this loss, we will start to implement a 'backfill option' in advance of the notice period and the delivery programme will be brought forward as part of the final WRMP24 plan. We are currently engaging in the RAPID process to progress this as an SRO.
- The date of the potential licence reduction on the River Derwent in North Yorkshire to meet our environmental destination has been brought forward from 2050 to 2040 in response to consultation feedback from Natural England and the Environment Agency.
- The scenario optimisation and multi criteria analysis to support the decision-making was redone to assess the impacts on option selection and timing of option delivery. The most significant changes are that the new transfer from Northumbria Water has been brought forward to meet the environmental destination need in 2040/41 and there has been some changes to supply side option selection and scheduling in AMP8.

Although these changes are important, the overall strategy remains a twin track approach for the final plan, delivering demand reduction and supply side solutions to close the supply demand deficit.

The adaptive plan strategy remains focused on the uncertainty and risks relating to the most likely triggers for new large-scale supply schemes and the risk of not achieving the ambitious demand reduction. We will continue to explore the phasing of schemes against all scenarios including various levels of climate change impact and drought resilience.

We have updated our monitoring plan to align with the adaptive pathway updates and ensure we have a robust monitoring programme with timely decision points and triggers.

1.6.2 Defra letter - February 2024

We resubmitted our draft plan to the regulators (Defra, EA and Ofwat) on 31 October 2023 for further feedback. In February 2024 Defra wrote to all water companies who had produced a revised draft plan with further recommendations relevant to the individual companies' plans. We responded to this letter in an annex to our original Statement of Response which is available on our website wrmp24_annex_to_sor_web.pdf (yorkshirewater.com). We resubmitted our revised draft plan, which reflected our response to the Defra letter, to the regulators in May 2024.

The Defra letter requested further information on eight issues:

1. clarification on levels of service in the final plan
2. drought option implementation and levels of service
3. resilience in the context of the 2022 drought
4. early delivery (pre-AMP8) of schemes and options development
5. Strategic Environmental Assessment (SEA) on alternative pathways
6. evidencing ambition of the Yorkshire Water demand management program particularly per capita consumption
7. representation of New Appointments and Variations (NAVs) within our WRMP24.
8. further information on the Habitats Regulations Assessment

We have addressed these issues in the Annex to our Statement of Response and only Issue 7 led to a change to our plan. This change was a request from Defra that companies include contractual volumes for transfers to NAVs in the water resource planning tables. We have implemented this request and the increase in export volumes to include the NAV contractual volumes increases our Grid SWZ deficit by around 1 Ml/d over the planning period.

We do not consider the change to be material as it does not drive any further investment. The impact to the supply-demand balance presents a 'worse-case scenario' for NAV exports that overestimates the near-term risk. This is because companies will not be able to fulfil the contractual volumes until property developments are complete, which will be over several years.

1.6.3 Permission to publish – August 2024

Defra, on behalf of the Secretary for State, asked Yorkshire Water to publish our final WRMP24 plan on 21 August 2024.

1.7 Review of our WRMP19

Our WRMP is revised every five years allowing us to take into account new information which could redefine our objectives and our solution. With each iteration there will be new challenges and new objectives to meet due to dynamic external changes. The core objective to maintain a secure and sustainable supply of water remains the same. Our understanding of the risks and uncertainties evolves, however, and new approaches are taken. We discuss changes since WRMP19 in each of the supply–demand balance component sections and the key factors are described below.

1.7.1 Critical period

Since publishing our WRMP19 we have experienced exceptionally dry weather in 2018 and again in 2022 (whilst our draft WRMP24 was being developed), as well as some exceptionally high short-term peaks in demand. This included May 2020 during the first Covid-19 lockdown and July 2022 when record breaking high temperatures were recorded across the UK. These events led to unprecedented demands on our supply system and highlighted the importance of planning for system resilience alongside drought resilience. As a result, our WRMP24 now considers what is referred to as a "critical period" scenario, in addition to the mandatory "dry year annual average" (DYAA) scenario. The critical period scenario assesses the supply-demand balance during a more intense period than the DYAA, when increased resources are needed and /or demand is significantly higher than the DYAA demand.

1.7.2 Per capita consumption

We have also experienced an unprecedented impact on our system as a result of the Covid-19 pandemic. During 2020/21 demand was significantly higher than average during the lockdown periods. The increase in demand was because more people were at home during the day throughout 2020/21 and this impact continued into 2021/22 due to new hybrid working patterns and home working. In 2020/21 there was a 10% increase in per capita consumption (PCC) and annual average distribution input was at a level similar to that experienced in 2018. Non-household demand was lower than normal as many businesses were closed for a significant proportion of the year. However, this reduction was not sufficient to counterbalance the rise in domestic use. The prolonged impact of the pandemic and change to customer behaviour has been considered in our demand forecast scenarios.

The impact of the lockdowns has had a major effect on our PCC projections, and we have rebased the year-on-year reductions we will achieve over the five-year period from 2020 to 2025. In the water industry each five-year period is known as an Asset Management Period (AMP). The period from 2020 to 2025 is referred to as AMP7. During AMP7 our WRMP19 forecast would reduce PCC to 119.3 litres/head/day (l/h/d) by 2025. In reaction to the Covid-19 pandemic and in view of the National Framework objectives, we have re-evaluated our water efficiency strategy and will enhance our activity to reduce PCC over the long-term. However, we are also conscious of the uncertainties demand reduction activities can create and we have considered this in our solution stress testing and adaptive pathways.

1.7.3 Leakage reporting

Our WRMP19 solution included a leakage reduction target of 15% during AMP7. We still aim to achieve this reduction and have incorporated it into our baseline demand forecast. However, since producing the WRMP19 the water industry has moved to more consistent reporting methodologies for sub-components of the demand forecast, which are intrinsic to the total leakage calculation. As a result, our reported leakage has seen a step increase that reflects the updated approach to reporting and is not an actual step increase in the level of leakage in our network. We have therefore rebased our leakage forecast for AMP7 to show the 15% reduction in the annual leakage target values. However, overall the leakage reported is higher than the leakage values presented in our WRMP19 tables. This is explained further in Section 4.4.5[10].

1.7.4 New methodologies

Our WRMP24 incorporates the National Framework for Water Resources policy requirements and changes to the latest WRPG and UKWIR methodologies. The National Framework has shaped the WReN regional planning objectives, which in turn have shaped our WRMP24. New approaches include use of the latest set of UK climate projections (UKCP18) to forecast our future supplies and setting the Environmental Destination for our long-term planning, both of which have significantly increased our supply-demand deficit compared to WRMP19. We have also applied an adaptive planning approach, which has shaped our strategy for addressing the deficit and achieving broader objectives.

The impact of the UKCP18 emission scenario and stochastics approach is a significant and immediate reduction in available water supply in the DYAA scenario. This is due to the stochastic data (based on the 1950-1997 time period) being far drier than our 1900-2020 historic series, since our extreme 1995/6 drought (the worst in 121 years) has a return period of approximately 48 years in the stochastic datasets. This is explained in more detail in Section 3.4 of this report.

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[10] An addendum was added to our WRMP19 main report in 2020 to explain the leakage reporting impact and the EA agreed to use post-convergence data for annual reporting

Over the longer-term the Environmental Destination has a significant impact on water availability. The most likely outcome based on the information available when compiling our WRMP24 (but subject to further assessment) is that we will lose 11Ml/d in groundwater supplies by 2035 and a further 104Ml/d from a single surface water abstraction (River Derwent) by 2040. The licence reduction included in our WRMP19 as a result of the WINEP investigation were 1.5Ml/d.

The impact of the revised climate change approach and the Environmental Destination combined with the loss of the STW transfer has raised significant large scale deficit risks in our supply–demand balance that must be addressed. To address this risk our WRMP24 requires substantial increased investment compared to our last plan and this is reflected in our WRMP24 solution.

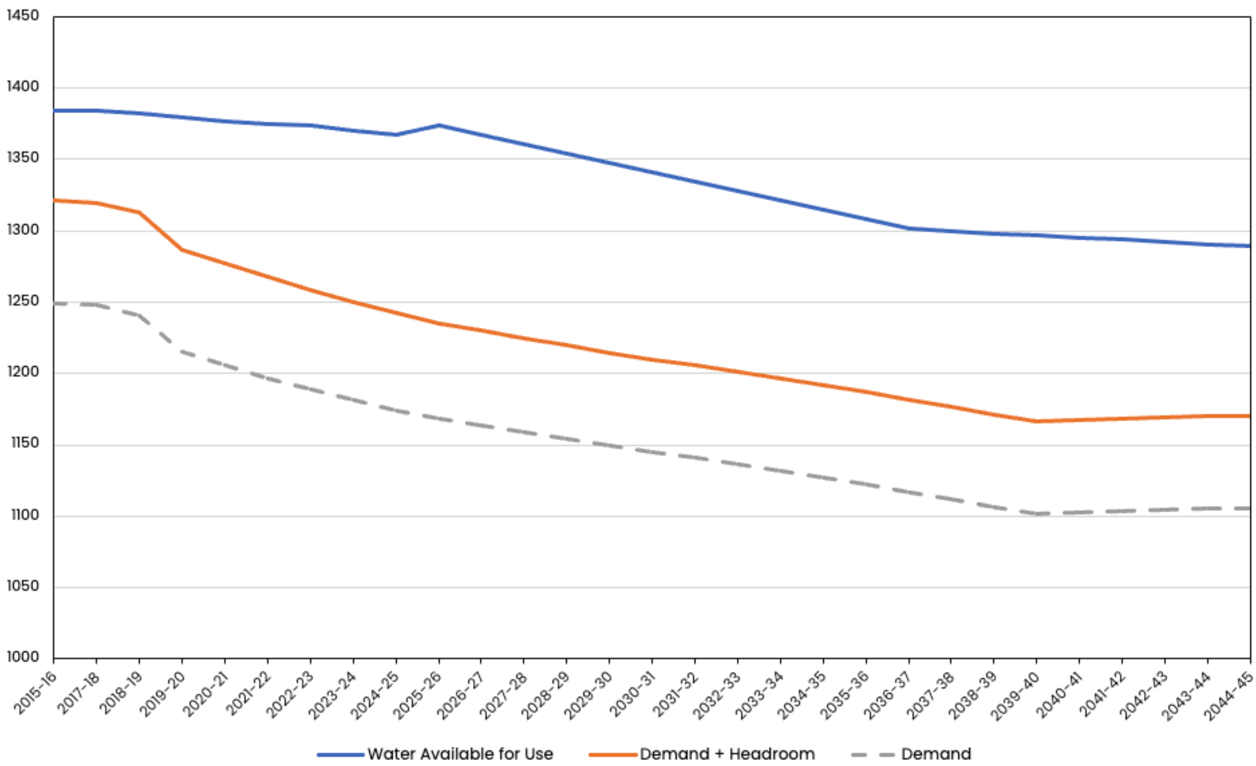
1.7.5 Review of our WRMP19 solution

Our WRMP19 covered the core 25-year planning period from 2020 to 2045 with data extrapolated to 2060. We produced supply–demand balance projections for two water resource planning zones, the East Surface Water Zone (SWZ) and Grid SWZ (for further information on water resource planning zones see Section 2.2). Our East SWZ represents a small proportion of our supply area and the zone supply–demand balance surplus was over 50% of the projected demand. We therefore did not require any investment in this zone to close a supply– demand deficit.

The supply-demand balance in the Grid SWZ identified a risk that without intervention we could be in deficit by the mid-2030s. The deficit was primarily driven by the impact of climate change reducing water availability. Sustainability reductions were minor, at 1.5Ml/d, and did not create any long-term risks. Demand was stable across the planning period and peak demands could be met through existing resources. However, our WRMP19 was collated before 2018 and at that time our supply system had shown resilience to dry weather events and a critical period scenario was not required. The prolonged dry weather we subsequently experienced in 2018 also led to unprecedented high demands that instigated the need to consider a critical period scenario in our Grid SWZ for WRMP24.

Compared to other parts of the country, the scale of the deficit in our WRMP19 was small, starting at 4Ml/d and increasing to 34Ml/d by 2045. However, the deficit was in the larger of our two zones, which includes 99% of our population and still posed a material risk. Figure 1.1 shows the WRMP19 supply demand balance to 2045 for the Grid SWZ baseline dry year annual scenario. This baseline scenario does not show the planned additional leakage reduction, or other investment activity, included in our WRMP19. At the start of the planning period the zone showed a surplus until the mid-2030s. After that point, we began to show a deficit below the target headroom although supply was above the projected demand throughout the 25 years.

Figure 1.1: WRMP19 baseline supply-demand forecast



Our preferred solution to the WRMP19 risk of deficit was to invest in increased active leakage control in the early part of the planning period to close the deficit in advance of the risk. We therefore included a 15% leakage reduction solution in our final WRMP19. Our preferred solution also included proposed investment in four borehole supplies to enhance our resilience to risks associated with outage and short-term peak demands. These solutions were planned for the 2020 to 2025 period and beyond this we planned to continue leakage reduction throughout the 25 years of the planning period.

Two borehole solutions, R9 North Yorkshire Groundwater Option 1 and R13 East Yorkshire Groundwater Option 2, included in our preferred solution for the Grid SWZ were identified outside of the supply-demand balance calculation and not selected to meet the deficit. A further groundwater abstraction variation, R63 North Yorkshire Groundwater Option 2 option was added to the final WRMP19 post draft to meet a localised demand increase. A River Wharfe licence variation (R72) was also added to provide drought resilience following the 2018 dry weather.

The R9 North Yorkshire Groundwater Option 1 was selected to provide security to a local area where there was much uncertainty over potential housing development in the area. The area benefiting from the licence increase is a small town that can be supported by a larger water treatment works (WTW) that is in close proximity. R9 North Yorkshire Groundwater Option 1 option was identified as a low-cost solution to increase resilience in the area, enabling demand from any housing developments in the near term to be met with no or limited additional support from the nearby WTW. The permit application for the increased abstraction has been submitted to the Environment Agency. In our WRMP19 plan the benefit was scheduled to start from 2022/23, however, in our WRMP24 tables the benefit is now delayed to 2025/26. As the scheme is programmed to be completed part way through the year, we have assumed a 1Ml/d benefit in 2025/26, increasing to 2Ml/d from 2026/27 onwards.

The R13 East Yorkshire Groundwater Option 2 option was linked to an existing licence in this area, where the borehole has not been used in recent years due to bacteria contamination and is not included in our available supplies. Alternative sources in the grid system have meant we could meet demand without this licensed resource. However, our PR19 maintenance programme identified we should bring the borehole back into supply to ensure we are resilient to future risks of increasing nitrates at nearby boreholes and uncertainty over licence reductions in this area due to WINEP. We could therefore invest in the current site to bring it back into supply. However, it was identified that a relocation of the borehole (invoking a new abstraction permit application) would reduce the risk of the maintenance scheme failing due to the bacteria at the original site.

The R13 East Yorkshire Groundwater Option 2 was scheduled to be delivered to provide a 6Ml/d benefit in 2025. This was reviewed for WRMP24 and therefore the benefit is not included in the WRP table YWSGRD line for "Total other changes to DO". The decision-making process has concluded this option is best value and the option will be delivered in AMP8.

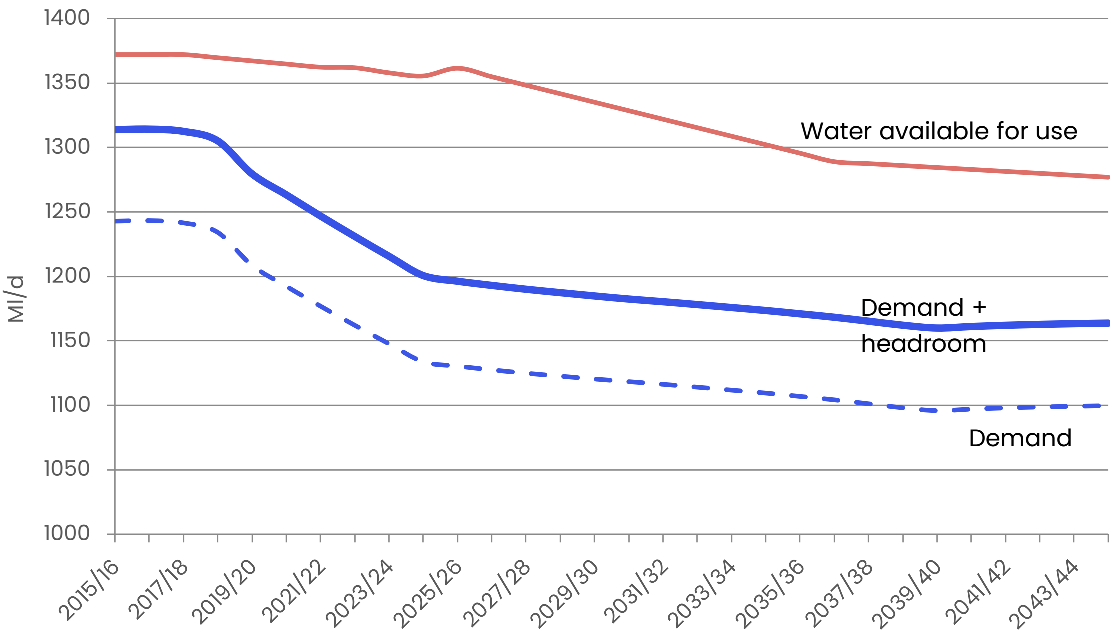
Our WRMP19 includes a variation to an existing licence to increase permitted abstraction from a second borehole in the North Yorkshire area (supplying Malton and Norton). The variation has since been granted by the EA. The licence increase provides support to the local area and, together with investment in additional treatment facilities, provided an alternative to a PR19 Business Plan scheme. The PR19 scheme was to link the villages in North Yorkshire to a large water treatment works in the Grid SWZ, which would have been a much higher cost to implement and subsequently higher pumping costs to deliver the benefit.

We also planned and applied for a variation on an existing abstraction licence on the River Wharfe (R72) in AMP7 which was granted in July 2023. An increase in the annual permitted abstraction volume will provide additional resilience against winter freeze-thaw events. Utilisation of the additional volume is dependent on the Grid SWZ experiencing high winter demands and the resources being available (high river flows and / or support from an upstream reservoir). This additional abstraction permission will provide resilience in extreme years where demand has been high during the summer months, and we have had to draw on both river and reservoir resources more than we would in a normal year.

The River Wharfe licence variation allows an increase in the current annual abstraction limit by 10Ml/d, from 65.05Ml/d to 75.05Ml/d. The daily and instantaneous limits on the licence conditions would not be changed. No additional infrastructure is required to implement this option. The River Wharfe option is currently a drought permit option in our Drought Plan 2022. The permanent licence increase that we have applied for will provide our region with greater resilience if we experience extreme cold weather such as the Beast from the East in 2017. Such events can drive supply and demand pressure and hence the need for this option outside of drought years.

Figure 1.2 shows the benefit of the WRMP19 solutions on the plan's supply–demand balance. Supply (water available for use) is above demand plus target headroom demonstrating a resilient water balance.

Figure 1.2: Preferred solution supply-demand forecast



1.8 What challenges do we face in WRMP24?

We have one of the most flexible water resource systems in the country. We take water from a variety of different types of water supply, which includes reservoirs, rivers and groundwater sources. We use our integrated grid network to move this water around Yorkshire and supply our customers from the water sources that are most abundant at any given time. At different times of the year, we can adjust the volume we use from each source in reaction to weather conditions. For example, over winter our reservoirs may be full and so we use them more. During the summer, when we receive less rain, we want to slow the rate of reservoir drawdown. We can do this by increasing our use of rivers and groundwater, provided the water is available for us to use.

Despite our current high level of flexibility, we are still vulnerable to dry weather events that create a risk of supply shortfalls if we do not invest to remove the risks. There are numerous challenges that we will face in the future. Our WRMP24 aims to identify and quantify the risks and address them in alignment with the long-term objectives identified in the National Framework for Water Resources (see Section 1.4). Some of these challenges, such as population growth and the impact of climate change, are fundamental to water resource planning and ensuring we have sufficient supply to meet future demand. Other challenges stem from our responsibility to provide a sustainable water supply that reduces our impact on the environment and considers wider societal objectives, for example carbon net zero.

1.8.1 Supply challenges

We have reassessed our supply forecast using the latest approaches for assessing our future supply availability. We have used stochastic data to model our deployable output and UKCP18 model outputs to assess the risk of climate change to future supply. We have also incorporated the WReN long-term Environmental Destination, as well as the loss of an existing transfer from STW. These three challenges have had a significant impact on our supply-demand balance, increasing the future deficit resulting in the need to identify solutions to remove the risk in the future.

The key components of our supply forecast are described below, and Table 1-2 summarises how these components have changed since our last plan.

Table 1-2: Summary of supply forecast and key changes since WRMP19

Component	Summary for WRMP24	WRMP19 position
Deployable output defined by 1 in 500 year system response using stochastic data	Year 1990 Deployable output of 1284.48 Ml/d, over 100 Ml/d less than in WRMP19.	1990 Deployable output of 1392.61 Ml/d. Modelled using historic inflows, and levels of service for temporary use bans (TUBs) and Drought Permits, but with 1 in 500 year estimated as the return period for emergency drought restrictions.
Deployable output base year reduction due to climate change	Loss of 36.81Ml/d in 2019/2020 due to climate because climate change impacts are modelled from 1990 instead of from the base year.	Assumed no loss of deployable output due to climate change in the base year of the plan.
Climate change impact on supply	Loss of 46.79Ml/d compared to base year by 2049/50 (note, base year already includes 36.81 Ml/d loss from 1990s)	Loss of 100Ml/d of deployable output in the Grid SWZ by 2044/45.
WINEP / sustainable abstractions (short term changes to protect the environment)	No confirmed losses beyond WRMP19 changes (where investigations are ongoing, allowances are made in adaptive plan as part of our Environmental Destination – see below)	Loss of 1.5Ml/d yield by 2024.
Environmental Destination (long term changes to protect the environment)	Licence reductions ranging from 0Ml/d (Baseline), 6Ml/d (Business as Usual), 115 Ml/d (Business as Usual+) and 180 Ml/d (Enhanced)	This is new and was not a component of WRMP19
Derwent Valley import from Severn Trent Water	Derwent Valley import stopped from 2035.	Derwent Valley import assumed to continue beyond 2035

Deployable Output and Climate change

Our last plan (WRMP19) projected that we would have a supply-demand deficit (against target headroom) in our Grid SWZ baseline Dry Year Annual Average (DYAA) scenario by the mid-2030s if no action was taken. For WRMP24 our Grid SWZ baseline DYAA scenario is showing the zone to be in deficit immediately. The baseline scenario represents an extreme drought and unprecedented drought event that demonstrates a high risk in our largest zone. One of the key reasons for this significant change to the baseline scenario, is that our approach to modelling deployable output and climate change has changed in order to comply with the latest WRPG.

The most significant changes to how we have modelled deployable output and the impacts of climate change are:

- In WRMP19 we modelled deployable output in our WRAPsim simulation model using our historic inflows series (1920-2014). For WRMP24, with the requirement to report deployable output at a 1 in 500-year system response, we have used 19,200 years of stochastic time series.
- In WRMP19 we used a sample of UK Climate Projections 2009 (UKCP09) medium emissions probabilistic projections for the 2080s. However, for WRMP24 we are using UKCP18 Regional Climate Model projections for the 2070s.
- In WRMP19 we used an alternative interpolation (similar to that used in 2014, but with a less steep initial gradient). In WRMP24 we are using scaling equations developed by *Atkins, 2021* in their project to derive scaling factors. Using these methods, climate change is scaled from the 1990s instead of the base year of the WRMP, resulting in a large immediate loss of deployable output.

Because of these changes, we are now seeing an increased loss of deployable output due to climate change.

Bulk transfer agreement with Severn Trent Water

The agreement and its implications are described in detail in Section 3.13.1. Our modelled deployable output includes an existing import from Severn Trent Water. The import transfers a raw water source (approximately 50Ml/d) from the Derwent Valley reservoirs in the Severn Trent Water supply area to a single water treatment works in the south of our area. STW has an option to reduce or terminate the transfer in its WRMP24. As part of the Regional Plan reconciliation process, WRW, which includes Severn Trent Water, informed us that the transfer termination option would be part of the WRW solution and therefore is part of Severn Trent Water's WRMP24 solution.

Our modelling has shown it is possible to make up a proportion of the loss through redeployment of other sources via our conjunctive use system. However, this proportion is only 8Ml/d and it reduces the resilience of our network, as the transfer from Severn Trent Water is a key resource in the South Yorkshire area. Our modelling shows in a dry year the loss is 39Ml/d on average but during peak demand could be up to 60Ml/d. To offset this loss, we will implement a 'backfill option' in advance of the notice period and the delivery programme will be brought forward as part of our WRMP24 plan.

Environmental Destination

Our WRMP24 aims to delivers actions to ensure that our surface and groundwater abstractions do not, and will not, cause environmental damage or deterioration. In the short-term sustainability (licence) reductions may be needed to meet RMBP requirements through the Water Industry National Environment Programme (WINEP). Our plan also considers the longer-term changes that we may need to make in the future beyond existing statutory requirements in support of our regional Environmental Destination.

We are in the process of delivering our AMP7 water resources investigations whilst concurrently developing our AMP8 programme. Some of YW's AMP7 WINEP investigations have been completed, whilst others are ongoing. Those which have been completed have not identified any changes to abstraction licences that would materially affect the supply forecast. This has been in agreement with the Environment Agency. For ongoing investigations which will not be completed prior to WRMP24, or where new investigations are planned for AMP8, our adaptive plan makes allowance for the uncertainty in the outcomes of these investigations. Reductions in deployable output linked to Environmental Destination vary by scenario and range from 6Ml/d to 180 Ml/d by 2040. We acknowledge the new requirement at WRMP24 to consider invasive non-native species (INNS) and we have considered this risk in the development of our options.

Resilience

The need for supply resilience is driven by future demand increase or supply reductions, which are predicted using WRMP methodologies and following regulatory guidelines. The scenarios account for dry years and the risks this creates.

In parallel to this, water companies produce business plans and drinking water quality plans to align with Ofwat and DWI requirements respectively. Business plans collate the investment needed to meet companywide objectives, which include the WRMP and Drinking Water Safety Plans. Non-drought resilience supply needs are also considered in the business plan and can include investment to refurbish assets or to meet short term risks that are not supply-demand solutions. The WRPG refers to risks that include critical period pressures that have a 'much shorter duration or localised impact than is considered in a WRMP' and states they should be addressed as part of the business plan.

Water quality

As part of our preparations for PR24, we continue to consider how water quality may change in the future, and how we will need to invest in a range of solutions to ensure that we do not compromise on the quality of water supplied to customers. We will continue to work closely with landowners, land managers and the agriculture sector to enhance the resilience of our raw water sources, as the first stage in the journey of ensuring water quality from source to tap. We have ensured that our WRMP24 is aligned with the requirements of our drinking water quality regulator, the Drinking Water Inspectorate.

1.8.2 Demand challenges

To help us understand the future demand for water in our supply area, we rebase consumption projections for both household and non-household water use for each iteration of the WRMP. For WRMP24 we have used a household consumption linear regression model to produce our household demand forecast. The model combines information on population growth and housing developments with factors such as meter uptake and technology changes that influence customer water use over time. It allows us to consider several different household forecasts, whereas for WRMP19 we limited by the number of household forecasts we could produce. Our non-household forecast has been produced using a linear regression model that was created for WRMP19 and has been updated with the latest data. We have rebased our per capita consumption (PCC) and leakage projections since producing our WMRP19. Our leakage projections have altered since our WRMP19 to represent a change to the reporting requirements. This has led to us rebasing the AMP7 leakage target. We have met the leakage target for this AMP so far. Since producing our WRMP19 we have also experienced a pandemic and the lockdowns had a significant effect on water use. People tend to use more water at home than in their place of work. PCC increased by more than 10% during the first year of the pandemic and it is still impacting on demand as home working remains higher than pre-Covid-19. This impacts on our PCC and we are no longer able to achieve the AMP7 PCC target included in our WRMP19.
We will continue to take action to reduce both leakage and PCC and our aims to achieve the policy requirements as set out in the National Framework objectives for PCC and leakage. The key components of our demand forecast, and how these components have changed since our last plan are shown in Table 1-3.

Table 1-3: Summary of WRMP24 demand forecast and key changes since WRMP19

Component	Summary for WRMP24	WRMP19 position
Household demand – population	Long-term population forecasts show marginally lower levels of population growth, with the population of Yorkshire set to reach just over 6 million by 2049/50.	Previous projections forecast a household population of Yorkshire at 6 million by 2044/45.
Household demand – new properties	Revised data show the 2.8 million properties served milestone will not be met until 2049/50, representing a 496,000 increase from our base year.	Up to 578,000 more properties to be served, taking total number up to 2.8 million by 2044/45.
Per capita consumption (PCC)	The baseline household PCC is 130 l/h/d then increases significantly in the following two years due to the impact of Covid, before reducing to around pre-Covid levels by 2024/25 (127.8 l/h/d). By 2049/50 average household PCC in the baseline is forecast to reach 116.9 l/h/d by 2049/50. The final plan includes further interventions, which reduces household PCC to 105.4 l/h/d by 2049/50 in a dry year (assuming a water labelling benefit and 111 l/h/d if assuming no water labelling).	Weighted average PCC was forecast to reach 111.7l/h/d by 2044/45.
Non-household demand	We have further refined our non-household forecasting model and taken account of known large developments. The forecast declines by 23.9 Ml/d by 2049/50 from our base position.	A projected continued slow decline in non-household demand, amounting to 18Ml/d over the 25-year plan, driven mainly by reduced non-service sector demand.
Leakage	The baseline forecast includes a 15% reduction in AMP7 (by 2024/25). For our baseline forecasts this level is maintained through the rest of the planning period. The final plan includes further leakage reduction from 2025 to 2050 to achieve the leakage policy requirement to halve leakage compared to 2017/18 levels.	Reducing leakage by 15% in AMP7. This increases to a 40% reduction by the 2030s and continues at a slower rate until 2045, the end of the planning period.
Dry weather influences and adjustments	Update to dry year uplift assessments taking into account the 2018 and 2020 warm, dry periods. Normal year to dry year uplifts remain similar to WRMP19.	Assessment of dry year influence based on available data to 2016.
Critical period demand	Given our experience in 2018 and 2022, we have decided to include a critical period supply-demand balance assessment in our plan for WRMP24.	No critical period assessment.

2 Developing our plan

This section describes how we have developed our WRMP24. It details our water resource zones and the scenarios that we plan for in each zone. This section also summarises how we have followed technical guidance in our problem characterisation and risk composition processes. Finally, this section explains the levels of service that we have agreed with our customers.

2.1 The WRMP process

Our WRMP24 has been produced in line with regulatory guidelines and water industry methodologies that have been devised specifically for creating the supply and demand components, allowing for uncertainties and determining a solution to any deficits. The process is well-established however, with each iteration there will be changes to approaches and new risks to consider.

The plans are a regulatory requirement for water companies in England and Wales to provide details on how they intend to provide a secure supply of water to customers whilst protecting and enhancing the environment. The duty to prepare and maintain a WRMP is set out in sections 37A to 37D of the Water Industry Act (HM Government, 1991). We prepare a WRMP at least every five years and review it annually. Our regulators provide guidelines and directions that we must adhere to in our plans unless we have robust justification for why we cannot comply.

The regulatory guidelines for WRMP24 include:

- Water Resources Planning Guideline (Environment Agency, Ofwat and Natural Resources Wales, 2021)
- Water Resources Planning Guideline supplementary guidance on: 3
  - 1 in 500
  - Stochastics
  - Climate change
  - Environment and social decision making
  - Preventing deterioration.
- Water Resources management Plan (England) Direction 2022 (Defra, 2022)
- Government Expectations for Water Resource Planning (Defra 2022).

In producing our WRMP24 we have also considered:

- *Meeting our future water needs: a national framework for water resources* (Environment Agency, 2020), referred to in this document as the National Framework
- PR24 and beyond: Final guidance on long-term delivery strategies (Ofwat, 2022).

In addition, we have used best practice guidelines and methodologies for building the components and evaluating the data. These are referenced in the relevant sections of our plan.

WRMPs must forecast supply and demand over at least the statutory minimum period of 25 years. Our WRMP24 produces a forecast over a 60-year planning period. The focus of the plan is the first 25 years and how we will close any deficits in this period. By planning beyond 60 years we include greater uncertainties, and the longer-term risks may influence our plan in the short term to ensure it is flexible to alternative futures.

Our WRMP24 builds long-term projections for both supply and demand for each of our water resource zones and includes an allowance for uncertainties. This is our baseline forecast. We recognise that there is uncertainty inherent in these projections and although we may refer to them as "forecasts" or "predictions" it is important to note that these are scenarios we use to identify risks. Unless specific targets are stated for components (such as leakage and PCC) the component level projections should not be interpreted as goals that we are aiming to meet.

The initial supply–demand forecasts assume no further intervention than those we have planned in AMP7 between 2020 and 2025. We compare our zonal baseline forecasts of supply and demand to understand the balance and assess if further interventions beyond the current AMP are required. The supply-demand balance is in "deficit" if demand is predicted to exceed supply or in "surplus" if supply is predicted to exceed demand. If our supply-demand balance shows a deficit, we need to identify and assess options to offset that deficit. Options are identified for any zone that is showing a deficit and include:

- supply-side options to increase the amount of water available
- demand-side options which reduce the amount of water we supply to customers.

We also consider alternative futures to the baseline scenario. This is important as our baseline scenarios represent potential futures based on the latest guidelines and data available to us. As we progress into the future new information may show we are not following the baseline scenario and, by considering alternative scenarios for the known risks, we can build a plan that is flexible if the future is materially different to the baseline.

Once we have assessed all the options that are available to us, taking into account multiple criteria represented by qualitative and quantitative metrics, we are able to identify our preferred solution to meet the baseline deficit. This represents our final plan scenario. We also produce solutions to the alternative scenarios and create solution pathways. The alternative pathways are linked to decision points and triggers defined by a fixed point in time.

The supply and demand component data for the baseline and final plan scenarios for our two zones is provided in the Yorkshire Water WRMP24 Tables (referred to in this document as WRP tables). These tables also include data on the available options (including benefits, costs and metric data) for closing the Grid SWZ supply-demand deficit, the solutions put forward as our preferred plan and for the solutions triggered by the alternative pathways. The full tables have been submitted to Defra, whereas the publicly available version has some details redacted.

2.2 Our area

The Yorkshire Water supply area is divided into two water resource zones. Our zones are:

- the Grid Surface Water Zone (Grid SWZ), which is an integrated surface and groundwater zone that makes up over 99% of our supply area; and
- the East Surface Water Zone (East SWZ), which is a small zone covering Whitby, part of the North York Moors National Park.

Figure 2.1: Water resource zones

2.3 Water resource zone integrity

In *Water Resources Planning Tools*, (UKWIR, 2012), a water resources zone is defined as:

"The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers will experience the same risk of supply failure from a resource shortfall." Appendix A of the Technical Report on Deployable Output and Climate Change describes how both the Grid SWZ and the East SWZ meet the definition of a resource zone.

The Environment Agency has published guidelines on ensuring the integrity of water resource zones, Water resource zone integrity, (Environment Agency, 2016). These guidelines include proformas for decision trees to establish if a resource zone complies with the Environment Agency definition. The proformas for the Grid SWZ and the East SWZ are shown in Appendix A of the Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request. This appendix describes how both the Grid SWZ and the East SWZ meet the definition of a resource zone.

The Grid SWZ is a large conjunctive use zone and, although not all resources within the zone can be shared, some of the major resources can be moved and used to support supplies in different areas. Due to the interconnected grid, the risk of supply failure is the same throughout the zone. Supplies can be moved around effectively to manage resource shortfalls.

A water resources computer simulation model, Water Resources Allocation Plan simulation (WRAPsim), is used to model our water supply network. The model is used to evaluate river flows, water storage and levels of service. WRAPsim was replaced by a PyWR model between draft WRMP and revised draft submissions. WRAPsim and PyWR schematics for the two resource zones are shown in Appendix B of the Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request. The schematics show major pipelines, treatment works, sources and demand zones. Our system is too complex to show the capacities and system constraints on these schematics, although these are all included in the WRAPsim /PyWR model.

The schematics, associated system constraints, and resource zone integrity proformas were shared and discussed with the Environment Agency in January 2022.

2.4 Planning scenarios

Our WRMP24 considers several future scenarios representing the known uncertainties that could impact on either available supply or demand for water in the future. The scenarios are summarised in Table 2-1 and further detail is provided in Section 7.

The "most likely" scenario is the dry year annual average (DYAA). The DYAA scenario, represents a year when weather conditions are significantly hotter and dryer than average and have led to an increase in demand and a reduction in available supply. Demand increases are usually experienced during the summer months and this impact is averaged across the year. Although it is termed most likely in our WRMP, the DYAA scenario is not representative of most years; it is representative of an extreme drought year when supplies are exceptionally low, and demand is exceptionally high. It combines the dry weather risk with other known risks (loss of STW import and environmental destination) and then calculates the impact this could have on our supply and demand balance. The DYAA is the minimum requirement of scenario planning in WRMPs and is relevant to both zones.

Table 2-1: WRMP24 scenario summary

Scenario	East SWZ	Grid SWZ
DYAA baseline (RCP6, BAU+ ED, local authority plan growth)	✓ (BAU+ baseline no impact)	✓ (BAU+ baseline reductions)
Critical period	N/A	✓
High climate change RCP8	✓	✓
Low climate change RCP2.6	✓	✓
Low environmental destination	N/A	✓
Enhanced environmental destination	N/A	✓
High demand	✓	✓
Low demand	✓	✓
High technology	✓	✓
Low technology	✓	✓
Hydrogen energy	N/A	✓
Reduced benefit of demand reduction	N/A	✓
Final plan scenario	✓*	✓

* The East SWZ final plan scenario incorporates demand reduction activity to meet the PCC policy requirement, but a solution is not required to close a deficit.

We have tested both zones to several more adverse and benign scenarios using the Ofwat common reference scenarios define by Ofwat in its Long-Term Delivery Strategy Final guidelines[11]. The environmental destination scenario is not applicable to the East SWZ as there is no risk of licence reductions.

We have produced a critical period scenario for our Grid SWZ. This scenario represents a period of peak strain on our supply system. A critical period can be experienced in any year and represents a short period when the deficit could be greater than the DYAA, for example, high seasonal demand such as during a heatwave, high winter leakage or when holidaymakers increase demand significantly during the summer. Our Grid SWZ critical period represents a heatwave and is based on a prolonged period of high demand lasting four weeks as experienced in 2018 and 2022.

[11] PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf (ofwat.gov.uk)

We did not include a critical period scenario for our Grid SWZ in our WRMP19. Since investing in our network following the drought of 1995/96 and up until 2018, summer peaks had put strain on our systems but there was sufficient resource and flexibility in our network to move water to where it was needed. The peak periods were of short duration, generally two or three days at a time. This would use up a greater proportion of our annual licence allowance and the strain was experienced in the annual average scenario rather than the peak period. In 2018 we experienced unprecedented peak demands in terms of magnitude (1450Ml/d) and duration (four weeks). In 2022 there was also a prolonged period of high demand however, although this included higher peaks than 2018 the average daily demand increase during the four week period was not as high as 2018.

In 2020 we experienced an increase in demand as a result of lockdowns during the Covid-19 pandemic and demand peaks were higher than 2018. We were experiencing a drought when we produced our draft WRMP in 2022. For the final WRMP we have considered the impact of the 2022 drought and how this influences our final decision making for WRMP24. Appendix F summarises the lessons identified from the 2022 drought, and how this drought has influenced our WRMP.

We considered the critical period risk in our East SWZ and determined it was not required. Our East SWZ is supplied by a run-of river source (where water is abstracted directly from the river and not via storage reservoirs or lagoons), and small springs with limited storage. This could limit supply during peak demands. In addition, the area sees an increase in its population during the summer, due to tourism, and therefore could be susceptible to peak summer demands. However, the deployable output in the East SWZ is considerably (30%) greater than demand. Therefore, there is no risk to the supply-demand balance during critical periods.

For both zones we will produce a final plan scenario. We will incorporate the benefits of our preferred solution to the Grid SWZ final plan scenario and the policy demand reductions will be built into the final plan scenarios for both zones. We have carried out stress testing for the two zones to assess how the common reference scenarios (alternative climate change, demand, technology and environmental destination scenarios) impact on the supply-demand balance. The Grid SWZ preferred plan has been subject to scenario testing and adaptive pathways created.

2.5 Supply availability

We have produced a forecast of available supplies over the next 60 years. This takes into consideration the factors which either increase or decrease our deployable output. We model supply availability using our WRAPsim and PyWR water resource simulation models. This model takes account of constraints in our supply system and historic inflows and calculates how much water can be supplied, whilst maintaining resilience with a system response that does not require level 4 drought restrictions such as rota cuts more than 1 year in 500 (0.2% annual risk). We also maintain a level of service of no more than a 1.25% risk of drought permits or orders and 4% risk of a temporary use bans in each year (one drought permit every 80 years on average and one temporary use ban per 25 years on average) in both resource zones.

Our modelling provides a supply forecast for a 1 in 500 drought return period which represents the baseline dry year annual average scenario for both our zones in our WRP tables. We have also considered in 1 in 200 return period, and this represents an option in our Grid SWZ. By planning to a 1 in 200 system response that does not require level 4 drought restrictions more than 1 year in 200, we have an increased volume of water available for supply but are less resilient as we are planning for a less severe drought event.

For our Grid SWZ we have produced a critical period baseline supply scenario. This represents the deployable output that could be available during a four-week period and is greater than the DYAA. We can only take water if we have licences or permits that are granted by the Environment Agency for abstraction from rivers, groundwater sources and reservoirs. Abstraction permissions limit how much water we can abstract on a daily and annual basis. Some permissions have a daily abstraction limit that is greater than the annual average daily abstraction limit. This means we can take more water on some days of the year provided we take less water on other days to offset the increase and comply with the annual average volume. Our critical period scenario assumes during periods of peak demand we will maximise supplies within the permitted allowed abstraction licence volumes and so put more water into supply than we do on average during the year.

Our supply forecast is described in detail in Section 3. We also take account of temporary reductions to resource and treatment availability in our planning. This is known as outage and can be unplanned, such as pollution events reducing water quality to an untreatable level, or unplanned events, such as asset maintenance or refurbishment. We reduce deployable output to allow for outages in our supply-demand balance calculations and this is discussed in Section 3.15.

Water loss also occurs during the process of abstracting, treating, and putting water into supply. In addition to outage adjustments, we include an allowance for process losses as this also reduces the deployable output. Process losses are discussed in Section 3.16. We allow for uncertainty within our supply and demand forecasts through a target headroom approach. Target headroom is considered for both supply and demand and details are provided in Section 6.

2.6 Demand forecast

We have produced a forecast of how demand will change over the next 60 years, starting from a base year of 2019/20. This forecast takes into consideration factors which could result in both an increase and decrease in demand. The key factors forecast to influence the future demand for water include changes to population, housing development, economic prospects, household metering and leakage management.

We have collated information on population and property projections in the Yorkshire area and combined with trends on household use and changes over time to produce a multi-linear regression model to provide a household demand forecast for a range of different growth scenarios. At the same time, we have updated our non-household consumption model which was created for WRMP19.

We have produced demand forecasts for DYAA and normal year scenarios for both the East SWZ and Grid SWZ. We have produced a critical period demand forecast for our Grid SWZ. Our demand forecast is described in detail in Section 4.

2.7 Supply-demand balance

We use our projections of the future supply and demand components to calculate a baseline supply-demand balance for each of our two water resource zones. The baseline DYAA supply-demand balance data has been used to populate the WRMP24 WRP tables for the East SWZ in Table YWSEST and the Grid SWZ in Table YWSGRD. The critical period supply-demand balance data has been populated for the Grid SWZ in Table YWSGRD. Normal year demand data has been presented in Table 2. WC Level data. The supply forecast is represented in the tables as water available for use (WAFU). The WAFU calculation is shown below:

The demand forecast components are summed together to produce what is known as distribution (DI). DI is added to the target headroom (THR) allowance to represent demand.

A supply-demand balance scenario compares the forecast WAFU with the forecast demand for each year of the planning period. If this balance shows a deficit between the available supply and the demand for water, we need to identify solutions to close the gap.

2.8 Available options

We have considered a wide range of options that could be used to address a future deficit in our supply-demand balance. These options include those that will reduce demand and enable us to achieve the ambition to half leakage (compared to 2017/18 levels) and achieve a 110 l/h/d PCC by 2050.

We have developed a strategy for achieving the Defra requirement to reduce non-household water use by 9% by 2038[12]. This is detailed fully in section 5, the final plan proposes options such as smart metering, water efficiency audits, water retailer incentives, and rainwater harvesting systems.

As part of our twin track approach, we have also considered options for new water resources or enhancing existing supplies. For example, increased use of existing and new boreholes and river abstractions, new water treatment works, desalination and bulk transfers from other water companies. For further information see Section 8.

2.9 Problem characterisation

Before producing our WRMP24 we carried out a problem characterisation evaluation in line with the UKWIR *WRMP 2019 Methods – Decision Making Process guidance,* (Atkins, 2016). The problem characterisation is carried out for each water resource zone and is used to evaluate the strategic needs and the complexity of individual zones. The guidance provides a decision-making framework to help water companies select appropriate investment appraisal and optimisation methodologies based on the outputs of the problem characterisation.

Problem characterisation is Stage 3 of the decision-making framework. Following the methodology provided in UKWIR *WRMP 2019 methods – Risk Based Planning,* (Atkins, 2016), we fed the output from Stage 3 into our risk-based planning methodology. We then used the outputs from the risk-based planning method as inputs to Stage 5 of the decision-making framework, “identify and define data inputs to model”.

We determined a solution to the Grid SWZ deficit in WRMP19 using *The Economics of Balancing Supply and Demand (EBSD) Guidelines* (UKWIR, 2002a). We expanded the EBSD approach to include monetised costs for a limited number of carbon and social environmental impacts. We monetised environmental impacts using an ecosystem services approach that focused on recreation and tourism. Monetised social impacts considered traffic related costs due to the construction work of WRMP options. A qualitative environmental and social impacts assessment was also used in determining the solution. Although, this expanded the traditional least cost approach for identifying solutions to the deficit, the approach is still classed as “baseline” in the Decision-Making Process guidance.

The problem characterisation for our WRMP24 was developed and shared with the EA in late 2020, with some minor updates made in January 2022 (*WRMP24 Problem Characterisation*, Yorkshire Water 2022). It is carried out at the start of the WRMP process as it is important to identify the decision-making approach early, so that the tools needed to deliver the approach can be developed in good time. At this early stage we had not yet developed the WRMP24 supply and demand components and, in accordance with the Decision-Making Process guidance, the assessment is largely based on supply and demand components of the previous iteration of the WRMP. This creates a risk as the WRMP process is delivered over a two-to-three-year period and during this time a zone’s strategic needs and complexity factors can change, which can impact the output of the problem characterisation at a stage when there is insufficient time to alter the approach.

This risk is considered acceptable as in most circumstances the selected approach is still fit for purpose even if the scale of the risk or the complexity does change.

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[12] [Defra Environment Act consultation on the targets, 2022]

As we completed our problem characterisation at the start of our WRMP24 process, we based it on our WRMP19 supply and demand components and any new information that was available at the time of the assessment. In our WRMP19, we forecast that the baseline scenario for our largest zone, the Grid SWZ, would be in deficit from the 2030s onwards. By contrast, the much smaller East SWZ showed a surplus for the full planning period.

At the time of the WRMP24 problem characterisation evaluation we had sufficient information to conclude that the Grid SWZ would be showing a greater risk of deficit than it did in WRMP19, as we were aware the new stochastic and climate change methodologies used in the supply forecast would lead to a significant reduction in deployable output. This meant we would need to select an appropriate decision-making method to identify a solution to the Grid SWZ deficit.

WRMP19 resulted in an East SWZ forecast demand that was around 50% of the available supply at the start of the planning period and reducing to 35% by the end. We carried out a WRP24 problem characterisation for the zone to review the complexity factors and if there were any issues that were not apparent in the previous plan. There was no evidence to suggest that any of the supply and demand components would have changed significantly since WRMP19 and that a decision -making approach was required for this zone.

2.9.1 WRMP24 Problem characterisation outputs

There are two parts to our problem characterisation assessment:

- Strategic needs ("how big is the problem?") – a high-level assessment of the scale of need for new water resources and/or demand management strategies; and
- Complexity factors ("how difficult is it to solve?") – an assessment of the complexity of issues that affect investment in a water resource zone or area.

Our assessment of strategic needs includes three headline questions that explore the size of any potential supply-demand deficit, and the cost (in relative terms) of the supply and demand management options. The three strategic WRMP risk questions apply to three types of risk:

- Supply-side risks;
- Demand-side risks; and
- Investment programme risks.

The assessment of the complexity factors provides an understanding of the nature of the risks and vulnerabilities within the WRMP24. It raises several questions on the supply-side, demand-side and investment programme complexity factors of the supply-demand balance.

The aim of this process is to identify whether these complexities, in combination with the level of strategic risk, indicate that methods beyond the previous EBSD methodology should be considered. These factors also provide an indication of which tools may be suitable.

Table 2-2: WRMP24 Problem characterisation output

		Strategic Needs Score ("How big is the problem?")			
		0-1 (None)	2-3 (Small)	4-5 (Medium)	6 (Large)
Complexity Factors Score ("How difficult is it to solve?")	Low (<7)	**East SWZ**			
	Medium (7-11)				
	High (11+)		**Grid SWZ**		

Table 2-2 shows the results of the problem characterisation assessment for both zones. The East SWZ scores very low on complexity and strategic need as there was no evidence to suggest the zone would show a risk of deficit in WRMP24. The subsequent DYAA scenario developed for this zone for WRMP24 confirmed the zone to be in surplus throughout the planning period. A critical period scenario was not created due to the high surplus relative to the demand.

The Grid SWZ WRMP24 total "strategic needs" score is three, which is classed as "small". The combined "complexity factor" score is 12 and the methodology classifies our "modelling complexity" as "high level of concern". This is the same outcome as WRMP19 and is at the lower level of the band, which has a range of 11 to 22. The combined problem characterisation score for the two metrics is medium level of risk.

When the problem characterisation was carried out, we anticipated there would be a deficit identified in the Grid SWZ WRMP24 baseline DYAA scenario, due to the impact of climate change on supply. Although the AMP7 leakage reduction was forecast to remove the WRMP19 climate change driven deficit before the start of the WRMP24 planning period, we anticipated there would be an increased deficit identified in the WRMP24 baseline DYAA scenario for this zone. This increased risk of deficit was based on the early indication that the regional projections within the UKCP18 climate change scenarios would result in a greater reduction in deployable output than predicted in the WRMP19 using the UKCP09 projections.

Our WRMP19 had assessed the potential risk of the Water Framework Directive (WFD) requirements for achieving sustainable catchments by 2027 reducing our available licence capacity. There was no risk of licence reductions identified in the East SWZ deployable output. There was a risk that the Grid SWZ deployable output would be affected. A 1.5Ml/d sustainability reduction was included in WRMP19 to be delivered in AMP7. A need for investigations on our use of some of our groundwater sources in the Grid SWZ was identified as part of the AMP7 WINEP and these investigations are scheduled to conclude in 2025.

As we were developing our WMRP24 the potential for further abstraction reductions was considered as part of the national environmental destination objectives. The environmental destination considers the long-term risks of abstraction beyond the next AMP period. The risks were considered through the WReN Regional Plan and at the time of collating our company problem characterisation for WRMP24 in 2020 and the revision in 2022 it was agreed with the Environment Agency that the baseline risk of abstraction reductions in both our zones should be zero.

At that stage the known risks concluded the Grid SWZ would have a deficit driven solely by climate change with an adaptive pathway to represent the risk of losing the STW transfer. Although the change to deployable output was estimated to be significantly higher than in our WRMP19, the scale of deficit was low relative to other water companies' deficit. The environmental destination impact was zero and the most likely outcome of the groundwater WINEP investigations was no or marginal reductions. Although demand related complexities were identified (see below), population growth was not found to be driving the DYAA deficit as the demand across the WRMP19 planning period was relatively stable and resulted in a net reduction by 2045. It was therefore concluded that that the Grid SWZ strategic need score was small.

Grid SWZ complexities

The Grid SWZ complexities covered a range of factors that had come to light since the publication of the WRMP19 and included the following:

- Aligning with Regional Plans and the National Framework policy objectives (1 in 500 drought resilience and demand reduction policy reductions)
- Recent dry weather events (2018 and 2020) and impact on supply system performance
- Covid-19 lockdowns and home working impacts on demand
- Uncertainty over the future of the existing import from STW
- Use of reservoirs for flood alleviation.

The regional planning process highlighted additional factors we would need to consider in developing our WRMP24 related to demand reduction policy reductions, strategic transfer potential and other sector requirements. Our own risk assessment highlighted risks linked to dry weather demand and resilience.

The Yorkshire area has experienced dry weather in recent years and the risk of a more severe drought in the future raised concern over the resilience of our conjunctive system and the operational constraints limiting water production. The unprecedented high demands experienced in 2018 and 2020 created a need to review the critical period risks and we have included a Grid SWZ critical period scenario in our WRMP24. The operational constraints and short duration peak demands (less than a week) are being assessed as part of our Water Supply System Strategy project. Our approach has considered the resilience benefits of supply-side options and included this as a metric in the decision making.

Although our demand profile is stable over the forecast period, there are near-term risks and uncertainties due to Covid-19 impacting on household and non-household demand. During the pandemic (2020) we saw demand increase due to more home working. Following the lifting of reductions demand reduced but has not returned to pre-Covid levels.

At the time of producing the WRMP24 problem characterisation it was known that the existing transfer from STW could cease in the medium-term. We commissioned Stantec consultants to review options for offsetting this loss as the transfer provides a significant proportion of the supply of water to the South Yorkshire area, which is strategically important for maintaining the flexibility of our grid network. This drove a need for new supplies to be considered alongside demand reduction, although at that time it was considered most likely that the transfer would be maintained.

A non PWS (Public Water Supply) need to support flood resilience schemes was identified. As we operate over 100 reservoirs across Yorkshire there is some potential to conserve reservoir capacity for flood alleviation. Studies and trials are required to understand the benefit and subsequential impacts of drawing reservoirs down, which can create a risk to water supply security and alternative sources of water may need to be found to support the drawdowns.

Once the problem characterisation was complete the complexities were considered in determining the decision-making approach for WRMP24. The Decision-Making Framework proposes four elements, shown in Figure 2.2, for companies to consider in the selection of their options appraisal and decision-making approaches for WRMPs.

Figure 2.2: Elements of decision-making and plan methods to consider when selecting an appropriate method (Source: UKWIR Decision Making Framework)

Objectives What do I want to achieve?	• Single metric • Multi-criteria
Approach How do we structure the problem?	• Aggregated (traditional approach – solve a discrete supply demand forecast); or • System simulation (new concept to WRMPs)
Selection How do we choose our solution?	• Expert judgement • Ranking • Mathematical programming • Evolutionary algorithm
Solution Our investment plan	• Schedule (as in a conventional Water Resource Management plan) • Portfolio (preferred investment, without scheduling) • Adaptive strategy (a set of alternative schedules, where the choice depends on how supply/demand/costs progress through time)

The four elements have been considered in the context of the Grid SWZ problem characterisation taking into account the latest WRPG and the UKWIR best practice guidance *Deriving a best value water resources management plan*, (H R Wallingford, 2020). Table 2-3 summarises the elements.

Table 2-3: Grid SWZ decision making elements

Element	Grid SWZ component assessment
Objectives what do we want to achieve	a) Close the supply-demand deficit. b) Provide a solution to address identified supply-demand problems including: – Drought resilience – Impacts of Covid-19 on demand – A robust scenario for replacing the STW import – Other scenarios – critical period, environmental destination. – Sensitivity testing - for example, climate change impact / high demand scenario. – Regional problems such as cross regionals transfers or local deficits. c) Provide options and a solution for meeting policy requirements to; – Reduce leakage by 50% from 2017-18 levels by 2050 – Achieve an average PCC of 110 l/h/d by 2050. d) Allow for uncertainties associated with demand side interventions to ensure there is no risk to security of supply if challenging policy targets are not met. e) Produce a preferred programme that can be flexible and adaptable. f) Considers the wider impacts and benefits of each option e.g.: – SEA / WFD – Environmental net gain score – Bio-diversity net gain – Six capitals (natural, financial, manufactured, social, human and intellectual) – Drought resilience benefit – Non-drought resilience benefit – Whole life carbon impacts g) Assess the programme (using metrics) against conflicting needs and/or preferences and identify alternative plans. h) Be transparent where quantification and/or trade-offs are not possible, and a company decision has been reached. i) Provide a ‘best value plan’.

Element (continued)	Grid SWZ component assessment (continued)
Approach **how do we structure the problem**	There are two approaches for formulating the 'problem' in the decision-making tool; aggregate and system simulation. We have used an aggregated approach but use our system simulation model to test solutions. The aggregated approach is based on the EBSD i.e., a form of mathematical programming. An optimization model has been used to identify solutions. However, the approach is extended to include, in addition to financial costs, quantitative and qualitative metrics at an option and plan level. This is a multi-criteria approach (MCA). This approach is in line with the UKWIR Best Value Plan methodology and follows WRPG, which requires water companies to include metrics in the decision making. Scenario and sensitivity testing are used to inform the decision making. The aggregated approach identifies solutions to several scenarios and compare the solution programmes to understand which of the objectives are met and the trade-offs. To address non-linear dependencies of options and utilization we include option dependencies in the optimizer and use our system simulation model to assess the utilization of solution programmes. A full system simulation approach is deemed unsuitable as it would not account for all the non-financial costs and trade-offs required or produce a scheduled solution. It is also recognized that the number of options and scenarios could not be built into a system simulation model in the time available to determine the solution for WRMP24.
Selection **how do we chose our solution**	The optimization results are assessed to understand which options appear most frequently and if a schedule of options can be identified as a 'best fit' for meeting the identified objectives. Pre-defined metrics combined with "exert judgement" are used to decide on a preferred best value plan. We have also identified key decision points and alternative pathway triggers through sensitivity testing and created alternatives to the preferred plan.
Solution **what form of investment plan is preferred?**	We have presented a preferred plan in the WRP tables alongside alternatives. A "decision tree" diagram represents the alternative solutions available to us as the risks become better understood.

2.10 Review of problem characterisation – September 2022

The Grid SWZ has been classed as small strategic needs with high complexity in its problem characterisation. The small strategic needs score was driven by climate change creating a deficit. The problem characterisation assessment is the first step in the process of delivering a WRMP and up until spring 2022 we were planning for a baseline environmental destination of zero following pre-consultation discussions with the Environment Agency. At this stage we had completed the Regional Plan reconciliation process phases 1 and 2 and the most likely outcome of the STW transfer was for it to continue but there was a risk of termination, and we should include an alternative pathway to be prepared for the agreement terminating in the late 2030s.

It was therefore concluded that the supply-demand balance deficit would be largely met by meeting the demand reduction policy requirements, reducing the potential need for supply investment which would be focused on strengthening the grid network to critical period and resilience risks. There was potential for further investment to offset any loss to the STW transfer and to allow for uncertainties in achieving the demand reduction.

In developing the WRMP24 it became evident that the scale of the risk was greater than initially identified in the problem characterisation, and that significant investment in both demand reduction and increased supply would be needed to close the deficit. This did not come to light until new guidance on the environmental destination was provided in early 2022, after the emerging regional plans had been published. A third reconciliation stage in spring 2022 resulted in a change to the most likely outcome of the STW transfer and it was agreed the transfer would terminate in 2035. The overall impact on our plan was that the Grid SWZ deficit by 2050 would be over 300Ml/d.

2.11 Our best value planning approach

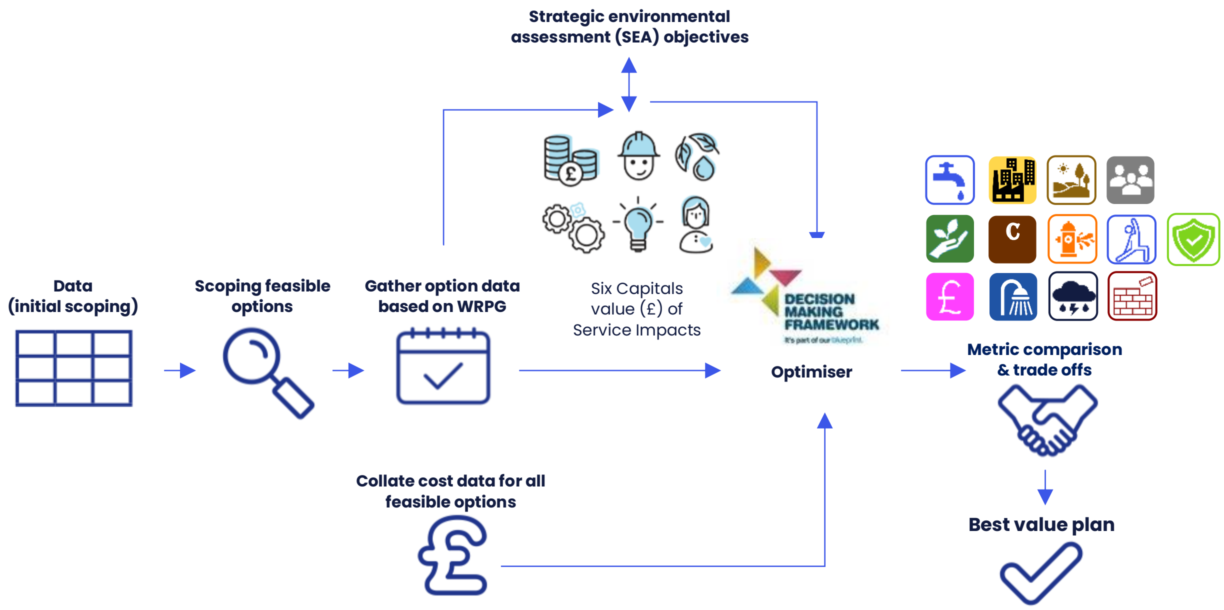
To ensure our plan meets our WRMP24 objectives, can be considered best value and is compliant with the latest WRPG we have developed a new decision-making methodology that expands on the approach used for WRMP19. To determine a solution to the Grid SWZ deficit in our WRMP19 we followed the approach defined in the Economics of balancing supply and demand (EBSD). The EBSD methodology is an aggregated approach with deterministic values of the supply and demand components over the planning period. The EBSD approach identifies the least cost solution based on financial whole life costs only.

In our WRMP19 we included additional non- financial costs and derived the least cost solution from financial costs, monetised carbon costs, and monetised costs for environmental impacts on recreation and tourism, social traffic interruptions and carbon emissions. We also considered nonmonetary factors in our WRMP19 decision making, such as customer and regulatory preferences, environmental and social impacts and resilience benefits of options. Environmental and social non-monetised costs were determined through SEA, HRA and WFD assessment.

Our preferred plan presented for WRMP19 was not the least cost plan, and instead we chose to close the deficit through active leakage control. Reducing leakage was considered a more sustainable solution, which would provide additional carbon reduction benefits. The Grid SWZ supply-demand balance for WRMP24 results in a more severe and earlier deficit that we cannot meet through demand management alone, but it is still an essential part of our plan providing multiple benefits.

For WRMP24 we have expanded the approach further to produce a best value plan using multi criteria analysis. As with previous plans we have followed the EBSD methodology and aggregated the supply and demand components to produce supply-demand balance scenarios. The feasible options and the associated costs and benefits are entered into an optimiser model which selects the optimum selection of options to close a deficit in a given scenario, which we refer to as a solution programme. Our WRMP24 optimiser is more advanced than our WRMP19 model and can optimise on one or more of the six capitals. Our approach is summarised in Figure 2.3 and detailed in Section 9.

Figure 2.3: WRMP24 Best Value Plan process summary



We are embedding the concept of the capitals into our long-term business planning, to help us ensure the affordability and resilience of our essential public services for current and future generations. The capitals are the valuable assets which are critical to the success of any organisation, and effective management of the capitals helps ensure the resilience of our business. As part of our decision making, we have considered the six capitals: Financial, Manufactured, Natural, Social, Human and Intellectual capital illustrated in Figure 2.4.

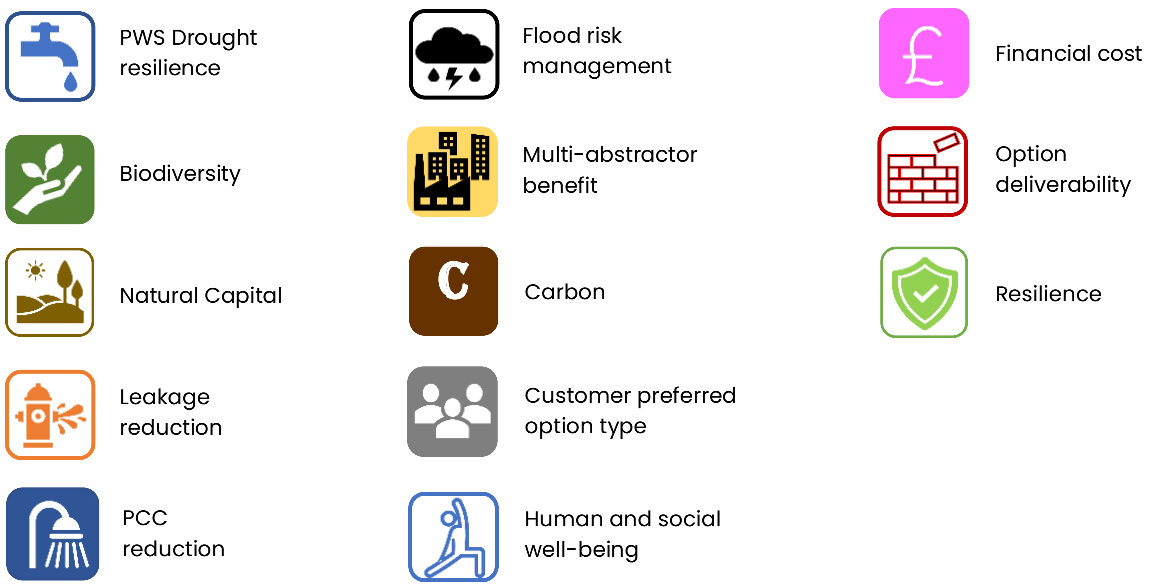
Figure 2.4: The six capitals

The optimiser was used to produce a least cost solution to the deficit to use as a benchmark when developing the best value plan. We then optimised on the carbon capital, the combined natural and social capitals and then all six capitals. This produced a portfolio of options from which we created candidate solutions for the best value plan. We assessed the solutions further by using criteria that had been identified as key decision measures – this is the multi criteria analysis (MCA).

The MCA approach measures quantitative and non-quantitative criteria using pre-defined metrics. For our WRMP24 decision making approach we have used metrics created through the WReN regional planning process plus an additional company level resilience metric. We use the metrics to score the solution programmes for criteria considered important when selecting a best value plan. The criteria were represented by the metrics summarised in Figure 2.5.

The best value plan was the candidate solution that was considered the most optimum when considering the metrics collectively. It is not possible to optimise all of the metrics individuals as the many of the measures can conflict against each other, therefore trade-offs must be made. Once the best value plan was selected from the candidate solutions, we carried out sensitivity testing against alternative futures. Some adjustments were made and alternative pathways created to ensure the plan could be adapted in the future.

Figure 2.5: Best value plan metrics for WRMP24 decision making



PWS in the diagram refers to Public Water Supply, also known as the Yorkshire Water supply system.

Our WRMP24 approach also expands on previous plans by creating adaptive pathways. Adaptive pathways consider uncertain futures as it is unrealistic to assume the future will always follow the baseline scenario. By considering how we might adapt to the alternative futures we can select a plan that is flexible to the known risks and be better prepared as the risks develop.

2.12 Drought risk assessment

We have carried out a risk composition as detailed in the *Risk Based Planning Framework* (UKWIR, 2017). Our risk is defined according to scoring of complexity factors, that is, how difficult the problem is to solve.

2.12.1 Grid SWZ drought risk assessment

For our supply forecast, we will use some of the risk-based methods more appropriate to a Risk Composition 3 classification than our overall Risk Composition 2 classification, because there is greater complexity in our supply side estimates, and because we are required to demonstrate resilience to a 1 in 500-year level. We will use scenarios and sensitivity testing to ensure our solution can be adapted in future planning scenarios if the future supply-demand balance is significantly different to that forecast in the baseline scenario. Our approach to calculating the conjunctive use deployable output reflects the risk to the whole system, and complements the groundwater methodologies, which already account for supply side losses in drought yield.

Our analyses include droughts outside our historic record as we have used the stochastic datasets developed by *Atkins, 2021*. We also calculate deployable output for different scenarios, and we explain the influence of supply side interventions in relation to the links with our Drought Plan.

For this plan, climate change remains the driver for significant future uncertainty and sensitivity analysis to still be appropriate. We have assessed headroom using *A re-evaluation of the Methodology for Assessing* Headroom (UKWIR, 2002b). We have also included a more extreme climate change scenario in our sensitivity testing.

2.12.2 East SWZ drought risk assessment

The modelling complexity for the East SWZ is low, as determined by our problem characterisation assessment. The East SWZ is included in our WRAPsim / PyWR water resources behavioural model used to model deployable output, and in most cases, we will use the same methodologies for the East SWZ as we do for the Grid SWZ.

2.12.3 Drought resilience statement

In our WRMP19 we planned to have temporary use bans no more frequently than 1 in 25 years, and drought permits no more than 1 in 80 years on average. We also planned to a 1 in 500-year level of resilience for emergency drought restrictions. We based our analyses on our historic inflows series and used extreme value analyses to calculate the return period for emergency drought measures, as they were longer than our period of record.

For WRMP24 we have a requirement to plan to a 1 in 500-year level of resilience for emergency drought restrictions by 2039/40 and have been required to use stochastic time series to do this. The use of these stochastic time series has reduced our deployable output estimate considerably, and so we are now planning to a lower level of resilience in the early years of the plan. In order to address this risk, we propose to implement components of the preferred plan to increase resilience to emergency drought restrictions at the 1 in 200 level by 2027/28, subject to agreement on early start schemes with regulators. In our preferred plan, we have identified a number of supply options which we have classified as 'early start', and in our preferred plan we commence delivery of these in AMP7.

The assessment of drought resilience is sensitive to changes in approaches used to make the assessment. This means we will need to work closely with regulators ahead of WRMP29 to ensure the approach we are using is appropriate to our supply system.

2.13 Levels of Service

For previous WRMPs, our deployable output was defined by our levels of service of:

- temporary use bans no more frequently than 1 in 25 years on average (4% probability in any one year);
- drought orders no more frequently than 1 in 80 years on average (1.3% probability in any one year); and
- we estimated our resilience to emergency restrictions to be no more than 1 in 500 years on average (0.2% probability in any one year).
- these levels of service apply throughout our planning period.

These levels of service and Deployable output were obtained using our Water resources simulation models, WRAPsim and PyWR.

With the requirement to ensure resilience at the 1 in 500-year system response, we have moved, as recommended, from the use of our historic data series of inflows, to stochastically generated inflows. We have kept the same levels of service for temporary use bans (TUBs) and drought permits but have had to reduce our levels of service initially for emergency restrictions, as modelling using the stochastic time series produces far lower values for deployable output. This is explained further in Section 3, and fully in our supplementary technical report on Deployable Output and Climate Change, which is available on request.

3 Supply forecast

This section describes how we have calculated the amount of water we can supply now and in the future – otherwise known as our supply forecast. We explain what we have included in our forecast, and how we have considered the effects of climate change. We show the links between our levels of service and deployable output (supply) and how we have considered other factors that may affect how much water we can supply.

3.1 Water resources

The Yorkshire Water region is bound by the hills of the Pennines in the west, the North York Moors in the northeast, and the North Sea to the east. The southeast and eastern parts of the region are low lying. Annual average rainfall in the region is highest in Pennine areas, whilst low lying areas average less than half of the rainfall each year compared with the Pennines, with little seasonal variation.

Urban areas in the west and south are principally supplied from reservoirs in the Pennines. The Pennines and the valleys of the Rivers Don, Aire, Wharfe, Calder, Colne and Nidd are the largest upland sources of water in the region. We operate over 100 impounding reservoirs, two of which are major pumped storage reservoirs. The total storage capacity of all the supply reservoirs is 160,410 mega litres (Ml) (equivalent to approximately 64,000 Olympic sized swimming pools).

We have an agreement with Severn Trent Water to abstract up to 21,550Ml per year from the Derwent Valley reservoirs in neighbouring Derbyshire. This water is used to supply part of South Yorkshire.

In the east and north of our region, the major water sources are boreholes and river abstractions, primarily from the rivers of the Yorkshire Wolds and North York Moors respectively.

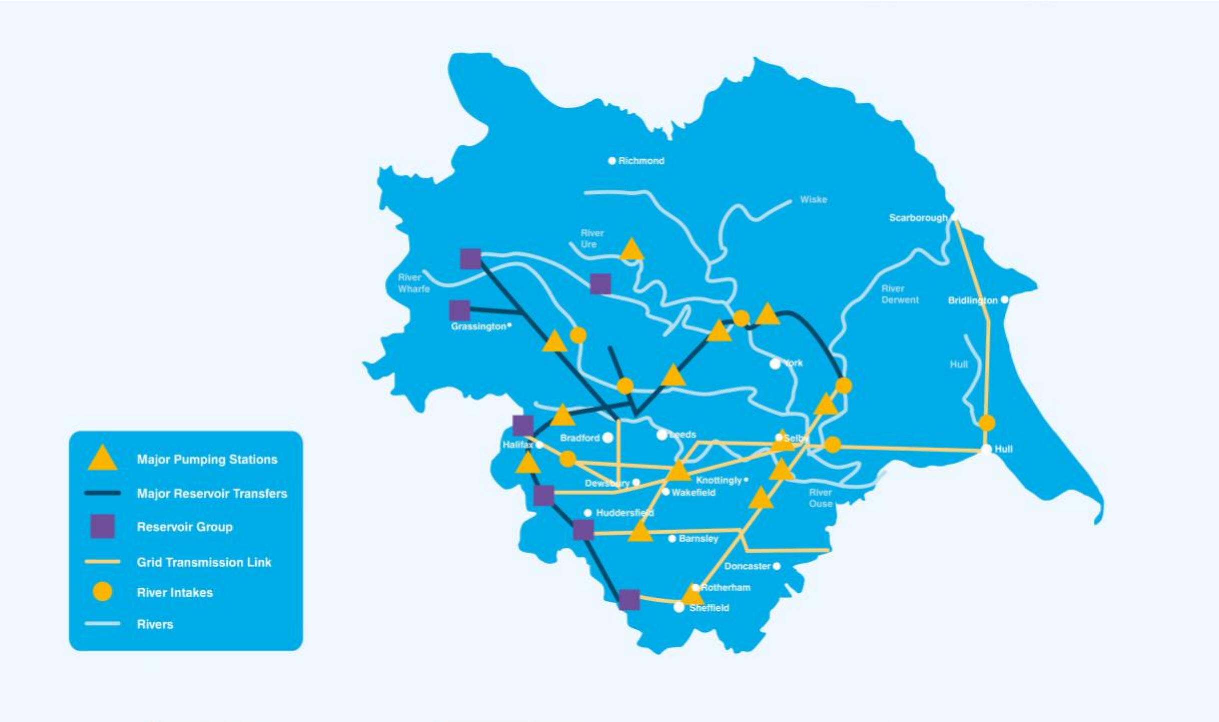
Most of these water resources are now connected by a grid network. The benefits of the grid are outlined earlier in Section 2.3 and allows us to be agile by balancing our supply and demand needs regionally.

Approximately 45% of the water that we supply is from impounding reservoirs, 30% from rivers and 25% from groundwater. This varies from year to year depending on weather conditions. In the dry year annual average planning scenario rivers are used more, with about 40% of supply coming from reservoirs, 40% from rivers, and 20% from groundwater.

As described previously, our region is divided into two water resource zones for planning purposes: the Grid SWZ and East SWZ. Each zone represents a group of customers who receive the same level of service from either groundwater or surface water sources.

The Grid SWZ represents a highly integrated surface and groundwater zone that is dominated by the operation of lowland rivers and Pennine reservoirs. Conversely, the eastern area of this zone is supplied mainly from borehole sources located in the Yorkshire Wolds and along the east coast. Previously referred to as the East Groundwater Zone, this area was linked to the Grid SWZ by the east coast pipeline completed in 2012, which was constructed to provide service resilience to the former East Groundwater Zone.

Figure 3.1: Overview of Grid system



In some parts of the Grid SWZ, there is the potential opportunity for changes in reservoir management to be made to help manage flood risk. This is illustrated by the trial that we carried out at Hebden Bridge over the winters of 2017/18, 2019/20, 2020/21 and 2021/22. The purpose of these trials was to keep the reservoirs drawn down by 10% to allow them to store water during rainfall events in order to help protect downstream communities in Calderdale from flooding. We will continue to explore this issue, recognising that possible flood risk benefits must be balanced against other risks such as water resources resilience and reservoir safety. We will continue to report on our partnership work on this issue through the Calderdale Flood Partnership Board. Our estimates of deployable output do not assume any drawdown of these reservoirs for flood storage.

The East SWZ is supplied by a river abstraction and moorland springs in the Whitby area.

3.2 Resources and abstraction licences

We have 100 public water supply abstraction licences for 156 sources. These have been reviewed as part of the Environment Abstraction Licensing Strategies (known as CAMs). Table 3-1 lists the CAMS areas in the Yorkshire Water region. All are in the Yorkshire area of the Environment Agency except for the Idle and Torne CAMS area which is in the East Midlands region. The objectives of the CAMS process are:

- to inform the public on water resources and licensing practise;
- to provide a consistent approach to local water resources management;
- to help balance the needs of water users and the environment; and
- to involve the public in managing the water resources in their area.

No changes to our abstraction licences were proposed by the Environment Agency during the first two cycles of CAMS reviews, the dates of which are given in Table 3-1 below. Where abstraction licences have been identified for review in support of our environmental obligations (including our long-term Environmental Destination) under the WINEP, these are summarised in Section 3.8.

Table 3-1: CAMS review dates

CAMS Name	First Published (CAMS)	Last published * (Abstraction Licensing Strategy)
Swale, Ure, Nidd, Upper Ouse	October 2003	February 2013
Don and Rother	October 2003	February 2013
Wharfe and Lower Ouse	March 2005	February 2013
Aire and Calder	May 2007	February 2013
Hull and East Riding	March 2006	February 2013
Derwent	March 2006	February 2013
Idle and Torne	March 2007	February 2013
Esk and Coast	August 2007	February 2013

* https://www.gov.uk/government/collections/water-abstraction-licensing-strategies-cams-process#yorkshire-(map-area-3))

We hold 17 time limited licences (TLLs). All existing TLLs have been renewed by the Environment Agency at current abstraction conditions, until their appropriate CAMS cycle end dates. The licences that are now due for renewal in 2029 and 2030 were most recently renewed in 2017 and 2018. Table 3-2 below outlines the Yorkshire Water licence time limits. We expect that all TLLs will be renewed on expiry and included no uncertainty related to renewal in this plan, as the renewal of all licences to date has been approved by the Environment Agency, who agreed they were all environmentally sustainable, and no information to the contrary has come to light since.

In our WRMP19 solution we planned to apply to increase a number of licences in our Grid SWZ in order to improve our resilience. These licences were planned in our previous plan to support local areas during peak demands or outages and reduce pumping from larger WTWs. Some of these schemes are no longer being considered (see section 1.7).

Table 3-2: Time limited licences

TLL Expiry Year	AMP period	No. of Time Limited Licences due for renewal
2027	AMP8	6
2029	AMP8	8
2030	AMP8	3

Following the drought permit applications that we made after a period of prolonged hot and dry weather in 2018, we applied to increase the annual abstraction limit on the River Wharfe in order to increase our resilience. This licence was granted in July 2023. The licences for reservoirs in the Worth Valley were re-issued in 2018, and are now also TLLs, expiring in 2027 (noting that these licences are under consideration in our WINEP – see Table 3-9).

3.3 Baseline operations

The process of planning and managing baseline water resources in Yorkshire is part of our fully integrated approach to operational planning from source to tap across the whole region. Our main objective is to ensure that good quality water is supplied at minimum cost to customers and the environment.

We have a dynamic weekly management process to determine key flow target settings (reservoirs, rivers, boreholes, water treatment works and pipelines) for the week ahead. The process uses the WRAP (Water Resource Allocation Plan) computer model. This determines the best use of available resources to meet demand and maintain security of supplies. Resources are selected to minimise costs, environmental impacts and carbon emissions.

The WRAP model takes account of expected demands, reservoir and groundwater operating rules, control curves and licensing constraints. Temporary constraints such as outages for maintenance work or water quality problems are also taken into account. The management of river resources is subject to licence conditions which restrict abstractions at times of low flow and permit increased abstractions during higher flows, typically in the autumn and winter. These are also taken into account by the model.

3.4 Deployable output assessment

Our "deployable output" is the highest demand that we can meet whilst still meeting our defined levels of service (see Section 3.4.4). We model our deployable output using our water resources simulation model. For our draft WRMP we used our WRAPsim model, but for our final WRMP we have used our new Python Water Resources (PyWR) model.

The WRPG states that "baseline supplies should be available in a 0.2% (1 in 500) annual chance of failure caused by a drought". Further details of this requirement can be found in *Water resources planning guideline supplementary guideline-Stochastics* (Environment Agency, 2021), and *Water resources planning guideline supplementary guideline-1 in 500* (Environment Agency, 2021). In this instance, the failure caused by drought relates to the requirement for level 4 drought restrictions such as rota cuts or standpipes.

To determine deployable output, we have followed the methodology defined in the *Water resources planning tools* (UKWIR, 2012); Annex E of *Water resource and supply: agenda for action* (Department of the Environment, 1996), *Re-assessment of water company yields* (Environment Agency, 1997) and *A Unified Methodology for the Determination of Deployable Output from Water Sources* (UKWIR / Environment Agency, 2000). Other deployable output assessment methods used include *Handbook of source yield methodologies* (UKWIR, 2014).

The Grid SWZ is a large and complex conjunctive use resource zone, so the assessment method used must be one suited to this highly complex zone.

This WRMP24 provides a summary of our deployable output assessment. Further detail is given in the Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request.

A key change from WRMP19 is that we are now required to assess our deployable output to be resilient to a reasonable range of droughts with an approximate return period of 1 in 500 years (0.2% annual probability). To adequately model such a high return period requires the use of stochastic time series, so we have used stochastic climate series produced by *Atkins, 2020 Regional Climate Data Tools Final Report Sutton and East Surrey Water on behalf of WRSE*, as detailed below.

3.4.1 Groundwater deployable output assessment

We maintain an ongoing programme of work to performance test our operational boreholes and where we have reassessed the deployable output of a groundwater source using a source reliable output assessment, it has been included in our WRMP24. The average output that a groundwater source can be relied upon to produce in a drought year is termed the average demand drought condition deployable output. The peak demand condition deployable output can be reliably supplied by a source for a short period. For our critical period modelling we have assumed a weighted average of the average and peak source reliable outputs. This is because our critical period is for a month, so longer than the peak output alone could be relied on.

3.4.2 Use of stochastic timeseries

Atkins (Atkins, 2020) have produced stochastic rainfall data for a number of sites nationally, of which about 22 are in the Yorkshire region. For each of these they have provided 400 stochastic replicates of 48 years, each representing a possible realisation of the 1950-1997 period. They have also provided stochastic Potential Evapotranspiration (PET) series for Yorkshire river and reservoir catchments. The rainfall data are based on the HadUK rainfall dataset (Hollis *et al.*, 2019), and the PET data are from the Environment Agency's new PET and PETI (with an added component for interception) datasets. Interception is defined as precipitation that does not reach the soil, as it is intercepted by vegetation (trees and other plants).

We have had GR6J rainfall-runoff models developed for our simulation model inflows by HR Wallingford (HR Wallingford, 2022a). We have used these to produce historic inflows from 1900-2022, and stochastic inflows for 19,200 years (400 x 48-year replicates).

3.4.3 Yorkshire Region deployable output modelling

As stated above, we model our deployable output using our water resources simulation models. Historically, and for our draft WRMP24 we used our WRAPsim model, but for our final WRMP we have used a new PyWR model developed by Jacobs. Our deployable output is the highest demand we can meet whilst still meeting our levels of service. For WRMP24, this includes being resilient at the 1 in 500-year level to emergency drought restrictions. We use the permitted failure (Scottish) method described in the Handbook of source yield methodologies (UKWIR, 2014). This enables us to develop a relationship between supply availability and failure frequency.

For WRMP24, we have updated our water resource simulation models for the following components:

- new inflow series generated using rainfall runoff models
- review of the demand profiles
- update to hydraulic and treatment capacities
- update of groundwater source reliable output studies
- update of power and chemical costs, and abandoned sources.

We have reviewed water treatment works capacity limits to reflect changes in reliable throughput due to factors such as water quality. Our Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request, outlines maximum water treatment works capacities used in our WRMP24.

For the Grid SWZ, the water resources modelling software is used to carry out the analysis required for the determination of deployable output. The model incorporates the following required elements:

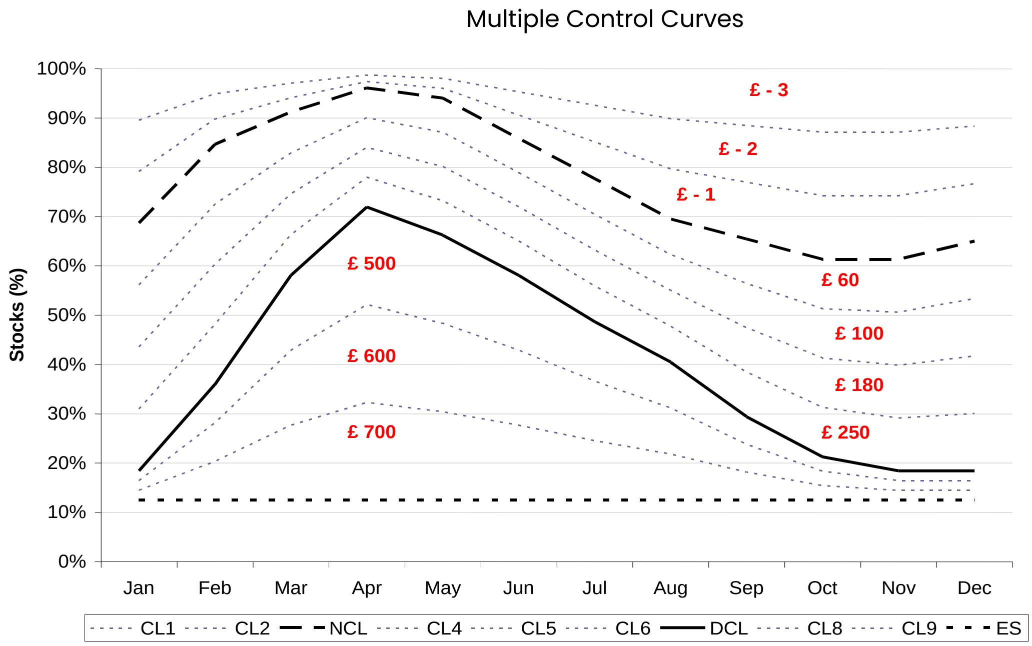
- the same demand profile should be used for every year of the simulation;
- the defined physical capacities of the existing system should be adopted for the simulation;
- each modelled system must incorporate emergency storage;
- inflows, from 1900 to 2020 for our historic period (ensuring a long simulation including critical droughts of 1920s, 1930s and mid 1990s);
- 19,200 years of stochastically generated inflows based on the period 1950 to 1997
- licence conditions are adhered to;
- the model is re-run at increasing demands to establish the relationship between demand and levels of service.
- Failure- level 4 restrictions such as rota cuts or standpipes triggered by Yorkshire regional reservoir stocks at 20%

The supply reservoirs and the Hull borehole group in our simulation models are modelled using control lines. The yield of the individual reservoirs and the control lines are calculated using minimum inflow sequences. This is to establish what reservoir stocks are required, given the historic minimum inflows, to maintain a given yield through the worst historic conditions.

Since we operate the sources within the Grid SWZ together, multiple control lines with notional costs, called penalty functions, are used to balance stocks between reservoirs across the region. This ensures that for our historic inflows, reservoir stocks are balanced throughout the region and enables us to meet the requirement of achieving the same level of service throughout the resource zone. When we use stochastic inflows to model deployable output, we have only considered Yorkshire regional reservoir stocks, and have assumed we would be able to balance stocks across the region if necessary.

Figure 3.2 illustrates how multiple control lines are used to assign different costs to water in different reservoir bands. This allows stocks to be balanced between reservoirs.

Figure 3.2: Example of control lines and penalty functions



The reservoirs in the model are in five groups: Central, East (including the Hull borehole group, which is modelled as a reservoir), North West, South and South West Reservoir Groups.

Although the Grid SWZ does contain some sources with only limited connectivity to others, it is considered as a single resource zone. This is because most demand areas can be supplied by alternative sources and restrictions on use would be applied to all demand areas within the zone at the same time. All areas within the Grid SWZ meet the level of service.

When using the simulation model to determine deployable output, we maximise demands to the point of failure. The model is re-run at increasing demands until the level of service is just met. This demand is the deployable output for the 1 in 500 level 4 restrictions level of service (for the Grid SWZ). The demand of the Grid SWZ is the combined demand of all the demand zones within the Grid SWZ at the regional demand, when the level of service is just met (excluding the demand met by the Severn Trent import).

For the East SWZ, we have analysed the stochastic flow data for the River Esk and calculated the 1 in 500 year return period of minimum river flows. The East SWZ is constrained by the capacity of the River Esk water treatment works. For the baseline stochastics, all 19,200 stochastic years have a flow that could support the WTW capacity of 14Ml/d.

For our Grid SWZ, we record minimum modelled reservoir stocks each year and use these to calculate the return period of regional stocks falling below the 20% threshold which would trigger emergency drought restrictions.

The move from approximately 100 years of historic data in WRMP19 to 19,200 years of stochastic data for WRMP24 has necessitated a change in approach. It is no longer possible to look in detail at each model failure and balance the model to ensure failures occur at the same rate in all areas. We have had to assume that stocks could be balanced across reservoirs and reservoir groups and have done so for selected stochastic replicates to give us some confidence in this assumption.

For the 1 in 500 resilience level, we have therefore considered only the Yorkshire regional reservoir stocks, and calculated the 1 in 500 failure rate by fitting extreme value (EV) distributions to annual minimum modelled stocks. We have decided not to use simple inverse ranking techniques, as these results are different to the EV calculations, which we think are more statistically correct. The process we have followed is explained in greater detail in our Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request. This report also details the sensitivity analyses we have carried out in relation to failure metrics and return period analysis of the modelled reservoir stocks.

PyWR Water Resources Simulation Model

We have had a PyWR model developed for our WRMP modelling. This has been used for our revised draft and final WRMP modelling, whereas WRAPsim was used for our draft WRMP modelling. The PyWR model was developed by Jacobs, and has undergone extensive testing and calibration to ensure it behaves sensibly before we were able to use it for WRMP supply modelling. Reassuringly, the results of the PyWR and WRAPsim models are similar.

The PyWR model uses schematics based on the WRAPsim schematics, with the same connectivity and constraints. Both models use a 'simplex solver' to optimise how water is supplied, and aim to meet demand by minimising costs. These costs are a combination of real (power and chemical) and notional (penalty function costs as shown in Figure 3.2).

The advantage of using the PyWR model, is that it overcomes many of the difficulties we encountered using the stochastic datasets in WRAPsim. In WRAPsim, inflow files are limited to 400 years (1800-2199), so we had to stitch the stochastic time series into 50 sequences of 384 years each, in order to facilitate running the models. Conversely, when using PyWR, we can run each of the 400 stochastic replicates individually, starting each from the same initial conditions, and removing inconsistencies produced when stitching series together for use in WRAPsim. Using PyWR has enabled us to run the scenarios using the full stochastic sequences instead of using samples of the sequences to save time. This should give more robust results.

3.4.4 Level of Service

Our current level of service was formally adopted in April 2000 and delivered by 2001. Table 3-3 shows our current level of service (WRMP19), and our levels of service for WRMP24.

For WRMP19 we estimated the return period of our level 4 restrictions (rota cuts/standpipes) as 1 in 500 years by analysis of minimum modelled historic reservoir stocks (*see UKWIR 2014, Handbook of Source Yield Methodologies, 11.3.2.4 Good practice examples*).

For WRMP24 we have used the stochastic sequences but have chosen to still use extreme value analysis (EVA) techniques to obtain a robust estimate of our deployable output. We have carried out these EVA techniques on each of the 400 replicates, and on the entire 19,200 years, and we use the median replicate to represent our deployable output.

As part of our customer research into our proposed outcomes and performance commitments for PR19 we discussed drought risk. This included the company position against the percentage of population that would be impacted by a 1 in 200-year drought risk measure. When compared to other performance commitment measures, it ranked in the bottom five of importance, as customers are happy with our performance in this area and the level of service we plan to.

Table 3-3: Target level of service

Restriction	Frequency of Restriction	Annual risk of restrictions (%)	Risk of restrictions in 25-year planning period (%)
Level 4 restrictions (Rota cuts/Standpipes)	1 year in 200 (WRMP24)** 1 in 500 (WRMP19 and WRMP24)**	0.5 0.2	12 5
Level 3 restrictions (Non-essential use ban, Drought Permit/ Ordinary Drought Order)*	1 year in 80	1.25	27
Level 2 restrictions (Temporary Use Ban Implementation*)	1 year in 25	4	64

* We assume restrictions would always be implemented for a period of at least 3 months, even if the modelling indicates they would be needed for a shorter period. We count all modelled triggering of restrictions, even if only triggered for a shorter period in the model.

** Our baseline DO is estimated for a 1 in 500-year system response, but in our preferred plan we have chosen to operate to a 1 in 200 level of resilience from 2027/28 until 2038/39, until we can increase our resilience to the 1 in 500-year level.

For PR24 we have not explicitly consulted with customers on levels of service for other restrictions as in PR14 customers were supportive of our overall level of service. However, our early engagement with customers for the PR24 business plan highlighted that the 'cost of living crisis' is affecting customer views. It is clear that both household and non-household customers anticipate challenging financial times in the near future, and this may mean that appetite to fund further improvements in levels of service is limited at present.

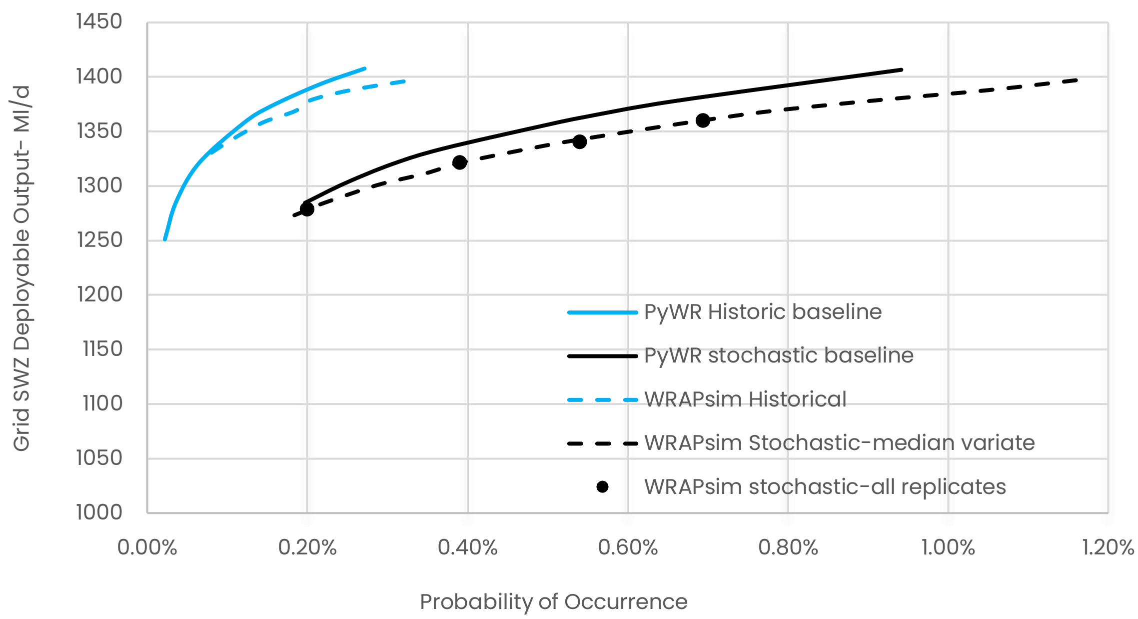
For each of the level of service deployable output calculations, the model was run at increasing demands until the level of service was just met (using the Permitted Failures method as described in *Handbook of Source Yield Methodologies* (UKWIR, 2014). The deployable output represents the highest demand at which the level of service is met, and the underlying assumptions for all runs are the same.

Figure 3.3 and Table 3-4 show the relationship between level of service for emergency drought restrictions and deployable output for the Grid SWZ, plotted as annual risk. In Figure 3.3 this relationship is shown both for the simulation runs using historical inflows, and those using the stochastic time series, and compares the results using WRAPsim and PyWR.

The link between groundwater sources and level of service are less clear than those for surface water sources, due to the limited data available for many groundwater sources. Many of our groundwater sources are constrained by licence or infrastructure, so alternative levels of service will not impact the deployable output of the sources. This may change in the future, if climate change alters the limiting factor constraining the source yield from the infrastructure or licence constraint.

In our draft WRMP, when using WRAPsim, in order to reduce the time taken to run all 19,200 years of stochastic series, we used a sample of the 400 replicates, and for some of our options testing, we used a single stochastic replicate which represented the median variate. We used this variate to run different scenarios at a number of demands and carried out the extreme value analyses (EVA) on these results to calculate the deployable output, and then to confirm these results, we ran at the deployable output demand for the entire stochastic series.

Figure 3.3: Relationship between deployable output and level of service for emergency drought restrictions for the Grid SWZ



For our final WRMP, we have been able to model the entire stochastic time series using the PyWR model. We have also been able to model all required scenarios using all 400 of the 48 year long stochastic replicates. This has enabled us to get better estimates of our baseline deployable output, and of the deployable output under different scenarios.

The interconnected nature of the Grid SWZ means that even areas mainly supplied by groundwater sources have the same level of service as those supplied by surface water sources. This is because most areas can be supplied by at least one other part of the grid. There is therefore no need to assess individual source links between deployable output and level of service.

Our level of service is consistent with our Drought Plan 2022, and we expect to implement temporary use bans no more frequently than 1 year in 25. Currently the deployable output forecast based on the 1 in 500-year resilience to extreme drought measures has a level of service for Drought Permits of 1 in 134 years. For the 1 in 200-year resilience to extreme drought measures, our level of service is 1 in 81 years for drought permits in the baseline planning scenario (Table 3-4).

Table 3-4: Relationship between level of service for emergency drought restrictions and deployable output for the Grid SWZ (PyWR simulation model using stochastic inflows): baseline scenario 1990s (without climate change impacts)

Frequency of Level 4 restrictions	Annual risk of restrictions (%)	Deployable output (Ml/d) PyWR	Temporary Use Ban (TUB) LOS-Level 2 restrictions	Ordinary Drought permit/ order LOS Level 3 restrictions
1 in 100 years	1	1406.60	1 in 26 years (3.85% annual risk)	1 in 50 years (2.00% annual risk)
1 in 200 years	0.5	1356.14	1 in 42 years (2.39% annual risk)	1 in 81 years (2.39% annual risk)
1 in 400 years	0.25	1302.34	1 in 68 years (1.47% annual risk)	1 in 106 years (0.94% annual risk)
1 in 500 years	0.2	1284.48	1 in 82 years (1.22% annual risk)	1 in 134 years (0.74% annual risk)

*We show the expected levels of service for our final planning scenario in Section 0 (Table 9-11).

The deployable output of the East SWZ is currently limited by the capacity of the water treatment works. However, if restrictions were required in the Grid SWZ, we would consider including the East SWZ. This is because during periods of reduced resources, we would want to communicate to all of our customers the collective need to preserve water stocks.

Until the temporary use ban that we imposed in August 2022, we had not imposed restrictions since 1995/96. This is consistent with forecast restrictions using historical inflows in our current model, although our model shows far fewer forecast restrictions than actually occurred in 1995 and 1996. This is due to the significant investment in the grid network which has taken place since the 1995/96 drought (and is reflected in our model), and to changes in operation and control lines which have resulted from analysis of inflows during extreme events.

The duration of temporary use bans and drought orders are assumed to be at least three months, as once we have imposed a temporary use ban we are unlikely to lift such a ban until reservoir stocks have made a considerable recovery. Therefore, a minimum three-month duration is a sensible one to apply. This does not mean that we are not counting restrictions that would apply for less than three months based on criteria for recovery, but that in our modelling, we would enforce restrictions for at least 3 months. In our baseline deployable output model runs, restrictions are triggered but not imposed, but in our modelling to assess the impact of imposing restrictions, we impose them for at least 3 months. For the PyWR model runs, the entire stochastic datasets have been used. The modelled levels of service for the level 4 restrictions have been calculated as described in section 3.4.3 using return period analyses, and for the level 2 and level 3 restrictions, they are calculated from the frequency of occurrence of each restriction reported by the PyWR model. At the 1 in 500 level of resilience for level 4 restrictions, the levels of service for TUBs and level 3 drought permits are far higher than our target levels of service, as this represents a relatively low demand. The 1 in 200 level of resilience for level 4 restrictions has a return period for level 3 restrictions of 1 in 81 years, similar to our target levels of service of 1 in 80 years, but has a higher return period for TUBS of 1 in 42 years (target 1 in 25). The 1 in 100 level of resilience for level 4 restrictions has a 1 in 26-year return period for TUBs- similar to the 1 in 20 target level of service, but a 1 in 50 year return period for level 3 restrictions- far lower than the target 1 in 80 years (Table 3-4).

3.4.5 Critical Period

We have calculated deployable output for our Grid SWZ for a critical period. We have done this by modelling our supply system for the period of July at increasingly higher demands until demand is not met. Our levels of service do not define the critical period, as it is too short a period for our drought measures to be triggered. Instead, the critical period shows how resilient our system is to periods of high demand and can help us identify any network improvements. For our final WRMP, we have carried out further modelling informed by the peak demands and issues we faced during the summer of 2022 (see 17.9 Appendix F: Lessons Learned from 2022 drought). Our ability to supply water during a critical period is mostly limited by treatment and network constraints. However, in 2022, risks associated with reduced abstractions due to licence constraints on the River Ouse were highlighted, and we have focussed on this in our critical period modelling.

As well as using our WRAPsim and now PyWR models to ensure we can maintain supplies in a month-long critical period, we have used our Water Resources Allocation Planning model (WRAPlan), which is more spatially detailed, but is run for a single timestep, in order to ensure peak demands in excess of those we have experienced can be met. Further details of this are shown in our technical report on deployable output and climate change, along with the WRAP schematics for some of the critical period scenarios. Our month-long critical period is an extreme test on our system, and the demand modelled is higher than previous monthly peak demands. It should be noted that there is no return period for the critical period as there is for our 1 in 500 and 1 in 200 year system responses: it is simply a test of our system in extreme demand situations, and helps us understand if supplies are capacity limited by licence, infrastructure, or resources.

3.4.6 Modelling the impact of climate change on deployable output

We have modelled the effect of climate change on our deployable output. To do this, we have applied climate change factors to the rainfall and PETI stochastic time series to generate climate change perturbed inflows representative of the UKCP18 Representative Concentration Pathway 8.5 (RCP8.5) regional climate change projections for the 2061-2080 period. The RCP8.5 scenario from UKCP18 represents a high emissions scenario which assumes that there are little or no efforts to reduce greenhouse gas emissions over the coming decades. This emissions scenario results in global temperature rises of between 3-5 degrees by 2100. The climate change projections were created by Atkins (Atkins, 2021), and provided for the Yorkshire catchments. We have used these climate change perturbed inflows in our simulation model to produce estimates of deployable output for the 2070s. These deployable output estimates have been scaled using scaling equations from Atkins (Atkins, 2021) to obtain deployable output representing RCP6.0 of the UKCP18 probabilistic projections (RCP6 is a medium emissions scenario, representing a future where more effort is made to reduce emissions, although this future still results in a global temperature rise of between 1.5 and 3 degrees by 2100.). Atkins discussed the use of a number of options for scaling the impacts of climate change, and we have used 'Equation 4' which scales the impacts from the 1990s (represented by the stochastic data) to the 2070s (represented by the climate change perturbed stochastic data), assuming deployable output changes in proportion to the change in temperature. The details of our climate change modelling of deployable output are described in Section 3.10, and in further detail in our supplementary technical report on Deployable Output and Climate Change which has been provided to the Environment Agency and is available on request.

3.5 Base year deployable output (2019/20)

The deployable output for each resource zone is shown in Table 3-5. The Grid SWZ deployable output is calculated from the water resource simulation model. The deployable output of the East SWZ is the sum of the deployable outputs in the zone, which includes any locked in yield not utilised in the water resource simulation model and is limited by the capacity of the River Esk water treatment works. The values shown include reductions in deployable output due to climate change from the modelled 1990s value to the base year of the WRMP24. The climate change modelling and scaling of climate change impact is described in Section 3.10, and later sections describe further considerations impacting deployable output over time.

Table 3-5: Deployable output (base year 2019/20)

Water resource zone deployable output	Dry year annual average deployable output 1 in 500 (Ml/d)	Dry year annual average deployable output 1 in 200 (Ml/d)	Critical Period deployable output (Ml/d)
East SWZ	13.52	13.93	n/a
Grid SWZ	1247.67	1317.23	1447.58

We have followed the WRMP guidelines, and so have not included any demand or supply side drought interventions in our deployable output assessment. We do, however, calculate the benefit of drought interventions, and these are shown in Table 6 of the WRP tables.

Our critical period deployable output of 1447.58Ml/d for the Grid SWZ in 2019 corresponds to a regional demand of 1488Ml/d, with 40Ml/d supplied by the import from Severn Trent Water. This regional demand is far in excess of our recent monthly demand peaks of 1400Ml/d in 2018, and 1374Ml/d in 2022, although we have had higher weekly peak demands (1480Ml/d in 2022, 1466ML/d in 2018, and 1441Ml/d in 2023). Testing our system to this prolonged high demand for our critical period shows how our system would cope with demands in excess of those we have experienced.

3.5.1 Deployable output confidence label

For WRMP19 we declared a confidence label AB for the deployable output estimate for both of our resource zone according to *Water Resources Planning Tools* (UKWIR, 2012). Confidence grade A was assigned because the data is available and of consistent quality. Confidence grade B is assigned due to the record length (71-99 years of data).

For WRMP24 we have used 19,200 years of stochastic data, so confidence should be higher. We have concerns about the stochastic data over-representing extreme droughts, as each of the 400 replicates is based on the 1950-1997 period, so our 1995-96 drought is an approximately 1 in 48-year event in the stochastic data, whereas in our historic record it is an outlier in 130 years of rainfall data. Due to these concerns, we have carried out sensitivity analyses to better understand the impacts of using the stochastic time series compared to the historic data. These analyses are fully detailed in our technical report on deployable output and climate change. We still classify our deployable output confidence as confidence grade A because the data is available and of consistent quality. The stochastics are based on a 48-year record (confidence label C), but there are 19,200 years of data (confidence label A), so we have chosen the intermediate value of B.

3.6 Resilience

The WRPG requires our WRMP to set out how we will ensure the wider resilience of our water supply systems to hazards such as drought and flooding. We have demonstrated the resilience of our systems in recent years and have maintained supply through several extreme events including widespread flooding, storms, and drought. We have also managed our water resources through the challenges of a global pandemic which has demonstrated considerable business wide resilience and our ability to respond to a fast changing and unprecedented situation.

WRMP19 described how we had developed a whole business resilience maturity assessment framework. The framework assessed 16 different systems spanning our operational, financial and corporate activities. We looked at different time horizons and assessed our resilience to a comprehensive range of shocks and stresses using the British Standard for Organisational Resilience (BS65000) and an extended version of the Cabinet Office model for effective infrastructure resilience[13]. This framework allowed us to quantify the maturity of our resilience in different systems across the company through a comprehensive evidence-based assessment. The maturity assessment was led by an external consultant and involved comprehensive internal stakeholder engagement, including 40 workshops and interviews with colleagues from across the business. The six levels of maturity included in the assessment are shown below.

The assessment of our four water resource related systems in terms of historic and future resilience to forecast shocks and stresses is shown in the table below.

Table 3-6: Historic and future resilience assessment of water supply systems

System	Priority shocks and stresses	1989	Now to 2020	2025	2050
Land (catchment) management	Climate change, environmental change, change in customer behaviour	Basic	Established	Established	Predictable
Water resources and collection	Climate change, population growth, environmental pressures	Basic	Established	Established	Optimising
Water treatment and drinking water safety	Aging infrastructure, vandalism, pollution	Basic	Established	Established	Predictable
Water distribution	Climate change, aging infrastructure, disruptive technology	Basic	Established	Established	Optimising

We are in the process of updating and improving this framework, building on the learning from its first iteration and incorporating and aligning with Ofwat's requirement to develop long term strategies and to test these against a set of common reference scenarios[14]. Our strategy will describe a number of different pathways we could take in order to meet our long-term ambitions. Our resilience framework will describe the outcomes we want to meet for each of our systems, along with a set of metrics which we will map against Ofwat's common reference scenarios. This will allow us to monitor our progress towards our long-term ambitions in a quantifiable and repeatable way, enabling us to change tack should our performance or external circumstances indicate that a different approach or pathway is required. We published our resilience framework and our long-term strategy as part of our business plan submission to Ofwat in 2024.

[13] https://www.gov.uk/government/publications/keeping-the-country-running-natural-hazards-and-infrastructure
[14] https://www.ofwat.gov.uk/publication/pr24-and-beyond-final-guidance-on-long-term-delivery-strategies/

3.6.1 Water supply system resilience

In addition to the whole company resilience framework described above, we also recognised the need to review the resilience of our water supply systems in more detail and at a more granular level. We therefore instigated and developed a Water Supply System Strategy (WSSS) to resilience. We segmented the water network into 19 hydraulically discrete areas, as well as the Yorkshire Water Grid system which allows for significant interconnectivity between these discrete areas.

The systems were risk ranked and eight of them were prioritised for study, review and optioneering for PR24 and WRMP24. The systems were reviewed against a range of external stresses such as deteriorating or changing water quality, population growth[15], water scarcity, third party/external damage to assets and asset health. The impacts of these stresses were considered against a range of resilience standards considering; system storage time, pumping systems redundancy, ability to undertake planned maintenance, water network redundancy in supply route, single points of network failure, treatment process redundancy and time to recover from asset failure. Outputs from this study informed a clear view as to which of Yorkshire Water's WSSSs were at risk of severe customer impact, due to lack of resilience and when cross referenced with our Security and Emergencies Measures Direction (SEMD) strategy and investment, which systems fall into the 'unacceptable zone' for resilience risk.

These strategic risks have had solutions developed for mitigation, and have been documented with likelihood, scale and impact for pre and post investment options. Each investment considers the constraints the investment places on subsequent investment options, allowing for the creation of a number of strategic pathways. These pathways are being prioritised and will inform a long-term resilience investment roadmap. This considers the impact of the initial investment on the systems resilience and the next available options in the future, allowing for adaptive planning if system triggers for deterioration in service or resilience are hit in the future.

As part of PR24, two main schemes have been included which will provide significant improvements to resilience. The first, at North Yorkshire WTW 1, has two elements; water resource & treatment and distribution. The water resource and treatment solution is to be funded via DWI Enhancement to resolve an issue with raw water quality local to the boreholes on site at North Yorkshire 1. Once delivered, as well as resolving the primary water quality issue, this solution also provides an opportunity to increase deployable output from site via additional improvements to the distribution system. These additional improvements are included in WRMP. Finally, delivery of both the DWI and WRMP elements at North Yorkshire 1 will have a further benefit in the form of increased system level resilience. North Yorkshire 1 WTW along with North Yorkshire 2 WTW and North Yorkshire 4 WTW form the North Yorkshire 1/North Yorkshire 2 WSS. Increased deployable output at one of these WTWs will significantly increase the survival time of reservoirs in the system, minimising impact to customers.

The second resilience scheme, included at PR24, is for a major scheme to address one of our highest resilience risks. However, the objective of the scheme is to reduce the number of properties solely supplied by a single water treatment works in one of our highest risk areas for resilience, by over 135,000 and in line with SEMD guidance. Additional storage in the system, will also increase survival time in the system by over 162 hours, to a total of 198 hours or over 8 days.

To date we have completed studies on 40% of our systems and will continue the process in AMP8 to create an even more resilient and flexible Grid. We are currently developing a delivery plan, including a review of priorities, to complete the review. The outcome of these investigations will feed into draft Drought Plan 2025 (where applicable), WRMP29 and PR29.

Further information around the supply resilience benefits associated with supply resource schemes is covered in Section 8.3.

[15] This was in addition to the WRMP demand forecast population growth analysis and looked specifically at in-AMP planning applications in areas know to have 'localised growth' that is creating 'hot spots' that are not identified by the long-term forecasts.

3.6.2 Water catchment resilience

Sustainable land management practices are critical to the resilience of our water services, as the land from which raw water drains influences the quality of that water. We are one of the largest landowners in Yorkshire, with 28,000 hectares of land across the region. We own about a third of the catchment land around our reservoir sources. This ownership enables us to work closely with our farm tenants and other stakeholders to lead by example in our land management practices and to actively support sustainable land management and foster catchment resilience. We work with other landowners and stakeholders across Yorkshire to protect all our sources of water, including rivers and groundwater sources as well as reservoirs.

Working with many stakeholders over the last couple of decades, we have matured conservation measures in response to water pollution from unsustainable land practices.

The quality of the raw water we collect in our reservoirs has been deteriorating in many catchments over recent decades, primarily as a consequence of unsustainable land management practices. Whilst we continue to invest in enhanced water treatment capabilities to ensure our customers always receive the highest quality drinking water, we also have a range of programmes to address the issues at source. These will help to secure the long-term resilience of our raw water sources.

In the upland environment surrounding reservoirs, our catchment management programme includes managing our 25,000 hectares of natural habitats to protect Yorkshire's raw water and biodiversity. In our region, many of the key catchments contain upland peat which must be in a healthy natural condition if it is to provide clean water to our reservoirs and water treatment works. In an area with high biodiversity and good land management practices, the diverse and complex community of plants, animals and micro-organisms work efficiently to filter and remove contaminants. We have longstanding programmes of working in partnership with others – notably Yorkshire Peat Partnership and Moors for the Future Partnership. The aim is to restore upland habitats both on our land and on third party land where there are water quality benefits for our service to customers. Our funding of this partnership work has also helped to unlock match funding from other sources. Examples of this include the MoorLIFE2020 project which was funded by the EU LIFE programme and co-financed by Yorkshire Water, Severn Trent Water and United Utilities. More recently, funding from Yorkshire Water has helped to support a bid by the Yorkshire Peat Partnership into Defra's Nature for Climate Peatland Grant Scheme. This has unlocked match funding to deliver additional upland restoration beyond that which could be delivered by Yorkshire Water funding alone.

Alongside our upland restoration programme, we also carry out extensive activity in lowland catchments to help protect and improve water quality in our river and groundwater sources. Our programme includes tackling a range of water quality issues, such as colour, pesticides, nitrates and saline intrusion.

The Sustainable Futures initiative is unique to the UK in terms of bringing together farmers, global food and drink producers, non-government organisations and supply chain partners. Since starting to work with consultants at Future Food Solutions during AMP6, we have continued to grow our Sustainable Landscapes programme, and now have three separate groups active across different parts of Yorkshire. A key focus is to collaboratively explore innovative ways to prevent farmland soil being lost to waterways. This helps our resilience by reducing the amount of pesticides, nutrients and soil entering our rivers and aquifers. It also helps the farmers involved make their businesses more sustainable and profitable.

The Sustainable Landscapes Innovation Group was the first that we set up, in 2018, and this now covers approximately 26,000 hectares around York. Following the success of that group, a second landscape area was identifed around the River Hull and Humber, which is not only delivering water quality improvements but also complements the work of our Living With Water (LWW) flood partnership programme in Hull and the East Riding. Our third was set up in the Yorkshire Wolds in 2021, and covers approximately 10,000 hectares around Kilham in the East Riding. The primary focus for our activity in this area is working with farmers to optimise the use of nitrogen in order to help protect the underlying chalk aquifer, which provides groundwater for drinking water as well as local chalk streams. However, the programme is not only focussed on nitrogen, but aims to provide multiple benefits including improving farm profitability, resilience, and enhancing biodiversity through active promotion of various cover crop seed mixes.

Whilst our activity has been focussed on specific catchments within Yorkshire, the various initiatives developed through our relationship with Future Food Solutions over the last six years are replicable across the rest of our region, the UK and beyond. The true value of the programme is not just in the water quality improvements that it will deliver for us and our customers. It extends to demonstrating to a wider audience of how changing land management practices can delivermultiple benefits that go beyond simply water quality. We have discussed possible trials of these approaches with other water companies, and our partners, Future Food Solutions, are already working in different areas of the country with different supply chain partners (outside the water sector).

Our catchment programmes also include activity to help prevent flooding. We have continued to develop our tree planting programme across the region, including a particular focus on working in partnership with the National Trust. This is to deliver landscape scale planting and restoration in the South Pennines, to support flood risk reduction, enhance biodiversity and store carbon, and to support delivery of regional priorities such as the Northern Forest.

We recognise the need to continue to grow our work, with partners, to restore and enhance upland, lowland and groundwater catchments. The aim is to improve their resilience to impacts from the growing pressures of a changing climate, loss of biodiversity, increasing pollution and population growth.

These are long-term interventions, and it will take many years for the full impacts and benefits to be delivered. We continue to monitor the effects of our approach and are committed to protecting and enhancing the range of benefits that people take from our land. This particularly relates to water quality, flood protection, nature conservation, recreation and carbon storage. We are using our six capitals approach to better quantify these benefits to inform improved decision making and investment choices.

We are committed to working in partnership and taking innovative approaches to sustainably manage our land, and to influence other landowners to do the same. We are also committed to sharing our research and monitoring data and working with policy makers to ensure effective legislation and incentive systems.

3.6.3 Drought resilience

Resilience is a key part of the WRMP and features prominently within our PR24 Business Plan. For WRMP24 we have used stochastic time series, and these have many droughts far worse than any in our historical record. This has revealed vulnerabilities in our system, and we are now planning how to make our Grid SWZ more resilient in the light of these much lower stochastic deployable output estimates. It should be noted that we were writing our draft WRMP during an on-going drought, the worst drought since 1995, and learning from that event has enabled us to review our WRMP24, particularly with respect to our critical period, and the resilience of our system. Our lessons learnt from the 2022 drought are summarised in 17.9 Appendix F of this document.

We carried out a high-level screening assessment within the drought vulnerability framework, which indicates no requirement to produce drought response surfaces for our East SWZ. The drought vulnerability framework for the Grid SWZ is discussed below.

3.6.4 Drought vulnerability framework

In order to assess our resilience to droughts we have tested our system against a range of droughts, we have followed the UKWIR and Environment Agency project *The Drought Vulnerability Framework,* and the following sections summarise how we have implemented these analyses. We have carried out analyses to demonstrate our drought resilience, and these are described in detail in our Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request. This shows drought response surfaces for our Grid SWZ for droughts ending in August and November for simulations run at the deployable output level of demand for the 1 in 500 and 1 in 200-year resilience levels.

We have estimated the return period of events ending in August and November, as recommended for our system in the *UKWIR, 2017, Drought Vulnerability Framework*.

We have used the modelled reservoir stocks from each year of the stochastic simulations to calculate how often stocks fall below the trigger for level 4 restrictions.

We have calculated the return period of droughts of different durations based on analyses of the stochastic rainfall data. We have worked out the percentage of the long-term average for each stochastic period ending in August and November from 6 to 60 months duration.

We have used this to assign each stochastic modelled minimum reservoir stocks into the correct cell of the Drought Response Surface (DRS), based on percentage of long-term average rainfall and duration.

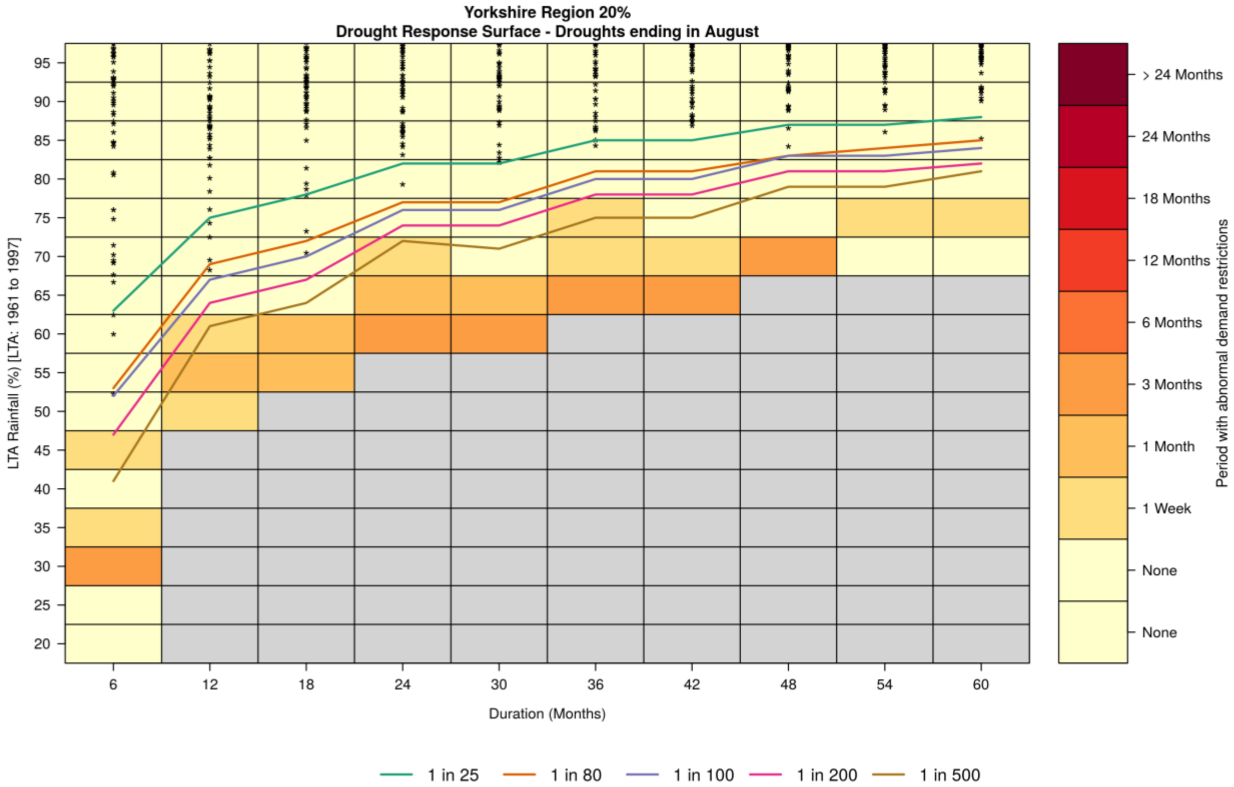
For each cell we have counted the number of failures and divided by the number of the stochastic years in each cell.

These analyses are markedly different from those we carried out for WRMP19, as we now have stochastic rainfall data. In line with the WRPG we are using these datasets for the Yorkshire region to inform our drought return periods instead of analysis of our now 120-year historic inflows record.

A drought response surface for our Grid SWZ for droughts ending in August at the 1 in 500-year level of resilience is shown in Figure 3.4. This shows that we could have level 4 restrictions for a week for 12-month long droughts with return periods of 1 in 200 years, and that the worst historic droughts in our 130-year rainfall record would not have level 4 restrictions. It should be noted that these analyses are based on the raw model results, so do not relate exactly to our estimation of deployable output using EVA techniques. The drought response surfaces are still useful to understand our system resilience to different severity and durations of drought, and how changes to our system would change this vulnerability. However, they do not give a vulnerability that directly maps to our deployable output. This is discussed further in our Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request.

Following the methodology of the Drought Vulnerability Framework, (UKWIR, 2017) we have not produced response surfaces for the East SWZ, as the screening indicated it was not required.

Figure 3.4: DRS for Grid SWZ for 1 in 500-year resilience level (August end month)



3.6.5 Links between our WRMP and Drought Plan

Table 6 in the WRP tables shows the contribution of drought measures for our deployable output at the 1 in 200 and 1 in 500 system response using stochastic data, and for the 1 in 500 system response using our historic inflows series.

The benefit of drought measures is relatively small, as it shows the contribution of these measures which are imposed over a small number of years, but this benefit in deployable output is spread over the period of record. For example, we assume that leakage reduction, voluntary calls for restraint and TUBs will save about 5% of demand, but because these measures are in place for only a short amount of time, they benefit deployable output by about 1%. We have only included levels 1, 2 and 3 (first and second year of drought) options in WRP table 6, and not our longer term drought options (known as "More before 4"), as we do not think it appropriate to include any benefits of longer term drought options. These long term drought options are also options in our WRMP, so are more appropriately considered in the optimisation process. Our level 2 options are TUBs and enhanced leakage detection, and our level 3 options are supply side drought permits and NEUBs. The drought options and levels are described in our Drought Plan 2022.

Some of our level 3 options may be classified as level 2 options, if implemented in the winter when there would be less environmental impact, but for our WRMP we have assumed they are higher impact level 3. In an operational drought, we may use these permits at a time of year when they have a lower impact. In addition, since the 2022 drought our option to increase the annual abstraction for a licence on the River Wharfe has been removed as a drought option as we have increased the allowable abstraction in the time-limited licence. We will ensure our Drought Plan 2026 aligns with this licence change and any changes in the understanding of the impact of our drought permits.

For our East SWZ, we have assumed the same proportion of savings are possible as in our Grid SWZ, to ensure consistency between how we model our water resource zones.

3.7 Biodiversity and ecosystems

All schemes featured in our WRMP24 were assessed against Strategic Environmental Assessment (SEA) criteria which included the objective 'to protect, conserve and enhance natural capital and the ecosystem services from natural capital that contribute to the economy' (for details of the SEA refer to Section 8.1).

Through consultation with regulators and key stakeholders such as regional Rivers and Wildlife Trusts, we are developing a corporate biodiversity strategy with the following four long term Aspirations for biodiversity:

- Aspiration 1: To achieve a net gain to biodiversity through our operations
- Aspiration 2: To improve the ecological resilience of our rivers and catchments
- Aspiration 3: To give a strong voice to nature in our decision making
- Aspiration 4: To help customers engage with their river and surrounding natural ecosystems

We realise that the most effective way to achieve outcome is to integrate biodiversity considerations across our projects and plans, rather than deliver them as stand-alone actions. As such, we have and will continue to revise our capital scheme framework requirements, repair and maintenance policies and land management practices to deliver this. To underpin Aspiration 3, Biodiversity is now a consideration within our corporate investment Decision Making Framework and is becoming more central to our corporate approach to valuation and planning through its inclusion within our developing natural capital models.

As examples of projects helping deliver against our wider aspirations for biodiversity, we are:

- Running biodiversity enhancement programme, facilitating volunteering, and access to our sites for our customers and colleagues;
- Undertaking conservation management of many of our Local Wildlife sites;
- Protecting endangered aquatic and riparian species such as Freshwater Pearl Mussel, White-Clawed Crayfish, greater water parsnip and tansy beetle
- Working with the Don, Aire and Calder catchment partners to deliver a catchment-scale river habitat resilience programme
- Outperforming SSSI Common Standards Monitoring condition targets and Special Area of Conservation (SAC) and Special Protection Area (SPA) conservation objectives on our land.

The delivery of these obligations is captured through our 'Land conserved and enhanced' and 'Length of river improved' performance commitments.

The Water Industry Strategic Environmental Requirements (WISER) (Environment Agency, 2017) document gave a clear expectation that water companies will develop measures to contribute to biodiversity priorities, and through extensive consultation, we are confident our AMP7 programme of biodiversity focused measures is delivering this.

3.7.1 Nature First

Our PR24 programme includes consideration of nature-based solutions and catchment programmes around many aspects of the water environment including upland restoration, engagement with the agricultural sector, and working with catchment partners to restore river catchments. These programmes have been developed in line with WINEP guidance and in collaboration with the Environment Agency.

We recognise the importance of nature-based solutions in delivering a resilient service for our customers, both mitigating and adapting to climate change while improving biodiversity.

Our new Nature First[16] commitment will ensure we use nature-based solutions as our preferred way to deliver our services, prioritising nature-based solutions in our decision-making. Through Nature First and other PR24 commitments, we will continue to explore where nature can be managed and restored to deliver regenerative and resilient solutions to the benefit of our water resources.

3.8 Environmental Destination

Our WRMP24 delivers the regulatory actions to ensure that our surface and groundwater abstractions continue not to cause environmental damage or deterioration. These are largely, but not exclusively in relation to the Water Framework Directive and Habitats Regulations. Our plan also considers the longer-term changes that we may need to make in the future beyond existing statutory requirements in support of our Environmental Destination. This section summarises how we are developing our long-term Environmental Destination and how we account for this in our adaptive plan.

3.8.1 What is Environmental Destination?

The National Framework for Water Resources sets out the size of the challenge of achieving long-term water resources and environmental resilience. As required through the regional planning framework, regional groups have begun to investigate these future environmental water needs and to identify the short, medium and long-term actions that may be required to achieve their 'Environmental Destination'.

The Environmental Destination driver requires water companies to look beyond their existing statutory requirements and develop a clearer picture of future environmental needs. To support this, the Environment Agency has developed national water resources scenarios[17] which illustrate the potential changes in abstraction that may be required to ensure the water environment is sufficiently protected in the long-term. The potential changes are based on a modelled prediction of alterations in the hydrological cycle linked to climate change, changes in water demand and, in the case of the national 'enhanced' scenario, more stringent environmental flow targets at ecologically valuable or sensitive sites. Using this information, the model estimates the reduction in abstraction required to ensure that the long-term needs of the water environment are maintained.

3.8.2 Accounting for Environmental Destination in our plan

Catchment Prioritisation

For each WFD management catchment, the national model estimates the total abstraction reductions required by all sectors to meet environmental needs by 2050, for two main scenarios:

- Business as Usual (BAU): the amount of water which needs to be recovered to continue to meet existing statutory requirements by 2050.
- Enhanced: The BAU scenario, plus additional reductions to meet more stringent flow targets in catchments considered to be more likely to deteriorate in condition due to climate change impacts. This includes European Protected Sites (SPAs and SACs), SSSIs, principal salmon and chalk rivers.

Through the regional planning process, we have reviewed the national model scenarios and validated the outputs with regional Environment Agency and Natural England representatives. Following an initial review of the scenarios, three WFD management catchments (River Derwent, Hull & East Riding, Aire & Calder) were prioritised for further review based on the potential long-term environmental risks (our approach to reviewing the national scenarios and prioritising investigations is described in more detail in WREN's draft regional plan). In each of these catchments, potential long-term abstraction pressures and associated water resources implications were identified and have been included in our Environmental Destination scenarios.

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[16] https://www.yorkshirewater.com/media/bctlh4xc/yky07_nature-first-commitment.pdf

[17] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/872759/National_Framework_for_water_resources_main_report.pdf

Ofwat Reference Scenarios

To promote consistency between each region's interpretation of the national Environmental Destination scenarios, Ofwat, working with the Regional Co-ordination Group and the Environment Agency, has developed a set of common references scenarios that the regional groups should consider, which should be mirrored in WRMPs (see Section 7.3). These reference scenarios are aligned with and adapted from the national scenarios.

We have taken BAU+ as the central scenario for environmental destination on which our adaptive plan is based. For each scenario we have calculated the available supply (as described in section 3.4) and calculated the difference between the BAU+ central scenario. In this way we ensure there is no double counting of deployable output losses linked to climate change. Through future water resources and regional plans, and informed by our programme of WINEP investigations, we will update our adaptive plan to ensure that we play our part in protecting and enhancing the water environment.

Table 3-7: Environmental Destination Reference Scenarios

Name	Ofwat CRS	Description
Baseline	Low	Based on current known legal requirements for abstraction reductions up to 2050 only. The scenario should represent the lowest plausible abstraction reductions that meet currently known legal requirements in force at that point in time, in alignment with low Ofwat common reference scenario.
Business as Usual (BAU)	-	National Environmental Destination BAU scenario used as starting point, locally validated to remove waterbodies with significant uncertainty whether reductions are required.
Business as Usual "Plus" (BAU+)	**Medium**	**Expands on BAU through the inclusion of Common Standards Monitoring Guidance (CSMG) flow targets for European protected areas. This should take account of any local flow target for European sites where one has been agreed (with the EA/NE). Where one has not been agreed the default would be to use the default CSMG flow target.**
Enhanced	High	High scenario aligned with the Water Resources National Framework (WRNF) Enhanced scenario.
Enhanced (locally agreed)	High	High scenario (as above) incorporating any local agreements with regulators (*noting that no local agreements have been made through Water Resources North and this scenario has not been considered*)

3.8.3 Water Industry National Environment Programme

The WINEP collates the actions that water companies are required to deliver as part of their environmental obligations. Water resources focussed WINEP drivers have an ongoing, cyclical role in determining the extent and pace of changes to abstraction and the resulting impact on WRMP supply forecasts. Yorkshire Water is in the process of delivering its AMP7 water resources WINEP investigations whilst concurrently developing its AMP8 programme, as summarised below. Both programmes will have a role in determining the pace and profile of any abstraction changes we make in support of our long-term Environmental Destination (summarised in Section 3.8.4).

AMP7 WINEP

Some of YW's AMP7 WINEP investigations have been completed, whilst others are ongoing. Through agreement with the Environment Agency, those which have been completed have not identified any changes to abstraction licences that would materially affect the supply forecast. For ongoing investigations which will not be completed prior to WRMP24, our adaptive plan makes allowance for the uncertainty in the outcomes of these AMP7 investigations.

Table 3-8 summarises the AMP7 programme and explains which licences have been included in our Environmental Destination Scenarios.

Table 3-8: AMP7 Water Resources WINEP Investigations

Name	Associated Licence(s)	Deadline	Scope	Scenario considered in: Baseline	BAU	BAU+	Enhanced	Justification
Hull Wellfield	02/26/32/126; 02/26/032/124; 2/26/31/006	March 2025	WFD No Deterioration Investigations linked to groundwater abstraction		✓	✓	✓	Investigation ongoing and outcome uncertain. Capping of licence to recent actual abstraction assumed pending outcome of investigation
Wolds Wellfield	2/26/30/002-004; 2/26/31/002; 2/26/31/087	March 2025	WFD No Deterioration Investigations linked to groundwater abstraction		✓	✓	✓	Investigation ongoing and outcome uncertain. Capping of licence to recent actual abstraction assumed pending outcome of investigation
Selby Wellfield	02/27/018/ 077-079-081; 02/27/018/120; 02/27/018/305	March 2025	WFD Groundwater Balance Investigations linked to abstraction		✓	✓	✓	Investigation ongoing and outcome uncertain. Capping of licence to recent actual abstraction assumed pending outcome of investigation
Doncaster Wellfield	03/28/83/10; 03/28/83/12; 03/28/83/100; 03/28/83/105	March 2025	WFD Groundwater Balance Investigations linked to abstraction		✓	✓	✓	Investigation ongoing and outcome uncertain. Capping of licence to recent actual abstraction assumed pending outcome of investigation
River Ouse	2/27/24/078	March 2025	WFD No Deterioration Investigations linked to fully licensed operation					Investigation ongoing into the sustainability of increased abstraction (within licence) to meet future supply needs. Not included in Environmental Destination scenarios but is considered elsewhere in adaptive plan (see Section 9).
West Beck	2/26/31/047	March 2024	Investigation to understand low flow Impacts linked to abstraction in riverine SSSI					The outcome from the investigation is unlikely to have a bearing on the WRMP supply-demand balance (the supply-forecast does not assume or account for any abstraction specifically from the intake under consideration).
Adaptive Management	Various	March 2025	Adaptive management programme of investigations at Yorkshire Water impounding reservoirs					Investigations are ongoing although outcomes unlikely to materially influence supply-demand forecast. Programme includes ongoing flow trial in the Worth Valley to increase environmental, operational and water resources resilience.
Colne Valley catchwater intakes	2/27/11/064	Complete	WFD Heavily modified waterbodies investigations to identified relevant mitigation measures to achieve Good Ecological Potential					Investigation concluded with no action required
Little Don	02/27/005/011	Complete	WFD Heavily modified waterbodies investigations to identified relevant mitigation measures to achieve Good Ecological Potential					Investigation concluded with recommendation for amended reservoir control rule (no change to upper and lower compensation flow volumes) therefore unlikely to have bearing on WRMP supply-demand balance.

Name	Associated Licence(s)	Deadline	Scope	Scenario considered in: Baseline	BAU	BAU+	Enhanced	Justification
Scout Dike	2/27/05/012	Complete	WFD Heavily modified waterbodies investigations to identified relevant mitigation measures to achieve Good Ecological Potential					Investigation concluded with recommendation for amended reservoir control rule (no change to upper and lower compensation flow volumes) therefore unlikely to have bearing on WRMP supply-demand balance.

AMP8 WINEP

Yorkshire Water is in the process of finalising the scope of its AMP8 WINEP, through agreement with the Environment Agency and other relevant stakeholders. Based on the latest position, our AMP8 programme is anticipated to include various water resources investigations.

Table 3-9 summarises the provisional AMP8 programme and explains which licences have been included in our Environmental Destination Scenarios.

Table 3-9: Planned AMP8 Water Resources WINEP Investigations

Name	Associated Licence(s)	Deadline	Scope	Scenario considered in: Baseline	BAU	BAU+	Enhanced	Justification
River Derwent	2/27/28/017; 2/27/28/083	December 2026	Article 6 assessment and feasibility study including modelling of meeting CSMG targets in the Lower Derwent.			✓	✓	Water resources modelling of meeting flow target would have significant impact on supply-demand balance (See section 3.8.4)
Regional Options Appraisals for Environmental Destination	n/a	December 2026	Regional options appraisal for Environmental Destination					No specific licences identified at present. Investigation may identify further licences for consideration and, where relevant, these would be reflected in YW's subsequent WRMP
How Stean Catchwaters	2/27/21/092	December 2026	Investigations into sustainability of the How Stean catchwaters abstraction licence and associated intakes.					Outcome of investigation is unlikely to materially influence supply-demand forecast. Any outcomes from investigation to be reflected in subsequent WRMP
Historic Act compliance	various	December 2026	Investigations to support formalisation of environmental conditions not currently contained within abstraction or impoundment licences					Outcome of investigation is unlikely to materially influence supply-demand forecast. Any outcomes from investigation to be reflected in subsequent WRMP
Reservoir adaptive management	various	March 2030	Adaptive management programme for long term environmental resilience in heavily modified waterbodies					Any outcomes from investigation to be reflected in subsequent WRMP, though will not be available until investigation has progressed in AMP8.

3.8.4 Yorkshire Water WRMP Environmental Destination Scenarios

The Environmental Destination scenarios are explained below and summarised in Table 3-10. This section describes the timing and extent of the impacts on deployable output through the planning period in relation to both the short and long-term components of our Environmental Destination. To avoid double counting the impacts of the Environmental Destination with other Ofwat common reference scenarios, a central climate change scenario was applied when calculating the deployable output impacts associated with the abstraction changes described below.

Short-term licence changes to meet Water Framework Directive Objectives

Potential licence changes have been identified through the WINEP at four of YW's groundwater sources (Doncaster, Hull, Wolds and Selby). Selected licences at each of these groundwater sources are subject to ongoing AMP7 WINEP investigations which will conclude in 2025.

As there are no confirmed legal requirements for abstraction reductions at these sources, no changes are assumed under the baseline scenario. Under the BAU scenario, we have assumed a total 6Ml/d reduction in deployable output (dry year annual average) across these sources, effective from 2035, based on licence capping to recent actual usage with peak use (within existing licensed volumes) permitted for short term operational use only. Under the BAU+ scenario used as the 'most likely' in our supply-demand balance, the reduction in deployable output from these sources (also effective from 2035) would increase to 11Ml/d. This is due to the additional impact of climate change on natural flows and water available for abstraction. Under the Enhanced scenario, a more significant climate change impact is assumed, resulting in a loss of 17Ml/d in deployable output.

No short-term licence changes to surface water licences have been identified through our AMP7 WINEP.

Long-term licence changes to meet Environmental Destination

Our review of the national Environmental Destination Scenarios through the regional planning process identified a potentially large reduction in abstraction for public water supply from the lower Yorkshire River Derwent in the Enhanced scenario. This is linked to environmental flow targets relating to the Lower Derwent SAC and SSSI complex (CSMG targets) and the EA's Water Resources National Framework modelled abstraction scenarios. The licences under consideration will be investigated in depth as part of an AMP8 Habitats Regulations WINEP scheme and the outputs reflected in future iterations of our WRMP including WRMP annual reviews. We are working collaboratively with the Environment Agency and Natural England to develop the scope of this complex investigation, which will require consideration of the infrastructure owned and operated by the Environment Agency that enables our river abstractions from the Lower Derwent.

As the Water Resources National Framework modelling is high level and any reductions will be dependent on the outcome of further detailed assessments, we have assumed zero long-term reductions in the Baseline and BAU scenarios respectively.

As the BAU+ scenario includes CSMG targets and in lieu of an agreement of alternative targets with regulators, we have assumed compliance with default CSMG targets for this scenario, although this is subject to further detailed assessment. In our draft plan, we stated that these reductions would be effective from 2050; however, following feedback from regulators we have brought forward the assumed to date to 2040.

In our draft plan we assumed a constant reduction in deployable output due to the implementation of the CSMG targets. To improve our understanding of the long-term supply risks, for our final plan, we have modelled the impact on deployable output for the base 1990s and 2070s climate change cases, and interpolated between as we have for the baseline scenario. This avoids any double counting of the impacts of climate change on the loss of deployable output. The relative loss due to the implementation of the CSMG targets therefore reduces post 2040 as climate change simultaneously reduces deployable output (that is, through impacting on the availability of water in river flows).

Under this scenario we have assumed a 104Ml/d loss in deployable output in 2040, reducing to a 90Ml/d loss in 2070 (dry year annual average) linked to CSMG targets for the River Derwent and our abstraction at York WTW. The losses quoted are for the 1 in 500-year drought scenario, but are similar for the 1 in 200.

Under the Enhanced scenario for the River Derwent, the reduction in deployable output under BAU+ would increase to 163Ml/d which is caused by additional losses at Yorkshire Water's River Derwent intake coupled with impacts of climate change on natural river flows. Combined with the groundwater licence reductions, this results in a total 180Ml/d reduction in deployable output from 2040.

Table 3-10: WRMP Environmental Destination Scenarios

Scenario	Licence Type	Deployable Output Reduction (Ml/d)	Total Deployable Output reduction (Ml/d)	Year licence change effective from
Baseline	n/a	0	0	-
BAU	Groundwater	5.9	5.9	2035
BAU+	Groundwater River	11.3 103.5*	114.8	2035 2040
Enhanced	Groundwater River	16.7 163.7	180.4	2035 2040

* Reducing to 90 Ml/d by 2070 due to impact of climate change

3.8.5 Developing our regional Environmental Destination

We will maintain an evidence-led approach within an adaptive planning framework to ensure that the long-term destination is achieved. Examples of where we will continue to support these ambitions include:

- Building on the success of the return of Atlantic Salmon to the River Don by continuing to work in partnership across various catchments to support the removal of barriers to migration and improve spawning habitats through river restoration and the appropriate timing / volume of reservoir releases.
- Supporting Defra's Chalk Stream Restoration Strategy to protect and enhance the UK's most northerly chalk stream habitats, including the development of a flagship restoration plan for the upper river Hull catchment.
- Further improvements in water quality, quantity and biodiversity through water company catchment management schemes, both business as usual and through PR24 activities.
- Continuing to grow our support for our region's Rivers Trusts and CaBA to deliver meaningful improvements in river water quality and to remove obstructions, to provide the greatest ecological benefit to our region's rivers.
- Continuing to explore alternative approaches to reservoir compensation flow management that could increase ecological, water resources and flood resilience in the region in the long-term.

Our anticipated short, medium and long-term activities in support of Environmental Destination are summarised in Table 3-11 below.

Table 3-11: Short, Medium and Long-Term Timeline of Activities

Short Term (0 – 5 years)	Medium Term (5 – 15 years)	Long Term (15 years +)
• Complete AMP7 WINEP investigations to improve understanding of individual and cumulative impact of abstraction licences and relevance to regional plan. • Prioritise further investigation for AMP8 in line with EA WINEP guidelines. • Continued engagement with stakeholders to understand long-term aspirations and trade-offs. • Explore alignment of regional planning activities with other initiatives (for example, chalk stream restoration strategy and lowland peatland taskforce), where appropriate.	• Undertake AMP8 investigations and reflect outcomes in future plans. • Improve understanding of future use from other sectors and incorporate into future plans. • Continue to review plans within adaptive planning framework, iterating the approach to environmental destination as required. • Reflect outcomes of AMP7 investigations in company water resources plans / regional plan • Undertake further investigation, where identified as being required following finalisation of first regional plan.	• Continue to review plans within adaptive planning framework, iterating the approach to environmental destination as required. • Continue to implement co-created WINEPs

3.9 Invasive non-native species (INNS)

We recognise that our abstraction operations present a pathway by which Invasive Non-Native Species (INNS) may spread. To help mitigate the risk of spread, we have been working closely with the Environment Agency, Defra, the GB Non-Native Species Secretariat and other water companies to implement our proportional actions from the GB Invasive Non-Native Species Strategy.

In summary, we have been working to understand the risk INNS pose to our operations through an extensive risk assessment and pathway analysis exercise across our reservoirs and water treatment works. We have been improving biosecurity through the provisioning of staff biosecurity training and equipment, investigation and installation of permanent biosecurity facilities and funding of a biosecurity project officer in conjunction with other regional stakeholders such as University of Leeds and the Environment Agency. We are also one of nine water companies supporting and funding the Defra's 'Check, Clean, Dry' biosecurity campaign, aimed at reducing the risk of INNS reaching our reservoirs and rivers on water-users' equipment.

We recognise through the Environment Agency's position statement on raw water transfers, that new schemes creating a new hydrological link will require mitigation to prevent spread of all life stages of INNS. This is currently an infeasible task given the diversity of mitigation required to deal with microscopic organisms through to plant fragments and fish. This is recognised in the Environment Agency's PR24 guidance issued to water companies, and as such, we have and will continue to research effective mitigation during the AMP8 period and onwards to enable us to meet this requirement in future.

The position statement notes that mitigation will be required on existing transfers on a gradual basis, informed by further into efficacy and applicability of mitigation technology. Options to further research and trial this mitigation on a risk prioritised basis have been included within our PR24 submission for delivery in the AMP8 and AMP9 periods.

3.10 Climate change

3.10.1 Introduction

This section of gives an overview of the development stages that we have used to assess the potential impacts of climate change on our deployable output. It shows how we have carried out basic vulnerability analyses of our sources to climate change, and how we have modelled the impacts of climate change on our deployable output using the stochastic data series.

The WRPG states that a company's plan should consider the impact of climate change on baseline supply at resource zone level. The guidance includes several methods for incorporating climate change and hydrological uncertainty in supply forecasts. The guideline is largely based on *Climate change approaches in water resources planning- overview of new methods* (Environment Agency, 2013), and the more recent 2017 guidelines and supplements. In addition, we use evidence and methods from the *Water resources planning guideline supplementary guideline-Climate change (Environment Agency, 2021), Lowe et al. (2018), UKCP18 Science Overview Report Version 2.0*, and *Environment Agency/Natural Resources Wales (2020) Review Report for estimating the impacts of climate change on water supply.*

The Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request, fully describes the approach we have taken to climate change modelling. We have adopted the risk-based approach recommended in the guidelines, by first assessing the vulnerability of our water resources zones to climate change, and then developing models according to the results of this risk-based analysis. We shared our proposed methodology and initial results with Ofwat and the Environment Agency.

We have chosen our approach by working with the other water companies in Water Resources North (WReN), to ensure consistency of approach across the region. We have used the same stochastically generated datasets, perturbed by the same climate change projections, and have used model results from both Yorkshire Water and Northumbrian Water to inform the choice of which stochastic samples to use to reduce the number of model runs required.

For WRMP24, we have modelled deployable output using our water resource simulation models, with inflows generated from stochastic climate series provided by Atkins (2020). Atkins also provided climate change factors for the rainfall and PET series for our modelled catchments, for the UKCP18 Regional Climate Model RCP8.5 (a high emissions scenario) for the 2070s, and for a sample of 100 representing the probabilistic RCP8.5 projections, and a smaller sample of 20 scenarios representing the probabilistic RCP8.5 projections. We have applied the Regional RCP8.5 factors to the stochastic climate data and used these perturbed series in our GR6J models to generate inflows representative of the 2070s. We have run our water resources simulation model using these perturbed inflows and calculated the deployable output of the system in the 2070s in the same way we did for the baseline deployable output. We have scaled our deployable output to represent the UKCP18 probabilistic RCP6 (medium emissions scenario) and interpolated deployable output in the years between the 1990s and 2070s using the scaling equations developed by Atkins (Atkins, 2021). The use of these scaling equations mean that our base year deployable output is scaled to represent the effects of climate change, and the effects of climate change on deployable output are reported relative to the deployable output of 1990.

For the East SWZ we have also carried out tier 1 analysis as described in the WRPG, but to ensure consistency of approach between our zones, we have reported results using the methods described above.

3.10.2 Basic vulnerability assessment

The basic vulnerability assessment determines whether a resource zone is classed as high, medium, or low vulnerability with respect to climate change, based on the WRMP19 climate change impacts. The Grid SWZ mid scenario had a loss of deployable output of 7%, and a range (difference between the wet and dry scenarios) of 19% during the WRMP19 planning period, making it a high vulnerability zone.

Table 3-12 shows the thresholds used for defining high, medium, and low vulnerability zones, and the East SWZ and Grid SWZ are plotted on it in their respective positions.

The East SWZ has a low vulnerability to climate change, so we only need to carry out tier 1 analysis as described in the *Water Resources Planning Guideline supplementary guidance-Climate change* (Environment Agency, 2021). However, because we have stochastically generated inflows, we have used the same methods as for our Grid SWZ for consistency of approach.

Conversely, the Grid SWZ has a high vulnerability to climate change, so we have used tier 3 analysis, using the UKCP18 regional models, to align with the work carried out by other water companies in WReN.

Table 3-12: Vulnerability scoring matrix showing Yorkshire Water zones

		Mid Scenario (% loss in deployable output)		
		< 5%	> 5%	> 10%
Uncertainty range (% change wet to dry)	<5%	**East SWZ**		
	6 to 10%			
	11 to 15%			
	>15%		**Grid SWZ**	

3.10.3 How we have used UKCP18 projections for water resources modelling

We have produced climate change perturbed data sets by factoring the stochastic rainfall and PET data by climate change factors for each climate change model. We have used the UKCP18 Regional projections as they provide spatially coherent projections which make them suitable for regional planning. The regional projections are only available for RCP8.5, so we have scaled them to represent RCP6 probabilistic projections using the scaling equations developed by Atkins, 2021.

In our draft WRMP, to reduce the number of water resources simulation model runs required to calculate the deployable output, we used a sample of 56 of the 400 stochastic realisations for the climate change modelling. These were selected to represent the whole range of the modelled system response for both Yorkshire Water and Northumbrian Water (HR Wallingford, 2022b). We selected one model that represents the median scenario for the base case and for the climate change perturbed results, and these are used to calculate values to be used in the WRP tables. For our final WRMP we have used the entire stochastic realisations to model climate change using our PyWR model. The supplementary technical report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request, shows the range of climate change deployable output results for the stochastic time series.

Figure 3.5 shows the monthly rainfall factors for our chosen climate change (model RCM09). In this projection, for most catchments there is a minimum factor in July, with rainfall generally lower than current from May to October, and higher in the winter months. The factors for the PET are shown in Figure 3.6. The PET factors are greater than 1 in all months, with the largest increases in the winter.

Figure 3.5: Monthly Rainfall factors for RCM09 RCP8.5 scenario: 2070s

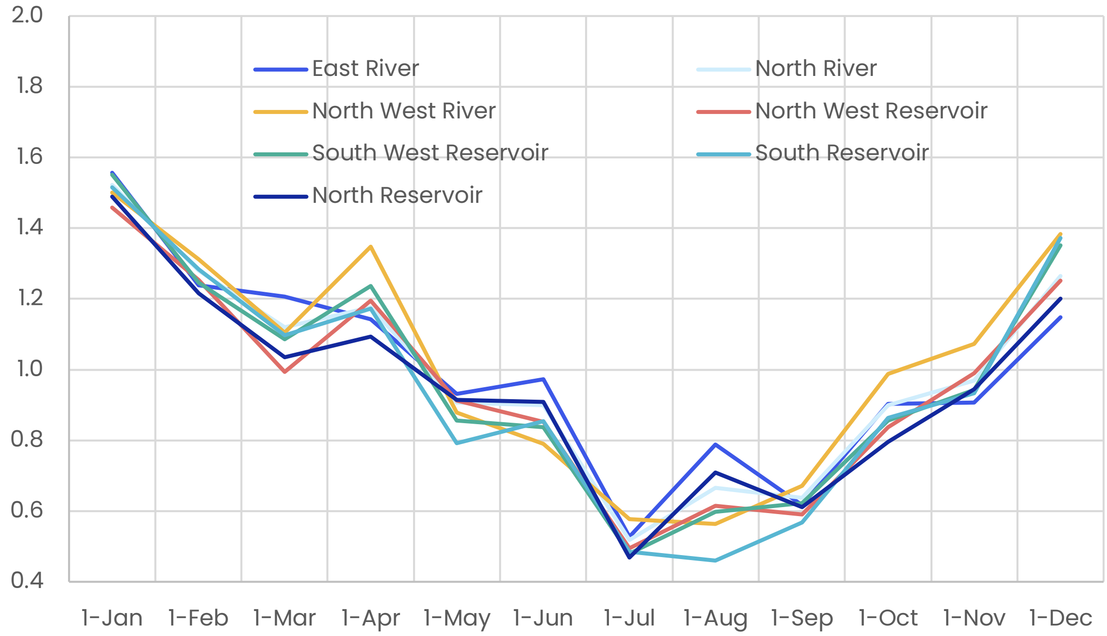
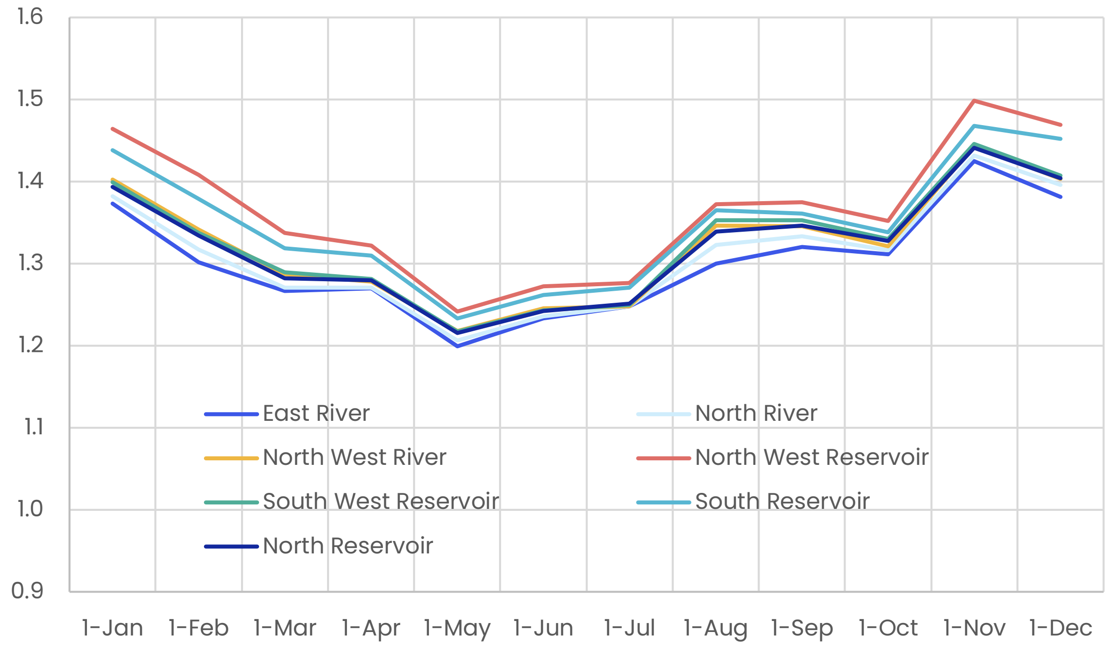


Figure 3.6: Monthly PET factors for RCM09 RCP8.5 scenario:2070s



These climate factors have been applied to the stochastic rainfall and PET to generate climate change perturbed inflows representative of the 2070s for our water resource simulation model. This has been done for all 12 RCMs for our stochastic datasets. The selection of the climate change samples used in our draft WRMP is described in more detail in our supplementary report on Deployable Output and Climate Change, and in full in HR Wallingford (2022b).

We have further investigated the impacts of using stochastic time series for our final WRMP24, and we have been able to extend our analyses using the entire range of stochastic data. We have also considered the impacts of the 2022 drought on our final plan assessment, and this is described more fully in our technical report on deployable output and climate change, and in our new appendix on lessons learned from the 2022 drought.

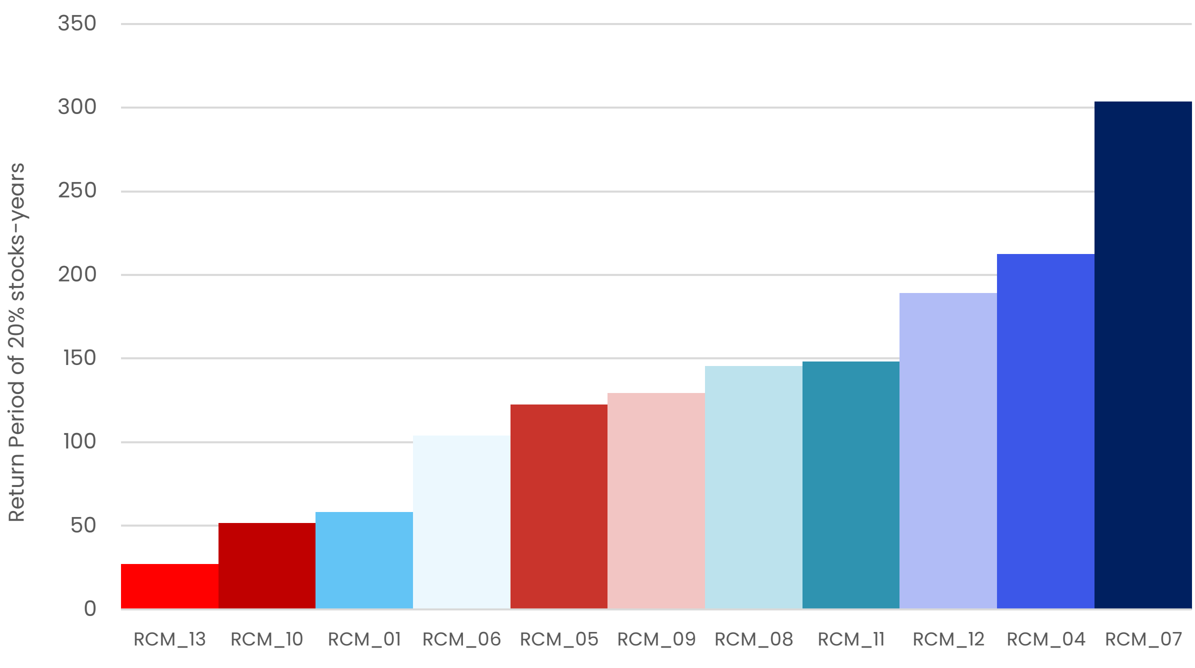
3.10.4 Interpolation of deployable output

The water resource simulation model is used to calculate deployable output for the baseline period (1990s) using the stochastic data series, and for the 2070s using the climate factored stochastic series. To calculate the deployable output for all years of the planning period, we have interpolated between the 1990s using the equations developed by Atkins (Atkins, 2021). We have used "Equation 4", which interpolates between the 1990 estimate of deployable output and the 2070 estimate for the regional projections for RCP8.5 and assumed the effect of climate change on deployable output is proportional to the projected change in temperature. We have also scaled these results to reflect the impacts of the Probabilistic RCP6 projections (a medium emissions scenario), rather than the regional RCP8.5 (a high emissions scenario).

3.10.5 Climate change model results

We first ran all climate change stochastic replicates for all 12 of the RCMs. Figure 3.7 shows the modelled return period for emergency drought restrictions for all RCMs modelled at a regional demand of 1164Ml/d in the 2070s. From this, we selected RCM09 as the median, RCM13 as the dry and RCM07 as the wet climate change scenarios and carried out further model runs to identify the deployable output for both the 1 in 500 and 1 in 200 resilience return periods.

Figure 3.7: Return Period of level 4 restrictions at 1164Ml/d regional demand for all RCMs



We calculated the deployable output for the climate change scenarios to determine the deployable output of the region in 2070. We used climate change perturbed inflow files in the model and ran the model at varying demands until the minimum modelled reservoir stocks had a 1 in 500 frequency of occurrence. We again selected a median variant for sensitivity analyses and options testing.

Figure 3.8 shows the relationship between regional demand and minimum modelled reservoir stocks for the 1 in 500 and 1 in 200-year system responses for both our original draft WRMP WRAPsim runs and for our final WRMP PyWR runs. The dots on the graph show the results of the median of all 56 variants sampled for the climate change analyses. The lines show the results of the single median variate.

We split regional deployable output between the two resource zones in the same way as for the current deployable output.

Figure 3.8 shows the sampled and median stochastic variate results modelled using WRAPsim are similar to the results obtained using the full stochastics series modelled using PyWR.

Finally, we estimated deployable output for each year between 1990 and 2100 using the methods described above.

Figure 3.8: Modelled minimum reservoir stocks versus system demand for RCM09:2070s

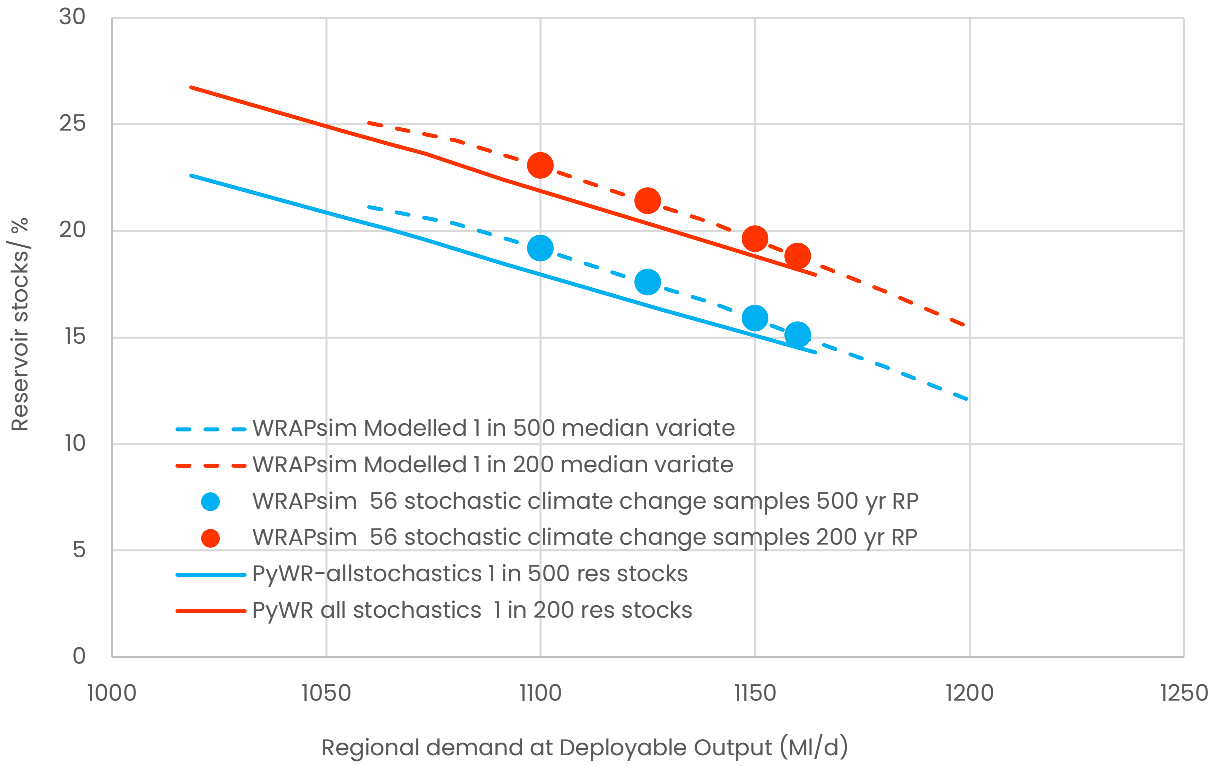


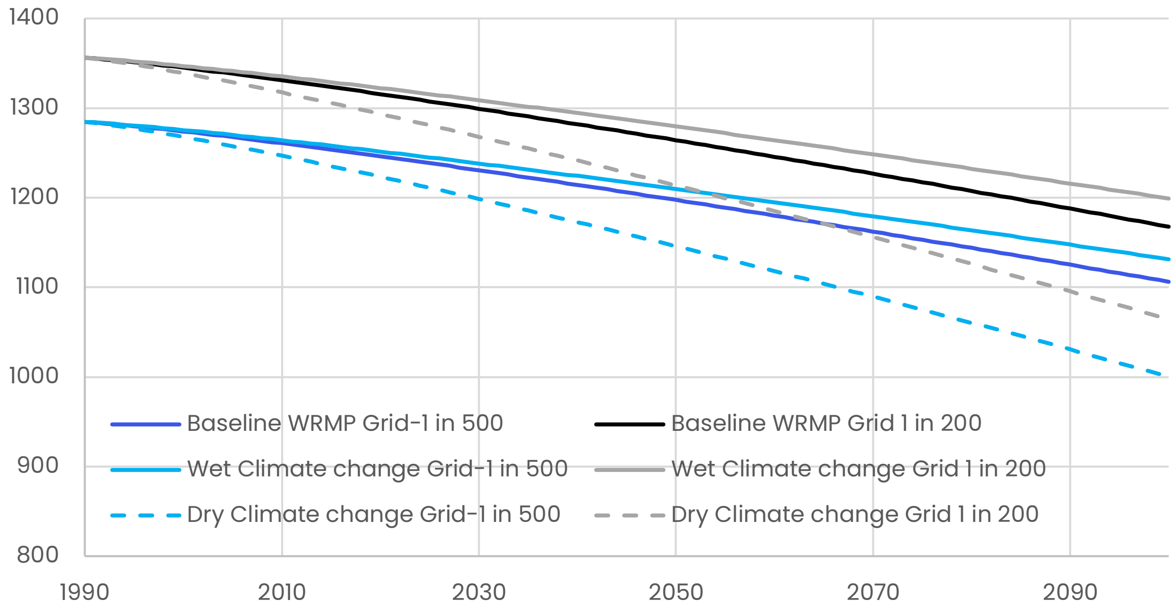
Table 3-13 shows the calculated deployable output in 2070 for the Grid SWZ, and the deployable output in 2070 factored to represent the impacts of the UKCP18 RCP6.0 probabilistic projections.

Table 3-13: Grid SWZ deployable output for RCM09

		Deployable output: Ml/d	
	baseline	RCP8.5 Regional Projections	Scaled to RCP6 probabilistic Projections
year	1990	2070	2070
1 in 500	1284.48	1035.14	1162.16
1 in 200	1356.14	1092.57	1226.84

The results shown and analyses described are for the current system configuration. Uncertainty is inherent with any modelling. A range of deployable output predictions are therefore given based on the 12 RCMs. Figure 3.9 shows the deployable output for the Grid SWZ, and how it changes over time due to climate change for the median RCM (RCM09), and the wet and the dry RCMs (RCM07 and RCM13).

Figure 3.9: Grid SWZ deployable output extrapolation



For our final WRMP, we have also used the sampled probabilistic climate change models developed by Atkins to compare to our regional models. We have modelled the 20 sampled models, and the median of these produces a deployable output (when scaled from probabilistic RCM8.5 in the 2070s to probabilistic RCM6), within 5Ml/d of our median of the regional projections. Our additional climate change modelling is described more fully in our supplementary technical report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request.

3.10.6 Climate change in the East SWZ

Our East SWZ has a far lower vulnerability to climate change than our Grid SWZ. Due to the lower risk posed by climate change for this zone, the guidelines recommend carrying out tier 1 analyses, but for consistency with the Grid SWZ, and because we have new GR6J rainfall runoff models, we have modelled the East SWZ using our climate perturbed stochastic inflows. We have modelled the River Esk flows (East SWZ) under climate change using a simple spreadsheet tool which allows the input of a threshold and shows whether river flows are above or below this threshold.

There are no hands-off flow requirements for the River Esk. However, if some of the more extreme climate change predictions do occur, it is possible that maximising our abstraction would result in a dry river with serious ecological and security of supply consequences. This situation would not be acceptable, so if this is forecast to occur, we would calculate a reduced deployable output for a given climate change scenario.

We have calculated the 1 in 500 and 1 in 200 return period for minimum river flows and used this to estimate deployable output. For this river dominated system, we have calculated deployable output as the demand that can be sustained for 30 days with river flow at the 1 in 500 (or 1 in 200) minimum flows. This is assuming a hands-off flow of 9Ml/d left in the river at all times, and springs can supply 1Ml/d, before the small reservoir is emptied.

For the baseline stochastics, all 19,200 stochastic years have a flow that could support the WTW capacity of 14Ml/d. For the climate change perturbed series, the deployable output has been calculated for each RCM and scaled in the same way as for the Grid SWZ. The median climate change deployable output for the East SWZ is from a different RCM than for the Grid SWZ. However, we have used the median in each case, and the East SWZ deployable output would still be far larger than forecast demand if the same RCM as for the Grid SWZ were used.

Table 3-14: East SWZ deployable outputs for UKCP18 climate change projections in 2070

Regional Climate Change RCP8.5 Scenario	2070s DO for RCM8.5		2070s DO scaled to probabilistic RCP6	
	DO 1 in 200 years	DO 1 in 500 years	DO 1 in 200 years	DO 1 in 500 years
RCM13	10.30	8.50	12.19	11.31
RCM08	11.60	9.30	12.82	11.70
RCM06	12.00	9.60	13.02	11.84
RCM10	12.10	9.80	13.07	11.94
RCM09	12.20	9.70	13.12	11.89
RCM01 median	**13.50**	**10.75**	**13.76**	**12.41**
RCM04 median	**13.50**	**10.75**	**13.76**	**12.41**
RCM07	13.60	10.80	13.80	12.43
RCM15	14.00	11.70	14.00	12.87
RCM11	14.00	11.60	14.00	12.82
RCM05	14.00	11.70	14.00	12.87
RCM12	14.00	12.20	14.00	13.12

3.10.7 Climate change conclusions

We have calculated the loss of deployable output due to climate change for the Grid SWZ and the East SWZ throughout the planning period (compared with the 1990s) for the median climate change projection. The calculated deployable output is limited by our stated levels of service.

A summary of deployable outputs for both resource zones, and how the deployable output changes over time, can be found in the supplementary technical report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request.

We have changed how we calculate deployable output and how we model the impacts of climate change since WRMP19. We now use climate factors and model flows using GR6J rainfall runoff models instead of using flow factors. And we now use stochastically generated rainfall and PET to calculate simulation model inflows instead of a historical inflows series.

We do have concerns about how well the stochastic data series represent our inflows, and we describe some of the analyses we have carried out in our report on Deployable Output and Climate Change. We will carry out further analyses, and explore the relationships between rainfall, flow, and modelled system response in order to improve our estimates of deployable output, both for the base year and for a climate impacted future.

The supplementary technical report on Deployable Output and Climate Change details how we have modelled the effects of climate change on groundwater sources, and the sensitivity analysis that has been carried out, to investigate the effects of different UKCP18 RCMs. The relative effect of climate change on groundwater and surface water sources is also discussed.

We are confident that the use of the 12 RCMs offers an acceptable and feasible method of using the UKCP18 scenarios to model the effects of climate on deployable output. We are aware of the high degree of uncertainty associated with the climate change forecasts, and the nature and consequences of these forecasts, and will model a sample of the probabilistic projections for our final WRMP24. Uncertainty due to climate change is also accounted for within target headroom.

During the AMP7 period we have continued our investigations into the use of catchment models, and the use of the UKCP18 projections for water resources planning. This has resulted in our development of GR6J rainfall runoff models which has enabled us to carry out water resources modelling using the stochastic time series required for this WRMP.

Implications of climate change on groundwater will be considered as part of ongoing work in the future. We will continue to carry out groundwater modelling to assess the potential impact of climate change on yield.

3.11 Supply Modelling Conclusions

This section explains how we have modelled our available supply using stochastic time series and our new PyWR model. We have discussed the uncertainties relating to the use of stochastic time series calibrated against the 1950-1997 time period, and that is because this period includes the 1995-1996 drought, which is extreme even in our 130-year rainfall record. This could mean that the stochastic time series we have used are unrealistically dry. We have considered adjusting our results so that the stochastic estimates of deployable output are scaled to the historic analyses, but we believe that this would negate the whole reason we have used stochastics. We have used stochastic data as they can represent conditions that could have occurred, but that we have not seen in our relatively short record. The stochastic time series give us 400 possible versions of the 1950-1997 period.

Despite the uncertainties, and our concerns about the apparent bias of the stochastics due to the extreme 1995-1996 drought, we believe our approach offers the most robust estimate of deployable output at the 1 in 200 year and 1 in 500 year drought system response levels. Our adaptive approach to filling the supply demand deficit will mean that even if future modelling increases our estimates of deployable output, our WRMP can adjust to take the most appropriate pathway.

The use of the PyWR model has changed our estimates of deployable output a little.
The main reasons for this are:

- The PyWR modelling enables us to use all of the stochastic time series (19,200 years) rather than just a sample of them.
- The PyWR model allows us to start the simulation for each of the 400 replicates from the same initial conditions instead of from the ending stocks of the previous replicates, as in WRAPsim (and the draft WRMP) the sequences were stitched together in blocks of 8 x 48 years.
- In PyWR, we were able to run all 400 of the climate change replicates, not just the sample of 56.

In modelling the 1 in 500 and 1 in 200-year drought system responses using 19,200 years of stochastic data, we have, by definition, tested our system to droughts far worse than the 1 in 500-year event. We have considered a wide range of drought events included in the stochastic time series, including the impacts of events that are more severe than 1 in 500 years, as stated in the guidance.

3.12 Scenarios to test our resilience

As part of our resilience tested plan, we have run a number of scenarios looking at the effect of various potential changes in supply on our deployable output. These scenarios are described below.

3.12.1 Failure of River Derwent weirs

We are reliant on two weir structures to support our abstractions from the River Derwent. These are owned by the EA and the Yorkshire Wildlife Trust and are in a poor state of repair. At WRMP19, the EA asked to consider failure of these structures. The consequence of catastrophic failure of these structures is that our ability to abstract at low river flows would be compromised. We have carried out a risk review in relation to the failure of the weirs, and should short term mitigation be required, we would install temporary pumps below the level of the intake structure to allow abstraction. A site mitigation plan has been developed to this effect.

The EA have confirmed the intention to maintain their section of the weir for the short to medium term such that existing abstractions can continue. The future requirements for Environmental Destination on the River Derwent will consider the long-term future for both these weirs. We discuss the requirements for Environmental Destination in Section 3.8.

3.12.2 Climate change scenarios

Climate change represents one of our largest risks to deployable output and is also one of our largest areas of uncertainty. We have modelled deployable output for the 12 RCM climate change scenarios using our WRAPsim model and used the median one of these for our baseline forecast in our supply-demand balance.

We have used the range of these scenarios to account for uncertainty due to climate change, and we have used scaling factors from the Atkins report (Atkins, 2021) to scale climate change impacts through time and to represent other climate change scenarios.

We have represented the Ofwat scenarios by scaling from the RCM models, and have used stochastic data series perturbed by a sample of the probabilistic projections to ensure the scaling between scenarios is appropriate.

3.13 Water Transfers

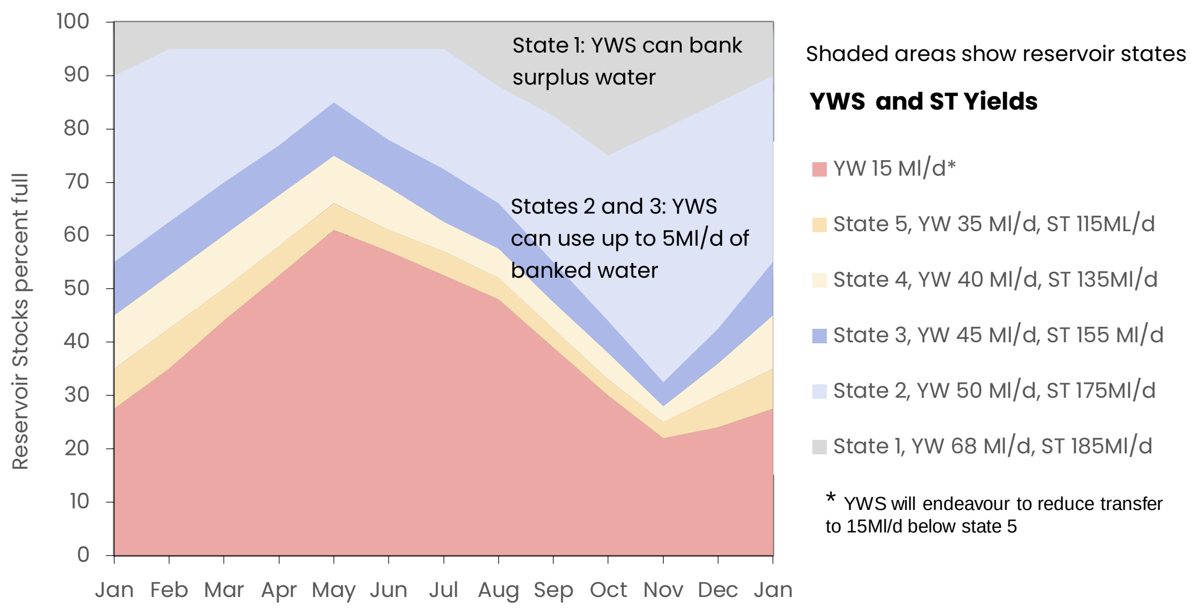
3.13.1 Raw water transfers

We have an agreement with Severn Trent Water to abstract up to 21,550Ml per year from the Derwent Valley reservoirs in Derbyshire. This water is used to supply our customers in a part of South Yorkshire. The agreement allows for either party to cease the transfer in 2035 provided noticed is provided no later than 2030.

The amount that can be taken by both Yorkshire Water and Severn Trent Water is set in operating guidelines based on the principle that we are entitled to 24.1 per cent of the available water (245Ml/d). In the event of serious drought in Severn Trent Water's region, we can assist them by taking a reduced supply. The minimum supply rate set in the guidelines between Severn Trent Water and Yorkshire Water is 35Ml/d. The agreement allows either party to alter the amount taken with agreement of the other party. Variations such as this have occurred frequently over the years, including 1995-1996, 2003, 2018 and 2020.

In operating the Severn Trent bulk supply, we use five control lines, taking different amounts from the reservoirs depending on the time of year and the reservoir stocks. This is illustrated in Figure 3.10 below. Severn Trent Water operates using several control lines, and the amount it takes depends on where reservoir stocks lie in relation to these lines. These lines show the maximum that will be taken by either Severn Trent Water or Yorkshire Water at any time, including in a drought situation. We have agreed with Severn Trent Water that we will endeavour to reduce our minimum transfer to 15Ml/d in the lowest band (below State 5). However, in this event, we would not impose demand restrictions on our customers, even if they were in force in Severn Trent Water's supply area, if the rest of our region was not subject to drought measures.

Figure 3.10: Derwent Valley Operating Rules



When we are in a drought situation, we will consult with Severn Trent Water on short term bulk transfers. The availability of a transfer from Severn Trent Water would be dependent on its own water situation. If Severn Trent Water is also in a drought situation, the yield is unlikely to be available. However, we would always discuss the possibility of increasing the import with Severn Trent Water. In 2020, Yorkshire Water and Severn Trent Water agreed operating rules around the use of additional abstractions for both companies, depending on reservoir states and demands. In 2022, Severn Trent Water were granted a drought permit for their licence on the Derwent Valley reservoirs. This drought permit imposed conditions which limited the Yorkshire Water allowed abstraction to an average of 32Ml/d until stocks recovered to above the Derwent Valley drought state 0. Drought permit conditions such as this, as well as operational or resource impacts, may mean that our assumed import is not always available. For our critical period modelling we have assumed a lower import than in our DYAA scenario due to this experience, to ensure we are not overestimating available supplies from Severn Trent Water in a dry period.

Modelling the Derwent Valley Import

In our water resource simulation modelling, the STW import has an average of 53.81Ml/d in 1990 and 22.80Ml/d in 2070 due to the impact of climate change (which has a significant impact on the demand that can be met in the Grid SWZ, and so reduces the required import due to the reduced demands). We have consulted with STW, and their modelling gives an export from their system of 56.74 Ml/d throughout the planning period. Our modelled import is smaller than that modelled by Severn Trent Water, so provides us with confidence that our smaller value will be available. Any uncertainty will be accounted for in our headroom component.

The STW values differ to the Yorkshire Water value for a number of reasons:

- Yorkshire Water used stochastic data for the Water Resources North area, whereas Severn Trent used the time series produced for Water Resources West
- We each have different levels of service and we each model our supply region, but do not model other company's regions.

We have worked with STW to improve the way we model the transfer between our systems, but modelling differences in different models are inevitable. Our scenario modelling has shown our estimates are robust to this modelling uncertainty.

Yorkshire Water and STW were jointly developing a strategic resource option (SRO) that would increase the reservoir capacity in the Derwent Valley. However, following concerns by regulators and stakeholders on the impacts of the reservoir expansion scheme, STW has now confirmed that it will not progress any further with this option. In an update to its dWRMP, STW has also confirmed that cessation of the existing transfer will be included in its preferred plan for WRMP24 (see Section 8.2 for further information), although Yorkshire Water are proceeding with the SRO to backfill the loss of the STW import.

3.13.2 Non-potable supplies

Non-potable supplies are raw water supplies that we provide to third parties in addition to transfer agreements held with other water companies. We provide some non-potable supplies to farm properties, but these volumes are minor and have not been included in the WRP tables.

We have a non-potable supply agreement that is held with the Canal and Rivers Trust and is within our Grid SWZ. Under the agreement we export raw water to the Huddersfield Canal at a maximum of 1272.88 mega litres per annum (Ml/a), which is on average 3.5 Ml/d but can be up to 9Ml/d. In the Grid SWZ WRP tables we have included the average 3.5Ml/d volume as the DYAA non-potable water supplies. In the Grid SWZ critical period table we have included the maximum 9Ml/d. The agreement held between Yorkshire Water and the Canal and Rivers Trust permits the volumes to be reduced as a result of exceptional shortage of rainfall by agreement or arbitration. The full allowance is included in the tables, however, the potential for short-term, event specific variations is not represented in the supply-demand balance calculation. In times of water stress, as part of our drought planning activity, we would consult the Canal and Rivers Trust and agree a reduction if required.

We do not have any treated (potable) bulk supply imports to our area. We have one small potable water bulk export from the Grid SWZ to Anglian Water Services. In line with previous plans, we have assumed the export is 0.31Ml/d throughout the planning period.

3.13.3 New appointments and variations supplies

As a wholesaler we export treated water to inset appointees. Inset appointees (often referred to as new appointments and variations, or NAVs) are companies which provide a water and / or sewerage service to customers in an area previously supplied by the incumbent water company (Yorkshire Water is an example of an incumbent). At the time of writing this plan there are four inset appointed water suppliers in our area. Two of these serve household and non-household customers with water services and the other two serve household customers only.

We currently provide services to NAVs in two areas of the business: Developer Services and Wholesale Market Services. We provide a point of connection or point of discharge for bulk supplies through our Developer Services department. Once a bulk supply has been established the enduring service to NAVs is provided through our Wholesale Market Services department. The enduring service, which we expect to significantly grow year on year, includes management of the bulk supply, a dedicated account manager, reporting, billing and collection services for water and wastewater, and provision of value added services, e.g., emergency services.

The volume supplied in total in 2022/23 was 0.77 Ml/d. As the demand forecast was produced in 2019/20 there was no material inset appointee use and the forecast assumed all new properties would be Yorkshire Water customers. However, following receipt of draft information from NAV WRMPs we have updated our export volumes to align with the forecasted NAV import volumes listed in that data set. It is worth noting, however, that the forecasted volumes prior to the current year have not been realised so we accept that there is a level of uncertainty accompanying the information the NAVs have provided. By using the higher forecasted numbers, as opposed to the outturn forecast, we reduce the risk of under forecasting this export volume, in alignment with the latest guidance from the Environment Agency.

A top-down process has been used to align our WRMP with the NAV WRMPs, this ensures no double counting of volumes, properties, and population. However, it is worth noting we have not discounted the NAV leakage from our final plan leakage profile. Our leakage programme and targets are set independent of growth and so we will not be adjusting our leakage targets due to the growth of properties in the NAV supplied properties. For context, a summary of the export volume and population/ properties served by NAVs is given below in Table 3-15.

Table 3-15: Summary of impact of NAVs on the WRMP24

Component	19/20	24/25	29/30	39/40	49/50
Export Volume (Ml/d)	5.78	6.54	6.77	6.77	6.77
Household Properties (000's)	1.01	13.27	18.06	18.06	18.06
Non-Household Properties (000's)	0.03	0.03	0.03	0.03	0.03
Population (000's)	2.42	32.69	44.29	44.29	44.29

We plan to engage much more closely with NAVs to ensure alignment of assumptions and data. This will occur through direct communication with NAVs and through the regional water group (WReN). We will also consult with NAVs on water efficiency messaging and services, and we will also contribute towards an industry group targeting how water companies can work more effectively with NAVs during droughts. The Wholesale Market Services team will also be liaising with non-household retailers on water efficiency and droughts and therefore this will be a centre of excellence we aim to use to showcase best practice.

3.14 Drinking water quality

The WRMP takes account of all statutory obligations for drinking water quality. Protection of raw and treated water quality is fundamental to water resources resilience and to the maintenance of our current and future deployable output.

In terms of the quality of drinking water supplies, we abide by Section 68(1) of the Water Industry Act 1991 and apply this governance to both our own sources and existing and potential transfers, in compliance within Regulation 15 of the Water Supply (Water Quality) Regulations 2016. We take a consistent approach to drinking water quality across both water resource zones.

In preparation of our WRMP24 we have followed guidance on drinking water quality provided by both the Drinking Water Inspectorate (DWI) and the Environment Agency. In September 2021, the DWI published a *Guidance Note on Resilience of Water Supplies in Water Resources* Planning (DWI, 2021). This did not set out any specific new requirements for how water quality is considered in water resources planning; instead, it brought together existing guidance to assist with water resources planning and to complement the requirements of existing obligations and legislation and this was followed by further guidance on their expectations for PR24 on DWI's website. The Environment Agency set out their expectations as to how water quality should be considered, in the WRPG. The WRPG also refers to the DWI's guidance note.

Our WRMP24 does not assume operating in ways which could compromise drinking water quality to meet future demand for water. Where we experience or predict non-compliance with drinking water quality standards, due to the impact of raw water deterioration, we take action in a range of ways to mitigate this.

In general, where raw water deterioration drives the risk of failure in drinking water quality in the short term (next 5 to 7 years, approximately) we will provide enhanced treatment processes, supported by catchment management activity to ensure the sustainability of the solution. Where drinking water failure under the Water Supply (Water Quality) Regulations 2016 (as amended) appears likely in the medium term (5 – 15 years), we will promote catchment management as our first priority activity to secure raw water quality, supported by minor treatment enhancements where required. Where raw water deterioration poses long-term risk to drinking water quality, we will promote catchment management activity to prevent this impacting on drinking water quality.

In planning this activity, we have regard to the use of Drinking Water Protected Areas and Water Safeguard Zones as enablers for this activity. Catchment schemes are developed with the Environment Agency through WINEP methodologies and drinking water treatment improvement schemes are developed with the Drinking Water Inspectorate through their Undertakings and Notices processes. There are a range of uncertainties associated with water quality management through catchment schemes; some, such as product substitution give clear cause and effect, whereas others, such as peatland restoration may deliver benefits over a much longer timescale.

For over 15 years we have undertaken remedial and protective activity within our catchments with the aim of reducing the risk of water quality deterioration, particularly mitigating an increasing trend in colour from upland catchments.

We are also aware that we must keep up to date with new and emerging risks. This includes the so called 'forever chemicals' as part of the PFAS[18] group and other micropollutants. We are continuing to follow the latest DWI guidance (Information Letters 02/23) and monitoring our catchments for potential risk . At this stage, evidence does not indicate widespread risk of PFAS compounds in supply to our customers. However, a limited number of detections been reported in raw waters. At one site interventions have been implemented to prevent contaminated land run-off enter an en-route storage reservoir. Oversight on a regional basis will continue and could lead to investment needs in future.

Our long-term strategic objective is to meet the standards required by the Drinking Water Directive, together with our national requirements, and we have plans and processes in place to achieve this goal over time.

In recent years, the risk of the presence of the molluscicide metaldehyde has been considered significant. Changes in legislation regarding its use are expected to have removed this risk, and data is indicating that this has been effective in our water systems. Another key risk is production of disinfection by-products (DBPs, for example, trihalomethanes) caused by the increase in dissolved organic carbon (DOC) in many of our raw waters. The chlorination of residual DOC after treatment results in the formation of DBPs, which we have an obligation to minimise (Regulation 26). We also continue to monitor long term trends indicating increasing levels of nitrate in some groundwater catchments.

[18] https://www.dwi.gov.uk/pfas-and-forever-chemicals/

Our plan is to take a twin-track approach to protecting drinking water quality and deployable output. We are continuing to propose significant catchment activity through the WINEP in AMP8 and beyond, with the goal of halting the decline in raw water quality and consequent risks to treated water quality. However, evidence gained over the past 10 years has shown that, in some catchments, land management will not provide a sufficiently rapid improvement in water quality. In these cases, catchment management will be complemented by water treatment solutions. This may involve additional treatment stages, such as MIEX (magnetic ion exchange), or upgrading and expanding existing treatment assets.

Further detail of our approach to resilient catchment management is provided in section 3.6.2.

In summary, our three primary risks to drinking water quality are colour from the peat uplands, pesticides from lowland rivers, and nitrate, especially in groundwater. These require a range of solutions to mitigate the risk to drinking water supply.

3.14.1 Colour from peat uplands

Increasing raw water colour is a risk in upland catchments due to deterioration of peatlands. The major cause of this degradation is how the vegetation on top of the peat has been historically managed. Overgrazing, artificial drainage (known as grips), atmospheric pollution and the burning of heather for grouse moor management all lower the water table and damage the structure of the underlying peat.

A long-term programme is ongoing to restore the hydrology of peatland catchments in Yorkshire. We work with stakeholders to re-vegetate bare peat and to identify mutually beneficial land management practices and policies which will deliver a sustainable ecosystem across Yorkshire's upland catchments. This will reduce the colour in raw water from these catchments, preventing water quality deterioration and loss of deployable output.

3.14.2 Pesticides in lowland rivers

Our approach to pesticide reduction is the development of partnerships to promote best practice in pesticide use and alternative approaches to pest management, reducing the reliance on chemical control. In partnership with Natural England, we employ catchment officers to promote catchment sensitive farming in high-risk sub catchments to protect both drinking water quality and deployable output.

3.14.3 Nitrate and groundwater

Under the WFD, water sources are protected, and mechanisms are in place to identify Drinking Water Protected Areas for catchments where there is a risk of deterioration, mainly through human activity. Where action is required, Safeguard Zones, sub-catchment areas can then be defined in collaboration with the Environment Agency, allowing the causes of deterioration to be addressed by working with landowners and interested parties under a Safeguard Zone Action Plan (SgZ-AP).

The Environment Agency has defined Source Protection Zones for groundwater sources used for public drinking water supply. These zones show the risk of contamination from activities that may cause pollution of the groundwater. The Environment Agency uses these zones to set up pollution prevention measures in areas at higher risk, and to monitor the activities of potential polluters nearby. We are working with the Environment Agency to agree if and what safeguard zones may be required where these are not currently in place (for example, at spring sources which are historically classed as surface water features)

Nitrate is a risk to our groundwater sources, as these are in the lowland areas of Yorkshire where arable farming predominates, and fertiliser use is widespread. In the past few years, we have investigated the risk to our catchments from nitrate application. This will now allow us to work with farmers in high-risk areas to better manage the catchment and reduce water quality and outage risks.

3.15 Outage

Outage is one of three types of planning allowances included in our supply-demand balance calculations. Outage is a planning allowance used to represent temporary reductions in water available for use (WAFU) due to planned or unplanned events. We also reduce our WAFU to allow for process losses, which occur during the process of abstracting and treating water before putting into supply. Process losses are discussed in Section 3.16. The third planning allowance is target headroom, which is described in Section 6. We add a headroom allowance to demand to account for the uncertainty in the supply and demand projections.

Outage allowances are calculated at resource zone level. We have assessed outage for the dry year annual average scenario for both the Grid and East SWZs and for the Grid SWZ critical period scenario. The Grid SWZ outage assessment includes unplanned events, planned events, reservoir safety events and licence margins. The East SWZ outage assessment includes unplanned and planned events only. As the East SWZ is a small zone relying on one river abstraction with support from a spring source, there are no impounding reservoirs to include in the assessment. Licence margins are only relevant to one river abstraction, which is in the Grid SWZ.

We calculate outage using the methodology: *Outage Allowances for Water Resource Planning* (UKWIR, 1995). The UKWIR method assumes past performance is a good indicator of future performance and we use information on previous outage events to produce outage planning allowance.

We have updated our outage assessments since we produced our draft WRMP24. At the draft stage our outage was based on two years of data. We have now added data for the report year 2022/23 and are basing our assessment on three years data. The additional year of data gives us more confidence in the results. The outage approach is the same as that used for our WRMP19 however, we have a new database for recording unplanned and planned outages. This database was introduced for reporting our PR19 outage performance commitment to Ofwat.

Outage events are recorded on the outage database by YW operational teams who input the volume that each of our water treatment works can produce each day. Each works has a target output and if this cannot be met it is an outage event. The works output is recorded daily, regardless of whether or not there is an outage event. This gives us a more reliable and consistent dataset than the previous database, which only recorded events as they occurred and was often limited to larger impacting events, creating a risk that some smaller events would be missed.

3.15.1 Unplanned outage

Unplanned outages are unforeseen events which occur with sufficient regularity that the probability and severity of the outage event can be predicted from previous events. The UKWIR methodology defines the following categories as unplanned outages: pollution of source, turbidity, nitrates, algae, power, and system failure. The methodology prescribes a probabilistic approach to assessing unplanned outage, which considers the duration and magnitude of previous outage events.

We have based WRMP24 unplanned outage on data recorded in our new outage database for the report years 2020/21 to 2022/23. In the draft plan, we used data for 2019/20 and 2020/21. We are no longer using data from the year 2019/20. This was the first year we used the new database, and the data was recorded in a different format to subsequent years. We have incorporated data for the most recent report year (2022/23), providing three years in total.

For our final plan we have created a process for converting the data from the outage performance commitment database, to the format we need to input into our unplanned outage model. This reduces the risk of errors in data transfer. The approach divides unplanned outage into system and water quality events. The 2019/20 data has been excluded as it was not compatible with the approach and did not distinguish between system and water quality events.

It is not possible to combine the events recorded in the previous outage database (known as KAM – Key Asset Management) with the events recorded in the new database as the two approaches do not provide the same data. The KAM database relied on operational staff recording events by exception and events could be attributed to types of outages, such as system failure or pollution. It was not always clear if this had impacted on the output of a works or if there was sufficient flexibility in the system on the day of the event to avoid an outage. The new approach requires operational teams to record the output of each water treatment works (WTW) daily, which means there is a clear record of outages at each works.

For previous WRMPs we modified the UKWIR approach to include frequency of events to make an allowance for the risk of the event reoccurring. This was appropriate when using the KAM database as some of the recorded events were unlikely to reoccur annually, but it was not always possible to separate these from more regular occurring events. The new database records all events and provides a consistent data set where any more extreme, infrequent events can be separated and excluded, which is more aligned with the UKWIR methodology.

The outage database provides a record of the duration and magnitude of unplanned outages by WTW. For each works we derive a minimum, medium and maximum distribution for outage duration and magnitude based on the historic events. The distributions are created for each month of the year, which allows seasonal variation to be assessed and the critical period outage to be based on the summer months.

Our data shows raw water quality challenges at our Hull WTW has historically led to significant outages in the East of our Grid SWZ. The outages at the Hull WTW can be partially offset by other WTWs in the east area of our Grid SWZ and our outage model groups the site with our East WTW. We are currently implementing a capital scheme at the WTW that will improve treatment processes and reduce outage at Hull WTW from 2025 onwards and improve outages in the 'East' group.

Once the capital scheme is complete, we would expect outages in the East area of the Grid SWZ to be significantly lower than currently experienced but cannot assume no outages. We have therefore reduced the magnitude of water quality outages in the East to 12% of the magnitude experienced historically. Our Asset Planning team has advised that in the absence of any data, outages of 5% should be assumed at any site. Historic values of system failure outages account for around 73% of 5% of throughput in the East and going forward we are assuming water quality will account for 27% of the outages, which is 12% of historic water quality outages.

There are no schemes planned in AMP8 that will impact on the unplanned outage assumptions. As part of our PR24 Business Plan there are two water quality schemes that will improve resilience in the Grid SWZ and reduce the risk of outages at North Yorkshire 1 WTW and South Yorkshire WTW 2. Historically outage events at these sites have reduced our peak week production capacity and have not led to a WRMP outage.

The North Yorkshire 1 WTW is exposed to high levels of supply interruption risk following unplanned outages and alternate supplies to this area are limited. We plan to mitigate this risk through refurbishing the borehole that feeds the works. There is also a scheme to provide an alternative supply to our South Yorkshire WTW 2. The schemes do not increase water available for use in our Grid SWZ and we have not adjusted the outage forecast. The North Yorkshire 1 scheme does provide potential for an alternative supply to a local area of our system, and this has been added as an option to our revised WRMP24.

Outage probabilistic model

For unplanned events, the distribution data is entered into a probabilistic software model (Crystal Ball) that combines the duration and magnitude of events to provide monthly unplanned outage allowances for each water resource zone. The results are provided across a range of certainty levels between zero and 100%. The outage allowance increases with increasing levels of certainty.

In previous iterations of our plan and in our draft WRMP24 submissions we planned to the median or 50th percentile level of certainty in our Grid SWZ. We selected the median percentile as the zone has high connectivity and, in most years, we have sufficient flexibility in our conjunctive use system to reduce the impact of outages. Historically reported unplanned outage was lower than the 50th percentile value.

For our final WRMP24 as part of our outage reassessment we have updated our calculations to take account of the conjunctive use system. We derive the outage values by WTWs from the database. We then group the sites and recalculate outage for the groups. This means if one WTW in a group does not meet its target, but another site can provide additional water, the outage is either fully or partially offset. In addition to the group connectively, the Grid SWZ has a number of centrally located WTWs in the York and Leeds area that provide additional supplies to the surrounding areas, either directly or indirectly through displacement. This has also been accounted for in the outage calculation.

This new approach is consistent with how we calculate and report outage in annual reviews of our WRMP19. As the connectivity is already accounted for the outage model results in lower total outage values. We are therefore planning to a higher level of uncertainty in our final WRMP24 to ensure we represent the risk relative to the conjunctive use outages and we have selected an 85th percentile risk to represent the Grid SWZ DYAA, which is within the UKWIR risk based planning suggested range for outage.

In the past we have based the DYAA unplanned outage allowance on the average for April to September as this represents the drier months of the year. We have reviewed this for WRMP24 and selected the annual average 85th percentile to represent the unplanned outage in the Grid SWZ. We are basing the DYAA unplanned outage on the average of all 12 months to align with other supply-demand components that are annual average values.

For the Grid SWZ critical period we are assuming a 75th percentile outage allowance for the modelled data. We assume a lower level of risk as during critical periods we will redeploy field teams to ensure any outages in areas that have potential to reduce throughput are prioritised where possible. It is not feasible for outages to be avoided altogether but we will aim to escalate repairs such as filter or pump replacements.

The Grid SWZ critical period scenario is based on the unplanned outage value for July as our critical period supply is based on data for this month. Critical period outage has been calculated using deployable output values for each WTW that are representative of the critical period deployable output, which for some sites is different to the DYAA outputs.

The East SWZ unplanned outage was reported in the draft WRP tables as zero. The zone only has one WTW and historically there are very few outages. The outage reassessment for the final plan has resulted in a 0.02Ml/d unplanned outage allowance. This is based on the annual average scenario and an 85th percentile risk.

3.15.2 Reservoir safety outage

Statutory requirements of reservoir maintenance require reservoirs to be periodically drawn down (that is, the water level lowered) for inspection and repairs. Around 45% of supply to the Grid SWZ is from reservoirs in our region and outage in this zone includes an allowance for loss of yield due to reservoir safety schemes. The East SWZ assessment does not require an outage allowance for reservoir safety as this zone contains no impounding reservoirs.

In the draft WRMP24 we included an outage allowance for reservoir safety schemes based on the average of reported values over five years from 2017/18 to 2021/22. At this time, we did not have enough information to estimate reservoir safety outage based on expected drawdowns in AMP8. For our final plan we have more information and the drawdown programme for AMP8 is expected to be a similar scale to AMP7. We have therefore based reservoir safety planned allowance on the average of the outage we reported in AMP7. At the time of writing this report this was for the years 2020/21 to 2022/23.

For the Grid SWZ DYAA we have used the average of the annual values and for the critical period we have based on the average value for the summer months. We extract data on reservoir drawdowns each year from our KAM database and assess if the drawdown would create a loss of supply in a dry year, when there is less rainfall to refill our reservoirs following drawdowns.

In previous plans we have used the probabilistic model to assign an outage allowance for reservoir safety. We have decided not to use the probabilistic model for WRMP24 as it will be more representative to base on the AMP8 scheduled drawdowns once available.

3.15.3 Planned outage

We assess outage due to planned events for both water resource zones. Planned outages result from a requirement to maintain the serviceability of assets. Maintenance of assets, such as water treatment works, river water abstraction works and raw water transmission mains, has the potential to lead to a temporary reduction in deployable output. These events need to be carried out relatively frequently however, we schedule most maintenance for periods when demand is low and alternative sources can be made available. In addition, we may need to reduce the output of a WTW to carry our capital schemes to make major repairs or refurbish assets.

Planned maintenance can be delayed if the water is needed for supply but, if demand increases once the work has started, there is a risk supply is reduced when we need it. Capital schemes are harder to delay but we plan delivery to avoid outages as much as possible. For example, capital schemes included in our Drinking Water Quality programme could temporarily reduce the output of water treatment works while the work is being implemented. However, a proactive approach to how the work is phased, and storage managed will be taken to minimise the actual outage.

We have included a planned allowance for general maintenance schemes, such as replacing pumps at river intakes or rapid gravity filters at water treatment works. In most instances the schemes will be delivered when there will be no or minimum impact on the supply-demand balance. However, it is not possible to avoid planned outage completely.

The WRMP is based on dry weather scenarios. As water availability and the timing of a dry period are unknown, it is not possible to provide an accurate estimate of planned outage. For the Grid SWZ we have based our planned outage allowances for maintenance events on past events and the average of the three years data available from our performance commitment outage database. Planned events recorded in our East SWZ result in an average planned outage of 0.003Mld. In our draft plan this value was zero.

This is a change to our previous WRMPs where historic planned events have been entered into our probabilistic model as were reservoir safety events. The new outage database categorises planned and unplanned events in accordance with the Ofwat approach for the PR19 outage performance commitment and we have aligned the WRMP24 outage assessment with this approach.

Following the outage performance commitment, some outage events previously classed as planned are now classed as unplanned. These are events where we have taken an asset out of service temporarily however, rather than it being planned maintenance, it has been in reaction to an unplanned event that has impacted on the asset's performance. This reclassification has reduced the number of planned events recorded and the probabilistic approach is no longer considered appropriate.

We have not included any planned outage as a result of capital schemes to be delivered in AMP8. There are no schemes planned on our capital programme for our PR24 business plan that would lead to significant outages, therefore we have not added any additional allowance above the historic planned outage average.

A capital scheme is planned in our PR24 Business Plan to enable maintenance of a WTW in West Yorkshire. The works is critical to our supply system and so cannot be taken out of service for refurbishment. A new WTW is being proposed to allow this critical refurbishment to take place and provide resilience in the system. The second treatment facility is not WAFU-impacting due to resource constraints."

3.15.4 Licence margins

The Grid SWZ includes an outage allowance due to licence margins. Licence margins represent the difference between volumes theoretically available under the abstraction licence conditions and volumes that are operationally available. A licence margin outage is applied to one river abstraction in the Grid SWZ where a reservoir release is used to support the downstream abstraction at times of low flow.

When river flows increase above the critical level there is a time lag between the recovery and stopping the release, and some water is lost due to over support from the reservoir. The licence margin allowed for at this site is 1Ml/d and is the same as that reported in previous WRMPs.

3.15.5 Total outage

The total outage for each resource zone is the sum of the outage components described above. We calculate unplanned outage over a range of percentiles for each month of the year. The other outage components are calculated as an annual volume. Table 3-16 shows the outage results for the DYAA scenario for the two water resource zones and the critical period scenario for the Grid SWZ. We assume outage will remain constant throughout the planning period.

Table 3-16: Resource zone outage

Water Resource Zone	Planned outage Ml/d	Unplanned outage Ml/d	Reservoir safety outage Ml/d	Licence margins outage Ml/d	Total outage Ml/d
East SWZ DYAA	0.02	0.003	n/a	n/a	**0.02**
Grid SWZ DYAA	3.74	32.76	6.38	1.00	**43.88**
Grid SWZ critical period	3.74	23.82	11.00	1.00	**39.56**

The Grid SWZ outage is the total of unplanned outage, planned outage, reservoir safety outage and licence margins. The total DYAA outage is 43.88Ml/d and has reduced compared to the WRMP19 value of 52.40Ml/d. The critical period value is 39.56Ml/d, slightly lower than the DYAA. We did not create a critical period scenario in WRMP19.

Figure 3.11 and Figure 3.12 show the percentage each outage category contributes to total outage value for the Grid SWZ DYAA and critical period scenarios respectively.

Figure 3.11: Grid SWZ DYAA outage percentages by category

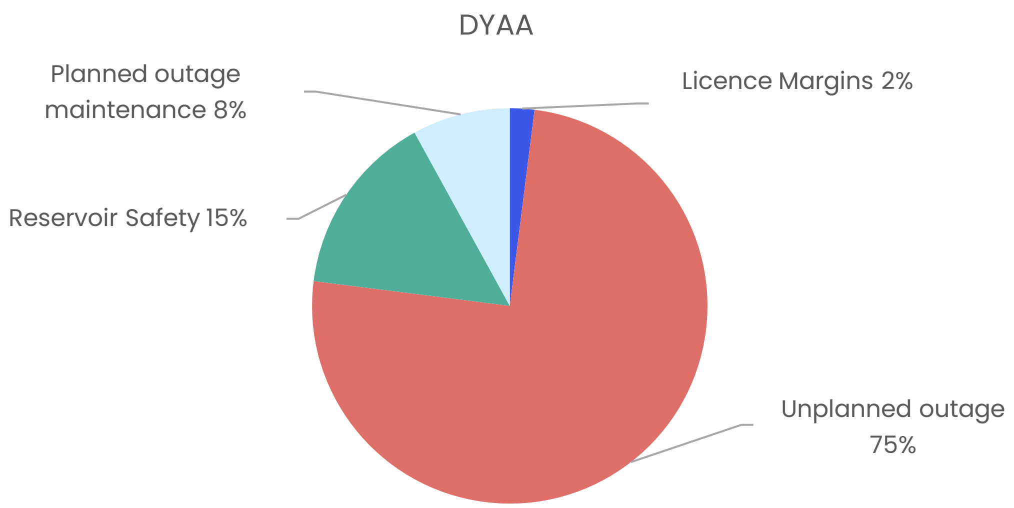
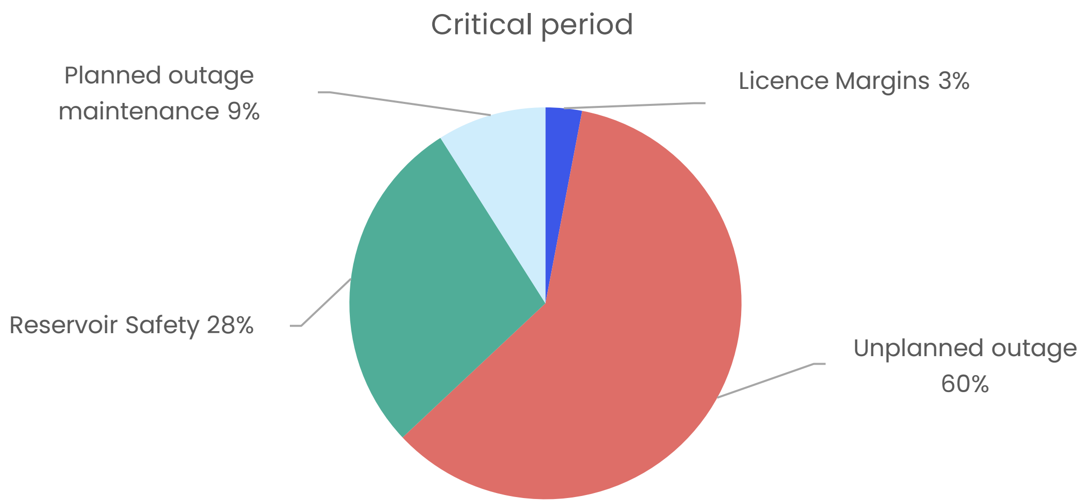


Figure 3.12: Grid SWZ critical period unplanned outage percentages by type of event



Unplanned outage makes up the largest proportion of the Grid SWZ allowance. The outage is recorded for each WTW and can be a result of source pollution, turbidity, power failure, system failure or a combination of issues. In many instances the failure may be recorded as system failure but can be a consequence of water quality. The events are not always avoidable as the majority are the result of naturally occurring events or pollution events.

The critical period scenario shows higher reservoir safety outage, as the impacts of drawdowns are higher in the summer months when rivers are low, and we are more reliant on our reservoir supplies. However, total outage is lower in the critical period scenario as we are planning to a 75th percentile risk for unplanned outage, whereas in the DYAA we plan to an 85th percentile risk.

To reduce the impact of outage events we can blend the water with high quality water or improve the treatment processes. However, outages still occur where we need to stop or reduce the use of a source until the quality improves. Our Grid SWZ connectivity means that we can provide alternative resource to the areas experiencing outages through utilisation of our central WTWs. In most years we report an outage volume (about 30Ml/d) that is lower than our WRMP outage allowance. We have considered if this would justify reducing our outage allowance, but this would create a risk in any year where outage was higher than recent trends.

During dry years, water quality can be lower than average, which can have an impact on the performance of some of our WTWs. There is also a risk that one or more of the key WTWs that provide the alternative supplies is impacted by a severe outage. We therefore, consider it prudent to include an outage allowance for our Grid SWZ that recognises this risk and does not overly rely on the conjunctive use of the system. We have therefore not reduced the outage allowance based on reported data.

The recorded unplanned outage in the East SWZ is 0.02Ml/d. In previous WRMPs we have reported outage in this zone (0.13Ml/d in WRMP19) as a result of turbidity. Turbidity has been a problem at the spring source and the river intake has in the past experienced outages due to turbidity, water quality and pollution issues. Water from the spring source is stored at the water treatment works and can be used for supply until outage events recover. As the works output of 14Ml/d is significantly higher than the demand (7Ml/d) even when the works cannot meet its design output there is no impact on WAFU.

In the draft plan we presented an outage of allowance of 0.65Ml/d. This is 5% of the WAFU volume for this zone and based on the draft WRMP24 Grid SWZ DYAA outage as a percentage of the zone's WAFU. Our updates to the data since draft have provided an actual outage value for the East SWZ and we have reported this in the WRP tables.

3.15.6 Prolonged outage reduction

The outage allowance represents temporary reductions in deployable output that are retrievable and deployable output should only be reduced for a short time. The period of time for recovery is variable and, depending on the cause, may recover naturally (for example, seasonal water quality variations) or require maintenance (for example, water treatment filters blocking) or refurbishment (for example, installation of additional treatment processes).

Unplanned outages are assessed regularly, and we would always aim to rectify the problem within three months. In some instances, unplanned outages may last longer than three months, depending on the nature of the repair and when it occurs. Outage repairs require scheduling, and we may at times delay until a suitable time such as during a low demand period, as the output may need to be further reduced while the repair takes place and cannot be carried out during high demands. In exceptional circumstances the loss of deployable output may not be retrievable in the short term or even at all, and deployable output / WAFU could be reduced to reflect the loss either for a prolonged period or permanently.

Planned outages can also lead to a site being out of service for a prolonged period. Most maintenance work can be carried out within three months. However, if a major refurbishment is required the output of a site could be reduced for some time. Refurbishments of treatment works, abstraction sites and raw and treated networks are planned every five years as part of our business plan and, as they are known events, we can assess the time for repairs. Reservoir safety work is also planned as part of our five yearly business plans and can lead to 'draw downs' in water levels that last longer than three months.

The WRP tables include a line for change in deployable output from prolonged outage reduction. At draft stage there are no planned events identified that would lead to a prolonged outage and this line is zero throughout the planning period for both zones. This position has not changed following the updates undertaken for our final plan. We cannot plan for prolonged unplanned outages and no allowance for unplanned outages is included in the WRP tables.

As part of our annual review of the WRMP we assess the outages recorded each year and if a prolonged outage occurred, we would review the deployable output and assess the impact on our security of supply. As our Grid SWZ has an integrated network it is often possible to displace an outage through alternative supplies and a prolonged event may not impact on deployable output. However, the loss could reduce our resilience to future outages and extreme dry weather, therefore we would still consider the wider risks in our longer-term planning.

3.16 Process losses

The supply-demand balance includes allowances for raw water losses, treatment works losses and operational use which are collectively referred to as process losses. These losses occur during the process of abstracting and treating water before it is put into our network for supply to customers.

Raw water operational use includes cleaning raw water mains. Cleaning occurs every two to three years on our largest raw water transmission systems, where sedimentation results in a loss of supply capacity. Other raw water mains are cleaned on an ad-hoc basis. Raw water losses occur when water is transferred from the point of abstraction to the treatment works, similar to leakage losses in our clean water network.

Treated water losses and operational use occur during the process of treating water at our WTWs before it is put into supply. Water is lost during the process of cleaning filters (often referred to as wash water or back wash) and sludge disposal (a by-product of water treatment). The percentage of water lost at WTWs varies considerably from site to site.

We also experience raw water losses during valve testing at reservoirs in the Grid SWZ. Raw water is released from reservoirs twice a year during valve testing, a legal requirement for reservoir safety. In WRMP19 we included losses during reservoir valve testing in our process loss allowance and based it on the average volume released per a year during April to September. We have reviewed these losses and have now included valve testing losses for the final WRMP24, having omitted these at draft WRMP24. The WRMP supply forecast is focussed on and defined by drought events and dry years. The values derived and included in the final WRMP24 are based on 2022/23 annual reporting values during an observed drought year.

3.16.1 Process loss calculation

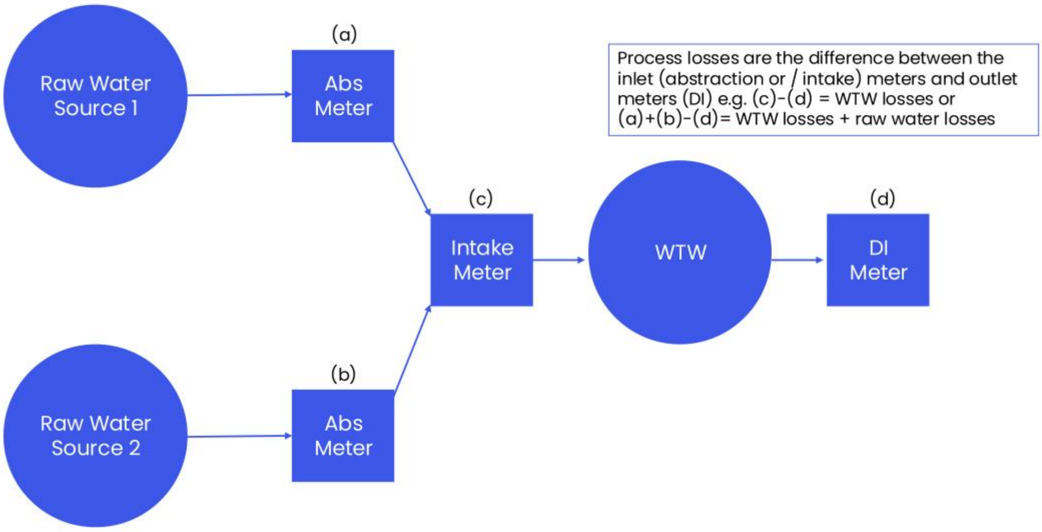
In recent years, we have reported an increase in the total volume of process losses recorded. To help assess the cause of the increases we reviewed the approach and identified a different way of calculating process losses from that used in the previous planning round. We consider the new approach for WRMP24 to provide a more accurate value of raw and treated losses than the previous calculation.

Previously we calculated process losses at WTWs based on the combined total of individual meters recording the volumes lost to wash water, tanker waste, washouts and sent to sewer. The losses at each works were summed and we added 0.25Ml/d to the total to represent raw water mains washing and a 0.79 Ml/d allowance for valve testing. The revised approach is based on the difference between either the meters at the inlet of a WTWs or the abstracted volume at the source, and the outlet meters at each WTWs, as shown in Figure 3.13 below.

No additional allowance is made for water lost due to raw water operational use for cleaning raw water mains in the Grid SWZ as this should inherently be accounted for in calculation method.

We have only included process losses for those sites where the deployable output constraint is either the water source or the inlet of the WTWs. Any works where deployable output is based on the outlet volumes are excluded from the process loss calculations. These works do lose water during the treatment processes, but to include in the supply-demand balance would be misrepresentative of actual supply availability as deployable output is constrained by the works output, which has already accounted for losses.

Figure 3.13: Process loss calculation method for WRMP24



There are no raw water losses or operational use recorded for the East SWZ using the WRMP24 approach. The deployable output of the zone is based on the WTW output and to include would be double counting. We have therefore reported zero in line 8BL of the tables, but include losses of 2.14Ml/d in 1BL. This is broadly comparable to the 1.71Ml/d process loss allowance in WRMP19.

Changes for our final plan

We stated our intention at draft WRMP24 to continually review the approach for estimating process losses to increase confidence in the calculation. A further revision to the approach is outlined below, which also takes into account the outcomes of the annual reporting process for WRMP components.

The process loss allowance at draft WRMP24 was based on three years of data (i.e., 2019/20 to 2021/22). Using the metered data, several sites reporting negative losses were reported as zero loss to avoid potential underestimation of the overall process loss estimate; however, there remained the potential for further increase given that most sites incur some degree of process loss in practice.

A review of the overall process loss estimate was commissioned by Yorkshire Water and undertaken for the final WRMP24 with support from Hydro-Logic Services. As well as completing further checks and reviews on the draft WRMP24 approach, Hydro-Logic explored potential alternative methods to account for negative process losses and understand the potential supply-demand balance impacts and uncertainties involved. Given that several sites were influenced by the impact of setting negative losses to zero, and in knowledge that several of these sites could reasonably be expected to experience material positive losses in practice, Hydro-Logic suggested the use of 'proxy site' loss values where data issues existed. Whilst recognising inherent uncertainties in the data available and the timescales for the assessment, the review indicated that such a method may have added over 20 Ml/d to the previous process loss estimates.

In addition, alongside this work, further work was also being completed on distribution input (DI) meter verification. In 2021-22 (coinciding with AR22), Flowlee Service Ltd. began a programme of work on Yorkshire Water's behalf to validate the recorded flow from our DI meters and 34 (43%) of the meters had been verified by the end of the 2021-22 year. The programme continued through 2022-23 and 96% of meter flows have now been validated.

As part of Annual Review 2022-23 (AR23), process losses for the Grid SWZ were reported as 60.70 Ml/d in the DYAA scenario. The reported losses represent the sum of the underlying process loss calculations (based on the new aforementioned approach established at draft WRMP24) of 35.23 Ml/d, a 3.04 Ml/d allowance for scour tests, and a 22.43 Ml/d adjustment of process losses resulting from the DI meter validation project. The latter adjustment was applied as the reduction in DI means the difference between the inlet and outlet volumes recorded at the WTWs is greater.

The latest annual reporting values have been adopted for the final WRMP24 process loss value, using the 2022/23 position following DI adjustments. The adjustment following meter validation, accounts for the majority of the uplift in the process loss position (i.e., the underlying raw water and treatment works losses for 2022/23 are comparable to the preceding three-year period, upon which the draft WRMP24 estimate was based). Given the risk of double counting for meter error and uncertainties, the adoption of 'proxy site' estimates was excluded from the estimates given the application of DI meter adjustments (noting that the scale of adjustment would have been of similar scale).

Notwithstanding that the total loss allowance is now based on only one year of data (as opposed to three at draft WRMP24), with a significant increase from the draft WRMP24, we believe this to be more robust given the majority of our meters have now undergone validation and as such, do not envisage further material year-on-year increases. Over time, additional years of data, and ongoing monitoring and tracking of process losses (with prioritisation given to the larger surface water treatment sites in the first instance) will allow us to continue to evolve and improve our estimation of this component of the supply forecasts. A future review of raw water meters (as opposed to focusing solely on DI meters) could potentially result in some lowering of process losses, although this remains uncertain. To reflect the ongoing uncertainty in the underlying data at a select number of treatment sites, an allowance has been made in Target Headroom.

Whilst we have assumed process losses will remain consistent throughout the planning period in both zones, Yorkshire Water commit to producing an action plan to better understand and explore the potential reduction of process losses over time. This may inform future WRMP supply-demand options to reduce process losses in future.

When considering the losses from non-DO impacting sites included in the raw water abstracted line of the WRP tables (1BL and 1FP), the total company losses are 69.57 Ml/d. This is 5.46% of the base year (2019/20) distribution input and considered to be representative of the industry average.

3.17 Water available for use

Water available for use (WAFU) is a term used to represent supply in our supply-demand balance calculations. The WRP tables include WAFU from our own sources and WAFU including any imports to our area.

Outage, raw water losses, treatment works losses and operational use are deducted from deployable output to provide the WAFU from our own sources of supply for each water resource zone. Table 3-17 and Table 3-18 summarise the impact of these losses on the deployable output for the East and Grid SWZs respectively. The WAFU from our own sources is then adjusted for imports and exports to give the total water available for use, as shown in Table 3-17 and Table 3-18. The total WAFU is the total supply that can be compared against demand and headroom to determine if there are any deficits in the supply-demand balance.

There have been some changes to the components of the WAFU calculation since we provided our draft WRMP24 and these are discussed in the relevant sections. The result of the changes are:

- The East SWZ WAFU has increased from 12.75Ml/d to 13.38Ml/d in 2025/26 and from 12.24Ml/d to 12.86 Ml/d in 2049/50.
- The Grid SWZ WAFU has decreased from 1196.61 Ml/d to 1182.90 Ml/d in 2025/26 and from 979.88Ml/d to 977.37Ml/d in 2049/50.

Table 3-17: Impacts of East SWZ outage and process losses on deployable output

East SWZ	2025/26	2030/31	2035/36	2040/41	2044/45	2049/50	2084/2085
Deployable output (Ml/d)	13.40	13.30	13.19	13.09	13.00	12.89	12.07
Outage (Ml/d)	0.02	0. 02	0.02	0.02	0.02	0.02	0.02
Process losses [19] (Ml/d)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WAFU (Ml/d)	13.38	13.28	13.17	13.07	12.98	12.87	12.05
Imports [20] (Ml/d)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports [21] (Ml/d)	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Total WAFU (Ml/d)	13.30	13.20	13.09	12.99	12.90	12.79	11.97

Table 3-18: Impacts of Grid SWZ outage and process losses on deployable output

Grid SWZ	2025/26	2030/31	2035/36	2040/41	2044/45	2049/50	2084/2085
Deployable output (Ml/d)	1239.50	1232.63	1205.74	1094.54	1089.48	1083.05	1035.57
Outage (Ml/d)	43.88	43.88	43.88	43.88	43.88	43.88	43.88
Process losses (Ml/d)	60.70	60.70	60.70	60.70	60.70	60.70	60.70
WAFU (Ml/d)	1134.92	1128.05	1101.16	989.96	984.90	978.47	930.99
Imports (Ml/d)	48.09	47.11	0.00	0.00	0.00	0.00	0.00
Exports (Ml/d)	-7.01	-7.01	-7.01	-7.01	-7.01	-7.01	-7.01
Total WAFU (Ml/d)	1176.00	1168.15	1094.15	982.95	977.89	971.46	923.98

[19] Includes raw water losses, treatment work losses and operational use.

[20] Accounts for both raw and potable imports

[21] Accounts for both raw and potable exports

4 Demand forecast

This section describes how we have calculated the baseline demand for water over the planning period – our demand forecast. We explain the components included in our forecast, and how we have considered the effects such as increasing population, new housing developments, leakage and changing patterns of use. The baseline forecast is our position before the benefit of any further water efficiency or leakage reduction activities are applied in our plan.

4.1 Introduction

4.1.1 Background

For our WRMP24, we have developed a demand forecast to cover the 60-year planning period from 2025/26 to 2084/85. This forecast is based on assumptions about how the key factors influencing water demand will change over time, with uncertainty increasing the more into the long-term the forecast looks. The forecasts are completed for both the Grid and East Surface Water Zones. The forecast period is aligned with the other companies in WReN.

We have taken appropriate steps to forecast demand, in alignment with the WRPG and supporting UKWIR methodologies, including Household Consumption Forecasting (UKWIR, 2015) and Population, Household Property and Occupancy Forecasting (UKWIR, 2016b)[22]. We have produced DYAA forecasts for both zones which include the impacts of dry weather and climate change on demand. In the case of the Grid Surface Water Zone, we have produced a critical period peak demand forecast to represent observed recent peak demand events. Further technical detail is available in the Demand Forecasting Technical Report, which will be provided to the Environment Agency and is available on request.

4.1.2 Summary of demand forecasting

To develop our demand forecast, the first step is to establish demand in the base year (2019/20). We then assess the key factors that could influence demand and use modelling to predict their impact in the future. Key drivers of future demand include population growth, changing household demographics, economic growth and new development, and customer behaviour. The methodology can be simplified to the process summarised in Figure 4.1.

[22] The WRPG includes reference to an additional household demand forecasting report *Integration of behavioural change into demand forecasting and water efficiency practices* (UKWIR, 2016). We have not used this report in developing our forecast as we do not consider it to be a robust methodology. The findings in the report are based on water usage data from a very small sample of 60 properties. These were then subdivided into cohorts, with limited representation of customers either regionally or nationally. The shortcomings of this report are recognised by the authors, and we do not consider the robustness of our household demand forecast would be improved by its inclusion.

Figure 4.1: Summary of demand forecasting methodology

The methodology includes the forecast of water use by four customer groups, which are defined by property type. These categories are defined below:

- Unmeasured households;
- Measured households;
- Unmeasured non-households; and
- Measured non-households.

Each of the property categories have their own set of demand drivers and assumptions for future growth rates. These include population projections, households switching to paying by meter (domestic meter optants), new connections and the economic environment.

In addition, there are other components of demand that also contribute towards the demand forecast. These include leakage, minor components such as distribution system operational use (water used by YW for operational purposes) and water taken unbilled (which covers a range of uses including sewer flushing and firefighting, as well as water taken illegally).

There are common terms used by water companies to represent the components that make up the demand forecast, and each component includes sub-components of demand. The main terms used in this report and the WRP tables are defined as follows:

Consumption – the water used by a property. It includes the volume of water used and meter under registration but excludes supply pipe leakage.

Water Delivered – the treated water delivered to customers can be defined as the total volume of water consumed (plus meter under registration for metered properties), including customer supply pipe leakage. It excludes the volume the water company uses (distribution system operational use), and water lost through the company's own pipes (leakage).

Distribution Input (DI) – the average amount of drinking water entering the distribution system to be supplied to consumers in an appointed water company's area of supply or zone. This is essentially the total demand for water as it includes consumption, leakage (all types), water taken unbilled and distribution system operational use.

The following key data sources and assumptions have been included in the forecasts:

- YW historical operational data;
- Population and property forecasts using local plans published by the local council or unitary authorities where available;
- The effect of climate change on demand for water;
- Micro-component based household demand forecasts; and
- Macro-economic based non-household demand forecast.

4.2 The base year

The base year has been defined for WRMP24 as 2019/20, which covers the financial year April 2019 to March 2020. We use data from the base year to forecast taking into account future changes to demand and applying dry year 'uplift' factors to produce DYAA and critical period demand forecasts. Since publishing the draft WRMP24 we have reported three years of outturn data since the base year, this includes 2020/21, 2021/22 and 2022/23. The demand component data for each potential base year is summarised in Table 4-1. We reviewed this data to assess if a more recent year should be used as the base year.

Table 4-1: Demand component annual reported data

	2019/20 (base year)	2020/21	2021/22	2022/23
Distribution input (Ml/d)	1253.86	1283.77	1267.65	1260.78
Measured non household – consumption (Ml/d)	270.11	234.72	249.26	266.17
Measured household – consumption (Ml/d)	286.49	324.28	325.32	311.68
Unmeasured household – consumption (Ml/d)	365.86	396.64	375.09	359.07
Total household – consumption (Ml/d)	652.35	720.92	700.41	670.74
Average household PCC (l/h/d)	127.71	141.16	131.51	123.87
Total leakage (Ml/d)	298.67	289.80	283.08	282.78

In both 2020/21 and 2021/22 we experienced an increase in demand in our region as a result of the Covid-19 pandemic. During these years lockdowns were in place and there were restrictions on non-household businesses opening. This led to an increase in household use as more people worked from home, and led to a reduction in non-household use as many businesses were closed or operating at lower capacity during these years.

The greatest impact of the pandemic was experienced in 2020/21. As lockdowns lifted household demand reduced and non-household demand increased in 2021/22 and 2022/23. In 2022/23 non-household consumption was only 5Ml/d below pre-Covid demand in 2019/20. Total household consumption is 18Ml/d higher than pre-Covid levels but has reduced compared to the previous two years. If we were to use 2020/21 or 2021/22 as a base year this would create a higher demand than that we would expect to see in the future.

Although the 2022/23 demand data is returning to pre-Covid levels, we experienced a drought in 2022, which will have influenced customer use. At the onset of the dry weather, we escalated our water saving communications, and from August to December a temporary use ban was in place. These drought related actions constrained demand and for our WRMP we need to represent an unconstrained demand in the baseline forecast

Due to the impacts of the pandemic in 2020/21 and 2022/23 and the drought in 2022/23 these years are not suitable as base years and therefore we have retained 2019/20 as the base year. We have added a Covid uplift to our future household forecast to represent an increased level of home working post pandemic (see Section 4.3). We foresee this uplift to persist throughout the remainder of the forecast.

Data for 2019/20 is taken from the annual water balance for this year. We have calculated the base year water balance from data included in our Annual Performance Report (APR) for 2019/20. The APR data is reported to Ofwat each year at a company level and is part of an audited process. Zonal level data is calculated and reported to the Environment Agency as part of the WRMP annual review process.

The water balance assessment compares the measured volume of water put into supply from our treatment works (distribution input) with the sum of the measured and estimated components of demand. The reported distribution input exceeds the water that can be accounted for, therefore there is an adjustment for this surplus water. The maximum likelihood estimation (MLE) technique has been used to allocate this discrepancy across all components based on the accuracy of measurement. For example, metered volumes are more accurate than volumes obtained from estimates and assumptions, and therefore the accuracy bands and volume adjustment around these components are smaller.

The water balance for the base year has been adjusted in line with guidance from UKWIR entitled 'Consistency of Reporting Performance Measures' (UKWIR, 2017). This affects the water accounted for and therefore the amount of surplus water that needs to be accounted for in the MLE adjustment. The adjusted MLE table is presented in Table 4-2. The second column from the right ('post MLE') is the base year data used as the basis for the WRMP24 demand forecast. Forecasts, as described in later sections, then adjust this data to represent either a DYAA scenario or a critical period scenario, as explained in Section 4.5.

Table 4-2: Regional maximum likelihood estimation table (2019/20 outturn)

Water Balance 2019/2020	Pre-MLE Ml/d	Confidence interval ± %	Range Ml/d	% of total %	Adjustment Ml/d	Post MLE Ml/d	Change Ml/d
Measured Households (Ml/d)	**311.12**					**312.68**	**1.56**
– Consumption	277.41	2%	11.10	4.01%	0.81	278.22	
– Supply pipe leakage (internally metered)	18.05	5%	1.80	0.65%	0.13	18.18	
– Supply pipe leakage (externally metered)	7.96	5%	0.80	0.29%	0.06	8.02	
– Meter Under-Registration	7.70	50%	7.70	2.78%	0.56	8.27	
Measured Non-Households (Ml/d)	**270.94**					**272.96**	**2.02**
– Consumption	250.60	2%	10.02	3.62%	0.73	251.33	
– Supply pipe leakage (internally metered)	1.09	5%	0.11	0.04%	0.01	1.10	
– Supply pipe leakage (externally metered)	1.73	5%	0.17	0.06%	0.01	1.74	
– Meter Under-Registration	17.51	50%	17.51	6.33%	1.27	18.78	
Unmeasured Households (Ml/d)	**397.91**					**404.75**	**6.84**
– Consumption	354.14	12%	84.99	30.72%	6.18	360.32	
– Supply pipe leakage	38.57	5%	3.86	1.39%	0.28	38.85	
– Meter Under-Registration	5.21	50%	5.21	1.88%	0.38	5.58	
Unmeasured Non-Household (Ml/d)	**2.47**					**2.55**	**0.08**
– Consumption	1.75	25%	0.88	0.32%	0.06	1.82	
– Supply pipe leakage	0.59	5%	0.06	0.02%	0.00	0.60	
– Meter Under-Registration	0.12	50%	0.12	0.04%	0.01	0.13	
Unbilled water (Ml/d)	**34.33**					**36.62**	**2.29**
– Water taken illegally (unbilled)	18.40	50%	18.40	6.65%	1.34	19.74	
– Water taken legally (unbilled)	8.08	50%	8.08	2.92%	0.59	8.67	
– Void supply pipe leakage	5.64	25%	2.82	1.02%	0.20	5.84	
– Distribution operational use	2.21	50%	2.21	0.80%	0.16	2.37	

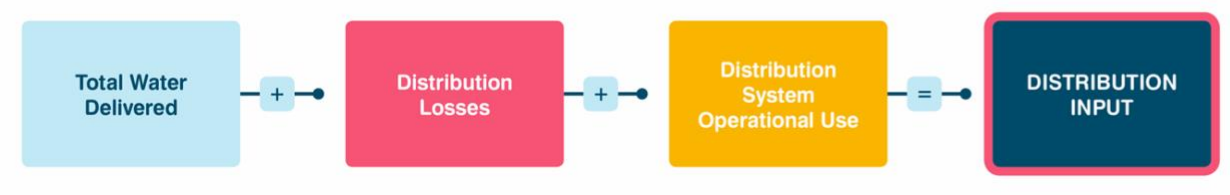
Water Balance 2019/2020 (cont.)	Pre-MLE	Confidence interval	Range	% of total	Adjustment	Post MLE	Change
	Ml/d	± %	Ml/d	%	Ml/d	Ml/d	Ml/d
Total Leakage (Ml/d)	**294.29**					**298.67**	**4.37**
– DMA Leakage (excl. SPL)	162.60	5%	16.26	5.88%	1.18	163.78	
– Trunk Main Leakage	56.71	30%	34.03	12.30%	2.47	59.18	
– Service Reservoir Leakage	1.35	10%	0.27	0.10%	0.02	1.37	
Distribution Input (Ml/d)	**1257.54**	**2%**	**50.30**	**18.18%**	**-3.66**	**1253.88**	**-3.66**
– Total Water Delivered (excl. dist. ops use)	1014.56					1027.18	
– Water accounted for	1237.42					1253.88	
– Unaccounted for Water (UFW)	20.12					0.00	
– UFW as %DI	1.60%					0.00%	
PCC (l/h/d)	**126.2**					**127.7**	**1.6**
– Total HH consumption (Ml/d) incl. MUR & excl. SPL	644.5					652.39	
– Total HH population	510814 0					5108140	
Measured household PCC (l/h/d)	**105.96**					**106.47**	**0.5**
– Measured HH consumption (Ml/d) incl. MUR & excl. SPL	285.1					286.5	
– Measured household population	269072 0					269072 0	
Unmeasured household PCC (l/h/d)	**148.65**					**151.36**	**2.7**
– Unmeasured HH consumption (Ml/d) incl. MUR & excl. SPL	359.3					365.9	
– Unmeasured household population	241742 0					2417420	
Additional lines							
Distribution Losses	220.66					224.33	
Total supply pipe leakage	73.6					74.3	

4.3 Accounting for demand in the base year

4.3.1 Components of Distribution Input (DI)

The distribution input is made up of several elements of demand as shown in Figure 4.2. We forecast each of the base year component parts and sum to provide the total distribution input forecast for each year of the planning period. By producing projections of demand at a component level the demand forecast is more representative of future demand than forecasting total demand.

Figure 4.2: Components of distribution input



4.3.2 Total water delivered (base year)

Total water delivered comprises the water delivered to each property category, plus an estimate of the water taken unbilled. Water delivered to customers can be defined as the volume of water consumed (including meter under registration, where appropriate), and customer supply pipe leakage. Meter under registration is the volume of water that is not recorded by water meters due to an error in recording as meters age and wear. We estimate meter under registration values for household and non-households which have been fitted with meters.

The amount of water delivered to each property category depends on the number of properties in that category, and, in the case of households, the population associated with that property. The following sections explain key aspects of allocating water delivered to the relevant categories:

Properties

Occupied properties are divided into four categories:

- **Measured households** – domestic properties with a meter. This category includes existing measured (metered) households, annual new build households (which are provided with a metered supply) and domestic meter optants (DMOs), which are the customers opting to have a water meter installed each year.
- **Unmeasured households** – domestic properties without a meter that pay for water based on the rateable value of the property.
- **Measured non-households** – commercial properties with a meter. This category includes new commercial connections and takes into account demolitions.
- **Unmeasured non-households** – commercial properties without a meter. These tend to be small businesses/properties, for example, family shops with a flat above (mixed use properties), scout huts, animal troughs etc.

The other two property categories, household, and non-household voids are properties that are registered as empty on our billing file. Although they have no consumption, they do have some leakage from the supply pipes which connect the properties to the mains. The only water delivered to these properties is therefore 'supply pipe leakage', which is not part of consumption.

Population

We estimate population for all four occupied property categories.

– Household population

For households, population is derived from known property numbers multiplied by an estimated occupancy rate for that category.

In previous plans, we obtained our estimated occupancy data from limited surveys of household customers, and the same occupancy rates were applied to the Grid SWZ and the East SWZ. For the WRMP24, we commissioned CACI Ltd. to provide household occupancy data for the East and Grid zones based on the billing file for 2018/19 as this was the most recent available dataset at that point in time. The occupancy rates used in the base year are provided in the table below:

Table 4-3: Occupancy rates for the different property categories in the base year

	Measured Households	Unmeasured Households	Unmeasured Non-Households (mixed use)
Grid SWZ	2.3	2.67	2.67
East SWZ	2.31	2.68	2.68

– Unmeasured non-household population

The unmeasured non-household population includes mixed-use properties which are primarily domestic use, for example, flats over small shops. There are approximately 1,500 mixed-use properties on our billing files, with an estimated population in the region of 4,000. These properties are assumed to have the same occupancy rates as unmeasured households.

– Measured non-household population

The measured non-household population is taken as the communal population obtained from the Office of National Statistics (ONS) census data and provided by Edge Analytics in *Population and Property Forecasts* (2020a). This population includes residents in prisons, nursing homes, university halls of residence and Ministry of Defence facilities.

The communal population for the Grid SWZ excludes the population of a public sector facility in North Yorkshire, which has a population of 3,392 and is included in the data provided by Edge Analytics. This facility has its own water supply and is therefore not supplied by YW. In Yorkshire, the communal population in the base year is 79,022 for the region.

– Clandestine and hidden population

In addition to the population recorded in the ONS census, there is a population category referred to as 'clandestine and hidden population' which is excluded from the ONS population data. Estimation of this clandestine and hidden population is an important component of the water balance calculation, as any population that remains unrecorded potentially increases the unaccounted-for water.

This unallocated population represents:

- Irregular migrants[23] - typically refers to migrants in a country who are not entitled to reside there, either because they have never had a legal residence permit or because they have overstayed their time-limited permit.
- Short-term residents – which refers to someone who is only resident in the UK for between 1 and 12 months.
- People staying at a second address – This includes armed forces bases, addresses used by people working away from home, a student's home address, the address of another parent or guardian or a holiday home.
- Domestic and foreign visitors to friends and relatives – While the water used by most visitors and tourists is likely to be reported from use at tourist sites, in hotels and other commercial accommodation, a proportion will not be captured, including both day visitors (domestic) and overnight stays (domestic or foreign).

Edge Analytics used a report produced by the London School of Economics (LSE) Economic impact on London and the UK of an Earned Regularisation of Irregular Migrants in the UK (Gordon et al, 2009) which provides a low, medium and high estimate of irregular migrants in the UK. An estimated 70% of this population is in London. Edge Analytics has disaggregated the remaining 30% into local authority areas that are fully or partially within Yorkshire Water's operational boundaries.

The low, medium and high estimates of population in the four clandestine and hidden categories for our total water supply area are shown in Table 4-4.

Table 4-4: Clandestine and hidden population estimates - water supply area

Clandestine and Hidden Population	Population Estimates		
	Low	Medium	High
Irregular migrants	32,400	40,500	48,600
Short term residents	13,614	23,681	38,055
Second addresses	2,960	7,053	11,146
Visiting friends and family	9,231	35,696	74,776
Total	58,205	106,930	172,577

[23] Typically refers to migrants in a country who are not entitled to reside there, either because they have never had a legal residence permit or because they have overstayed their time-limited permit.

We have used the central 'medium' estimate of population in our WRMP24. The estimated population in our two water resource zones is shown in Table 4-5.

Table 4-5: Medium clandestine and hidden population used in WRMP24

	Irregular Migrants	Short-term Residents	Second Addresses	Visiting Friends and Relatives
East SWZ	17	27	327	593
Grid SWZ	40,484	23,654	6,726	35,104
Region	40,500	23,681	7,053	35,696

We used the number of households in the measured and unmeasured household categories in the base year to split this population between the two household categories.

Consumption

Consumption is defined as the water directly used by a customer. This includes meter under registration but excludes supply pipe leakage.

– Measured households

The volume of water delivered to measured households is obtained from meter reading data from our company billing system. To calculate water consumption for these properties we subtract an estimate of supply pipe leakage from the measured volume and include an additional volume for estimated meter under registration. The total consumption of measured households is divided by the estimated total population of these properties to give a measured per capita consumption (PCC) value.

– Unmeasured households

Unmeasured households are properties where water charges are based on the rateable value of the property rather than a metered supply. The consumption of water by these properties is estimated from our Domestic Consumption Monitor (DCM). The DCM consists of, on average, 1,000 unmeasured properties which have logged meters installed but which continue to pay for water on an unmetered basis. The properties have been selected to be representative of our unmeasured property base, including property type, number of occupants and geographic location. Consumption data from all properties on the survey is obtained daily through a telemetry system.

From this we obtain the average daily volume of water used by our unmeasured household customers, known as unmeasured household PCC. We include an element of sample bias in the PCC estimation, to account for the frequency of contact from Yorkshire Water and a deficit of high-water users in the survey sample. Following a review by Leeds University, this bias was estimated to be 4%.

– Household meter under registration

As described earlier, meter under registration is the volume that is not recorded by water meters due to an error in recording as meters age and wear. For metered households, we assume a meter under registration value of 2.70%. This is based on previous flow testing of meters, and relative age and throughput of billing meters and meters at properties on our domestic consumption monitor. For unmetered customers (that is, covered by DCMs), we assume a meter under registration of 1.47% on basis there are fewer meters and as reflecting a sample of larger population there is more focus on maintenance / replacement.

– Clandestine and hidden population water use
The household volume of water used also includes the water used by the clandestine and hidden population. We have changed the methodology by which this volume is added to household water delivered for WRMP24. Previously this has been added onto unmeasured household consumption as a volume. For this plan, the clandestine and hidden population estimate was provided by Edge Analytics (Hidden & Clandestine Populations, Edge Analytics, 2020b). We have divided this population between measured and unmeasured household numbers.

For measured households, we assume that the consumption of the clandestine and hidden population is captured by the water meters at these properties. Therefore, no additional volume is added into this category. For unmeasured households, the clandestine and hidden population are assumed to have the same PCC as the rest of the unmeasured household population. Their consumption is therefore calculated in the same way as the rest of the unmeasured household population.

- Non-household consumption
For most measured customers, the volume of water consumed by non-household properties is taken from the billed volumes in 2019/20. This data was obtained from our non-household billing file. In the case of unmeasured non-household customers (who have very low or irregular water use, and where fitting a meter is not cost-beneficial), consumption is based on estimation of measured non-household per property consumption for low water users.

We also add an estimate of meter under registration onto the measured non-household volume, obtained from the billing file, to take account of under recording due to meters aging and wearing. Previously we have used an industry average meter under registration estimate for measured non-households. However, as part of our data improvement plan, set out in WRMP19, we have now determined a Yorkshire Water specific value for meter under registration based on a sample of non-household customers.

Statistical analysis of the meter under registration due to meter age and size in the sample was carried out and applied proportionately across all our non-household meter stock. This provided a meter under registration value for measured non-households of 6.94%.

– Supply pipe leakage
Supply pipe leakage is defined as leakage from pipes located within property boundaries, that is, between the point where the pipe supplying the property crosses the property boundary and the customers' taps.

The base year supply pipe leakage rates are calculated from the total leakage calculated for the same year. The supply pipe leakage volume is allocated to all properties based on estimated leakage rates for different property types and meter locations.

We have three different supply pipe leakage rates for properties:

- standard supply pipe leakage rate for unmeasured and internally metered properties.
- measured households with meters located external to the property (half standard rate); and
- measured non-household (one-quarter standard rate).

Within measured households, meters can be positioned either internal or external to the property, and this makes a difference in terms of supply pipe leakage rate. If the meter is located externally to the boundary of the property, any leakage on the supply pipe between the meter and the actual property will be registered by the meter. If the supply pipe leakage is significant, this will result in a higher than usual metered volume and the customer's bill value will increase. If the meter is internally within the property, any leakage on the supply pipe between the boundary and the property will not be registered on the meter and will not impact the measured volume or customer's bill.

As a result, the time taken for supply pipe leakage on an externally metered property to be identified is likely to be less than for an internally metered property, due to the abnormally high bill value. Consequently, the estimated supply pipe leakage rate for externally metered properties is lower than the estimated value for internally metered properties.

Measured non-household customers are typically higher water users, reflected in per property rates of supply pipe leakage.

– Water taken unbilled
Water taken unbilled includes water taken legally and illegally that is not paid for by the customer.

- **Water taken legally** includes water used for firefighting and training, metered standpipe use, and unbilled water used at our own operational and office sites. It also includes a small number of free potable supplies to properties subject to historic agreements, usually to allow access to land where water pipes or mains cross the area.
- **Water taken illegally** includes occupied voids, illegal hydrant use and illegal connections. At any one time, there are approximately 100,000 void household properties on our billing file. These properties are visited by Yorkshire Water staff to determine if the void status is valid. When investigated by our staff to validate a void status, approximately 45% of properties visited are found to be occupied. The water use by these customers is estimated based on assumed duration of occupancy, average household occupancy rate and PCC. For non-household customers, an automated process in our billing file identifies void properties with recorded water use or frequent change of occupier. The water use by these properties is estimated using an average non-household consumption volume.

The total estimated volume remains relatively constant at approximately 30Ml/d (2% of distribution input) each year. In the 2019/20 base year, water taken unbilled is 34.35 Ml/d (2.7% of distribution input) when associated supply pipe losses are included.

4.3.3 Distribution losses

Distribution losses are total leakage, less the total supply pipe leakage for our customers. Total leakage for 2019/20 was 298.67Ml/d and total supply pipe leakage was 74.33Ml/d. Therefore, distribution losses were 224.33Ml/d. Distribution losses are composed of three components:

- service reservoir leakage;
- trunk main leakage; and
- leakage in DMAs.

The leakage associated with service reservoirs and trunk mains is fixed at 60.55 Ml/d (as reported for the base year). The leakage in DMAs makes up the remainder of total leakage, with supply pipe leakage estimated as 55% of this figure.

Further details on calculating the leakage components are presented in Section 4.4.

4.3.4 Distribution system operational use

The final component of the base year distribution input is distribution system operational use. This is water that we use for activities such as mains flushing, service reservoir cleaning and water quality testing at our water treatment works and in distribution (from our water mains, service reservoirs and customer's taps). In 2019/20, we:

- cleaned 208 service reservoirs and treated water storage tanks;
- collected 72,035 treated water samples for water quality testing; and
- carried out over 5829 mains flushing operations.

The estimated water use for all these activities post MLE adjustment was 2.23Ml/d, as used in the annual water balance.

4.3.5 Dry year effects

In accordance with the WRPG, demand forecasts are created for a DYAA scenario for each water resource zone. We therefore need to understand the weather influence in the base year to understand it in the context of a dry year. This allows us to determine an appropriate adjustment factor to uplift it to an equivalent dry year. For our WRMP24 we have also created a critical period scenario for our Grid SWZ. This includes a dry year uplift factor that is representative of a defined short duration during the summer and is not averaged for the year.

To determine household demand in a dry year we have used methodologies presented in the report WRMP19 methods – Household Consumption Forecasting (UKWIR, 2015). In general, water use increases during periods of dry warm weather due to increased garden watering, personal washing and use of paddling pools and hot tubs, etc. The most accurate approach to estimating dry year demand is to analyse historic weather effects on household level consumption data.

Historical demand and weather data were analysed to determine annual average demand for a typical 'normal' year and typical 'dry' year, and to develop weather-demand models. This analysis was then used to adjust consumption in our base year (2019/20) to a dry year scenario by application of an uplift factor to average PCC.

Two approaches presented in the Household Demand Forecasting report were explored to understand the relationship between weather and demand:

- **Quadrant analysis**, which uses long-term total summer rainfall and average summer temperature to identify potential reference 'normal' and 'dry' years; and,
- **Regression modelling**, to describe the relationship between demand and weather parameters.

In considering an appropriate uplift to the base year, we have considered both of these two methodologies, from work undertaken by Yorkshire Water and Artesia Consulting separately. The full detail of this work is explained in the supporting Demand Forecasting Technical Report, which will be provided to the Environment Agency and is available on request. However, the use of quadrant analysis was deemed to be the most appropriate when 'ground truthing' the scale of uplift to the base year considering operational experience in recent years.

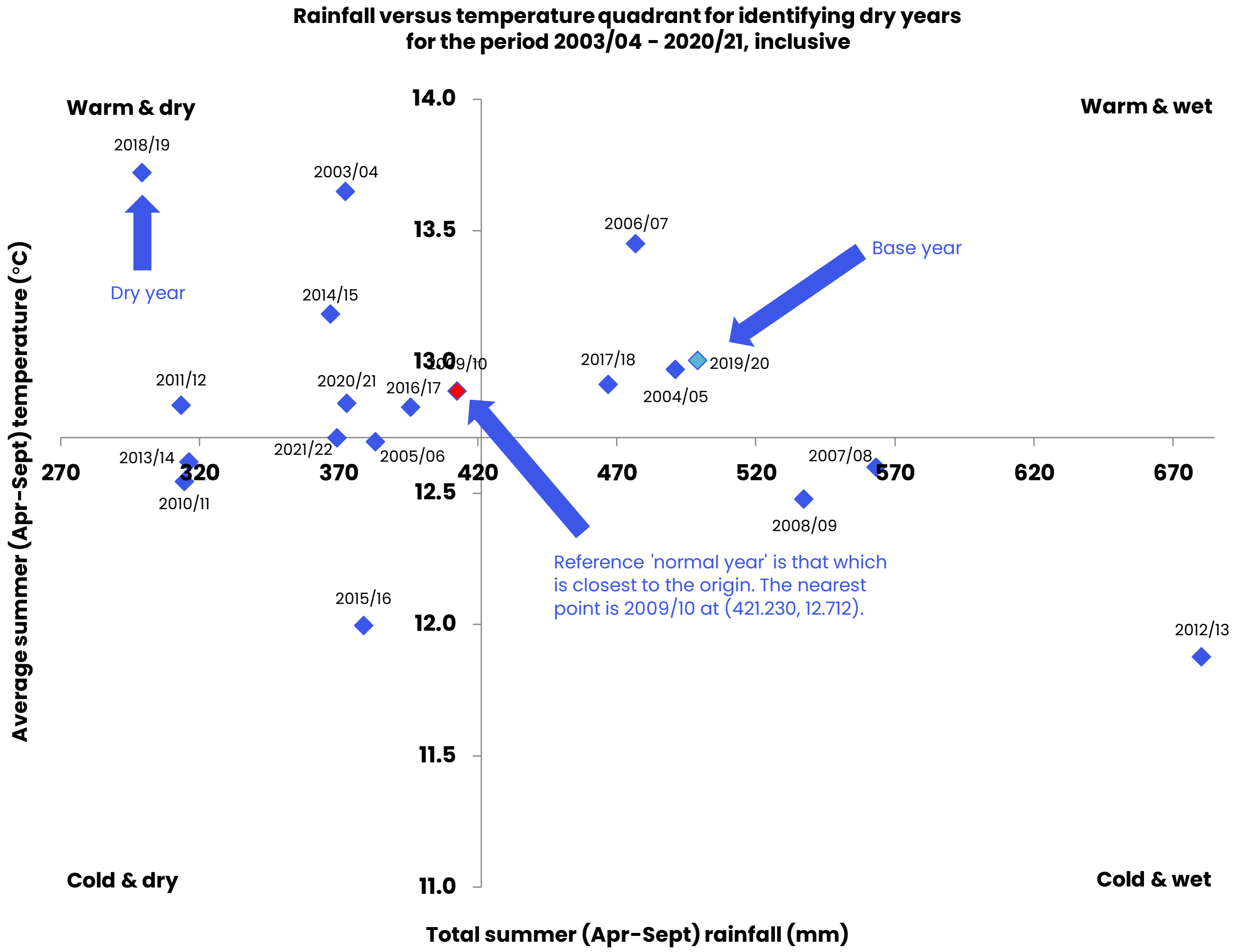
Yorkshire Water's quadrant analysis is shown in Figure 4.3 to determine the reference normal and dry years, relative to the 2019/20 base year. The plot shows long-term total summer (April to September) rainfall (mm) and temperature (degrees Celsius) for the period 2003/04 to 2019/20, split into quadrants for 'type' of year. The reference 'normal year' is that which sits closest to the origin (that is, long-term average weather).

2009/10 is the nearest to the origin of the quadrant analysis in terms of average weather and was identified as a 'normal'' year. Candidate 'dry years' are found in the 'warm and dry' quadrant, that is, less than average summer rainfall and greater than average temperatures. The 2019/20 base year is in the warm and wet quadrant. Candidate dry years suggested by this plot are 2003/04, 2011/12, 2014/15, 2016/17, 2018/19 and 2020/21, and 2018/19.

2018/19 was selected based on expert judgement for the reasons below:

- In this case, 2018/19 is used as it is known to be a dry year
- It is one of the most distant from the origin point
- 2011/12 and 2012/13 are excluded as they are relatively old, and some reporting might have changed; 2018/19 by contrast is more recent data

Figure 4.3: Quadrant analysis to contextualise base year relative to reference normal and dry years

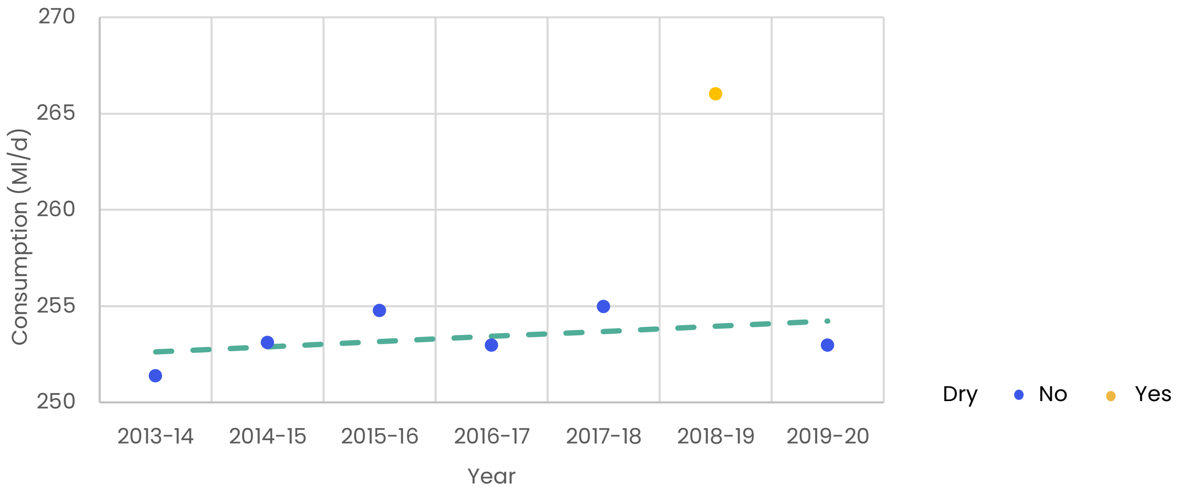


The household consumption forecast was produced by Artesia Consulting using the multi-linear regression approach. This approach reduced the 2019/20 base year household consumption values by 2% to make it representative of a normal year. It then forecast forward and applied a normal year reduction factor to each year of the planning period that was in the region of 2% but varied slightly each year. The DYAA modelled scenario applied an uplift factor to each year that was also in the region of 2% and resulted in a DYAA base year consumption that was similar to the actual.

On reviewing the outputs of the model, we considered the modelled approach to not be representative of a dry year. We subsequently rebased the 2019/20 base year to the outturn data, which was a 2% increase to the modelled household consumption output and applied the same uplift to each forecast year to produce the normal year forecast. We then applied a further 2% increase to produce a DYAA annual forecast that was effectively aligned with the conclusion from the quadrant analysis that 2019/20 had been a normal year.

For the WRMP24 we have also added a non-household uplift factor to the DYAA scenario. This was not applied to our WRMP19 forecast, however learning from the dry weather of 2018/19 concluded that an uplift in non-household demand was experienced in this year. To calculate the non-household uplift factor Artesia Consulting carried out a linear regression on data from 2013/14 to 2019/20 that excluded 2018/19 – the candidate dry year. The results are shown in Figure 4.4. This produced a factor that was 5% higher than a normal year. As our quadrant analysis had concluded the base year to be normal, we applied the full 5% uplift to the measured non-household consumption forecast. We did not apply the uplift to unmeasured non-households as it is unlikely these properties would increase their use by the same proportion.

Figure 4.4: Annual average consumption regression model compared to the 2018/19 dry year



4.3.6 Critical period

Artesia Consulting has also produced a critical period household consumption forecast for our Grid SWZ. The method used follows the UKWIR, Peak Demand Forecasting Methodology report, 06/WR/01/7 (UKWIR, 2006). For the Grid SWZ a rolling average approach was used to estimate the peak period demand if the dry year (2018/19) conditions were to reoccur in the base year. Seven day rolling average data was provided to Artesia Consulting who compared the 28-day peak period data to the annual average of the seven-day rolling average data.

The Artesia Consulting analysis assigned probability of peak demand by applying cumulative distribution functions (CDFs) to the peak volumes. This resulted in an 18% (1.1803 factor[24]) increase compared to the normal year demand and 16% compared to the DYAA for a 1 in 500 event. We also extended this analysis to include the 2022 summer event, and this concluded no change to the uplift level. We have applied the 18% normal to critical period uplift to our Grid SWZ to produce the critical period household consumption. However, the critical period scenario is not representative of a drought return period, it is used to compare peak summer demand against reducing water availability over the planning period.

[24] A marginally lower factor of 1.1766 from the base year was derived for a 1 in 200-year event.

We have applied a higher uplift factor to the critical period non-household consumption by doubling the non-household annual average dry year factor of 5% applied to the baseline forecast. This is assuming the uplift would be during the spring and summer months, and there would be zero uplift during the autumn/winter months.

In our draft plan, we applied an uplift factor of 8% to leakage for the critical period scenario based on our experience in 2018. During dry weather we experience higher leakage due to increased ground movement and our comparison of 2018/19 leakage data to 'normal year' data resulted in an 8% increase. We have reviewed this assumption for our final plan, incorporating data since the 2018 dry year and we have assessed data for the period from 2017 up to the 2022 drought year. Our analysis compares 2018 and 2022 to non-dry years to assess if there is an uplift in leakage. This revised data set is showing that leakage does not increase during the summer looking at this more up to date data set. We have therefore removed the leakage CP uplift from our baseline forecast for this scenario and our final plan CP scenario leakage uplift is zero. We have also since revised triggers in our drought plan following the 2022 drought to mobilise leakage reduction activity more quickly in periods of increased demand. The net effect of this in the 2022 drought was very little change in expected leakage compared to a non-dry year. Our assumption of no leakage uplift in a dry year accounts for the fact that our leakage interventions will step up in the short-term to manage leakage outbreaks.

We increase our leakage detection and repair activity to bring leakage back down to normal levels and meet our annual average targets, therefore we have not applied a leakage uplift to the DYAA scenario, but during the critical period it is likely leakage will be higher than normal.

4.3.7 Covid-19

To understand the impact that Covid-19 has had on customer demand in terms of behaviour towards consumption, Artesia Consulting assessed our company datasets using the same approach as used in the national research project *The impact of Covid-19 on water consumption* (Artesia Consulting, 2021). The outcomes of this national project were tailored to Yorkshire Water specific demand data and incorporated into the regional forecasts *Covid adjustment factors for 2019-20 and 2020-21 base years* (Artesia Consulting, 2021). Consumption was significantly impacted due to changing customer behaviour while working from home instead of an office environment or on furlough.

The adjustment factor and the bounce back to a 'new normal' was assumed on the back of consumption obtained from the DCM before and after the pandemic wave. Analysis on data recorded for 1019 properties every 15 minutes, over a period of three years was intrinsically modelled, providing differing uplifted figures year on year. Based on the Artesia Consulting analysis, we applied an increase in household demand of 11.50% in 2020/21 and 4.41% in 2021/22. From 2022/23 onwards, an uplift of 1.68% was applied to represent the 'new normal' with more people working from home than pre-Covid-19.

The impact of Covid-19 on non-household demand was considered in the econometric regression model used to produce the forecast and we did not apply any adjustments to the modelled data in the draft plan. Since producing the draft forecast, we have actual reported data for 2020/21, 2021/22 and 2022/23. This shows non-household demand to have been lower than our model predicted in 2020/21 and 2021/22. We have adjusted measured non-household demand in these years to align with the recorded demand.

4.3.8 Water resource zones split

The WRP tables that accompany this WRMP24 are completed at a water resource zone level. Therefore, all elements of the demand forecast discussed above are split between the Grid SWZ and the East SWZ.

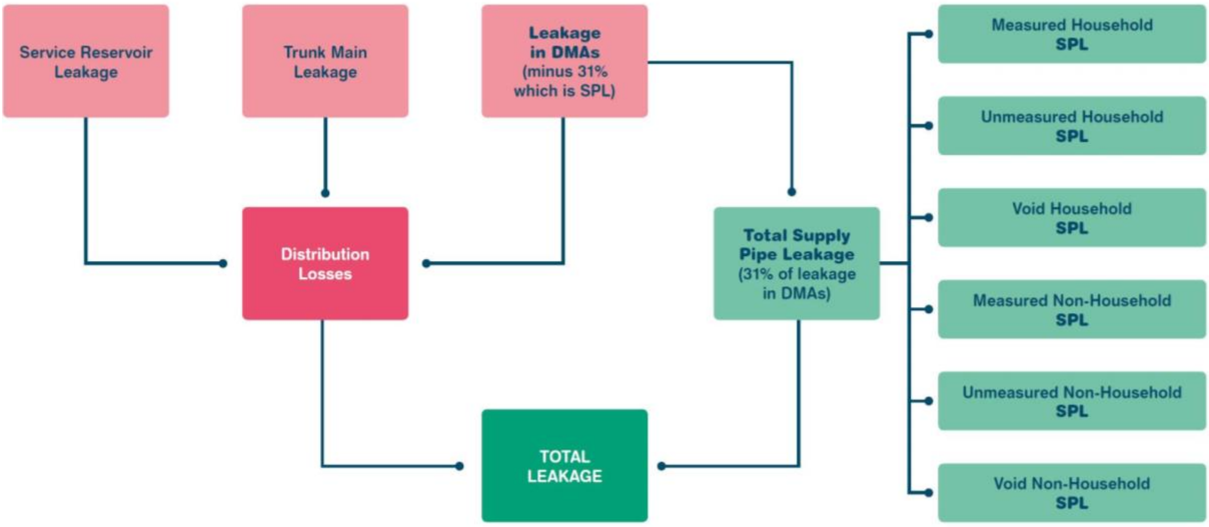
The water delivered to each property category is based on the number of properties or population in each zone. For the other components, such as water taken unbilled, distribution losses and distribution system operational use, zone ratios were used to split the volume of water between the two water resource zones. This ratio is approximately 0.6% to East SWZ and 99.4% to the Grid SWZ, as per the annual water balance calculations.

4.4 Estimating total leakage

Total leakage is a key performance reporting metric for regulators. We report leakage annually against targets that are derived through our WRMP and business planning processes. Total leakage is the sum of distribution losses plus leakage from customer owned supply pipes. Distribution losses are leaks within our mains network and include losses from large trunk mains and service reservoirs. The components of total leakage are depicted in Figure 4.5.

The baseline demand forecasts assume continuation of our current leakage reduction activities, in line with annual leakage targets for the 2020 to 2025 period. The sections below briefly explain our approach to estimating current leakage, by each component:

Figure 4.5: Total leakage components



4.4.1 Distribution losses

We continually monitor leakage to target leakage management activities. The distribution network has been divided into approximately 3,000 Distribution Management Areas (DMAs), with an average size of approximately 780 properties.

98.4% of these DMAs are permanently metered and have flows in and out of the area recorded every 15 minutes, from which a 'night flow' can be derived. We aspire to establish 100% coverage, however we also recognise this may not be economically viable, particularly in areas with complex supply systems.

Monitoring of night flows within DMAs, when usage is at its lowest, allows derivation of leakage estimates. Permanent loggers are installed on DMA meters. Most are telemetered loggers, using GPRS technology. This enables DMA flow data to be gathered every 30 minutes for operational purposes and twice daily for leakage purposes.

This data is processed by our leakage and pressure monitoring system Netbase, which calculates the level of leakage in each DMA. The night flow taken between 3am and 4am is used to produce the daily leakage level at DMA weekly leakage level, which is aggregated for annual figures.

An allowance for household and non-household night use is subtracted from the average gross night flow to produce the average net night flow. Large night users are logged, and the logged data subtracted from the DMA net night flow. This is the best estimate of all the leakage within the DMA, including supply pipe leakage.

Where properties are not within an established DMA, and are therefore not monitored, we undertake a full sounding of the area each year: Leakage detection staff complete field-based checks to identify potential leakage.

These staff use a variety of traditional techniques such as sounding of fittings, step-tests, correlator surveys, acoustic noise logger surveys and more innovative techniques, such as the use of satellite imaging.

Repairs are carried out by a service partner. All repair jobs are tracked in our operational reporting database, so that repair times and backlogs are closely monitored.

4.4.2 Trunk mains losses

Trunk mains are defined as all mains between the treatment works outlet and the inlet to DMAs and include distribution of water to and from service reservoirs. We have 4,279km of trunk mains. Each year we carry out flow balances on a sample of the trunk mains network. The number of successful flow balances is increasing annually, from 7.8% of our trunk main length in 2009/10 to 22.13%. In 2021/22 we calculated trunk main losses to be 8.72 m3/km/d which is 37.23 Ml/d.

We have a dedicated trunk main detection team focused on proactive leakage detection, identifying and pinpointing trunk main leakage. The trunk main team also maintains trunk main meters and work on increasing trunk main reporting length.

4.4.3 Service reservoir losses

There are two components of service reservoir losses; structural leakage and losses due to overflow. Location of service reservoir leakage is part of our service reservoir maintenance programme. This is a rolling programme of cleaning and inspection, based on factors including water quality compliance, asset age, date of last refurbishment and known structural faults.

Following cleaning and inspection, a drop test is carried out on the refilled service reservoir to assess leakage. The reservoir is filled, inlets and outlets are shut off, and changes in water level over 24 hours are recorded; any drop in level will indicate a leak. Under the rolling inspection programme, all service reservoirs are assessed for leakage every one to five years. Those reservoirs with the highest risk of leakage or ingress are prioritised for assessment.

As well as losses through the structure of service reservoirs, water can be lost through reservoir overflows. The volume of water lost through a period of overflow is estimated from the duration of high alarm events at service reservoir sites.

4.4.4 Customer supply pipe leakage

The total volume of supply pipe leakage is estimated to be 31% of leakage within DMAs. Currently this is equivalent to about 72Ml/d, providing opportunity within the leakage strategy to leverage smart metering potential and reduce customer side leaks. This was calculated from an assessment of properties in a number of cohorts to best represent leakage on properties with no meter, those metered internally and metered at the boundary of the property.

Where a supply pipe leak is identified, we raise customer awareness of supply pipe ownership and give options to manage the associated responsibility. Under the policy, we may attempt to repair a leaking supply pipe free of charge for household customers, however further repairs will/may be at the customer's own expense in line with our policy and eligibility criteria. We also consider financial circumstances to ensure we support those most vulnerable in our communities.

4.4.5 Leakage convergence (consistent leakage reporting)

During AMP6, Water UK and the UK water companies worked together to derive a more consistent method for reporting leakage. The outcome of this work was published in the report *Consistency of Reporting Performance Measures* (UKWIR, 2017)[25]. For the remainder of AMP6, water companies were required to report leakage performance following existing reporting methodology and 'shadow report' total leakage in accordance with the consistent methods.

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[25] https://ukwir.org/Consistency-of-Reporting-Performance-Measures

The full impact of applying the consistent method to our reported leakage figure was not known at the time of producing the WRMP19 leakage forecast. Our WRMP19 was produced in 2017 and we applied the calculation changes we had made at that point in time, combined with our planned data improvements, to the 2015/16 base year. However, to be fully compliant with consistency of reporting we required additional monitoring to increase sample sizes in 5 of the 16 data quality measures described within the UKWIR report.

During the period between producing our leakage target for our WRMP19 in 2017 and producing our leakage target for our PR19 business plan performance commitment, we progressed with developing our leakage convergence reporting and we increased our compliance with the consistency reporting requirements. However, it was not until 2020/21 that we were fully compliant, after both our PR19 business plan and WRMP19 had been published. At this point, we 'back casted' our water balance and leakage calculations to produce a consistent three years of leakage calculations. We updated the PR19 leakage performance commitment target to align with this data.

The outcome of the transition to consistency reporting was that the leakage target values presented in our WRMP19 were not representative of our leakage levels under the leakage convergence approach. Using the convergence approach, the WRMP19 baseline leakage value was under representative of actual leakage and not aligned with the PR19 performance commitment leakage target. This meant the leakage target presented in our WRMP19 was unachievable and we needed to realign with current leakage values and the PR19 target.

The leakage target we presented in our WRMP19 for the period from 2019/20 (base year) to 2024/25 (end of AMP7) has been re-evaluated since we published our final WRMP19. The leakage performance commitment target is a three-year rolling average target, whereas our WRMP forecasts leakage annually. Although based on different data sets, both the WRMP19 final plan leakage target and the PR19 leakage target had a common goal to reduce leakage by 15% by 2025. Prior to producing our WRMP24 we consulted the Environment Agency on how to report our leakage performance in annual reviews of our WRMP19. It was agreed that the WRMP19 target should be realigned to be consistent with the PR19 three-year average target, but it should be presented as an annual target rather than the three-year average.

The AMP7 regional leakage targets are shown in Table 4-6 with the outturn values for the AMP so far showing we have achieved the leakage targets. The target values have been carried through to our WRMP24 and split across the two resource zones.

Table 4-6: AMP7 regional leakage target

Year	2019/20	2020-21	2021-22	2022-23	2023-24	2024-25
East SWZ WRMP24 leakage (Ml/d)	1.4	1.4	1.4	1.4	1.4	1.4
Grid SWZ WRMP24 leakage (Ml/d)	297.23	288.36	286.06	278.36	266.46	254.86
Company baseline leakage target (Ml/d)	298.7	289.8	287.5	279.8	267.9	256.3
Company leakage reported (Ml/d)	298.7	289.8	283.1	282.8	-	-

4.5 Forecasting components of demand

The baseline forecast demand from our base year through to 2084/85 is built up from forecast changes in the underlying components of distribution input. These baseline forecasts align with existing investment programmes and regulatory commitment and assume no further interventions beyond 2025.

It is important to state that with any long-term forecast, we are unable to determine anything as a matter of fact. The forecasts are subject to inherent uncertainties given the data that they are dependent upon (for example, forecast population and economic growth) and the ability of models to replicate complex real-world factors. They reflect our best estimate of the future, and the uncertainties are reflected in our target headroom assessment (Section 6) as part of the supply-demand balance.

However, the projections draw upon the latest data and best information at this point in time, including our performance commitments, historical trends, academic or industry research projects, and internal and external engagement. The WRMP is revised every five years and forecasts are recalibrated.

This section is split by the components of distribution input (DI). Further detailed explanations of forecasting methods are described in the supporting Demand Forecasting Technical Report, which will be provided to the Environment Agency and is available on request.

4.5.1 Forecasting water delivered

The forecast water delivered is driven by our current (that is, baseline) company policies; changes to property numbers, population, and consumption; and climatic variations.

Yorkshire Water Policies

The demand forecast is produced in alignment with current internal demand management. This is through both reduction in customer's water use by metering and water efficiency, and through reduction in leakage from our distribution system. Section 4.4 describes our existing leakage performance commitment. Section 5 describes our baseline water efficiency and demand reduction activities and includes our strategy for demand reduction in AMP8.

– Baseline metering strategy and DMO uptake

Household properties which opt to switch to a metered supply are known as domestic meter optants (DMOs)[26]. We promote domestic meters in our communication to customers through billing and on our website, however uptake in recent years has slowed.

This is due to the following factors:

- Over time, the number of new DMOs is expected to fall. This decline reflects the decreasing number of unmeasured households both available to opt for a meter, and with a financial benefit of opting as an incentive. In general, low occupancy households and low rateable value properties that would usually benefit from a meter have already opted. The remaining, larger occupancy households/higher rateable value properties are less likely to benefit financially and so do not opt to a metered supply.
- There is a strong correlation between the value of unmetered customers' bills and the number of optants each year. When unmetered bills increase, there is a corresponding increase in customers opting for a metered supply. In recent years, increases in unmeasured bill values have been relatively small, resulting in a lower number of optants in these years.
- Historically, we have promoted a metered supply to customers with affordability issues as a means of managing their water charges. In recent years there has been a decrease in the number of such customers choosing to switch to a metered supply. Instead, they elect to join one of our customer support schemes, such as Water Direct, Water Support and Resolve, which help customers with low income or bill arrears manage their water charges.

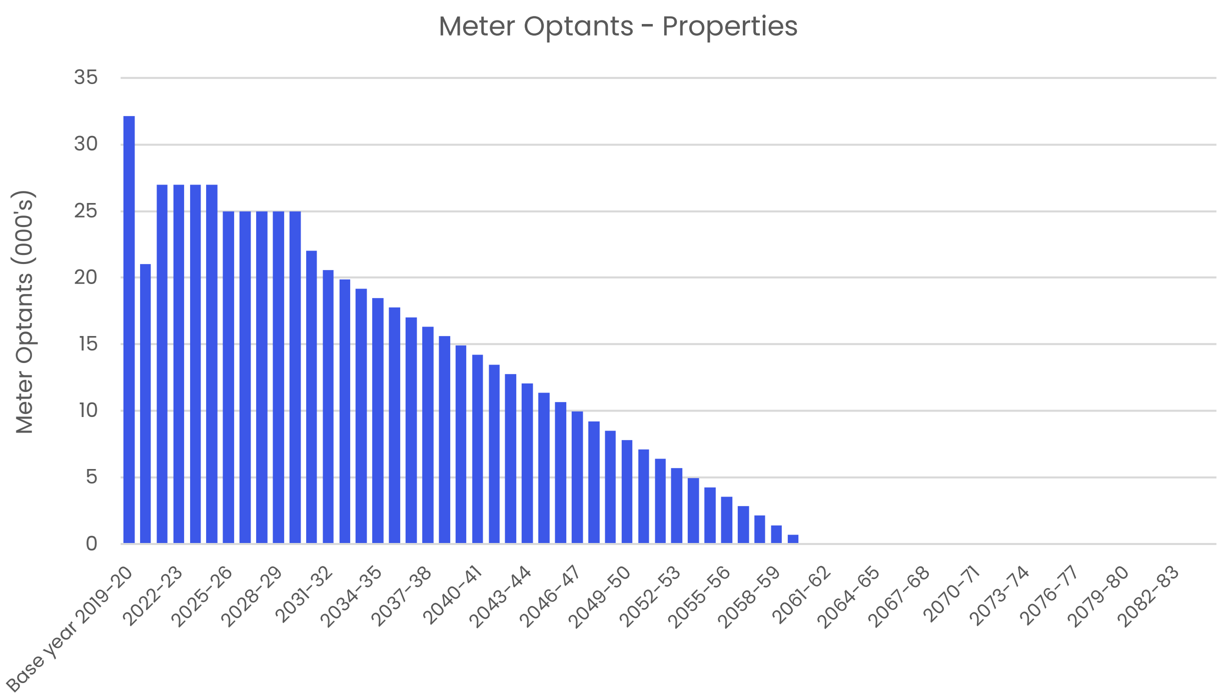
[26] By default, new properties would be expected to have a meter installed.

- In 2020/21, Covid-19 lockdowns increased the proportion of the population working from home. This led to increases in household water usage and therefore unmetered customers were reluctant to have a meter installed due to a potential increase in bills. Internal meter installations had stopped due to Covid-19, therefore we could only fit external meters and this reduced the number of installs as some properties are not suited to fitting externally.

A meter optant forecast has been developed taking account of the above factors and historic trends. The assumptions behind this forecast are as follows:

- The starting point for the projection of DMO's is set at the actual number of domestic meter optants (DMO's) in the base year (32,139); compared to WRMP19 forecast that 2019/20 would be 34,045.
- The forecast has been reduced to 21,000 in the outturn year 2020/21 due to Covid-19 and fewer properties opting for a meter.
- A bounce back to the 'new normal' in 2021/22 has meant that there is expected to be an increase in meters fitted, assumed to be around 27,000.
- AMP8 – AMP11 figures compared to WRMP19 projections have been reduced to reflect the uptake in AMP7 Years 2-5 forecast (Figure 4.6).

Figure 4.6: Projected meter optants over the planning period



Over time, there is a gradual decline in DMOs, which is broadly linear after 2030. In addition to meter optants, all new build properties (property growth forecasts are described in subsequent sections below) are fitted with a water meter. Between DMOs and new connections, we therefore forecast that around 84% of all households (excluding voids) will be metered by 2049/50.

The total annual DMOs are split between the Grid and East SWZ and based on the distribution observed in the most recent data we had on DMO's which was in 2020/21. The Grid SWZ had 99.43% of DMOs, and the East 0.57%.

– Water efficiency savings

Our current water efficiency and demand reduction strategy as defined in Section 5 is reflected in the baseline demand forecasts. The baseline forecasts exclude the benefit of potential future government policy changes on water labelling and building regulations, and the potential roll-out of smart meters (which is considered as part of our final plan choices).

For household customers, we will continue to promote behavioural change in water use and to provide water saving devices through free packs and other initiatives. The water savings calculated from these activities is, in combination with increasing ownership of more water efficient appliances, projected to drive a downward trend in PCC presented in our household demand forecast. Household PCC in the (dry year) baseline forecast is expected to decline from around 130 l/h/d in 2019/20 to around 117 l/h/d by 2049/50.

We are also forecasting a continuing downward trend in total non-household water demand, driven by decreasing water use by the non-service sector. A variety of factors influence long-term non-household water demand, but economic growth and the development of water efficient technologies are considered central. The forecast of non-household demand originally provided by Route2 for WRMP19, has been updated internally for WRMP24. The decline in non-household demand is driven by a combination of macro-economic factors and an underlying drive for efficiency.

Properties, population, and occupancy rates

The amount of water delivered to each property category depends on the number of properties in that category and, in the case of household properties, the population associated with those properties. All three WReN water companies have worked with Edge Analytics to develop our property and population forecasts.

– Household properties

The forecast for total household properties and their associated population was produced by Edge Analytics Ltd, *Population and Property Forecasts* (2020a). A wide range of scenarios and variants were explored as part of the demand forecasting, informing our understanding of uncertainties on the forecasts. Edge Analytics have provided population and property growth scenarios for all water resource zones[27] in the WReN region.

Edge Analytics has developed a database ('Consilium') which contains details of planned housing growth and phasing from all local planning authorities. Data is continuously updated in collaboration with local authorities, and this provides the best available evidence on future housing growth for inclusion in property and population forecasts.

Two broad types of forecast are relevant in the context of the WRPG and our assessment of scenarios on our plan (Section 7.3). The first is a housing-led scenario, using housing growth evidence from Local Plans published by the local council or unitary authorities where available, known as a plan-based forecast[28]. The second is based on the Sub-National Population Projections (SNPP) from the ONS, known as a trend-based forecasts, used mainly as part of scenario analysis on the plan.

The WRPG emphasises the importance of using housing growth evidence from Local Plans. Therefore, we have selected to use the 'Housing Plan scenario' from Edge Analytics for the plan-based property and population forecast in the baseline forecasts. The Housing Plan scenario is a housing-led scenario, with population growth underpinned by each local authority's Local Plan housing growth trajectory.

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[27] We provided Edge with GIS shape files, which allowed splits to be calculated between zones for property and population forecasts relative to the underlying local plan area (LPA) or ONS data units, as appropriate. Where ONS level data is used, Census Output Area (COA) has been used for WRMP24. To align to our base year property records in billing data, a small number of Output Areas (mainly on the periphery of the YW area), required the use of Royal Mail's Postcode Address File (PAF) data instead.

[28] Where local plans are not available, alternative methods such as household projections from the Office for National Statistics (ONS) or other analysis are permitted.

Beyond the local plan period, sub-national projections have been extrapolated following the final year of Housing Plan data, then projected housing growth in non-London areas returns to the ONS-14 & ONS-16 long-term annual growth average by 2050.

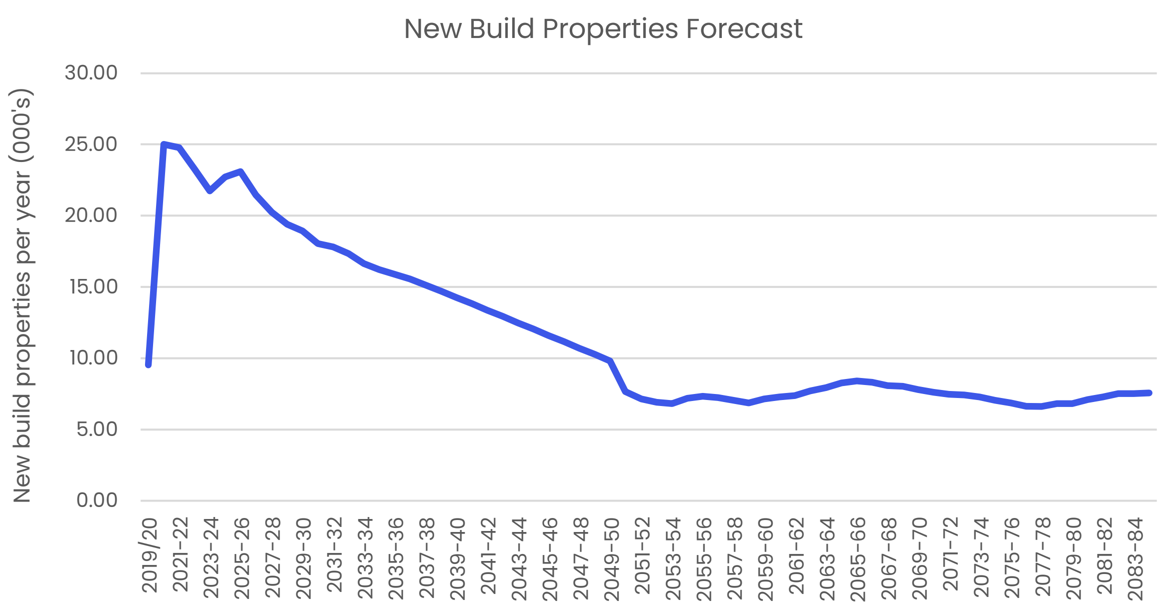
Where available, Edge Analytics used the annual allocation of the overall housing target from the information provided by each local authority. When not available, the overall housing target was distributed equally over the Local Plan period, with adjustments made to account for historic completions if this was available.

Under the trend-based forecast, which is based on historic trends in births, deaths and migration, the number of household properties and population forecasted are significantly fewer than the plan-based forecast. The impact of this potentially lower number of households and population on future demand for water has been assessed and included in our allowance for uncertainty. This is described in the Allowing for Uncertainty (Headroom) Technical Report, and our scenario testing process (this report will be provided to the Environment Agency and made available on request).

The annual housing growth trajectories formed the basis of the plan-based household forecast used in the demand forecast. Figure 4.7 shows the forecast new build household properties over the planning period.

The change from local plan data to the ONS data in 2049/50 has created a 'dip' in the forecast that is evident in Figure 4.7. This 'dip' is not apparent in the total household property forecast shown in Figure 4.8 and given that this issue does not occur until the late 2040s, it is not material to the planning approach. Housing growth is inherently uncertain and there will be many influences on actual housing numbers delivered between now and the late 2040s. New connections will be reviewed in future iterations of the plan, and we will use more accurate data for this period once it is available.

Figure 4.7: New build household property forecast

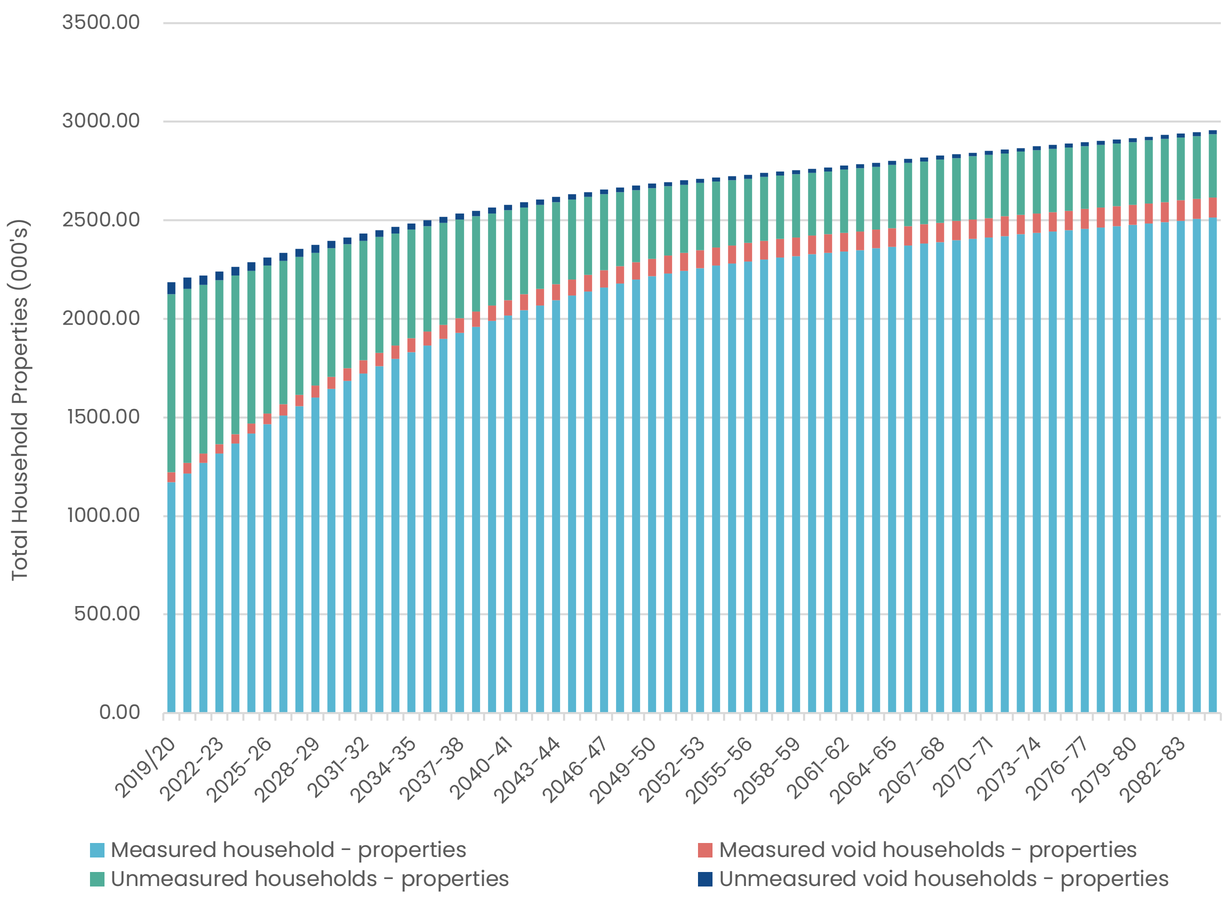


We rebased Edge Analytics' plan-based forecast of household properties to align with the base year numbers, which were taken from our billing file. The total forecast household properties were then divided between the measured and unmeasured household categories using our DMO forecast, and the Edge Analytics new builds forecast, as follows:

- Measured households = measured households in previous year + new builds + DMOs
- Unmeasured households = unmeasured households in previous year – DMOs

The household property forecast is presented in Figure 4.8:

Figure 4.8: Household property forecast



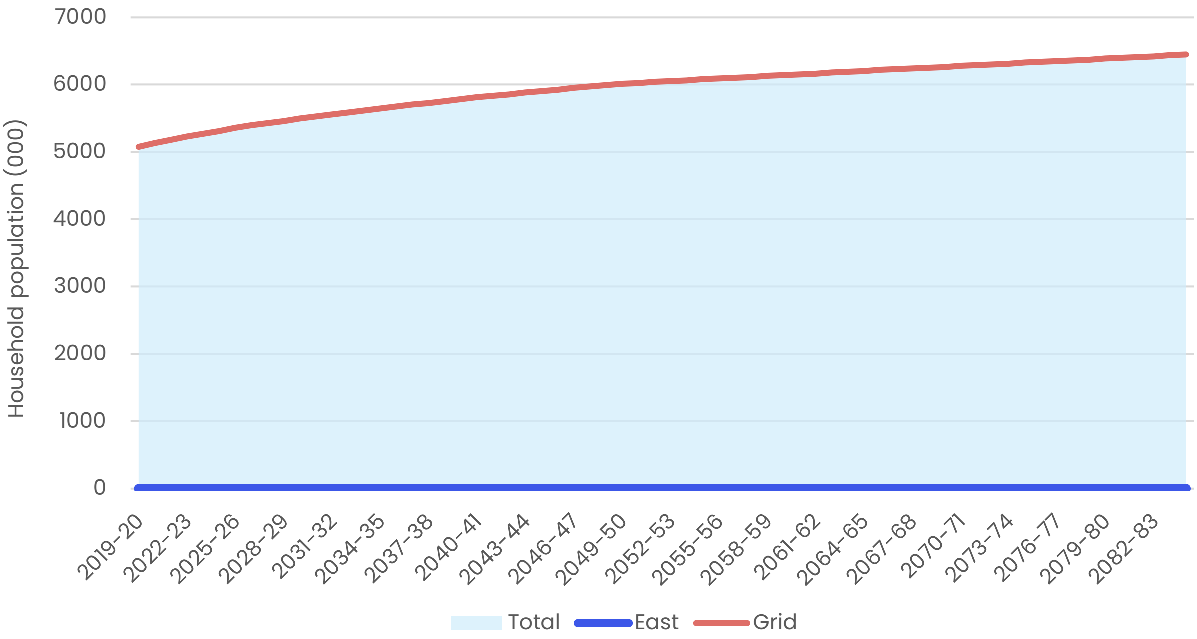
– Household population

The total household population used in the demand forecast is taken from the Edge Analytics plan-based forecast (Housing Plan scenario), rebased to the base year population, as described in the previous section on properties. The household population needs to be split between the measured and unmeasured household categories, which is done using occupancy rates.

The measured household occupancy rate shows a gradual decline over the plan period and the unmeasured household occupancy rate shows a gradual increase. This is linked to the assumption that the DMO properties will be those households within the unmeasured household category with lower occupancy rates, for whom switching to a metered supply will present a cost saving.

The household population forecast is summarised in the figure below. These numbers exclude the Hidden and Clandestine population, which is the population not captured in census data. This population has been fixed at the base year number (74,687) provided in *Clandestine and Hidden Populations* (Edge Analytics, 2020b) and is split between the measured and unmeasured households as described earlier.

Figure 4.9: Household population split between East and Grid SWZ

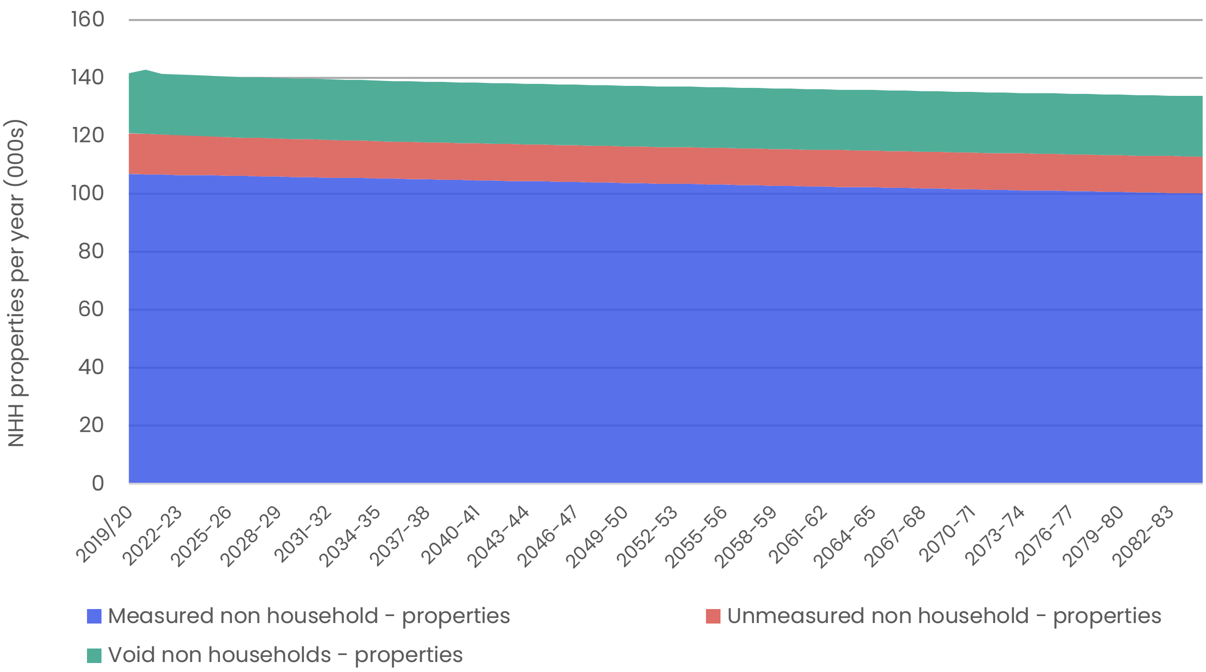


Non-households

– Measured non-household properties

The measured non-household properties are forecast based on estimated new commercial connections and demolitions/change of use properties, which are inferred from analysis of historical trends, that is, new connections and demolitions are based on our company records of connections and demolitions in recent years. The total number of measured non-household properties is forecast to decrease over the plan period as the number of demolitions / change of use properties exceeds the number of new commercial connections (Figure 4.10). The total measured non-households were then split between the water resource zones using the base year percentage split for this category.

Figure 4.10: Non-household property forecast



– Measured non-household population

The measured non-household population is the communal population, which was forecast in *Population and Property Forecasts* (2020a) at water resource zone level. A forecast of the 'communal' measured non household population (population resident in hospital, prison, care homes etc.) has been provided at a water resource zone and COA level. For the Grid SWZ, the population of a public sector facility in North Yorkshire was removed from the communal population as it has its own water supply.

– Unmeasured non-household properties

The unmeasured non-household property forecast is based on an observed declining trend in the annual water balance data. In WRMP19, the most appropriate forecast was assumed to be annual decreases of 200 properties for AMP6, and 100 properties from AMP7 onwards. This was to avoid too many properties being lost by the end of the planning period by extrapolating short-term reductions.

For WRMP24, we spoke to our non-household retailer team and asked for their advice on how best to profile the long-term forecast. The non-household team provided a profile of de-registrations, (that is, those properties that are no longer classified as non-household) reflecting a slowing rate over time, that is, 120 annually in AMP7, 50 annually in AMPs 8-9, 20 in AMP 10-11, and from AMP12 onwards no further changes. This would assume that all change is due to de-registrations. This also implies no shift from unmeasured non-household to measured over the period of the forecast.

Mixed-use properties, which are a sub-division of the unmeasured non-households, were calculated as a percentage of the total unmeasured non-households based on historic data.

– Unmeasured non-household population

Within the unmeasured non-household property category, only the mixed-use properties have a population associated with them. This population was calculated as the number of mixed-use properties multiplied by the unmeasured household occupancy rate.

Table 4-7: Unmeasured non-household population

Unmeasured NHH population (000)	2019/20 (end AMP6)	2024/25 (end of AMP12)	2029/30 (end AMP8)	2034/35 (end AMP9)	2039/40 (end AMP10)	2044/45 (end AMP11)	2049/50 (end AMP12)
East	0.09	0.08	0.08	0.08	0.08	0.08	0.09
Grid	2.65	2.62	2.61	2.61	2.65	2.69	2.75
Total	2.74	2.70	2.69	2.69	2.73	2.77	2.84

– New large commercial users

The approach to forecasting non-household consumption is described later in this section. Whilst modelling accounts for sectoral growth over time, it does not reflect specific new large commercial users. For WRMP24 we have considered planned non-household needs for large volumes that is not evident in the Route2 trend forecast. A company that produces soft drinks has requested a supply increase of 3.45Ml/d to be available by 2025 in North Yorkshire. This would make the company the second largest user in our supply area. This volume has been added to our demand forecast as it is not represented by the Route2 analysis. As well as this we have also considered the additional need for water due to the emerging hydrogen production sector and as such have considered a scenario whereby an additional 15 Ml/d is required by 2027/28 to support this as part of modelled optimisation runs. Any new large user of water could significantly impact our ability to deliver overall demand reduction and therefore should be excluded from our baseline. More information about our adaptive planning is covered in section 10.2

– Void properties
The household void property forecast is intrinsically linked to our billing retailer Loop's performance commitment, which had been set by Ofwat to reduce the total number of voids to 4.15% at the end of AMP7. The percentage reduction figures are shown below:

Table 4-8: Void property performance commitment

OFWAT void reduction PC				
2020/21	**2021/22**	**2022/23**	**2023/24**	**2024/25**
5%	4.33%	4.15%	4.15%	4.15%

We revisited the past 5 years' worth of available historic actual figures from 2015/16 up until the base year 2019/20. The starting point for the forecast is the base year at 20,835, with this increasing slightly in 2020/21 to address the economic impact of Covid-19 on NHHs and the closure of large businesses (22,228). The following years of the forecast have been flatlined at 20,900 to reflect the previous historic trends that were relatively stable.

Total population

The total population forecast for the plan period is summarised in Figure 4.11 and Table 4-9. These indicate that the Grid SWZ will see a percentage growth in population of 22% over the plan period, with 27% for the East SWZ.

Figure 4.11: Total population forecast

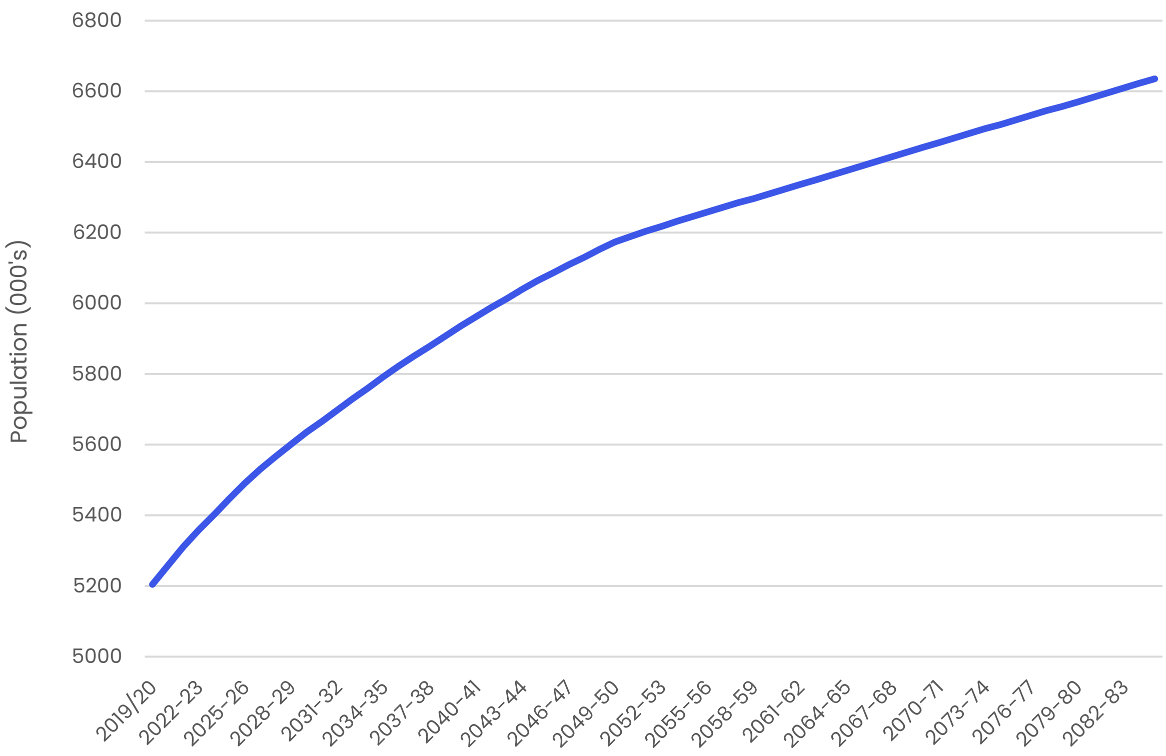


Table 4-9: Summary of total population forecast by AMP period (presented as thousands)

Population Forecast	2019/20 (end AMP6)	2024/25 (end AMP7)	2029/30 (end AMP8)	2034/35 (end AMP9)	2039/40 (end AMP10)	2044/45 (end AMP11)	2049/50 (end AMP12)
East	31.01	32.78	35.38	36.37	37.23	37.97	38.68
Grid	5,170.97	5,381.32	5,555.53	5,712.08	5,854.47	5,982.17	6,090.55
Total	5,201.98	5,414.10	5,590.91	5,748.45	5,891.70	6,020.14	6,129.23

Consumption

As stated earlier, consumption is the water used by a customer, which includes the volume used by the property and meter under registration but excludes supply pipe leakage. The following sections provide a summary of our approach to forecasting consumption into the future.

– Household consumption

The forecast volume of water used by household properties is calculated from PCC and population.

The household consumption forecast for WRMP24 has been based on 2019/20 data but uplifted in 2020/21 by 11.5% to reflect the impact of Covid-19 on customer demand. In 2021/22, an uplift factor of 4.41% has been added to consumption and 1.68% for the following years of the forecast. These adjustments allow for the short and long-term changes in behaviour due to Covid-19. Findings have been based on analysis of Yorkshire Water specific demand data and the finding of a water company collaborative project (*The impact of Covid-19 on water consumption during February to October 2020*, Artesia Consulting, 2021[29]).

– Household consumption model

We commissioned Artesia Consulting Ltd. to develop a household consumption model, which provides PCC for measured and unmeasured households throughout the plan period (*WRMP24 Household consumption forecasting – Multiple linear regression model* (Artesia Consulting, 2021b)). In line with relevant UKWIR methodologies, Artesia Consulting used multivariate linear regression modelling to validate historic demand data to create consumption models for our two water resource zones.

The multivariate linear regression models integrate drivers of future household demand, such as occupancy, property type, socio-demographics and meter penetration. The models can be used to test sensitivities of different parameters, such as meter uptake and maximum meter penetration.

Artesia Consulting validated their models using four different approaches:

- Firstly, the model was constructed using standard statistical methods from which uncertainty can be quantified.
- Secondly, the model was validated temporally, both within the trainer set and by applying the model to historic data and forecasting forwards to the current year and comparing with reported figures.
- Thirdly, the model was validated spatially at household level.
- Finally, the model coefficients were shown to be similar between models derived from different Yorkshire Water databases.

[29] https://www.artesia-consulting.co.uk/blog/Collaborative%20study%20report%20on%20the%20impact%20of%20Covid-19%20on%20water%20use%20published

In the preparation of our household demand model, we have chosen to segment our customers by meter status, property type, occupancy rate and socio-demographic profile. This is due to the availability of comprehensive data for these segments. We have not segmented by behavioural typology as we currently have insufficient customer information of this type available to allow us to do this. We therefore have not used the methodology described in *Customer behaviour and water use*: *A good practice manual and roadmap for household consumption forecasting* (UKWIR, 2012d) in developing our demand model.

Artesia Consulting combined observed micro-component trends with calculated endpoint scenarios to derive possible trends in water use. For example, the water efficiency of washing machines and dishwashers is improving, whereas frequency and duration of showering may be increasing.

From this they have derived potential scenarios of water use based on upper and lower trends.

- The **sustainable development** scenario assumes the current regulatory-driven efficiency in technology will continue beyond 2045, resulting in water use reductions that are currently not economically viable (10th percentile estimate)
- Conversely the **market forces** scenario assumes the projected trend in micro-components does not continue beyond 2022 (95th percentile estimate). This would be driven by the decoupling of UK building standards from current standards.
- The two calculated trends are considered by Artesia Consulting to be the extremes that represent the upper and lower bounds of the forecast. The observed trend was averaged with the sustainable development and market forces trend to give a **central** trend.

The central trend has been used as the forecasting trend within the measured and unmeasured household demand forecast. The central model outputs provide measured and unmeasured household PCC and per household consumption (PHC) forecasts for the planning period. Uplifts for climate change and dry year to the household PCC values as described. The PCC forecasts derived from the sustainable development and market forces scenarios have been included in our modelling of uncertainty for this plan (refer to our Allowing for Uncertainty (Headroom) Technical Report, which will be provided to the Environment Agency and made available on request, for details).

– Meter under-registration

Meter under registration is assumed to remain the same through the forecast period.

– Water taken unbilled

We estimate the volume of water taken unbilled annually as part of our water balance calculations. The total estimated volume remains constant at around 34.25Ml/d (3% of distribution input) each year. Therefore, the amount of water taken unbilled which includes void supply pipe leakage (5.84 Ml/d), and distribution operational use (2.37 Ml/d) is assumed to be fixed at the base year volume (36.62Ml/d) for the remainder of the 60 year plan period.

Historic water taken unbilled actual outturns show that these components stay relatively stable, with no obvious changes that would pose risk to the forecast.

Climate change

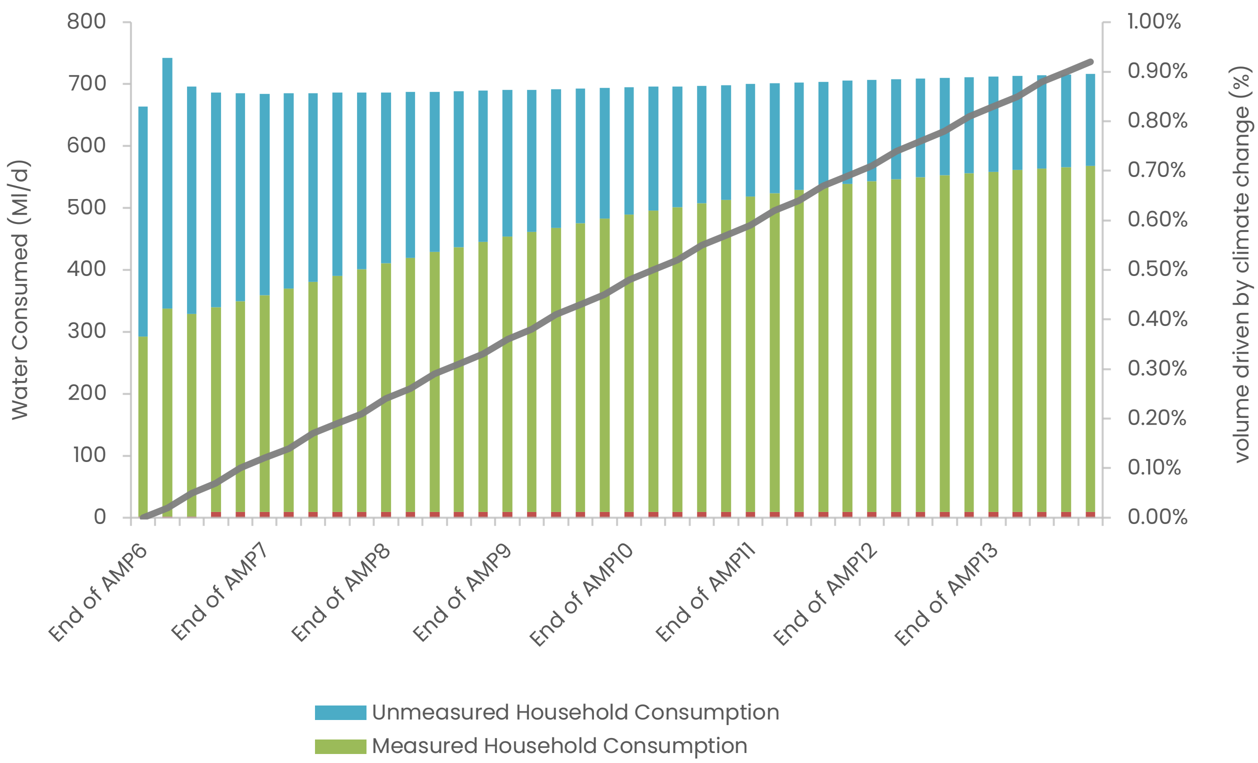
Following guidance from the EA, we have used the climate change scenarios[30] presented in the *Impact of Climate Change on Demand* (UKWIR, 2012c) to determine the potential impact of climate change on customer demand.

We have assumed that the Severn Trent scenarios are more appropriate to Yorkshire Water than the Thames Water scenarios, due to geographical and climatic similarities. We selected the Household Annual Average for the Humber North region as the most appropriate climate change scenario for the Yorkshire Water supply area. We also selected the mid-range P50 percentile scenario within the Humber North region as there is no evidence to justify use of the higher or lower ranges.

The Defra commissioned report *Climate Change and Demand for Water* (Downing et al, 2003) states that the major impact of climate change in north east England is likely to be on garden use and personal washing. Climate change has therefore been added on to these two micro-components of household demand.

The result is a forecast growth in household consumption due to climate change of 0 to 0.61% over the planning period.

Figure 4.12: Impact of climate change on household demand



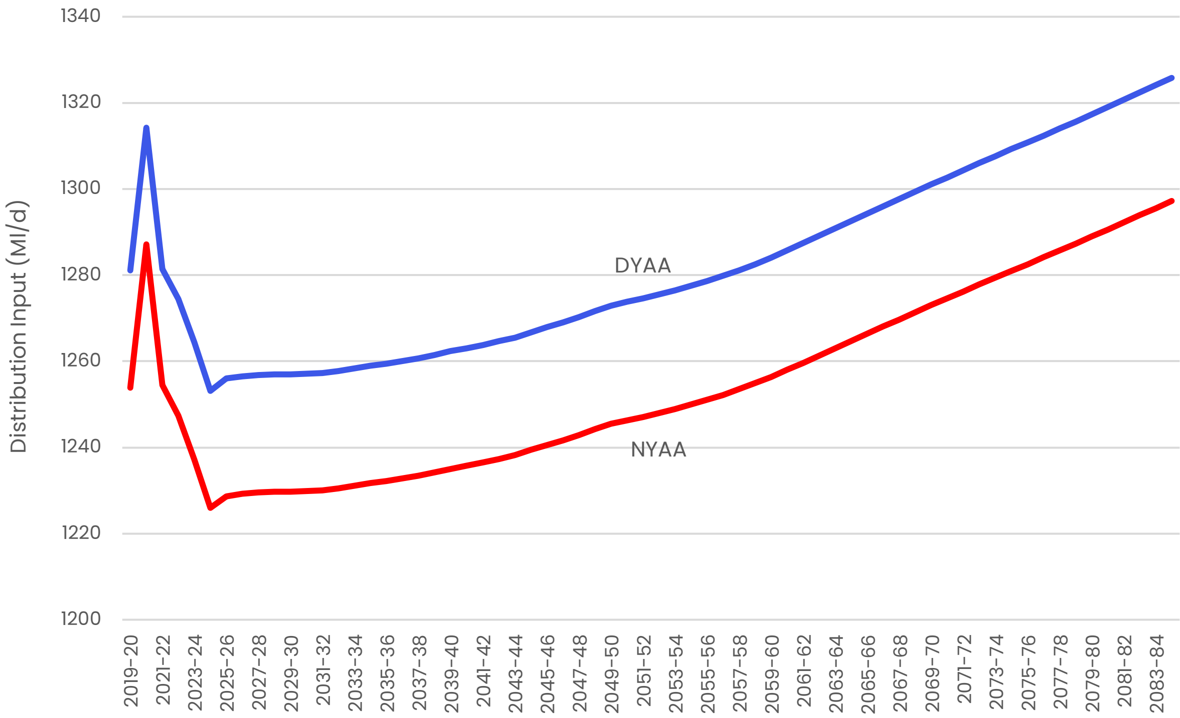
We have not added any climate change uplift to the non-household consumption. This is because there is no evidence of an impact on industrial demand. Equally, there is little potable water supplied for irrigation purposes in Yorkshire, and therefore, we are assuming no impact on agricultural demand in our region.

[30] These differ from individual climate change projections for UKCP18 used in supply forecasts. Scenarios were specifically derived in a study of climate change on demand, drawing on the previous UKCP09 climate change projections (a scenario reflects the outcome of analysis using the projections, or may be informed by multiple projections). The UKWIR approach is industry standard, and whilst older climate projections are used, the influence on demand for climate change is small in the context of the overall supply-demand balance.

Dry year effects

The methodology used to estimate a dry year uplift effect was described in Section 4.3. This value (2.09%) is applied as a percentage uplift to average PCC each year. The difference in normal year to dry year DI can be seen in the graph below at company level:

Figure 4.13: Comparison of NYAA Vs DYAA DI values



The WRPG specifically requests presentation of PCC forecasts against the equivalent normal year annual average (NYAA) forecasts, to allow an understanding of dry year influence on demand, and to enable direct comparison to business plan submissions and annual WRMP reviews. Data is required for each of the first five years of the plan, and every 5-years thereafter (provided at these intervals to the end of the statutory planning period only). Comparative tables of NYAA and DYAA based PCC are shown below.

Table 4-10: Comparison of Normal Year Vs Dry Year Annual Average PCC (Baseline)

Average Household PCC (l/h/d)	2019/20 (Base Year)	2024/25 (end AMP7)	2025/26	2026/27	2027/28	2028/29	2029/30 (end AMP8)	2034/35	2039/40	2044/45	2049/50	2084/85
Normal Year Annual Average (NYAA)	127.7	125.2	124.4	123.7	123.0	122.3	121.7	119.0	116.9	115.4	114.5	114.8
Dry Year Annual Average (DYAA)	130.4	127.8	127.1	126.3	125.6	124.9	124.2	121.5	119.4	117.8	116.9	117.2

Components of PCC

Currently approximately 54% of total households (including voids) are metered, and this number is increasing each year due to meter optants and new development. Unmeasured household PCC is forecast to decline due to increasing water efficient behaviour and ownership of water efficient appliances, such as dishwashers and washing machines. The forecast is for a slightly increasing measured household PCC driven by:

- those households that use more water gradually switching to a metered supply; and increasing numbers of low occupancy households, which have an associated higher PCC (proportionately higher water use per person due to use of appliances such as washing machines/dishwashers).
- The average household PCC is forecast to decline due to an increasing proportion of measured households (with associated lower PCC), increasing water efficient behaviour and use of water efficient appliances.

In compliance with the WRPG, Artesia Consulting produced a micro-component forecast which was developed from property survey data. This micro-component model allows us to report the breakdown of PCC into the following categories, as required for the WRP tables:

- toilet use;
- personal washing;
- clothes washing;
- dish washing;
- garden watering; and
- other use (includes plumbing losses, swimming pools, and drinking water).

Table 4-11 and Table 4-12 summarise the breakdown of PCC at the end of each AMP period.

Table 4-11: Breakdown of Grid SWZ PCC by micro component

Component	2019-20	2024-25	2029-30	2034-35	2039-40	2044-45	2049-50
Measured Household – PCC	**108.7**	**109.5**	**109.2**	**109.1**	**108.9**	**108.8**	**109.0**
Measured toilet flushing	26.6	26.8	26.8	26.7	26.7	26.7	26.7
Measured personal washing	42.6	42.9	42.8	42.8	42.7	42.7	42.8
Measured clothes washing	13.9	14.0	14.0	14.0	14.0	13.9	14.0
Measured dish washing	11.0	11.1	11.1	11.1	11.1	11.1	11.1
Measured miscellaneous internal use	13.7	13.8	13.7	13.7	13.7	13.7	13.7
Measured external use	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Unmeasured Household – PCC	**154.5**	**155.8**	**155.2**	**154.5**	**153.8**	**153.3**	**153.1**
Unmeasured toilet flushing	35.2	35.5	35.3	35.2	35.0	34.9	34.9
Unmeasured personal washing	56.5	57.0	56.8	56.5	56.3	56.1	56.0
Unmeasured clothes washing	19.2	19.3	19.3	19.2	19.1	19.0	19.0
Unmeasured dish washing	14.7	14.9	14.8	14.7	14.7	14.6	14.6
Unmeasured miscellaneous internal use	20.1	20.3	20.2	20.1	20.0	19.9	19.9
Unmeasured external use	9.2	9.3	9.2	9.2	9.1	9.1	9.1
Average Household – PCC	**130.4**	**127.8**	**124.2**	**121.5**	**119.4**	**117.8**	**116.9**

Table 4-12: Breakdown of East SWZ PCC by micro component

Component	2019-20	2024-25	2029-30	2034-35	2039-40	2044-45	2049-50
Measured Household – PCC	**108.3**	**108.5**	**107.8**	**107.4**	**106.8**	**106.3**	**106.1**
Measured toilet flushing	26.5	26.6	26.4	26.3	26.2	26.0	26.0
Measured personal washing	42.5	42.6	42.3	42.1	41.9	41.7	41.6
Measured clothes washing	13.9	13.9	13.8	13.8	13.7	13.6	13.6
Measured dish washing	11.0	11.0	11.0	10.9	10.9	10.8	10.8
Measured miscellaneous internal use	13.6	13.6	13.6	13.5	13.4	13.4	13.3
Measured external use	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Unmeasured Household – PCC	**162.4**	**165.3**	**164.8**	**164.4**	**164.1**	**163.9**	**164.2**
Unmeasured toilet flushing	37.0	37.7	37.5	37.4	37.4	37.3	37.4
Unmeasured personal washing	59.4	60.5	60.3	60.2	60.1	60.0	60.1
Unmeasured clothes washing	20.2	20.5	20.5	20.4	20.4	20.4	20.4
Unmeasured dish washing	15.5	15.8	15.7	15.7	15.7	15.6	15.7
Unmeasured miscellaneous internal use	21.1	21.5	21.4	21.4	21.3	21.3	21.3
Unmeasured external use	9.6	9.8	9.8	9.8	9.7	9.7	9.8
Average Household – PCC	**135.6**	**132.5**	**127.2**	**124.0**	**121.3**	**119.3**	**117.9**

Figure 4.14 and Figure 4.15 present the percentage breakdown of PCC into these micro-components. Each figure shows this breakdown for the base year and the final year of the plan period. Climate change, which affects personal washing and garden watering, alters the percentage splits year on year.

Figure 4.14: Percentage breakdown of measured household PCC – Base year vs 2049/50

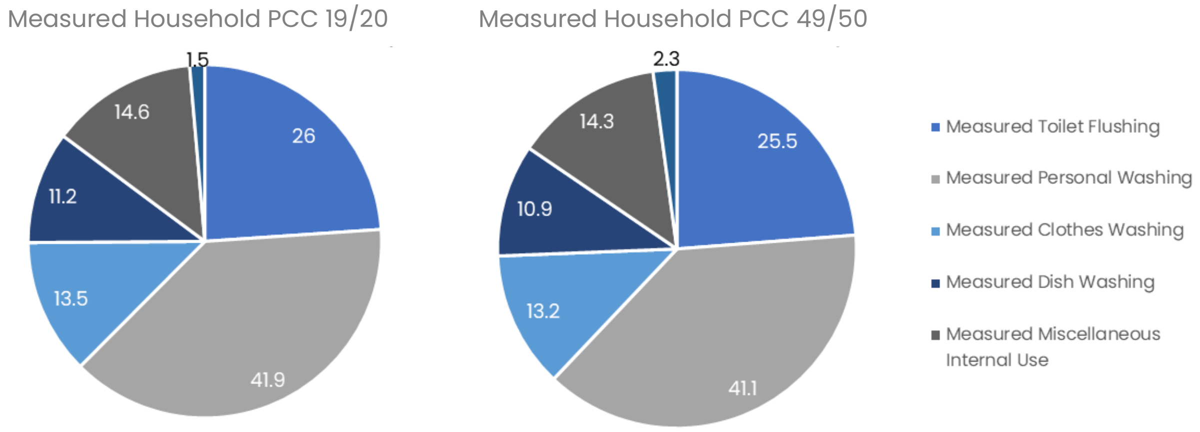
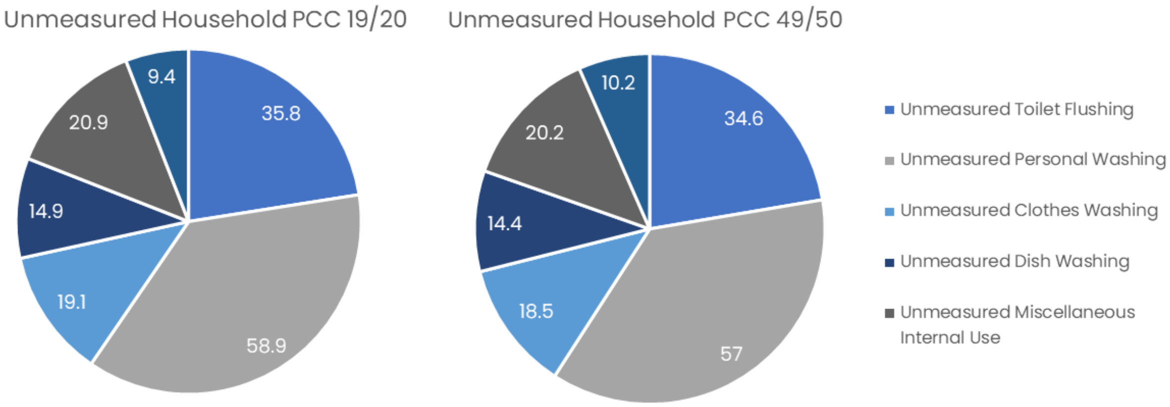


Figure 4.15: Percentage breakdown of unmeasured household PCC– Base year vs 2049/50



Clandestine and hidden consumption

The clandestine and hidden consumption is calculated in the same way as for the base year. It is assumed that the measured household clandestine and hidden consumption is captured by the water meters and therefore no additional consumption is included. For the unmeasured household clandestine and hidden population, consumption is calculated using the unmeasured household PCC.

Measured non-household consumption

There have been several changes associated with the measured non-household sector in recent years. The opening of the retail market has resulted in changes in customer classification. In developing our measured non-household demand forecast we have used a dataset that reflects the eligibility criteria regarding the measured non-household retail market in England.

As part of our preparation for market opening, we reviewed our measured non-household portfolio to ensure that all eligible customers are in the market. The demand dataset used to develop our forecast demand reflects the current eligibility criteria in historic measured volumes.

Measured non-household demand within Yorkshire has been broadly declining over the last 25 years. In developing our demand forecast we have looked seperately at the two categories of measured non-household customers, non-service (industrial) and service (commercial) sectors. A steady increase in total demand from the service sector has been observed, with a steady decline in total demand from the non-service sector.

The measured non-household consumption forecast has been modelled in-house (building on work with Route2 in WRMP19) using a multi-variate regression model for service and non-service demand. Updates to the model include more recent billing file data and insight to forecast non-household demand prior to completion of the model for the WRMP24.). This also incorporated the forecast impact of Covid-19 on non-household demand, including the forecast percentage of people working from home, changes in industrial ownership, as well as closures within certain business sectors.

As discussed in Section 4.3.7, our reported data showed measured non-houshold demand to be lower than we forecasted in 2020/21 and 2021/22. We have therefore adjusted measured non-household consumption in both zones to align with the reported data. We have made no change to future years' forecasts and this change does not impact on our WRMP24 investment plan.

We requested Artesia Consulting to review the non-household forecasting process and ensure that the non-household demand forecasts for the WRMP24 follows guidance correctly, with the process followed by other water companies, and by ourselves in the WRMP19. Artesia Consulting have been able to provide feedback on any areas where improvements may be necessary during the process. They have been involved with supporting many water companies around the UK, developing the non-household demand forecasts for the previous WRMPs and WRMP24 regional plans. Their input resulted in updates to the model for WRMP24.

Multi-variate regression analysis uses known values, known as 'independent' variables, to predict as unknown value, or 'dependent' variable. Water demand in the modelling is the dependent variable, with three independent variables used to determine future water demand. A variety of potential influences on long-term service and non-service sector water demand were considered. Of 120 independent variables explored, the top-three which best determined demand for each of the two sectors are summarised below:

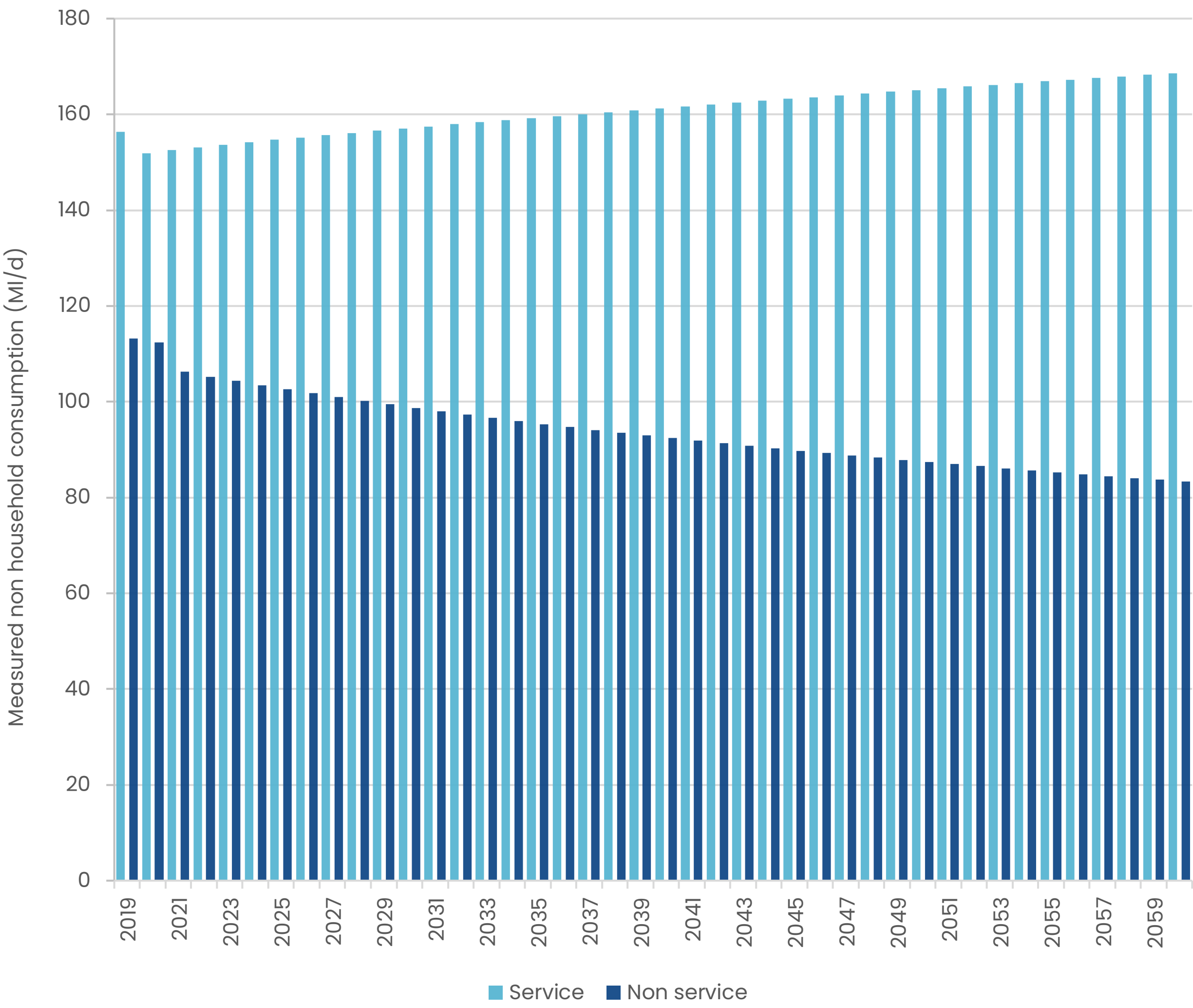
Table 4-13: Measured non-household forecast models

Forecast Model	Model 1 – Service sector	Model 2 – Non-service sector
Dependent Variable	Yorkshire Water service sector water demand (Ml/d)	Yorkshire Water non-service sector water demand (Ml/d)
Independent Variables/ Predictors	GDP / Capita (GBP) Labour Productivity in Service Sectors (Hours / Week) Total Energy Consumption in Service Sectors	Yorkshire Non-Service Sector Employment (No.) UK Multi Factor Productivity (Hours / Week) Petrol Consumption in Non-Service Sectors

In the development of forecasts there is an inherent level of uncertainty or inaccuracy in predictive modelling. To deal with this uncertainty, four scenarios have been used to assess the impact of key uncertainties on the forecasts. The four scenarios of consumption and governance; business as usual, heavy government, resilience and consumer power, were based on the *Water for people and the environment* (Environment Agency, 2009) report. Forecast demand under these scenarios has been included in uncertainty modelling for WRMP24 (refer to the Allowing for Uncertainty (Headroom) Technical Report, which will be provided to the Environment Agency and is available on request).

The scenario used for the demand forecast was rebased to our annual water balance data for the base year. A 5% dry year factor has been applied to measured non-household consumption based on modelling of demand in normal and dry years. We have considered that the model outputs do not acknowledge any large water users, which we will need to provide water to in the future, increasing demand. Consumption for specific new large users is applied to the non-household demand forecast. Information on any new non-household large users is provided by our customer experience team who are made aware of future plans.

Figure 4.16: Measured non-household consumption forecast



Non-household demand is split across service and non-service categories. “Service” use covers sectors including distribution, hotels and catering, transport, shops and office-based activity. “Non-service” comprises agriculture, energy, manufacturing and quarrying/minerals use. In Yorkshire we have approximately 84,000 service non-household customers and 34,000 non-service non-household customers.

We have also considered the potential impact of new customers swapping from a non-public water supply, such as salad growers requiring a potable water supply. This requirement has historically been minimal in Yorkshire, and it is considered unlikely to become a significant driver of demand in the future. As well as this we have considered the impact of the emerging hydrogen economy as an additional modelled scenario, whereby an estimated non-household demand increase of 15 Ml/d is needed by 2027/28.

Unmeasured non-household consumption

The estimated volume of water used by unmeasured non-households has been revised in line with best practice provided in *Consistency of Reporting Performance Measures* (UKWIR, 2017). The report recognises that this component is normally a small proportion of total non-household demand and suggests that an estimate of consumption is derived from a study of the consumption of Standard Industry Classification (SIC) equivalent measured non-households of similar SIC categories.

However, this would lead to a significant over-estimation in unmeasured non-household volume. This is because it is incorrect to assume that unmeasured non-household and measured non-households within a SIC category have similar water use. Unmeasured non-household properties have very low or irregular water use compared to measured non-households, and because of this fitting a meter at these properties is not cost-beneficial.

As these unmeasured non-household properties are traditionally seen as low consumers, the methodology was revised to limit comparison to metered non-households with similarly low water use. In WRMP19, a total unmeasured non-household consumption of 2.12Ml/d was estimated, with an estimated volume per property of 125l/prop/day (based on measured properties with water use of less than 0.349m3/day were considered, which was the current average unmeasured household consumption at the time). In our draft WRMP24 the unmeasured non-household consumption forecast was a constant value based on a base year unmeasured non-household consumption of 1.95 Ml/d (1.92Ml/d Grid SWZ and 0.03Ml/d East SWZ). This volume was assumed unchanged for the planning period.

For our latest report year (2022/23) we have assumed a higher volume for unmeasured non-household use. This is based on an external review of non-household consumption that used metered data to re-estimate the consumption for unmeasured non-households and provided a value of 679 litres/property/day (l/p/d).

In our final WRMP24 demand forecast we have used this volume from 2022/23 onwards. We have multiplied the number of non-household properties for each year of the plan by 679 l/p/d to provide the non-household consumption for each zone. The consumption is then adjusted to allow for meter under-registration. This is also based on the 2022/23 reported volume, which was 0.63Ml/d. This volume has been proportioned by the number of properties in each zone and added to the consumption for each year of the plan.

Table 4-14: Unmeasured non-household demand

Consumption	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
UMNHH	2.09	1.96	1.95	1.88	1.95	9.87

Meter under registration

Meter under registration is assumed to remain at the base year rates.

Supply pipe leakage

Leakage has been calculated based on achieving a 15% reduction by 2024/25, in line with our PR19 performance commitments and then flatlining for the remainder of the planning period in the baseline scenario. Further interventions are then considered as part of the preferred plan.

The forecast total volume of supply pipe leakage is directly linked to total leakage, in that after 2024/25 the baseline assumes no further enhancement in leakage reduction activities. Total supply pipe leakage has been estimated to be 24.89% of leakage total leakage in the base year in DMAs (or 28.36% for 2024/25, reflecting greater increases in the other components of leakage). Supply pipe leakage does vary slightly in future years, as it relates to the number of properties etc.

The supply pipe leakage volume is allocated to all properties based on estimated leakage rates for different property types and meter locations.

Our approach assumes that the supply pipe leakage rates for each property type remains broadly constant over the planning period. Supply pipe leakage varies between each cohort of the forecast, reflecting the forecast number of properties in each category. The proportions of internal and external meters are assumed to be constant over the plan period.

New Appointments and Variations (NAVs)

New Appointments and Variations are incorporated into the demand forecast by reducing the final plan components by the value stated in the draft NAV WRMP's. This ensures that the forecasted export volume, properties, and population are not double counted as growth within the household consumption forecast. This process is explained in detail in section 3.13.3.

4.5.2 Water delivered forecasts

This section presents the outcome of the forecasting of water delivered from the approaches described in the previous section.

Household water delivered

The forecast regional water delivered to household properties over the planning period is presented in Figure 4.17 and Table 4-15. The measured household water delivered is forecast to increase from 318.70 Ml/d in the base year to 591.12 Ml/d by 2049/50. This increase is a combination of increased property numbers (new build households and DMOs) and a small uplift due to climate change.

The unmeasured household water delivered is forecast to decrease over the planning period, from 412.38Ml/d in the base year to 180.39 Ml/d by 2049/50. This is due to a continuing trend of households switching to a metered supply.

Figure 4.17: Water delivered to households

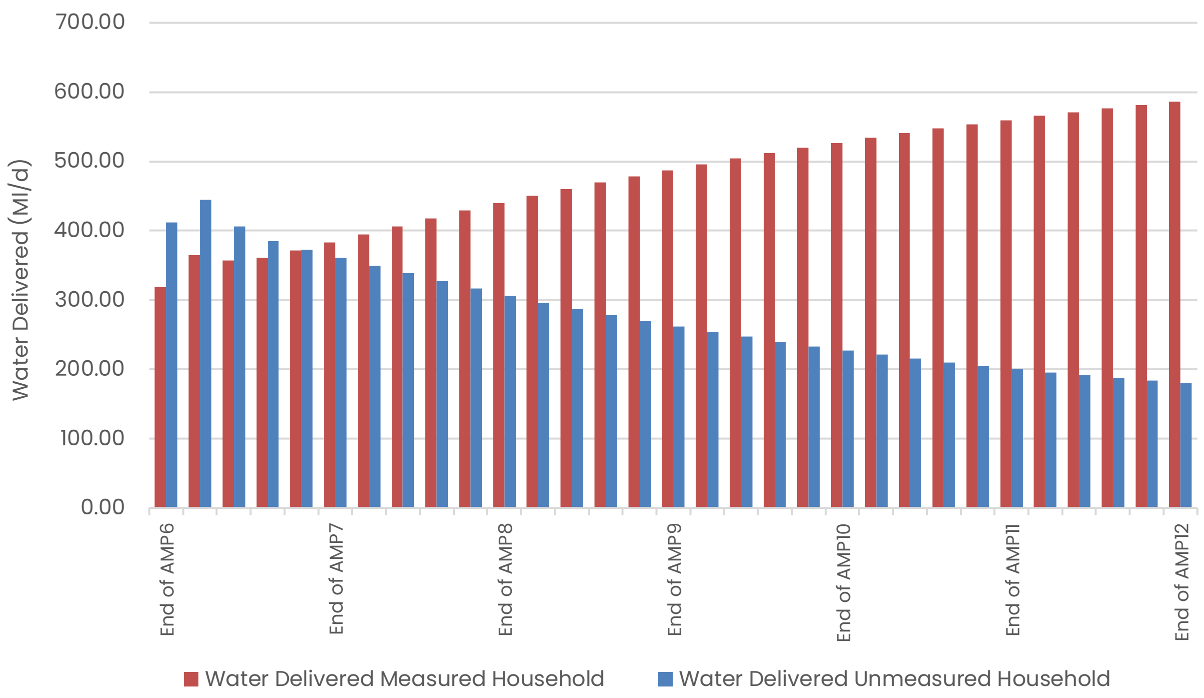


Table 4-15: Water delivered to households

Dry Year Forecast Water Delivered with Covid impact (Ml/d)	Measured Households		Unmeasured Households	
	2019/20	2049/50	2019/20	2049/50
Grid SWZ	316.63	582.74	409.64	179.01
East SWZ	1.77	3.49	2.74	1.38
Total	**318.40**	**586.23**	**412.38**	**180.39**

Measured non-household water delivered

Table 4-16 shows the decrease from the base year to 2049/50 for water delivered to measured non-households for covid impact in a dry year. This could be due to the economic effect the pandemic had on the non-household market.

Table 4-16: Water delivered to measured non-households

Water delivered measured non- household in a dry year with covid	2019/20	2049/50
Grid	285.08	270.71
East	1.45	1.36
Total	**286.54**	**272.08**

Unmeasured non-household water delivered

As discussed above in the section on unmeasured non-household consumption for our final plan has been updated to reflect latest reporting assumptions. This volume is added to supply pipe leakage to provide the water delivered volume. There is a decline in non-household demand as the number of unmeasured non-household properties reduce over the planning period, as shown in Figure 4.18.

Figure 4.18: Water delivered to unmeasured non-households

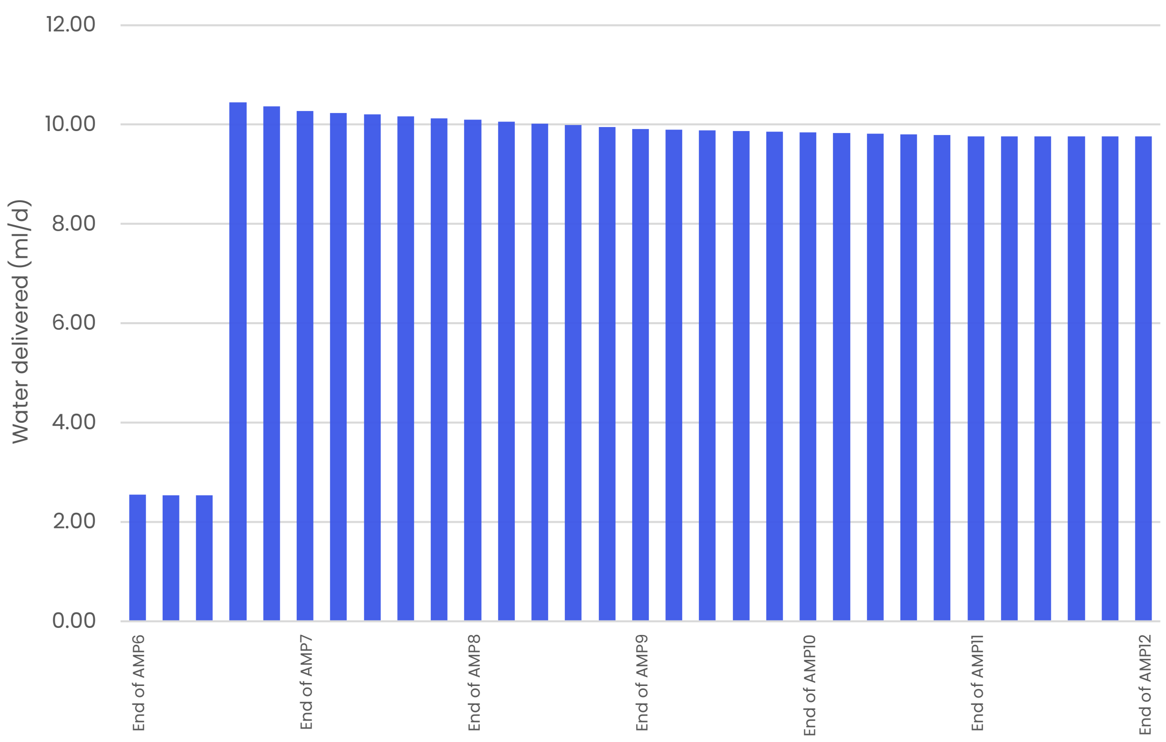


Table 4-17: Water delivered to unmeasured non-households

Water delivered unmeasured non- household in a dry year with covid	2019/20	2049/50
Grid	2.51	9.63
East	0.03	0.14
Total	**2.55**	**9.77**

Total water delivered

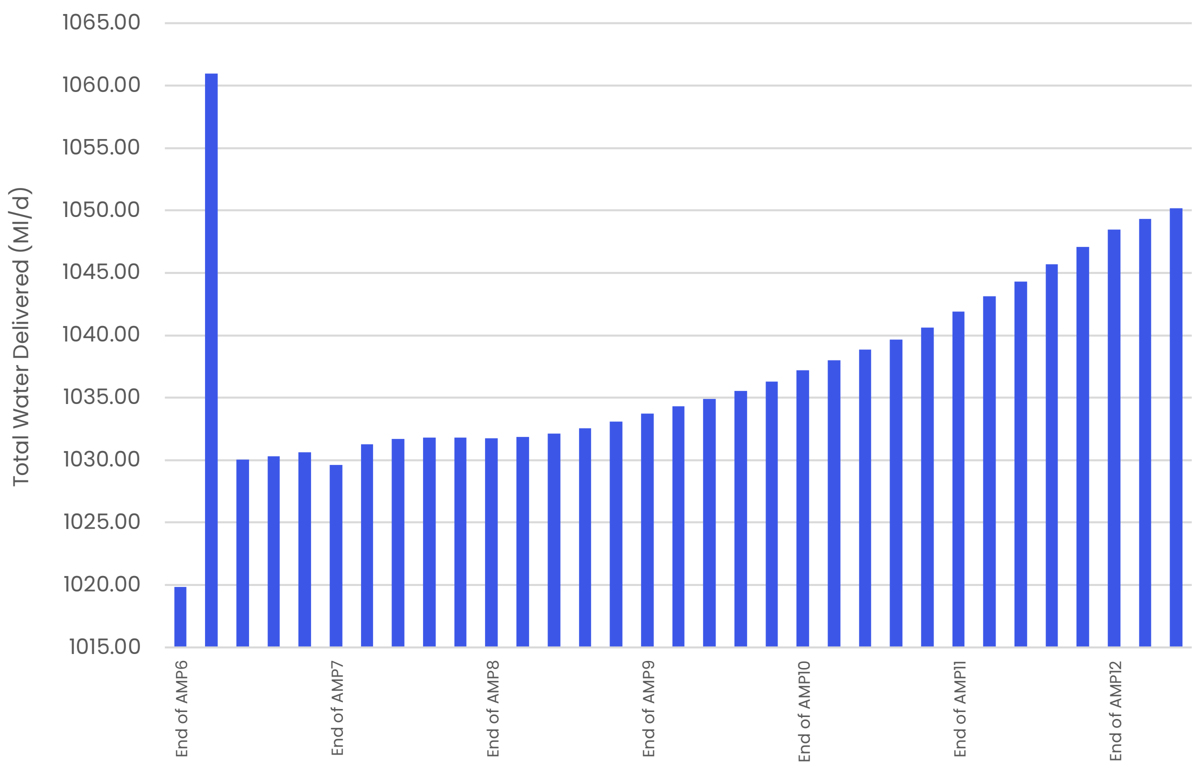
The total water delivered is the sum of water delivered to all properties (including voids) and unbilled water.

The water delivered to void properties (households and non-households) decreases over the planning period, from 5.85Ml/d in the base year to 5.61Ml/d in 2049/50. This is based on supply pipe leakage volumes and total property numbers.

Water taken unbilled is fixed during the plan period.

The total water delivered is forecast to increase slightly over the planning period from 1,054.49Ml/d in the base year to 1,087.64 Ml/d in 2049/50, as presented in Figure 4.19.

Figure 4.19: Total water delivered



4.5.3 Leakage forecast

In our WRMP24 baseline demand forecast we have assumed we will achieve the 15% leakage reduction by 2025 that we included in our WRMP19 preferred plan. Our WRMP19 included further leakage reduction to achieve a 40% reduction by the 2030s, then to continue leakage at a reduced rate until the end of the planning period, which was 2044/45 for WRMP19. The WRPG states that leakage should remain static from the first year of the plan (2025/26) throughout the whole planning period. We have therefore fixed leakage at 2024/25 values in the WRMP24 baseline forecast.

This is a change to previous plans, where baseline leakage was based on the Sustainable Economic Level of Leakage (SELL). This is the point at which the cost to repair leaks, including the carbon and social costs of leakage control, is equal to the cost to treat water including the social, environmental and carbon costs. At this point, there is no overall economic benefit in reducing leakage further. However, in practice our WRMP19 baseline leakage was static as we were operating at or below the SELL. If a water resource zone is found to be in deficit, we considered further leakage reduction as part of the solution to maintain the supply-demand balance.

4.5.4 Distribution losses

As discussed earlier, distribution losses comprise leakage from service reservoirs and trunk mains, plus the losses in DMAs which are not supply pipe leakage.

The leakage from service reservoirs and trunk mains for the base year was estimated as 60.55Ml/d. Leakage in DMAs, excluding supply pipe leakage 163.78Ml/d in the base year.

Distribution losses is assumed to be the difference in total leakage, minus the sum of all supply pipe leakage components. Then the proportional percentage of distribution losses in relation to total leakage is applied year on year throughout the plan.

4.5.5 Distribution system operational use

The volume of water used for distribution system operations (for example, mains flushing, service reservoir cleaning and water quality testing) is assumed to be fixed during the plan period at the base year volume (2.37Ml/d).

Historic actual outturns show that these components stay relatively stable, with no obvious changes that would pose risk to the forecast.

4.6 Baseline demand forecasts

Forecast total demand (distribution input) decreases slightly over the planning period from 1,280.82Ml/d in the base year to 1267.82Ml/d in 2049/50 and through to 2084/85, down to 1320.64Ml/d. Overall, demand is therefore expected to be relatively stable in the long-term from the 2019/20 base year and following the initial short-term impacts of Covid-19. A summary of distribution input is presented in Table 4-18[31].

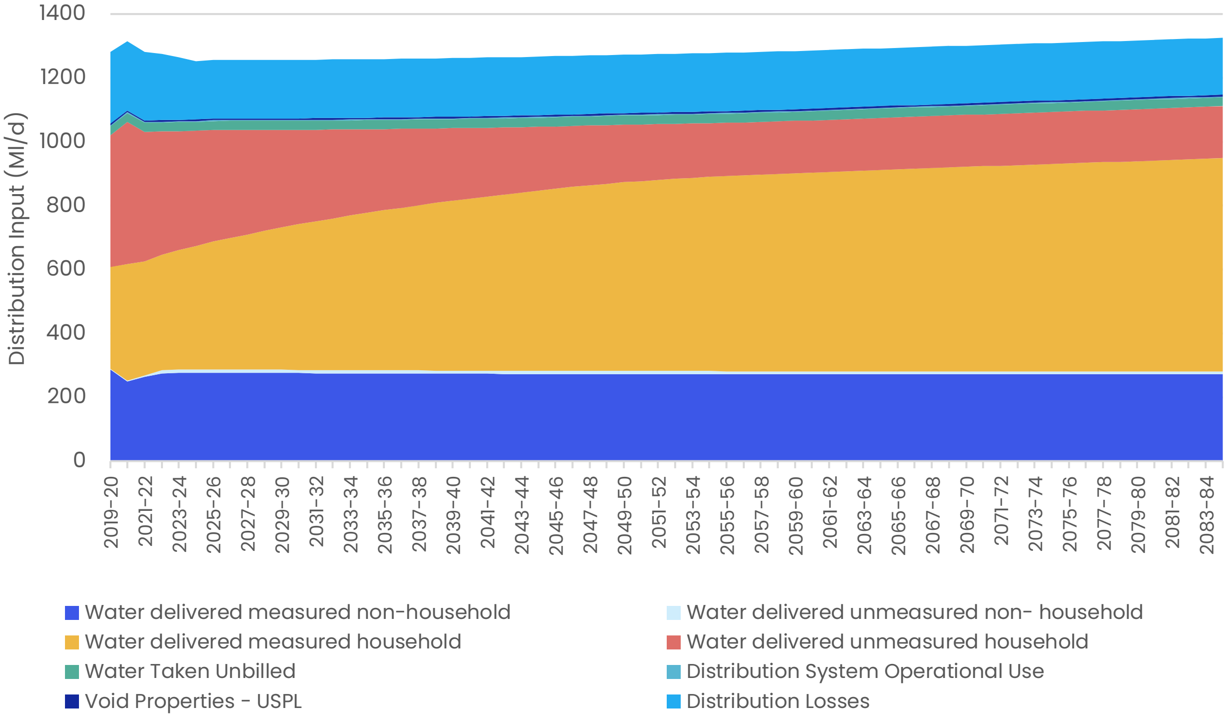
[31] The dates presented align to the dates shown for summary supply-demand data in other sections. 2019/20 and 2024/25 are specifically shown for the demand forecasting section due to their relevance. 2019/20 shows the base year position upon which forecasts are based, whereas 2024/25 is relevant as it incorporates the leakage target position (which for the baseline is maintained from this point into the future forecasts) before the WRMP24 plan period starts in 2025/26.

Table 4-18: Distribution Input for the Region (DYAA)

Distribution Input	2019/20	2024/25	2025/26	2030/31	2040/41	2044/45	2049/50	2084/85
East SWZ	7.18	7.41	7.47	7.51	7.50	7.51	7.53	7.88
Grid SWZ	1273.64	1241.51	1243.08	1243.93	1250.21	1253.99	1260.29	1312.76
Total	**1280.82**	**1248.92**	**1250.55**	**1251.44**	**1257.71**	**1261.50**	**1267.82**	**1320.64**

The overall breakdown of DI at Company level, by major component is shown below.

Figure 4.20: Distribution input (DI) over planning period, with major component breakdown



4.6.1 Normal year and dry year DI comparisons

The WRPG specifically requests presentation of DYAA forecasts against the equivalent normal year annual average (NYAA) forecasts, to allow an understanding of dry year influence on demand, and to enable direct comparison to business plan submissions and annual WRMP reviews. Data is required for each of the first five years of the plan, and every 5-years thereafter (provided at these intervals to the end of the statutory planning period only due to space in the main report). Comparative tables of NYAA and DYAA are shown below, noting consumption has been presented rather than water delivered in these tables to allow total leakage to be presented in line with the guidance requirements.

The baseline normal year forecast data is calculated using the same approach as the dry year annual average baseline. The difference is the dry year uplift is not applied to the normal year forecast as it represents demand during an average year where we may experience higher than average demand during the summer weeks compared to the rest of the year, but this would not be exceptionally high. The DYAA demand assumes demand is higher than most (normal) years and a dry year uplift is applied to the NYAA consumption. The dry year uplift data is based on demand experienced in 2018, our most recent dry year at the time of producing this report. The dry year effect is explained in section 4.3.5. The DYAA dry year effect is a 2% increase on household consumption, applied to both measured and unmeasured properties, and a 5% uplift on household consumption that is applied to measured consumption only.

We have reviewed our dry year factors to assess if there should be any change following the drought in 2022. This review did not suggest the uplifts should change and we have therefore applied the same percentage increases as used in the draft plan. This is discussed further in Appendix F.

Table 4-19: DYAA DI and breakdown – Company (as used in baseline supply-demand balance)

Distribution Input	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2034/35	2039/40	2044/45	2049/50
Measured non-household consumption	272.73	274.20	273.85	273.51	273.19	272.89	271.60	270.61	269.88	269.32
Unmeasured non-household consumption	9.70	9.67	9.63	9.59	9.57	9.53	9.37	9.29	9.23	9.23
Measured household consumption	351.94	362.07	372.89	383.37	393.67	403.89	446.81	482.92	512.79	537.09
Unmeasured household consumption	327.43	317.46	307.50	297.59	287.71	277.88	238.55	207.01	182.51	165.09
Water Taken Unbilled	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41
Distribution System Operational Use	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Distribution Input	1248.87	1250.49	1250.96	1251.15	1251.23	1251.28	1253.41	1259.93	1261.50	1267.83

Table 4-20: NYAA DI and breakdown – Company (equivalent data to WRMP24 forecasts for normal year)

Distribution Input	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2034/35	2039/40	2044/45	2049/50
Measured non-household consumption	259.60	261.00	260.66	260.34	260.04	259.75	258.53	257.58	256.89	256.37
Unmeasured non-household consumption	9.71	9.67	9.64	9.60	9.57	9.54	9.37	9.30	9.23	9.23
Measured household consumption	344.62	354.54	365.11	375.38	385.48	395.49	437.53	472.90	502.16	525.97
Unmeasured household consumption	320.70	310.94	301.19	291.48	281.81	272.17	233.65	202.76	178.76	161.70
Water Taken Unbilled	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41	28.41
Distribution System Operational Use	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Distribution Input	1221.71	1223.23	1223.69	1223.88	1223.98	1224.03	1226.15	1229.62	1234.12	1240.34

5 Reducing the Demand for Water

This section outlines our demand journey in AMP7 to date and the creation of our demand strategy for AMP8. In this section we also describe how we intend to continue promoting water efficiency to our customers and investigate new, innovative measures for reducing demand in the future.

5.1 AMP7 Demand Journey

5.1.1 Leakage

Yorkshire Water's leakage reduction target in AMP7 is 14.2% in year reporting terms for WRMP19 and 15%, based on a 3-year rolling average set in 2019/20 for Ofwat. Yorkshire Water has achieved its Ofwat performance commitment for leakage through the first three years of AMP7 year. Yorkshire Water delivered an in-year improvement in year 3 of AMP7, however this was 1% short of the WRMP19 target of 6.3%. This adverse year was due to climatic conditions in 2022/23 being very challenging for leakage reduction, with a very dry summer resulting in high levels of soil moisture deficit, which drive a summer leakage breakout period, followed by a colder than average winter providing a second leakage breakout within the same reporting year.

Yorkshire Water has based its WRMP24 planning on achieving the in-year leakage reduction as agreed with Defra in post convergence reporting methods. It is however, forecasted that by the end of the AMP Yorkshire Water may be adverse to plan by 2.7% (8Ml/d). This performance outturn is due to a funding gap as a result of the PR19 final determination. Following PR19 final determination Yorkshire Water challenged the PR19 financial allocation for leakage. The Competition Market Authority (CMA) agreed with Yorkshire Water's case that leakage reduction should be funded, however the funding granted at £28.6million was around a third of the requested funding to achieve the Ofwat 15% 3-year average leakage reduction target, and 14.2% in year WRMP19 target. This has resulted in a funding shortfall to deliver the required schemes for leakage reduction.

Planning for WRMP24 has assumed we achieve the in-year leakage target of 256.3Ml/d, with the potential performance gap being an ongoing risk, which Yorkshire Water will have to address through AMP8.

Table 5-1: AMP7 Leakage performance and AMP7 targets (convergence reporting methodology)

	AMP6			AMP7				
	2017-18	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**
In-Year Leakage performance	323	324.1	298.7	289.8	283.08	282.8	269.3	256.3
3-year rolling average leakage performance (Ml/d)			315.3	304.2	290.5	285.2	278.4	269.5
% Reduction In Year				3.0%	5.2%	5.3%	9.8%	14.2%
% Reduction WRMP19 target (post Convergence)				3.0%	3.7%	6.3%	10.3%	14.2%
% Reduction 3 Year Average				3.5%	7.8%	9.5%	11.7%	14.5%
% Reduction Ofwat Target 3 Year Average				3.4%	7.4%	9.4%	11.7%	15.0%

Yorkshire Water have delivered the leakage savings in AMP7 through a blended programme of active leakage control (including acoustic logging, upstream leakage management and advanced analytics), pressure management and through the introduction of smart meters as standard from 2023.

Underpinning the leakage interventions undertaken in AMP7, and the future options appraisal has been a focus on root cause analysis. Yorkshire Water is undertaking non-destructive condition assessments of assets, detailed network studies and proactive monitoring of the network to increase the effectiveness of interventions by identifying the cause of repeat failure, and better tailoring investment to reduce the likelihood of future failure. A prime example of this is pressure transient investigations, whereby identifying and removing short duration high impact changes in pressure can significantly reduce the frequency of pipe bursts and leakage.

5.1.2 Household and non-household demand

Yorkshire Water's PCC performance was industry leading across AMP6 and our performance has remained strong in AMP7. We out turned Year 3 with the lowest PCC in the industry for both our in-year and 3-year rolling average performance.

In WRMP19 the planned household options, which produced a PCC reduction of 8.9% across AMP7, was to be achieved through the volume of new meter optants and technology improvements throughout the AMP. Given this target was to be achieved through increased meter optants, only base funding was allocated for water efficiency activities, and no enhancement funding was received in AMP7.

The 8.9% reduction from the baseline in AMP7 was a jump from the PCC target in year 5 of AMP6 as outlined in Table 5-2 and we set an ambitious target for AMP7 but one which we were confident could be achieved from increased meter optants, technology improvements and the existing water efficiency offerings (including 'use less, save more' campaign and water saving devices) funded through base expenditure.

Table 5-2: AMP7 PCC performance and AMP7 targets

	AMP6			AMP7				
	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
In year MHH (l/h/d)	103.79	106.08	106.47	117.33	111.43	103.7	105.4	
In year UMHH (l/h/d)	152.02	151.88	151.36	169.27	155.87	149	152.1	
In Year PCC (l/h/d)	128.3	128.6	127.7	141.2	131.5	123.9	125.3	125.2
Rolling 3 year average (l/h/d)	132	130.5	128.2	132.5	133.4667	132.2	126.9	124.8
WRMP19 PCC Target	140.40	139.30	138.30	125.12	121.92	118.71	117.56	116.79

However, due to Covid-19, which started in March 2020, the step change in lifestyle of our customers resulted in a higher than forecast PCC outturn in 2020/21 and 2021/22 which impacted our ability to achieve our PCC target in those years.

Ofwat recognised the challenge of Covid-19 on the industry's ability to achieve their PCC target so following consultation they decided to freeze the outcome delivery incentive (ODI) performance measure applied to PCC in AMP7 and instead conduct an end of AMP review and apply an appropriate ODI measure based on level of performance.

The higher PCC in Year 1 and Year 2 of AMP7 resulted in an increased 3-year rolling average across AMP7 to date. We have seen reduced consumption in Year 3 and the forecast for Year 4 and Year 5 in the WRMP24 show we should outturn AMP7 lower than our 2019/20 baseline although this is still adverse to the targets set in WRMP19 as outlined in Table 5-2.

The non household performance commitment is commencing in AMP8 so during AMP7 there haven't been any initiatives delivered for non-household reduction but some small-scale trials for household reduction including flow regulators and household water efficiency audits have been conducted.

5.2 Creation of Demand Strategy for AMP8

5.2.1 Leakage

Yorkshire Water have created a 25-year strategy to achieve long term leakage reduction targets. This strategy is built on the principles of creating a Smart, Calm and Resilient Water Network, supporting efforts to reduce leakage, and bursts. This strategy aligns with the Water UK Leakage 2050 roadmap but moulded to the Yorkshire Water asset base and specific challenge.

Leakage reduction actions

Since committing to our WRMP19 leakage target we have been investing in our leakage reduction capabilities and solutions, whilst continuously assessing ways to improve both the number of bursts occurring each year and the efficiency of reducing leakage. Through AMP7 at a national level the leakage glidepath strategy has been developed and created a PALM methodology to categorise and group investments and demonstrate the blend of intervention types being undertaken to achieve the leakage targets. This framework is summarised below:

P= Prevent

- activities which are associated with asset rehabilitation, such as mains renewal, which will reduce burst rates and improve background leakage.
- activities which are associated with pressure management, whereby reducing pressure and changes in pressure, will reduce burst rates and the amount of water lost during a burst and as background leakage.
- activities which are associated with calm networks, identifying, and mitigating assets, customers, and network design, which may be causing accelerated pipe ageing and higher than expected burst rates.

A= Aware

- activities which are associated with establishing the insight that leakage or burst have occurred. This allows for better awareness time and prioritisation of resources to manage leakage.

L= Locate

- activities which are associated with establishing the location of the burst or leakage. This would incorporate assets, analytics, tools, and resources to reduce the time pinpoint the location of a leak ahead of undertaking a repair.

M= Mend

- activities which are associated with undertaking the repair of the network to reduce leakage.

To underpin this national strategy Yorkshire Water have developed a Water Network Strategy named Smart, Calm and Resilient. Together these strands enable improvements in leakage, water efficiency, asset health, water quality and interruptions to supply performance.

The WRMP strategy focuses mainly on the P, A and L elements of the national strategy, laying out Yorkshire Water's approach to improving efficiency and capability for leakage management.
The Yorkshire Water strategy is reviewed below and its alignment to PALM.

Smart, Calm and Resilient Strategy

Smart – aims to improve the visibility, timeliness, and accuracy of network performance understanding. This is underpinned by the ambition to move to a "Point of Interest" leakage strategy, whereby we can quickly identify bursts and leakage and optimally plan resource response and deploy to a specific location to pinpoint, resulting in <100 Meters of main needing to be surveyed to pinpoint the burst.

Alignment with Aware and Locate national leakage glidepath.

Calm- aims to manage water network pressure more precisely at a system level, minimising water loss and reducing pressure strain on the network which can cause bursts. It also looks to identify the root cause of network performance such as bursts caused by pressure transients.

Alignment with Prevent national leakage glidepath.

Resilient – aims to ensure asset health is maintained through network investment and by proactive monitoring and control of the network. Together this will provide capability to condition the system to a given performance level or provide the opportunity to remotely control network assets and mitigate the impact of a network event.

Alignment with the Prevent and Aware nation leakage glidepath.

The types of leakage intervention within the Smart, Calm and Resilient strategy are listed in Table 5-3.

Table 5-3: Leakage techniques to achieve the 50% policy reduction by 2050

Smart	Calm	Resilient
Fixed Acoustic loggers	Pressure reduction valve (PRV) installation	Mains Renewal
Lift & Shift Acoustic devices	PRV control & modulation	Service/Supply pipe renewal
Customer side lift & shift devices	Water Pumping Station modulation	Actuated valves
Customer Smart Metering	Transient logging	Remote PRV modulation
Trunk Main metering	DMA optimisation	City level network control
Satellite leakage detection Enhanced pressure monitoring	Boost to reduce network redesign	Proactive network conditioning
Leakage ALC analytics/AI platforms	Hydraulic Digital Twins	
Hydraulic Digital Twins & associated higher levels of network monitoring		
Acoustic AI platforms		
Fibre in Water		

All the options above have been included in the Yorkshire Water optimisation runs to create a bottom-up build of leakage reduction activities and glidepaths. The leakage options have been assessed to create a volume of leakage reduction opportunity in Ml/d, and a cost curve to achieve the reduction, which becomes more difficult through time. These cost curves have been used for planning and optimisation of the lowest cost plan, best value plan and common reference scenarios. Further optimisation using the options above occurred, using the RPS Strategic Optimisation of Leakage Options for Water resources (SoLow) tool.

In terms of phasing, the YW optimisation tool has been used to determine the leakage reduction strategy, to bridge the supply demand balance. For instance, that given the supply and demand options available the optimised feasible solution would be to reduce leakage by about 50%. The Solow tool was used to find the cost optimal delivery plan to achieve the required targets.

When creating leakage options scenarios have been created for 30-60% leakage reduction, considering a range of policy constraints such as mains renewal rates and metering policy. The SoLow model represents industry best practice for leakage strategy development, and includes all options for mains replacement, smart metering, and other interventions across the Smart, Calm, and resilient options. The output provides a yearly summary of the interventions chosen, the investment cost per year, the Ml/d reduction per year and cyclical maintenance and replacement needs for the continuation of leakage reduction benefits.

Yorkshire Water has two related strategies to delivering leakage reduction. They are our 10-year asset health strategy and our customer metering strategy.

A range of policy options were considered when creating the delivery plan for metering, including the phasing of the ambition, the use of compulsory metering and separate approaches for household and non-household customers. The choice of differing metering strategies considers multiple benefits outside of demand reduction such as C-Mex, BR-Mex, D-Mex and Operational Carbon.

For asset health, Yorkshire Water has an ambition to reduce the number of mains bursts through directed investment in mains renewal. This 10-year plan to improve network performance has multiple benefits outside of demand reduction such as water quality, interruptions to supply and C-Mex.

As such these aspects of strategy were developed in parallel to the WRMP leakage plan to ensure benefit maximisation and cost efficiency were achieved. The preferred policies were then included for final optimisation within the demand reduction delivery plan.

5.2.2 Household and non-household customer demand reduction strategy

This section describes our new water demand reduction strategy and how we intend to drive future water demand reduction through customer behavioural change, targeted interventions, technological advancement and playing our part in the industry.

Demand reduction and water efficiency are an integral part of planning for water resources resilience into the future. Water companies have a duty to promote efficient use of water to all customers. The importance of demand reduction is increasing as climate change and population growth impact our ability to effectively manage the water resources.

In recent years, we have been active contributors in national forums which seek to ensure water supplies remain resilient, drought impacts on customers are alleviated and water efficiency is driven. We currently co-chair the National Drought Group (NDG), chair the Retailer Wholesaler Group (RWG) Drought Group and participate in the Waterwise water efficiency strategy steering group.

Working with Waterwise alongside our regulators, including Defra, Environment Agency, Water UK and MOSL, we will play our part in embedding water efficiency into our demand management strategy to ensure a sustainable supply of water for our customers in the future.

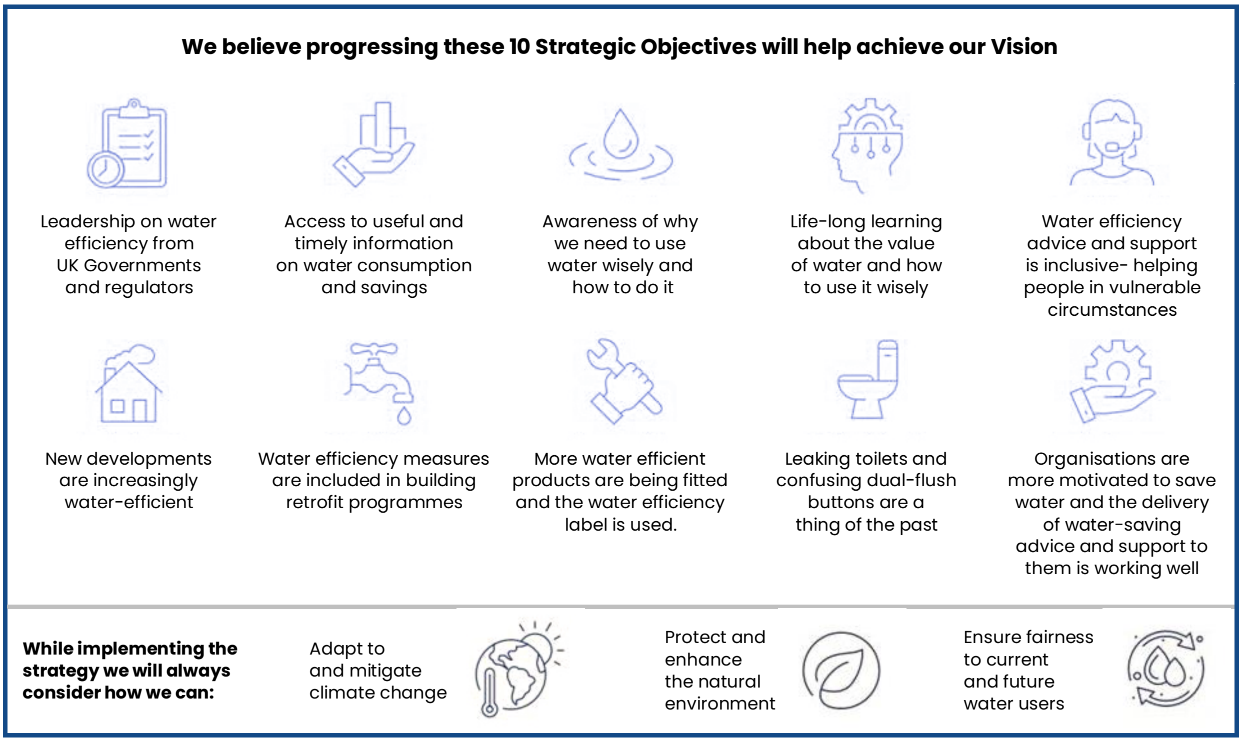
Our long-term strategy for household water efficiency across all water companies nationally is to achieve a PCC target of 110 l/h/day by 2050. The non-household business demand targets set by the UK Government are a 9% reduction by 2037/38 and 15% by 2050[32].

Reduction in household and non-household consumption will provide sustainable benefits to water demand reduction, as evidenced in this WRMP, which will help to ease the pressure on the water environment and the forecast of future supply-demand deficits.

For PR24, we have created a new long-term water demand reduction strategy which is overarching across all customers including household, non-household, and developers. In preparing this new strategy we have:

- designed our proposals to meet the requirements of UK Government Policy including as set out by Defra and Ofwat,
- carefully considered feedback from all stakeholders from the draft WRMP,
- completed an extensive review of external evidence and literature,
- benchmarked with other water companies,
- created an internal water demand reduction forum bringing together a variety of skills and expertise from across the business which includes household, non-household, smart metering, developer services and regulatory change,
- worked with a specialist consultant, exploring a variety of initiative options which have then been prioritised based on costs and benefits,
- ensured alignment with Waterwise's UK Water Efficiency Strategy (2022)[33].

Figure 5.1: Waterwise 10 Strategic Objectives outlined in their UK Water Efficiency Strategy to 2030

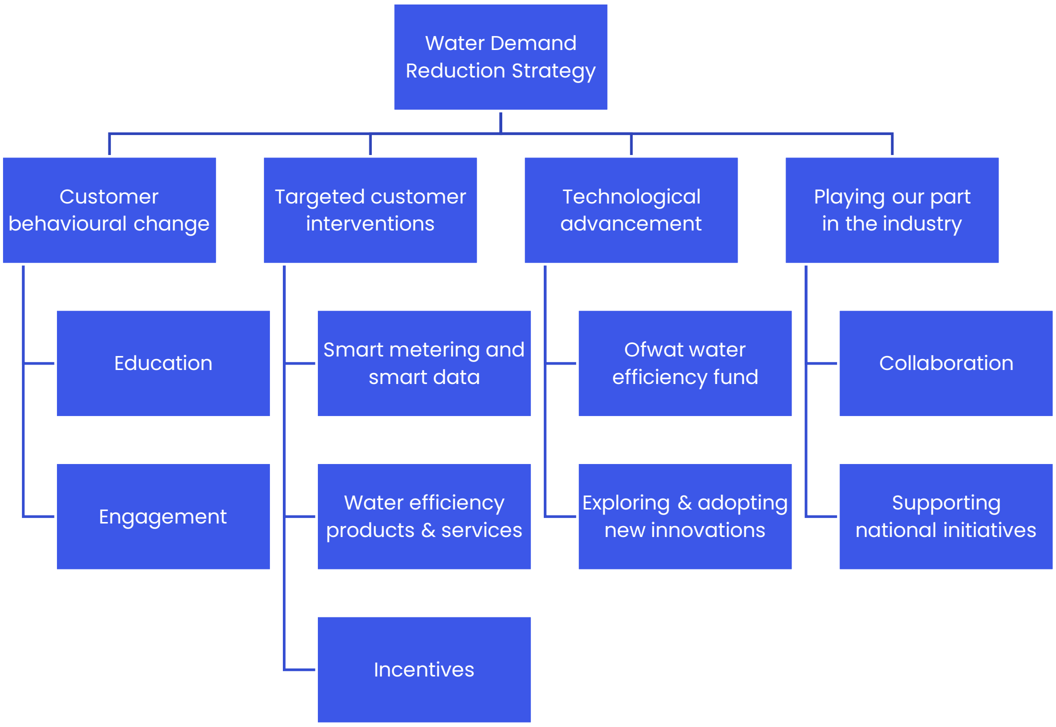


32 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1168372/environmental-improvement-plan-2023.pdf page 105

33 https://database.waterwise.org.uk/wp-content/uploads/2022/09/J37880-Waterwise_Water_Efficiency_Strategy_Inners_Landscape_WEB.pdf

The framework of our new long-term water demand reduction strategy is outlined in the chart below:

Figure 5.2: New Water Demand Reduction Strategy Framework



We outline below the four main components of our new long-term water demand reduction strategy before covering a greater level of detail in the household and non-household sections below.

Customer behavioural change

Customer behaviour is key in how we will manage demand and we already know that various factors influence how customers use water including price, psychology, social-demographics, and contextual determinants[34]. The price of water is affordable compared to other utilities such as gas and electricity and therefore we cannot rely on price alone to nudge customer behaviour in the right direction.

Our approach will therefore be to educate and engage with customers. We will continue to educate customers on the value of water, starting with school children who, after all, are the water consumers of tomorrow. We will continue to engage with customers on water efficiency via multiple channels, including a substantial and sustained media campaign.

UKWIR research on the Drought 2022[35] shows clear evidence of water demand reduction following water company communication campaigns so we know that targeted customer engagement works. Our customer engagement will be tailored to different customer segments and will be carefully targeted, tracked and monitored to maximise its impact.

This work will be delivered by a collaborative approach through our internal Water Demand Reduction forum attended by colleagues with a cross section of skills and expertise in water efficiency, communications household retail services, and wholesale market services.

[34] https://database.waterwise.org.uk/wp-content/uploads/2019/09/D6.1_Study_of_consumer_behavior_v1.0.pdf
[35] https://ukwir.org/review-of-2022-drought-demand-management-measures-summary-report

Targeted customer interventions

– Smart meters enabling effective interventions
Key to customer interventions is our plan to roll out smart meter to customers which will provide the identification of water efficiency opportunities as well as the ability to clearly measure the success of any associated interventions. Smart meters will provide the granularity of the right data at the right time to support the following:

- A GDPR compliant data platform that will allow data to be used for a number of purposes and made available to a number of internal teams, customer segments and other stakeholders as required.
- The creation of a number of business rules which will identify customer intervention opportunities.
- A new customer portal which will enable customers to track and monitor their own consumption.
- A new customer and premise data field which will be populated where evidence is identified of a water efficiency intervention being carried out.

- How we will use smart meters to drive water demand reduction
Smart meters will support us in effectively identifying demand reduction opportunities which will then be referred through to our enhanced water efficiency service. This enhanced service will include water efficiency smart water visits and provision of water efficiency devices to all customer types. These services will be targeted on the interventions that drive the greatest efficiency gains and will be adapted over time based on the evidence we collate.

To supplement the above we will also provide financial incentives to some customer groups to drive water efficiency in areas where the standard smart water visits isn't the right approach, e.g., water efficiency incentives to developers and non-household retailers and customers.

- Other metering considerations
We operate a free meter optant scheme, details of the scheme are provided to customers on our website. This includes a water use calculator to allow customers to calculate their likely water bill on a metered supply.

Water savings are typically seen after the installation of a meter, due to the increased financial incentive to use less water. A forecast of domestic meter optants is included in the demand forecast. Further details are provided in section 4.5.1 of this WRMP.

For new properties, Yorkshire Water is adopting a policy of future proofing by installing AMI smart meters as standard from 2023 outlined in section 8.4, allowing for the potential for the turning on of the smart capability in the future if the business case is positive to encourage water efficiency and reduced water waste.

Metering is instinctively an appropriate method of charging for water and sewerage, based on payment for use. However, metering is expensive to deploy compared to unmeasured billing and would significantly increase customers' bills through the additional cost of the meter, a replacement cost every 10 to 15 years and the ongoing operating costs of servicing a measured account. The cost of metering coupled with a policy of maintaining an element of customer choice, results in a continued policy of demand led (meter optant) household metering in Yorkshire.

As many of the automatic meter reading (AMR) solutions, which we have installed since 2010 are expected to become life expired due to the limitations of battery life within the AMR device, Yorkshire Water are assessing the potential to retrofit the meters with an AMI smart device, again future proofing the next 15 years reinvestment in metering solutions, to achieving leakage and water efficient gains. This is dependent on whether the business case is positive, and the AMI is subsequently turned on into smart mode.

We are currently considering multiple metering strategy options including smart metering and change of occupancy compulsory metering. We have included a smart meter retrofit, new build and optant installation programme as part of our solution to achieving the 110l/h/d policy requirement (see section 8.4). We have not included change of occupancy compulsory metering, as further work is needed to understand customer views, the benefits, and the wider implications. The metering strategy will be developed further and consider broader AMP8 commitments for the PR24 Business Plan. The business plan and final WRMP24 will be aligned once both plans are complete.

- Selective metering
Selective metering is the installation of meters at existing billed household properties where a customer has not chosen to have a meter fitted. Under the Water Act 1991, we can selectively meter properties when there is a change of occupier or at properties that meet certain criteria for water use. For example, if the water supply to a property is used to automatically refill a pond or swimming pool with capacity greater than 10,000 litres or for watering a gardening with a fixed irrigation system.

Currently we do not have a policy of selective metering in either circumstance, therefore we have no associated water savings for this category.

- Technological advancement
The creation of an Ofwat Water Efficiency Fund[36] signals that there is a need to stimulate a transformative, sustained, and measurable reduction in water demand nationally, using a range of water efficiency approaches. As well as providing feedback to Ofwat via the recent consultation we commit to exploring opportunities to submit bids to this new fund using in-house and external expertise and working with our partners.

The Ofwat fund will not be available until April 2025, so in the meantime we will explore other funding opportunities via the MOSL Market Improvement Fund and the Waterwise UK Water Efficiency Fund. We will share industry insight on technology through our internal water demand reduction forum and seek out opportunities to adapt our business approach accordingly.

In conjunction with our partners and stakeholders, we will seek out opportunities to pilot and trial new technologies and will share the results with other water companies through existing industry forums. We will work with Developers to assess the viability of new non-potable water solutions to reduce the impact of new emerging industries.

- Playing our part in the industry
Water demand reduction is a shared national challenge, and it is important that we play our part in contributing to the wider industry. We will continue to collaborate with a range of stakeholders in driving water demand reduction including Ofwat, Defra, Waterwise, Environment Agency, the non-household market operator MOSL, and non-household retailers.

We will seek being active on national forums and nominate company delegates and chairs where appropriate. Internally as we have already outlined, we will continue to operate our internal Water Reduction Demand Forum which is made up of a number of colleagues from across the business representing different customer groups which provides a wide range of expertise to ensure the right level of focus drives Demand Management across the business, for example ensuring we are efficient in water use at our own operational and administrative sites.

We will review resources focussed on water demand reduction and ensure we have the right focus across all customer segments including non-household. In addition, we will continue to support national initiatives, such as water labelling, if and when required to maximise their impact in our region.

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[36] https://www.ofwat.gov.uk/ofwat-accelerates-action-on-water-efficiency-with-new-100-million-fund/

5.2.3 Household customer water efficiency

Understanding how our household customers use water and their overall consumption is key to help us help our customer to reduce their demand by reconnecting them with water. We currently promote our water saving message to household customers through our current water efficiency initiatives.

When aligning to our long-term demand management strategy, to achieve our 2050 target for PCC of 110l/h/d per day, we need to include other initiatives beyond the existing base activity which provide demand reduction benefits to enable us to achieve our 2050 target.

Between draft WRMP and revised draft WRMP, Yorkshire Water engaged RPS to conduct a thorough review of all available household options which could be applied between 2025-2050 to help deliver our long-term PCC target by 2050. These options are discussed further in sections 8.4 and 10.2.

Customer behavioural change

Customer behavioural change starts and is sustained with communication and education. We need to communicate water efficiency messages with household customers and provide them the tips on how they can reduce their consumption. In addition to communicating with customers, we also need to educate them, which starts with providing them water saving tips, but stretches further by engaging with children and educating them on the importance of reducing our water use.

Understanding household water consumption and promoting our water saving message to customers is evidenced in our current water efficiency initiatives summarised below:

- Behavioural change – we have several channels in place for promoting water efficiency behavioural changes through:
  - Water efficiency section on our website which includes information on water efficiency, tips to reduce water use and our water use calculator.
  - 'Use Less. Save More' campaign providing water saving tips for home and garden including a 4-minute shower playlist and self-audit leaflets (https://www.yorkshirewater.com/your-water/save-water/).
  - My water use pilot, which measures customer's water consumption and evaluates their usage in comparison with their neighbours with similar house sizes and occupancy.
  - Green Classroom school pack and visits to our four education centres across Yorkshire.

- Education

We continue to offer visits to our four education centres[37] across Yorkshire. During these visits, attendees are taught about the water cycle, shown where they use water in the home and provided opportunities to reduce water consumption.

Examples of our existing education programme and teaching resources are included at https://www.yorkshirewater.com/education. We provide a Green Classroom school pack[38] with details and activities on understanding the water cycle, where our drinking water comes from and calculating how much water they use and provide tips for saving water.

Providing water efficiency education directly in schools as part of the curriculum would ensure a greater coverage across Yorkshire. We are exploring the option to work with schools by providing a visit to their school where a water efficiency workshop session is conducted during the day. Conducting face-to-face sessions would help to reinforce the understanding of the principles of water efficiency and the message to sustainably reduce water use.

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[37] To gain an insight into our education centres, including promotional videos, please see https://www.yorkshirewater.com/education/teachers/headingley/ and https://www.yorkshirewater.com/education/teachers/ewden/.

[38] https://www.yorkshirewater.com/media/lp3ftuf3/childrens-work-book_0.pdf (Lesson 3 - Water use)

Figure 5.3: Example educational materials and promotions

- Engagement Strategy

Our approach to communicating water saving to people in Yorkshire has evolved over the years and using that learning, insight, and research we have a robust campaign approach.

Research conducted in 2018 told us that customers were more likely to get on board with messaging and change their behaviours around water usage when the advice feels achievable, and they can understand why there is a need for change. It also highlighted the need to tailor messages to certain segments of customers, for example a financial benefit is more likely to prompt some people to make changes, versus other segments where the environmental benefits can cause a greater change.

Alongside insight into how we should deliver our campaign, we use data on reservoir levels, rainfall, and demand to set triggers on message escalation. At each escalation point we have a suite of red, amber, and green messages that we are able to target at different areas of the region across multiple channels that we choose based on demographic information. This approach allows us to increase and decrease the message severity to have the most impact, at the right times and across the right channels.

The campaign which we call 'Use Less. Save More', uses messaging and creative that speaks to customers in the right tone of voice, feels relatable and includes enough of the 'why' (explaining why we need to save water) as well as practical, achievable tips that most people can apply in their everyday lives.

Figure 5.4: Examples of our customer water saving leaflet as part of our 'Use Less, Save More' campaign

We have a comprehensive media plan that we can activate that includes digital channels, social media, out of home advertising, broadcast advertising and experiential events.

Some of the more dynamic channels in our media plan, such as social and digital advertising allow the flexibility to be able to switch the messaging on ads depending on the weather, for instance: we have referred to 'There's not been much rain lately' or 'No need to water the lawn, there's been a bit of rain.'

This helps customers understand the link between rainfall, the impact on our reservoir levels and how they can help. Whereas our more traditional less dynamic channels help us to reach large numbers of customers with more generic messaging.

Supplementing our paid-for marketing activity, we develop content plans that help us create news 'hooks' for regional and national media titles and organic content across our social channels that all aim to drive great engagement with the topic of water saving.

Targeted customer interventions

The key to reducing water demand is ensuring we have accurate data that evidenced where our water is being used so we can work with customers with higher consumption and encourage them to reduce water use by providing products and services which facilitate this reduction.

- Smart Metering & Smart Data

Many of the existing automatic meter reading (AMR) solutions, which we have installed since 2010 are expected to become life expired due to the limitations of battery life within the AMR device, Yorkshire Water has assessed the investment options to achieve the long-term targets for leakage, PCC, and non-household demand.

The result is that smart metering is a central part of this plan, contributing to over 20Ml/d of demand reduction through AMP8.

We have commenced our AMR smart meter deployment on all new developments and domestic meter optants in 2023. Of the existing circa 1.5 million metered properties in Yorkshire Water's operational area approximately 1.39 million will be at the end of their life in AMP8, as the AMR battery is expected to fail in AMP8 (10-15 year expected asset life).

As such a significant asset replacement programme is required to maintain service so we are planning on exchanging 1.39 million AMRs across AMP8 and installing 0.19 million new meters through domestic meter optants & new developments. 1.28 million of the 1.39 million meters will be on households, with the remaining 106,000 meters being non-household properties.

The introduction of AMR smart meters from 2023 will unlock data of an improved granularity to the existing data offerings from our AMR meter stock. To accompany this policy change, systems and analytics are being put in place to realise the benefit from smart meters, such as identifying continuous flows.

This enriched data from the smart meters is an enabler to ensure that we identify the most suitable household customers when implementing water efficiency initiatives in AMP8.

If we effectively utilise the data and identify customers with high consumption, there is potential to increase our total benefit realisation from each initiative which could enable us to achieve our long-term targets sooner than forecasted.

In addition to utilising the AMR data to inform areas or household customers who would benefit from a water efficiency initiative. Metered customers will have access to their consumption data to connect them to their water use and help communicate which of their habits are water demanding and which are water efficient.

This transformation programme, enabling significant demand reduction, is subject to required levels of investment granted through the PR24 process from Ofwat.

Throughout AMP8, our metering and smart metering teams will continue to work closely across AMP8 to ensure any opportunities to incorporate demand reduction in their strategies are realised and ensure that demand reduction is included in any adaptive planning.

- Water Efficiency Products & Services

We have previously offered customers free water saving devices which they can request via our website. The water saving products available are a shower regulator, 4-minute shower timer, buffalo cistern bag and LeakyLoo detection strips with install instructions. Customers can select which products they would like to receive, and these products are then self-installed.

Uptake of free water saving packs and products is evident across our region, with over 30,000 units being requested and sent each year to our customers, who self-fit the products in their homes.

In July 2023, we have extended the existing offering by commencing a trial of the Save Water Save Money's 'Get Water Fit' platform which allows customers to register on the platform and complete a questionnaire to gain an understanding of water use in their home, providing them tips to reduce their usage and request free water saving devices.

However, we won't achieve our PCC target for household customers solely through the implementation of water saving devices, as the measured savings from these products isn't as much as previously thought. The saving per property from water saving products is circa five litres per property per day (l/p/d), compared to around 50 l/p/d previously assumed. This can, in part, be attributed to the fact that customers ordering the free packs do not necessarily fit the products.

Therefore, in 2023 we are restarting our water efficiency audit and product retrofit service pilot. Between 2018 and 2020 we delivered a pilot project where we offered customers a home water audit and installation of water saving products applicable to their property. This pilot was stalled in 2020 due to Covid-19 and the inability to enter customers' properties.

Once the pilot is complete, if it is successful, we will include smart water household visits and virtual visits as part of the wider water efficiency strategy to reduce demand for water. During the visit a technician will either visit properties face to face or conduct this virtually, fit the appropriate water saving devices for that property and discuss ideas with the customer on ways to reduce their consumption.

- Incentives- Housing Developers
Population in the UK is rising, and we are forecasting the development of around 20,000 new build properties per year from 2025, decreasing to closer to 10,000 further into the planning period. This increase in households in Yorkshire will increase future demand for water and put pressure on our wastewater network and treatment processes if we do not invest in new assets and infrastructure.

To reduce the requirement for investment in new assets and infrastructure, we work with developers and provide an environmental incentive which reduces the infrastructure charges on each home they build if they can evidence that it was built to water consumption level of less than 110l/h/d.

If a developer can evidence that they have built a home to 110l/h/d or lower, they receive a 20% discount of their water and foul water infrastructure charge. We are hoping to develop this further by increasing the discount but reduce the consumption levels further to align with our long-term targets for PCC.

This further reduction would be a more aggressive strategy, but we believe that the increased incentive to reduce their infrastructure charges would encourage more developers to operate to the Integrated Water Management (IWM) principles and reduce usage through step changes in water supply to homes.

To do this we would need additional funds to offset the reduction in infrastructure changes and the costs of implementing a metric to check that the new developments achieved the target when they apply for the grant.

In further support of this target, Yorkshire Water have adopted a smart as standard approach to new development metering, meaning from 2023 all new developments will be fitted with a smart meter. The inclusion of smart meters will help to identify continuous flows and help communicate to customers which of their habits are water demanding and which are water efficient.

Technological advancement
Whilst the interventions discussed above are useful and help to reduce demand, they are soft measures to reduce water use based on behavioural change or from installing water saving devices in customer's home. To meet our long-term target for PCC reduction the need to introduce SMART technologies and install more water efficient devices is imperative.

- Ofwat Water Efficiency Fund
Ofwat are introducing a water efficiency fund of £100M in AMP8 and the framework of that fund has been used to share the new strategy for demand reduction. Yorkshire Water will work collaboratively with other water companies and partners to explore innovative ideas for water efficiency and demand reduction, so we are able to submit suitable bids to obtain funding to reduce water use.

We have previously submitted bids as both the lead water company or as a supporting partner on bids submitted by other water companies for the Ofwat innovation fund. However, the introduction of the water efficiency focused fund will enable collaboration across the industry in tackling demand and the need for customer to reduce consumption.

- Exploring & Adopting New Innovations
We conducted a 'my water use pilot' in 2022/23 which measured customer's water consumption and evaluated their usage in comparison with their neighbours with similar house sizes and occupancy. The data used in this pilot was smart meter data from meters which had been installed in an area in Sheffield.

In September 2023, we are commencing a trial in Leeds of flow regulator installations on 1000 household customer properties to reduce their flow and capitalise on the reduction in water use. This measure means that customers don't need to change their behaviour as this product is installed on the supply pipe at the customer boundary, so they continue to use water in the same way.

The potential saving of the flow restrictor has been estimated to be at circa 22l/h/d so the realised benefits from installing 1000 in the trial could reduce water use significantly with no change on customers' water usage behaviour. If the trial is successful and we realise the expected benefits, we have plans to install these devices on new build homes and offer these to a proportion of meter optants and existing metered properties.

Playing our part in the industry

Yorkshire Water already have employees who attend, and chair water efficiency groups and forums attended by representatives from across the industry. We are an affiliated partner with Waterwise who organise the Water Efficiency Strategic Steering Group (WESSG) which is currently chaired by MOSL.

Within this strategic group we work together in task and finish groups in alignment with Waterwise's strategic objectives so we can share learnings cross industry to ensure we are able to achieve our long-term target for PCC of 110l/h/d by 2050.

In addition to attendance at task and finish groups we also share learning from water efficiency initiatives which have been trialled by us or other water companies so we can ensure that any innovation or technologies that we plan on trialling have consumption reduction benefits.

5.2.4 Non-household water efficiency

Since retail competition was introduced for non-household customers, the relationship with the customer has changed from being direct with Yorkshire Water to more indirect as the retailer is now responsible for most customer interactions.

Despite this during AMP7 we have delivered the following initiatives: promoting water efficiency to non-household customers and working in collaboration with retailers; established and continually updated a new dedicated web page for non-household customers which has business tailored water efficiency advice; offered free 'save a flush' cistern bags which are available to all businesses; ran a Water Saving Promise Campaign where we incentivised businesses to ensure they were efficient with their water use; offered an industry leading value added meter reading service to retailers, provided granular consumption data services to non-household customers and retailers, e.g. data loggers; were represented on the RWG Water Efficiency Group; and sponsored or co-sponsored several water efficiency Market Improvement Fund Projects (LIDA Project and Project Discovery).

Whilst these initiatives are useful, insight from the non-household market through the Retailer Wholesaler Group Water Efficiency Subgroup has noted that customer willingness to pay is below the efficient cost to supply these services. Market participants require £22m of funding[39] to achieve the 9% non-household demand reduction targeted by 2038 by Defra. Therefore, driving real improvements in water efficiency remains a challenge.

As we transition into AMP8 we see the introduction of the new Business Demand Reduction performance commitment which helps to define roles and responsibilities within the market structure and provides the much-needed opportunity to secure funding to support Yorkshire Water in meeting its targets and ultimately promote resilience of supply for the whole customer base.

In order to work towards the targets, set out for 2038 (9% reduction) and 2050 (15% reduction), Yorkshire Water has worked collaboratively with stakeholders from across the business, enlisted the expertise of a specialist water efficiency consultant and taken into account feedback shared through multiple PR24 and WRMP forums and mechanisms. We are seeking to deliver a suite of new initiatives within AMP8 which will allow us to supplement our existing activity and make significant headway against these targets whilst also optioneering initiatives for future AMPs.

[39] https://www.economic-insight.com/2022/06/14/increasing-water-efficiency-in-the-nhh-water-retail-market/

Given the relationship between non-household customers and water companies is less direct since market opening, as we referenced above, the approach we will take will aim to be collaborative and supportive to the needs and requirements of all stakeholders across the market. We will consult with retailers on our intended approach and adapt our plan based on feedback we receive.

Yorkshire Water will seek to introduce initiatives which support the four pillars of our demand reduction strategy referenced at the beginning of this section.

Customer behavioural change

Non-household targeted media campaign

As we move into AMP8 and beyond, we will work to build on and enhance our media campaigns to support the raising of awareness around the needs to adopt water efficient practices and mentalities. We will continue to provide advice, guidance and learning tools to all non-household customers but will go one step further by targeting non-household customers and customer groups through a significant and sustained media campaign. We feel by tailoring and targeting this campaign will can make a significant difference by ensuring our campaigns drive maximum impact. Given the varying needs of non-household customers, many using water for similar purposes as a domestic customer but others using water for business specific processes, it is key to ensure we tailor our content so we can provide relevant advice and information to all non-household customers, from micro business to our largest users.

Figure 5.5: Examples of previous communications shared with customers as part of our 'Use Less, Save More' campaign

Targeted customer interventions

Non-household smart metering

A key enabler of several initiatives listed in this document is smart metering. Smart meters will support a cultural change to the way in which water usage is viewed by non-household customers through increased granularity and availability of consumption data. Yorkshire Water intend to continue to provide meter reading services and additional services related to the provision of granular consumption data in order to support customers understand their usage, quantify the impact any water efficiency interventions may have and identify leakage. The increased availability of the granular consumption data captured by our smart meters will give Yorkshire Water the opportunity to accurately baseline and monitor consumption which will support a targeted approach to water efficiency initiatives and proactively notifying customers when something doesn't look right e.g., constant flow notifications etc.

Business Smart water visits – schools, leisure centres and hospitality

Business Smart water visits will be offered to specific customer types, whereby water efficiency experts will provide tailored audits and advice to businesses on changes they could make, both physical and cultural, to reduce their usage. These audits will also include where applicable identifying leaks and retrofitting water saving devices tailored to that property. These visits will be targeted at sectors where evidence from Thames Water suggests there is the greatest opportunity to reduce usage, e.g., sport and leisure facilities, education establishments and the hospitality sector.

Business Smart water visits – domestic use

Business Smart water visits also be offered to business customers where water use is similar to that used by domestic customers, e.g., kitchens, toilets, showers. Our approach here will be similar to the smart water household visits providing a water efficiency audit and accompanying interventions albeit we will consult on our approach on this with non-household retailers.

Subsidised retrofits of rainwater harvesting for large users

Specific to our customers who have the largest usage, we propose to offer subsidies for the introduction of retrofitted rainwater harvesting solutions. Many of our largest users will have processes which don't require potable water. To utilise alternate methods of supply for such activities will help support the resilience of supply for all customers and be beneficial for Yorkshire Water's performance against the targets set out by Defra & Ofwat.

Water retailer & non-household customer incentives

We recognise that water retailers have a huge part to play in supporting non-household customers and Yorkshire Water in achieving the targets set out. Water retailers are the key to the relationship with the customer and a collaborative effort between all parties will likely see improved take up and action. In recognition of this we propose to offer incentives to water retailers to support us on our journey of sustainably reducing their customer's usage in AMP8 and beyond.

In addition to water retailer incentives, we will explore options to incentivise non-household customers to make changes to deliver significant and sustained reduction in their water usage. Furthermore, we recognise from a non-household customer and water retailer perspective consistency of approach towards incentives will be key. In view of this we will seek to collaborate with the industry to drive a national approach to incentive schemes and in doing so hope to remove unnecessary complexity from this key deliverable.

Technological advancement

We will actively seek to explore new and emerging technologies to help support deliver our commitments around business demand reduction. We are keen to trial new and innovative ways of driving water efficiency to make sure they are, first and foremost right for our customers and their needs but also to ensure they deliver a return on investment to give non-household customers in Yorkshire the confidence we're investing wisely.

In addition to technological solutions, we will carefully consider other areas such as tariff-based changes which may help support cultural change and awareness around water usage. This isn't an option we will implement in AMP8 but we are conscious that the existing tariff structures are not aligned with environmental needs and therefore changes should be carefully considered. As with many of the initiatives we've detailed above, another reason why we're keen to consider our approach to tariffs is due to the differing needs of business customers. Changes to tariff structures will impact micro businesses differently to the largest consumers and therefore we must carefully consider the potential impact to non-household customers of all sizes and come up different approaches that treat all customers fairly based on their needs and circumstances.

Furthermore, we welcome the news of Ofwat's new Water Efficiency Fund which is being set up to support measurable reduction in business and residential demand. Yorkshire Water will seek to prepare and submit innovative bids with the hopes of being able to supplement the good work we've already set out to do over the forthcoming AMPs. We will also consider other funding opportunities such as MOSL's Market Improvement Fund and the Ofwat Innovation Fund to help with the development of new and exciting initiatives and sharing best practice with the wider industry to support optimised customer outcomes.

Playing our part in the industry

Yorkshire Water will commit to working with stakeholders across the industry to explore new and innovative approaches to business demand reduction. We will continue to support the good work which is happening collaboratively in industry forums to drive consistency of approach and importantly the ease of application and adaptation for non-household customers. Yorkshire Water will ensure we continue to maintain and build on our current representation and leadership of national industry groups. Yorkshire Water currently chair the Retailer Wholesaler Group (RWG) drought subgroup, we also sit on the Waterwise Water Efficiency Strategy Steering Group and are represented on a number of water efficiency specific working groups.

Further information on our plans for household and non-household demand reduction in AMP8 and our option selection process can be found in section 8.4 and our best value plan for household and non-household demand reduction is discussed in section 10.2.

6 Allowing for uncertainty

Our plan includes a headroom allowance to provide a buffer between forecast supply and forecast demand. Headroom is an accepted concept in the water industry to define a planning allowance to account for uncertainties that could have a permanent impact on the water balance in the future. The headroom planning allowance is separate to the outage planning allowance, as outage accounts for temporary reductions in supply. For WRMP24 we are also taking an adaptive pathway approach to address uncertainties that could drive us to deliver a different solution to that needed to close the baseline deficit.

6.1 Target headroom allowance

Our supply and demand forecasts are based on a single future scenario (sometimes loosely referred to as the 'most-likely' scenario) for the dry year annual average and critical period assessments. Once we have addressed any deficits as part of our WRMP process, if the future follows the forecast expectations, we will have an adequate supply of water to meet future demand. However, it is impossible to predict the future precisely. There is potential for the future to be more extreme than our baseline forecasts, which creates a risk of under investing, or less extreme, which creates a risk of over-investing.

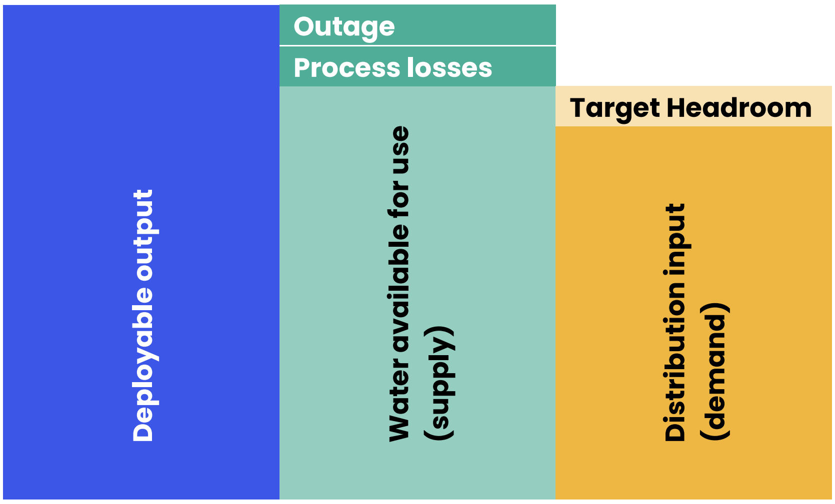
To allow for uncertainties, the supply-demand balance calculation includes a headroom allowance to account for the future turning out differently to our forecasts. The headroom allowance is a buffer between our supply and demand forecasts, calculated from an assessment of the range of uncertainties on key components of the supply-demand balance.

Separately from target headroom, major or large-scale uncertainty areas are tested via supply-demand scenario testing, which is also used to identify adaptive pathways. Adaptive pathways address more fundamental uncertainties that could trigger a change to our plan at some point in the future. These are described separately in Section 10.

The target headroom risks are aligned with the approach defined in An Improved Methodology for Assessing Headroom (UKWIR, 2002b) and we include risks that are relevant to our individual zones. The risks are related to data inaccuracies, climate change uncertainty and water quality. The target headroom allowance represents the combined impact these risks could have on the baseline supply-demand balance and provides a buffer between the forecast supply and demand. This buffer ensures that any inaccuracy in the forecasts does not create a risk that supply cannot meet the demand over the 60-year planning period.

Figure 6.1: shows target headroom as a component in the supply-demand balance. We must ensure WAFU is greater or equal to distribution input plus target headroom throughout the planning period. If WAFU is less than distribution input plus target headroom, measures must be taken to ensure the deficit will be met.

Figure 6.1: Supply-demand balance components



We undertook a problem characterisation as detailed in Section 2.9 to confirm the appropriate method to adopt for the headroom assessment. As for previous plans, we have calculated target headroom following the UKWIR guidance *An Improved Methodology for Assessing Headroom* (UKWIR, 2002b) and used a stochastic model to produce an estimate of target headroom at a range of percentiles. This is included in the *WRMP 2019 Methods – risk-based planning guidance* (UKWIR, 2016f) as an accepted methodology for calculating target headroom.

For WRMP24, we have worked with other companies in the WReN regional group, to align technical approaches adopted for target headroom assessments where feasible. For example, we have aligned distributions for the climate change and demand headroom components. However, individual resource distributions have been applied to represent the specific risks and will vary within resource zones as well as companies.

Further detail on our approach to uncertainty is provided in a supporting document Allowing for Uncertainty (Headroom) Technical Report, which will be provided to the Environment Agency and is available on request.

6.2 Headroom components

The UKWIR 2002 headroom methodology prescribes a probabilistic approach to assessing headroom, applying probability distributions to individual headroom components. We use a stochastic model (Crystal Ball software) to derive the target headroom for the 25-year planning period then fix the allowance in the latter stages of the planning period. Headroom components are based on known risks to supply and collated in consultation with key Yorkshire Water staff.

Headroom components can be divided into two categories, those that represent the uncertainties in the supply forecast, and those that represent the uncertainties in the demand forecast. We consider headroom components for each water resource zone individually, to provide target headroom values for the dry year annual average scenario for each zone.

Table 6-1 shows the headroom components we considered for each zone based on the UKWIR 2002 methodology. In accordance with the WRPG, we do not include uncertainty due to the risks of future reductions in abstraction permission on surface water or groundwater sources. Known reductions have been included in our deployable output forecast. The guideline also states that we “should not include uncertainty related to non-replacement of time-limited licences on current terms.” We therefore assume that our time-limited licences will be renewed on expiry unless there is a known reason for change at renewal, and this would be addressed in the deployable output assessment. Components S1, S2 and S3 are therefore excluded from the assessment for both resource zones.

Table 6-1: Headroom components assessed for each water resource zone

Headroom component	East SWZ	Grid SWZ
S1 Vulnerable surface water licences	✗	✗
S2 Vulnerable groundwater licences	✗	✗
S3 Time limited licences	✗	✗
S4 Bulk transfers	✗	✓
S5 Gradual pollution	✗	✓
S6.1 Accuracy of supply side data	✓	✓
S6.2 Process losses	✗	✓
S8 Climate change impact on supply	✓	✓
D1 Accuracy of sub-component data	✓	✓
D2 Demand forecast variation	✓	✓
D3 Impact of climate change on demand	✓	✓

6.2.1 S5 Gradual pollution

We have identified 14 groundwater headroom risks due to pollution. This includes nitrates, pesticides, saline intrusion, bacterial contamination, and Cryptosporidium. Some sites are affected by more than one risk, and interdependencies are accounted for in the headroom assessment to ensure no double-counting.

6.2.2 S6.1 Accuracy of supply side data

Data accuracy impacts on the overall headroom for each zone. Supply data accuracy uncertainty in surface water zones is due to measurement errors in river flow data. In both the Grid SWZ and the East SWZ we estimate the uncertainty due to supply data accuracy is between +6% and 10% of water available for use (WAFU) throughout the planning period.

6.2.3 S6.2 Process losses

An additional source of supply-side uncertainty is potential variation in the baseline values of raw and treated water process losses. This component has been added to the final plan and was not included in the draft WRMP24 (see section 3.16). It is only relevant to our Grid SWZ and has been added to account for the change in scale of the process losses calculations (informed by further investigations and meter validation assessments) and the risk that the volume could change again in the future. This is a separate component used in the calculation of the supply-demand balance (subtracted from deployable output along with outage to calculate WAFU). We have added a separate subcomponent with an uncertainty range of initially +/- 25% but reducing over time to reflect future improvements in measurement and calculation of this component.

6.2.4 S8 Climate change impact on supply

We included uncertainty due to the impact of climate change on source yields in the Grid SWZ and East SWZ headroom estimates. This was based on the methodology applied to both zones in the deployable output climate change assessment. For each of the two zones, the analysis produced climate change forecasts over a representative number of samples from the UKCP18 projections. The climate change headroom component was calculated from the difference between the selected (baseline) deployable output scenario and the deployable output produced by each of the sampled scenarios. The minimum, median and maximum differences were used as the parameters of triangular distributions (at five-year intervals) to represent the uncertainty of climate change on yield in the *Crystal Ball* probability model. The climate change risk in the target headroom assessment therefore represents a risk that the impact could be higher or lower than the baseline.

The Grid SWZ headroom calculation also includes a component for uncertainty in the bulk raw water transfer from Severn Trent Water due to climate change (component S4 bulk transfer).

We have also calculated headroom without the impact of climate change to understand how much this component contributes to the total target headroom values.

6.2.5 D1 Accuracy of sub-component data

Uncertainty in the demand forecast has been applied to both water resource zones. We attribute the uncertainty in demand data accuracy to measurement error. Demand is measured by recording the volume of water going into supply, known as distribution input. The meters we use to record distribution input have an accuracy specification of +/- 2%. Therefore, for both zones, we estimate demand data accuracy to increase or decrease distribution input by up to 2%. We have maintained this uncertainty range over the planning period.

6.2.6 D2 Demand forecast variation

We account for uncertainty in our forecast demand for household and non-household properties. For households, we have considered uncertainty in our forecasts of domestic meter optants, per capita consumption and population. For non-households, we have considered uncertainty in future growth or decline in service and non-service sectors, based on modelled scenarios. All estimated uncertainty for household and non-household properties are combined into one component known as demand forecast variation.

6.2.7 D3 Impact of climate change on demand

The demand forecast also includes an assumption on the change in water use due to climate change. The headroom assessment component allows for + / - 50% uncertainty of the increase built into the baseline demand forecast.

6.3 Target headroom risk profiles

We assign probability distributions in the stochastic model to represent the uncertainties of each individual headroom component. The model calculates target headroom at five-year intervals between 2025/26 and 2084/85. It combines the probability distributions to produce headroom estimates for levels of certainty between zero and 100% in 5% increments (that is, percentiles).

A headroom estimate with a zero percentile would provide no certainty that supply will meet demand over the planning period. Whereas a 100th percentile risk would mean there is no risk that supply would fail to meet demand (due to the uncertainty factors considered in the headroom assessment). The A Re-evaluation of the Methodology for Assessing Headroom (UKWIR, 2002b) methodology does not include guidance on the percentile risk water companies should plan for in the supply-demand balance.

The WRPG does not specify a level of target headroom certainty water companies should plan for but does state “If target headroom is too large it may drive unnecessary expenditure, if too little you may be unable to meet your planned level of service.” It also advises companies to plan for a higher level of risk in the future compared to the early years. This assumes uncertainties will reduce and it is possible to adapt to changes over the longer term.

Since 1996, we have invested to provide a minimum target headroom of 5% of WAFU. This follows recommendations from the *Water supply in Yorkshire. Report of the independent commission of inquiry* (Uff et al., 1996) to increase the supply-demand planning margin following the impacts of the 1995/96 drought in Yorkshire.

For WRMP24 we have worked with the other water companies in the WReN region to explore the use of a set of standardised risk profiles on which to base the target headroom allowances, based on the characteristics of individual resource zones. However, the final choice of risk profile for each resource zone rests with individual water companies. The target headroom allowances are taken from the headroom model output at the specified percentile (risk level) for each five-yearly interval.

For the East SWZ, we selected a profile with a percentile risk starting at the 95th percentile in the first ten years of the planning period and decreasing in five percentiles with each ten-year interval. This provides a target headroom allowance of about 8% of WAFU at the beginning of the planning period reducing to 6% by 2050. We selected the 95th percentile at the beginning of the planning period to minimise the risks in the East SWZ, as this small zone has limited supply flexibility compared to the Grid SWZ. A decreasing profile was selected as it is appropriate to accept a higher level of risk in the future than at present.

For the Grid SWZ, we have selected the 85th percentile risk at the beginning of the planning period, reducing by 5% in each five-year period to a minimum of 60th percentile. This provides a target headroom value of around 6% of WAFU at the start of the planning period, reducing to around 2% of WAFU by 2050. We have selected a lower headroom risk profile for the Grid SWZ compared to the East SWZ, as a 95th percentile would be disproportionate to the risks and could potentially drive additional investment early in the planning period which would not be required later. A 100% certainty assumes the worst-case scenario for each headroom component is realised in the same year, which is highly unlikely. It is most likely that the 50th percentile scenario would be realised.

Our selection of risk profiles for WRMP24 also take into account that some of the key areas of uncertainty in our supply-demand balance are considered through our adaptive planning scenarios (for example, more extreme climate change scenarios then those incorporated in the headroom uncertainty distribution). This allows us to test our preferred plan against future climate change risks, adapt our plan in the future if required and reduces the need to account for climate change in the target headroom allowance. However, we have still allowed for some uncertainty due to climate change in the baseline scenario target headroom allowance. This takes a more precautionary approach than excluding climate change, without risking large investment in schemes that would be unnecessary if the worst case does not occur.

6.4 Headroom assessment results

Table 6-2 shows the target headroom results using the selected percentile / risk profile for each zone.

Table 6-2: Target headroom using the probabilistic model

WRZ	Demand scenario		Target headroom allowance					
			2025/26	2030/31	2035/36	2040/41	2045/46	2049/50
East SWZ	Baseline dry year annual average	Certainty percentile	95th	95th	90th	90th	85th	**85th**
		Ml/d	1.02	1.02	0.86	0.87	0.75	**0.77**
		% of WAFU	8	8	7	7	6	**6**
Grid SWZ	Baseline dry year annual average	Certainty percentile	85th	80th	75th	70th	65th	**60th**
		Ml/d	69.77	60.77	52.31	34.64	27.94	**23.34**
		% of WAFU	**5.9**	**5.2**	**4.8**	**3.6**	**2.9**	**2.3**

Sensitivity checks have been carried out on the headroom probabilistic model output to identify the components that make up the greatest proportion of headroom distributions. In both resource zones, the accuracy of supply-side data (S6) is the dominant factor in the combined headroom distribution. Further details on the component contribution to headroom are provided in our supporting document Allowing for Uncertainty (Headroom) Technical Report, which will be provided to the Environment Agency and can be provided on request.

To determine the contribution climate change uncertainty makes to the selected target headroom glidepaths, the Crystal Ball model has been used to calculate target headroom at a zonal level without any allowance for uncertainty of climate change impact on source yields, the Severn Trent Water import (applicable to the Grid SWZ only) and demand. All other headroom components remain the same.

For the Grid SWZ, target headroom is reduced by about 6.5 Ml/d in 2025/26 when the climate change components are removed; the reduction reduces to about 2.3 Ml/d by 2050/51 but this is partly due to the reducing risk profile over time, which means that target headroom overall reduces significantly by 2050/51. In percentage terms, the climate change components contribute about 9% of target headroom in 2025/26, increasing to almost 16% by 2035 but then reducing again to around 10% by 2050/51, as shown in Figure 6.2.

This is a change from the draft plan, where the impact of climate change on supply was negative due to asymmetrical distributions where the 'most likely' values were closer to the maximum than the minimum. This offset the small positive impact of climate change on demand, leading to a neutral effect of the climate change components overall within the headroom distribution, at the selected annual level of risk. In the final plan, the distributions representing the impact of climate change on supply are asymmetrical in the other direction (with most likely values closer to the minimum than the maximum), leading to a positive impact on headroom from both supply and demand climate change impacts.

For the East SWZ, target headroom is reduced by 0.09 Ml/d in 2025/26 and this reduction increases over the planning period to a 0.17 Ml/d reduction in 2050/51 if climate change components are not included. As there is no forecast deficit in the East SWZ, and the surplus is between 37 to 41% of WAFU during the 25-year planning period, the impact of including climate change in headroom is not material. Figure 6.3 shows that the percentage contribution to the target headroom allowance is between about 9% in 2025/26, rising to about 22% in 2050/51.

In our East SWZ climate change uncertainty represents 9-22% of target headroom across the planning period from 2025 to 2050, and there is no deficit or adaptive plan approach for this zone. In our Grid SWZ climate change uncertainty represents between 7-16% of target headroom for the same period.

Figure 6.2: Percentage contribution of climate change – Grid SWZ

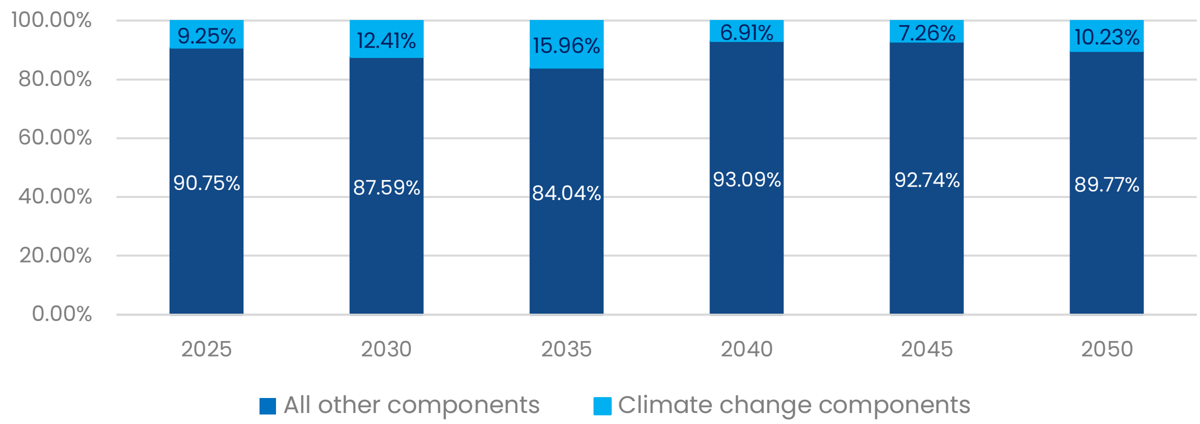
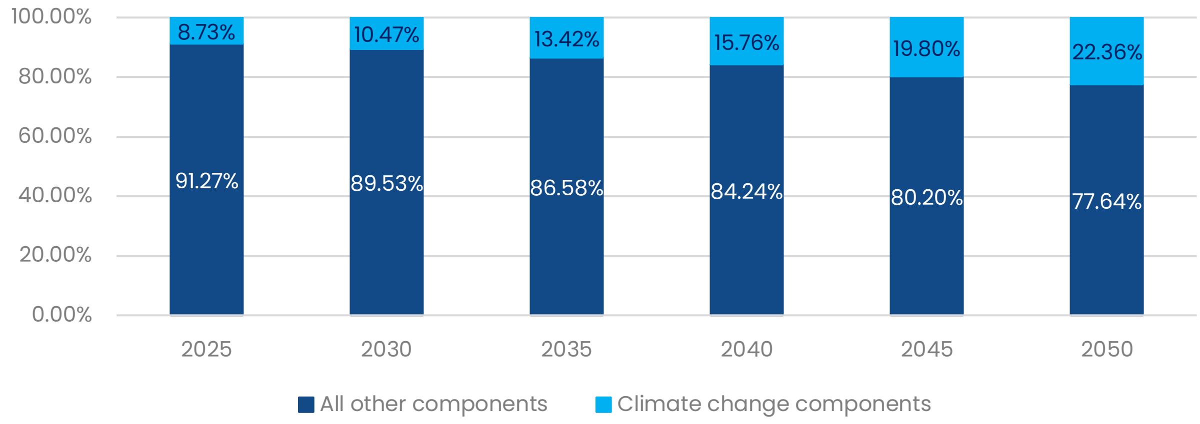


Figure 6.3: Percentage contribution of climate change – East SWZ



6.4.1 Final plan target headroom

We did not re-evaluate target headroom for the final WRP tables for the Grid SWZ as this would have led to an increased uncertainty allowance that would double count the risks considered in the scenarios and sensitivity testing. Uncertainty in the outcome of our planned demand management programme is covered by our adaptive planning approach (see section 10). The East SWZ was not re-evaluated for the final plan as there was no deficit to address and therefore no additional uncertainties to consider.

6.4.2 Alternative drought return period

We assessed the supply-demand balance in this plan at target headroom values to ensure the security of supply is maintained at the target levels of service. This assessment is in line with the Intermediate Approach presented in the *Economics of Balancing Supply and Demand Methodology* (UKWIR, 2002a). Initially we created a target headroom allowance that represented the 1 in 500 drought return period. As the 1 in 500 drought scenario highlighted a risk of deficit in the Grid SWZ, we re-evaluated for a 1 in 200 drought return period. This resulted in an increased target headroom.

6.5 Alternative scenarios

Our alternative scenarios are based on key known risks and aligned with the Ofwat Common Reference Scenarios[40] as defined in PR24 and beyond: Final guidance on long-term delivery strategies (Ofwat, 2022). We also include scenarios that are specific to our area.

We use the alternative scenarios to account for risks of a much larger scale than the target headroom considers. We assess which of the alternative scenarios trigger significant additional investment or remove the need for investment. The target headroom risks have a much lower impact on the supply / demand and as such provide a buffer, as it is impossible to accurately predict the future. Investing to meet a target headroom driven deficit can be considered low regrets, as it is realistic not to assume precise forecasts. Whereas the adaptive plan pathways represent alternative scenarios in the future that could lead to over or under investment if not managed appropriately.

We plan to our most likely scenario and define informed decision points and triggers that could mean we deviate to an alternative scenario in the future. The impacts of the common reference scenario are outlined in Section 7.3 and the WRMP24 adaptive plan is discussed in Section 10.1.

[40] https://www.ofwat.gov.uk/wp-content/uploads/2022/04/PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf

6.6 Reducing uncertainty

Uncertainty is an inherent factor to manage in long-term water resource planning. As described earlier, we account for key uncertainties within our target headroom allowance, and larger uncertainty areas are subject to scenario testing to inform the development of an adaptive plan. However, given the potential impact of uncertainty on our future supply-demand balance and long-term plans, it is important that we continue to reduce uncertainty over time where possible to inform future WRMPs.

Yorkshire Water are committed to tracking and monitoring key areas of uncertainty through the Annual WRMP review process. Given the scale of our future supply-demand challenge, this is even more important than ever before. Key activities to reduce uncertainty are outlined below:

- We will continue to engage closely with other water companies and regional planning groups (in particular WReN) in relevant forums as we collectively work to reduce uncertainties. In particular around:
  - Utilisation of future updated climate change projections and forecasts
  - The effectiveness of demand management and leakage reduction interventions, including government policy interventions
  - Common barriers and challenges in large-scale supply scheme implementation and water transfers associated with the RAPID portfolio of SRO schemes
- Through our Annual Performance Report to Ofwat we will continue to track and monitor trends in key supply-demand components, and continue to improve our data where required over time. Specific areas of focus include:
  - Factors associated with demand forecast variation (D2), for example, linked to customer behaviour (PCC), population growth, new property development, for example.
  - Improving datasets linked to process losses, both to reduce the uncertainty of estimates and better understand opportunities to reduce losses over time. We intend to undertake further meter validation work on raw water meters, building on that recently done for DI meters.
  - Effectiveness of demand management and leakage reduction interventions
  - Non-household demand growth, with a particular emphasis on tracking the energy sector growth (hydrogen) in concert with WReN.
- Tracking the benefit of our catchment management programme to mitigate pollution risks, which are assumed not to impact DO in future.

7 Supply-demand balance

This section compares the supply forecast against the demand forecast (including target headroom) to understand if we have sufficient supply to meet demand over the 60-year planning period. Baseline figures reflect the position before the benefit of any new supplies, demand management, leakage reductions and drought measures have been applied in our plan. If the supply-demand balance shows there is a deficit, we will need to invest in schemes to either increase supply or decrease demand.

7.1 Baseline – Dry year annual average (DYAA)

7.1.1 East Surface Water Zone supply-demand balance

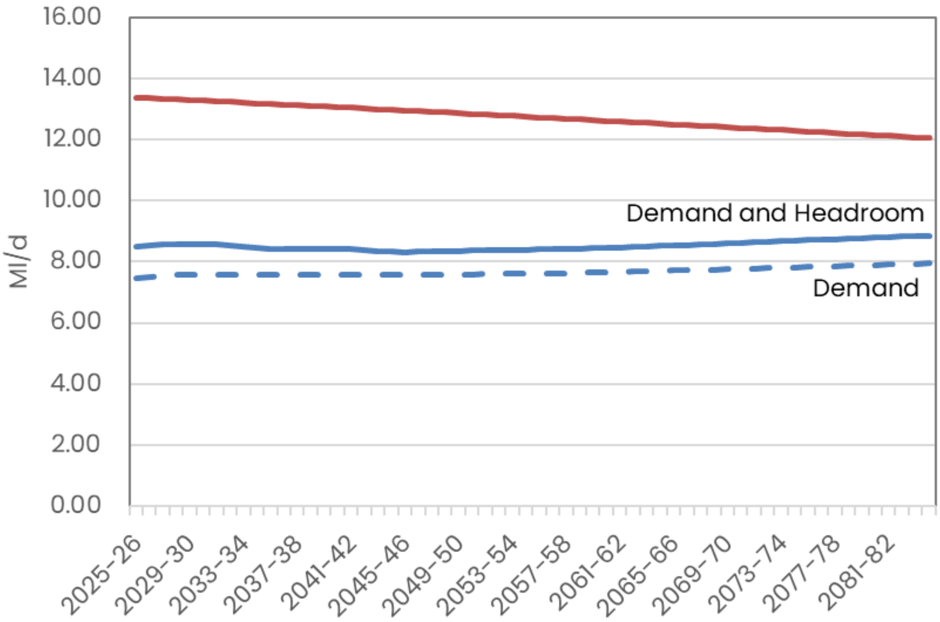
A supply-demand appraisal has been undertaken for the East SWZ dry year annual average (DYAA) planning scenario. The scenario is based on a 1 in 500 level of service for Level 4 drought restrictions (emergency drought orders). The forecast in this zone, as shown in Figure 7.1, shows a surplus throughout the planning period.

We have not identified any potential impacts on demand that would drive a deficit in this zone, nor any cross-sector demands that could be met through investment in the East SWZ. There is a temporary increase in demand after the base year due to the high demand we experienced during the Covid-19 lockdowns, which did not create any risk to meeting demand in this zone.

Both supply and demand remain broadly stable in the East SWZ baseline dry year annual average scenario, although available supply (WAFU) in the zone decreases over time due to the impacts of climate change. No other supply risks were identified.

The supply-demand surplus is 4.88Ml/d in 2025/26 and reduces over the planning period to 3.17Ml/d by 2084/85, mainly as a result of the climate change impact. The surplus equates to 58% of the distribution input plus target headroom in 2025/26, reducing to 36% by the end of the planning period. As the surplus is large relevant to the zone's demand, no investment is required to meet the 1 in 500 level of service in this zone.

Figure 7.1: East SWZ baseline supply-demand balance (DYAA)



7.1.2 Grid Surface Water Zone supply-demand balance

The baseline supply-demand balance for the Grid SWZ dry year annual average scenario is shown in Figure 7.2. As for the East SWZ, the baseline scenario forecast is based on the 1 in 500 level of service for level 4 drought restrictions (emergency drought orders). This shows our Grid SWZ is not resilient to a 1 in 500 drought risk using the latest stochastic modelling assessments, and, following guidance and regulatory requirements, we must invest to become resilient by 2039/40 at the latest (considerations on timing are considered as part of the decision-making approach). The zone is shown to be in deficit from the start of the planning period. The impact of Covid-19 on demand has also exacerbated the risk temporarily and re-enforces the need for investment.

In addition to reflecting the 1 in 500-year drought resilience using the latest planning methods into our forecasts, the long-term deficit is driven by a decline in water supply over time resulting from three key risks or needs:

1. **Climate change:** The climate change risk has an immediate impact on available supply, with 36.81Ml/d of supply loss due to climate change at the outset, that is, in our base year. Inclusion of the 1 in 500-year drought resilience with climate change (in combination), makes up the majority of the 175 Ml/d reduction in baseline WAFU compared to the equivalent year in the WRMP19 base year position (even though in "normal year" conditions there are sufficient supplies to meet demand). In addition, there is a risk that climate change will lead to a continuing decline in available water supply over the planning period. Climate change is forecast to create a year-on-year incremental reduction in supply that increases our climate change impact to 45.98Ml/d in 2025/26, further increasing to a 85.31Ml/d reduction in 2049/50 and around 148Ml/d by 2084/85.

2. **Termination of import:** The import from Severn Trent Water is expected to cease in 2035. The volume we take from this import varies each year as it is dependent on the levels in the reservoirs owned and operated by Severn Trent Water, which in a 1 in 500-year drought event will be lower than a "normal" year. Our dry year annual average scenario shows the initial loss to be just over 46Ml/d. In addition, there is a further loss of yield of around 7Ml/d which results from a treatment constraint at existing South Yorkshire sources that cannot be operated in isolation (the precise figures in both cases change slightly over time due to the impacts of climate change). In 2035/36 the net impact is 53.66Ml/d, reducing to 42.43Ml/d by 2084/85.

3. **Environmental Destination:** The baseline scenario includes the impact of the BAU+ Environmental Destination on water availability. The impact on a number of our groundwater sources will reduce supply by 11.3Ml/d in 2035/36. In 2040/41 the supply reduces by a further 103.5Ml/d (114.4Ml/d total) if the abstraction on the River Derwent is reduced to address the CSMG target. The total environmental destination impact is 111.09Ml/d by 2049/50. Over time the loss due to environmental destination actually reduces, due to the impacts of climate change so that by 2084/85, the combined impact is 95.84Ml/d[41], the reduction reflects the underlying loss of availability of the River Derwent supply.

The forecast demand in the Grid SWZ does not change significantly over the planning period. Following the initial increase during the Covid-19 pandemic, it increases steadily from 1234.08Ml/d in 2025/26 to 1260.29 Ml/d in 2049/50, and 1312.76 Ml/d in 2084/85. During the AMP7 period, before the first year of the WRMP24 planning period there is a decline in demand, largely due to the planned leakage reduction activity we will deliver before 2025 (as determined in WRMP19).

A summary of supply-demand balance and the factors contributing to the surplus / deficit in the Grid SWZ is given in Figure 7.2 and Table 7-1. The deficit is due to insufficient supply to meet the target headroom allowance plus demand.

[41] Whilst the impact of the environmental destination change on the Derwent reduces by 2084/85, the supply-demand balance loss would still occur; the impact is rather simply just attributed to climate change.

Figure 7.2: Grid SWZ baseline forecast supply-demand balance (DYAA)

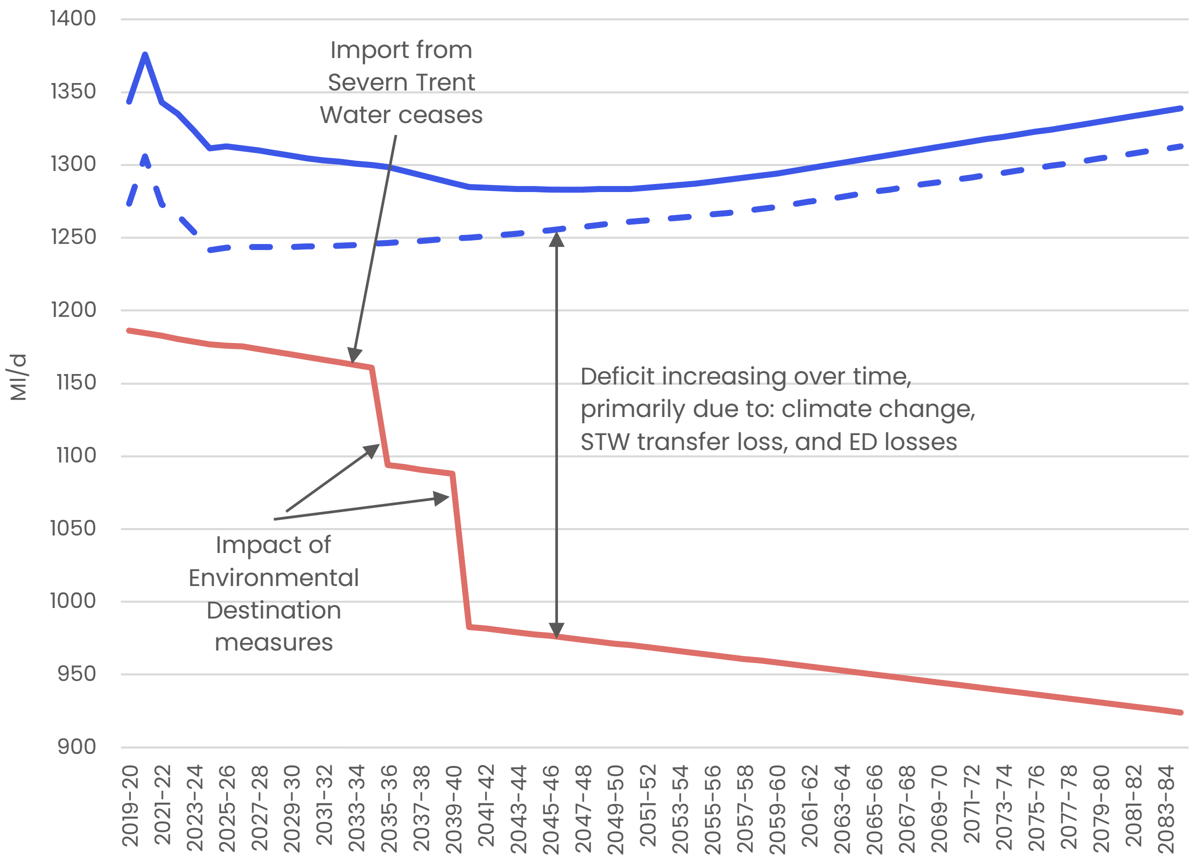


Table 7-1: Summary of the Grid SWZ DYAA deficit and key drivers of changing need over time

^ Denotes the start and end of the Statutory 25-year planning period respectively

	2025 /26	2030 /31	2035 /36	2040 /41	2044 /45	2049 /50	2084 /85
Climate change reduction on supply (Ml/d)	45.98	53.85	61.91	70.13	76.82	85.31	148.04
Impact of terminating the STW transfer (Ml/d)	0	0	53.66	52.11	51.28	50.23	42.43
Environmental destination reduction (Ml/d)	0	0	11.28	114.78	113.15	111.09	95.84
Overall Grid SWZ dry year annual average deficit (Ml/d)	136.87	136.55	204.65	301..90	305.39	312.18	414.79

As the Grid SWZ is showing a large and immediate risk of deficit we have produced a baseline DYAA supply forecast for the Grid SWZ 1 in 200-year level of service drought scenario for emergency drought orders. The new 1 in 500-year drought resilience level is expected to be met by 2039/40 at the latest, based on the National Framework for Water Resources. This creates a degree of choice as to when the 1 in 500 level of service will be adopted by companies, however, it is also dependent on the time required to implement the solutions to achieve the higher level.

The comparison to the 1 in 500-year position before 2040 allows us to understand how operating to a different level of service could influence our future plans in the short-term. Under a 1 in 200-year drought resilience level before 2040, the level of water availability forecast is expected to be materially higher. However, as shown

Figure 7.3 and Table 7-2 below, there is still a material supply-demand deficit at the start of the planning horizon of 68.81 Ml/d in 2025/26, rising to 137.86 Ml/d by 2035/36. Whilst the baseline supply-demand figures do not include the benefit of drought measures, this reaffirms the underlying risks and need to invest in both supply and demand interventions to ensure we are resilient to future dry weather conditions.

We have created optimised plans for achieving the 1 in 500-year drought resilience level in alternative years. This includes planning to achieve this objective both before and after the 2040 National Framework for Water Resources requirement and the analysis is discussed in Section 9.2.

Figure 7.3: Grid SWZ baseline with 1 in 200 year resilience level up to 2039-40

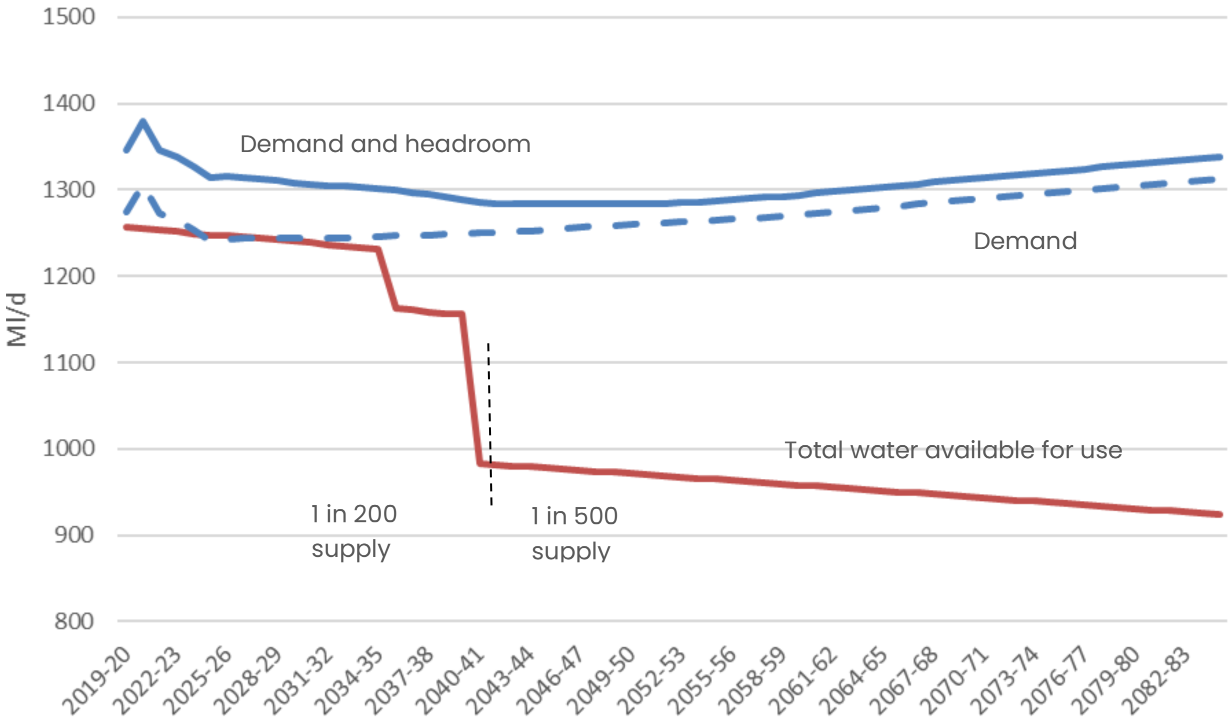


Table 7-2: Summary of the Grid SWZ supply-demand deficit under 1 in 200 year drought resilience level before 2040

	2025/26	2030/31	2035/36
Grid SWZ dry year annual average deficit (Ml/d)	68.81	68.17	137.86

7.2 Baseline – critical period (Grid SWZ)

The Grid SWZ critical period scenario reflects the water available for use during a four-week dry period experienced in our region in 2018. The critical period is not subject to drought return periods and represents a risk we could experience during peak summer demands in any year. The risk increases over time due to the same supply reduction factors as the DYAA scenario. Distribution input and target headroom are also based on dry weather, and peaks in demand we expect to experience during the four-week critical period.

The 2018 event indicated the potential challenges faced by a short-term critical period and drove a need to assess this additional supply-demand scenario. For the final plan we have completed further supply modelling assessments to assess our critical period supply capability (see Section 3.4.5, noting that this has also been informed by the experience in the 2022 drought year) and reviewed our critical period demand position.

The critical period assessment, as with that for the DYAA, shows significant deficits throughout the planning period, although these are generally lower in magnitude than the DYAA plan position. The critical period deficits are now lower than the baseline 1 in 500-year DYAA supply-demand position (or broadly comparable to the first ten years of the plan for a 1 in 200-year equivalent baseline), which reflects the updated supply side modelling completed for the final plan.

Climate change has a small impact in critical period forecasts compared to the dry year annual average, but the capacity loss associated with loss of the Derwent transfer and environmental destination has a greater influence.

Figure 7.4: Grid SWZ baseline forecast supply-demand balance for critical period

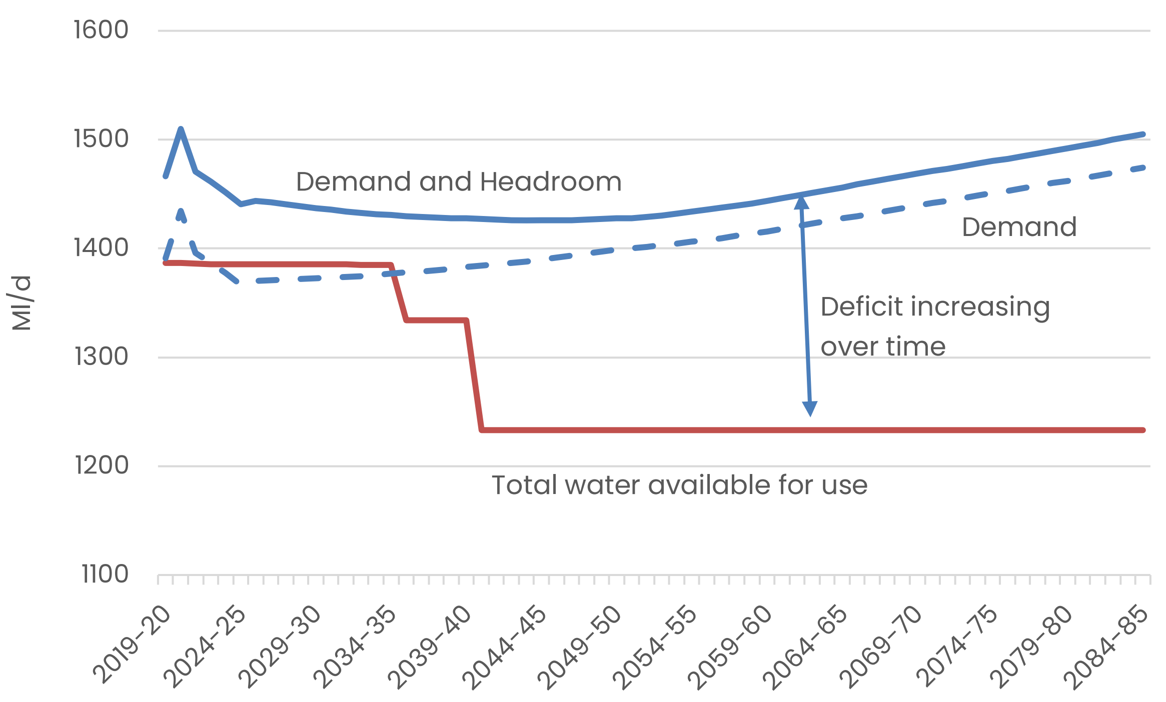


Table 7-3: Summary of the Grid SWZ Critical Period deficit across the planning period

	2025 /26	2030 /31	2035 /36	2040 /41	2044 /45	2049 /50	2084 /85
Climate change reduction on supply (Ml/d)	1.03	1.21	1.39	1.58	1.73	1.92	3.32
Impact of terminating the STW transfer (Ml/d)	0	0	39.50	39.44	39.38	39.30	38.81
Environmental destination reduction (Ml/d)	0.00	0.00	11.28	112.22	112.07	111.88	110.48
Overall Grid WRZ Dry Year Critical Period Deficit (Ml/d)	57.62	48.55	101.50	199.58	198.54	200.39	277.65

7.3 Common reference scenarios

The supply-demand balance position above is based on forecasts that represent our best estimation of the risks to future supply and demand conditions. As with all long-term water resources problems, there is inherent uncertainty in the forecasts, for example, the level of future climate change impacts. Whilst we account for supply-demand component uncertainties in the target headroom allowance, we also undertake specific testing of alternative supply-demand balance scenarios. The alternative scenarios represent major areas of uncertainty, some of which may not be evident in the headroom assessment.

It is important to note that in all cases the scenarios represent variations on the dry year annual average position, to help us identify the risks impacting on our ability to meet customer demand in future years. These scenarios do not represent the current in-year conditions; in most years we will not be experiencing a 1 in 500 or even 1 in 200 drought event and we will have sufficient supply to meet demand. The water resources planning process is focussed upon low likelihood, but potentially high consequence events.

We have not carried out a separate critical period alternative assessment for our Grid SWZ critical period scenario. As noted above the deficit levels are of lower magnitude than the DYAA and any plan to close the DYAA deficit will meet the critical period risk. We shall review the critical period in future WRMPs when the longer-term risks are more certain and for WRMP24 we have focused on the DYAA scenario for the adaptive plan.

As part of the publication *PR24 and beyond: Final guidance on long-term delivery strategies* (April 2022), Ofwat set out good practice for scenario testing as part of development long-term adaptive strategies. We have followed this guidance to complete our own plan testing, which uses the 'Ofwat common reference scenarios' for the purpose of testing sensitivity around our baseline position. The common reference scenarios (CRS) set out a set of plausible bounds or extremes for key uncertainty areas for testing, although it is important to note that our baseline does not necessarily sit in the 'middle' of these extremes (as is demonstrated later in this section).

The key scenario areas, which much be tested individually, are:

- climate change – representing higher and lower impacts than our baseline.
- technology – reflecting different scenarios of pace for smart metering implementation, which may influence investment[42].

[42] Noting the baseline supply-demand balance does not include the benefit of smart metering.

- demand – reflecting different positions on government policy on future water labelling and building regulations, and different future population growth.
- environment – meeting defined short-term regulatory commitments only (low), or higher levels of environmental destination (enhanced).

Figure 7.5 summarises the structure of our scenario testing around our WRMP baseline, which allows us to understand the sensitivities of our supply-demand position and how this may impact future investment needs and required solutions. 'Compound' scenarios, which group low or high scenarios together are generally discouraged by Ofwat, because they represent an aggregation of more than one unlikely scenario occurring simultaneously (although they may be used to complement the process).

Figure 7.5: Ofwat Common Reference scenarios, comparison against baseline

Scenario	WRMP Baseline (least cost)	High CC	Low CC	High ED	Low ED	No ED	High Demand	Low Demand	High Technology	Low Technology	Core scenario
Climate	BL	H	L	BL	BL	BL	BL	BL	BL	BL	BL
Technology	none	none	none	none	none	none	none	none	H	L	FP
Demand	H	H	H	H	H	H	H	L	H	H	H
Environment	BL	BL	BL	H	L	none	BL	BL	BL	BL	L
LoS	1 in 500	1 in 500	1 in 500	1 in 500	1 in 500	1 in 500	1 in 500	1 in 500	1 in 500	1 in 500	1 in 200 to 2030s
Drought measures	none	none	none	none	none	none	none	none	none	none	To 2030s
STW transfer	Cease	Cease	Cease	Cease	Cease	Cease	Cease	Cease	Cease	Cease	Cease

Scenario			
Climate change	H = RCP8.5	BL = RCP6	L = RCP2.6
Technology	H = smart metering by 2035	L = smart metering by 2045	FP = smart metering by 2040
Demand	H = Housing Plan P; no water labelling	L = ONS 18; water labelling included	-
Environment	H = enhanced	BL = BAU+	L = WINEP (current)

Key
BL = Baseline
FP = Final Plan
H = High Ofwat CRS
L = Low Ofwat CRS

Of particular note is Ofwat's concept of a 'core scenario', which reflects no or low regret investment for work needed to tackle short-term requirements, investments required in both benign and adverse scenarios, and across a wide range of plausible scenarios. The core scenario also includes investment that is needed to keep future options open (for example, enabling works for a potential future scheme), or is required to minimise the cost of future options. These concepts are important when it comes to selecting the investments, particularly in the immediate period of our plan later in this document.

It is also worthy of note that beyond the testing of the Ofwat CRS, Yorkshire Water has undertaken specific and / or bespoke scenario tests to help define the best-value adaptive plan and consider options. These include testing different timings of meeting the 1 in 500-year resilience level, the impact of drought measures, future increases in non-household demand (driven by hydrogen development) and the impact of future demand reduction interventions realising lower than expected benefits (section 9.4).

The following sub-sections explain the outcomes of the Ofwat CRS testing for each water resource zone against the WRMP24 baseline.

7.3.1 East Surface Water Zone scenarios

This zone has already been shown to have a healthy surplus of supply over demand. As Figure 7.6 shows, all scenarios result in a significant material surplus compared to the baseline forecasts.

Most of the scenarios represent improvements over the baseline position, with only the high climate change scenario resulting in erosion of the surplus to around 1.5 Ml/d by 2084/85. This is because there is high confidence in our position on abstraction reductions in this zone in the baseline, and our baseline demand scenario already reflects the higher population growth forecasts in line with WRMP guidance (but does not assume government policy interventions for water labelling and building regulations). The technology scenario has a negligible impact on the supply-demand position. Figure 7.7 illustrates this, in terms of where our baseline forecasts lie relative to the low and high scenarios at the end of the statutory planning period in 2049/50.

The scenario analysis for this zone gives us good confidence in the forecast surplus position in the future.

Figure 7.6: East Zone Scenarios SDB over time

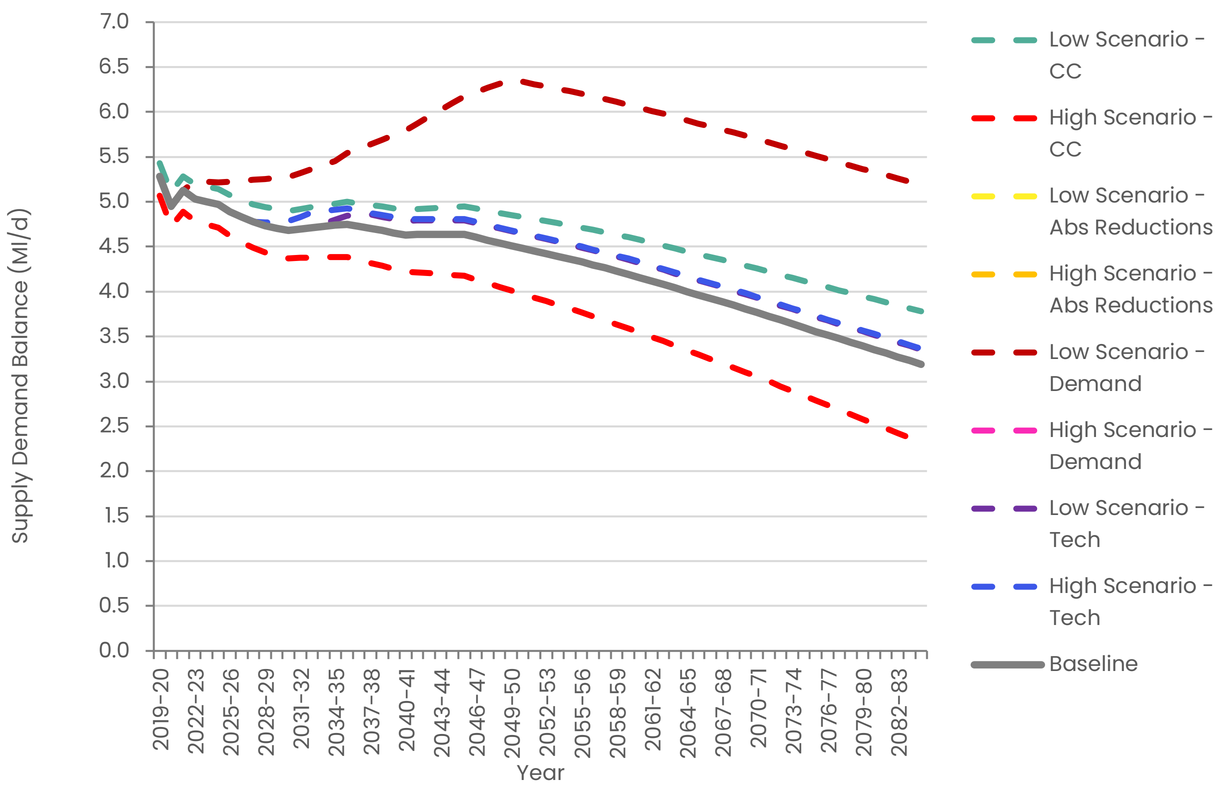
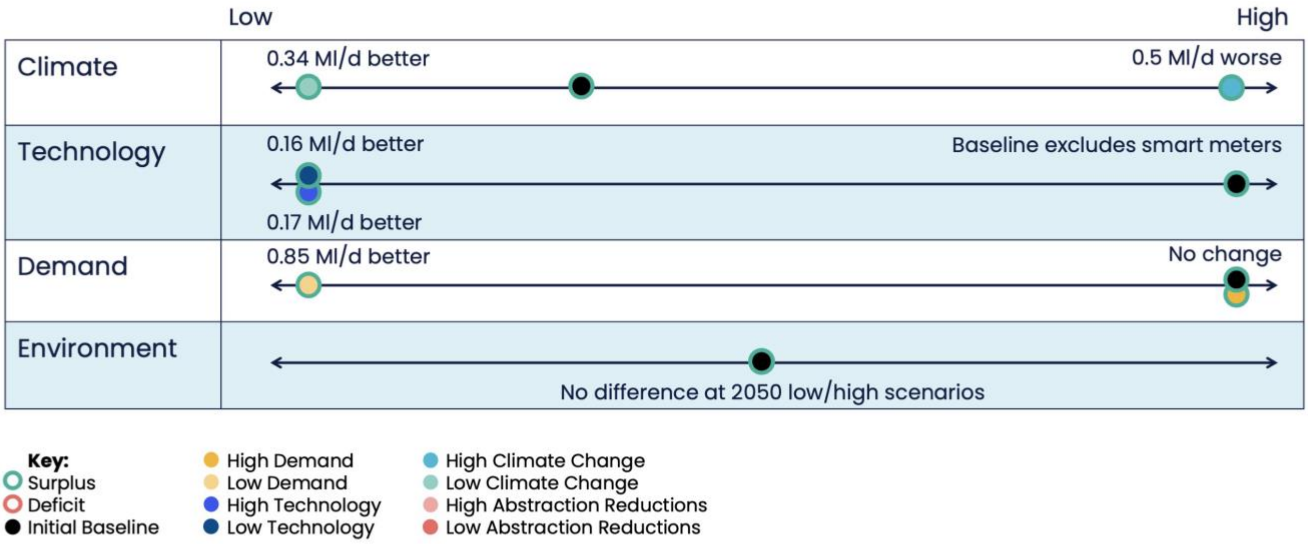


Figure 7.7: East zone scenarios Vs baseline in 2049/50



7.3.2 Grid Surface Water Zone scenarios (DYAA)

The baseline supply-demand deficit in this zone means future investment needs are required. The Ofwat CRS are particularly important therefore to help inform the resulting planned investment and solutions, so that they can suitably meet the needs of the future if the forecast position changes as part of the best-value adaptive plan.

As with the East Surface Water Zone, most of the scenarios result in an improvement in the long-term supply-demand position, but in all cases significant long-term deficits remain, supporting the need for investment. The baseline demand position is already equivalent of the high scenario, and the technology scenario represents an improvement as the baseline supply-demand balance does not include the benefit of smart metering (although compared to other scenarios the impacts are relatively subtle). The fluctuations in the supply-demand balance around the low demand scenario are due to the inclusion of the benefits associated with the alternative government initiatives.

Figure 7.9 is informative, as in combination with Figure 7.8 it shows the relative position of the baseline to the low and high scenarios, and which scenarios represent the greatest uncertainties.

In the draft plan, the environment scenarios previously had the greatest bearing on the overall supply-demand position in the long-term, with a low scenario reducing the supply-demand deficit by 105.22Ml/d.

However, for the final plan, the low demand scenario estimates now show the potential for large reductions in demand if a lower growth trajectory is followed in combination with government policy interventions on future water labelling and building regulations. Climate change still remains a material potential influence, and the technology shows the potential benefits of smart metering in future if adopted as part of the plan.

The findings of our scenario testing are important in defining our preferred plan, later in this document (section 9.4).

Figure 7.8: Grid Zone Scenarios SDB over time*

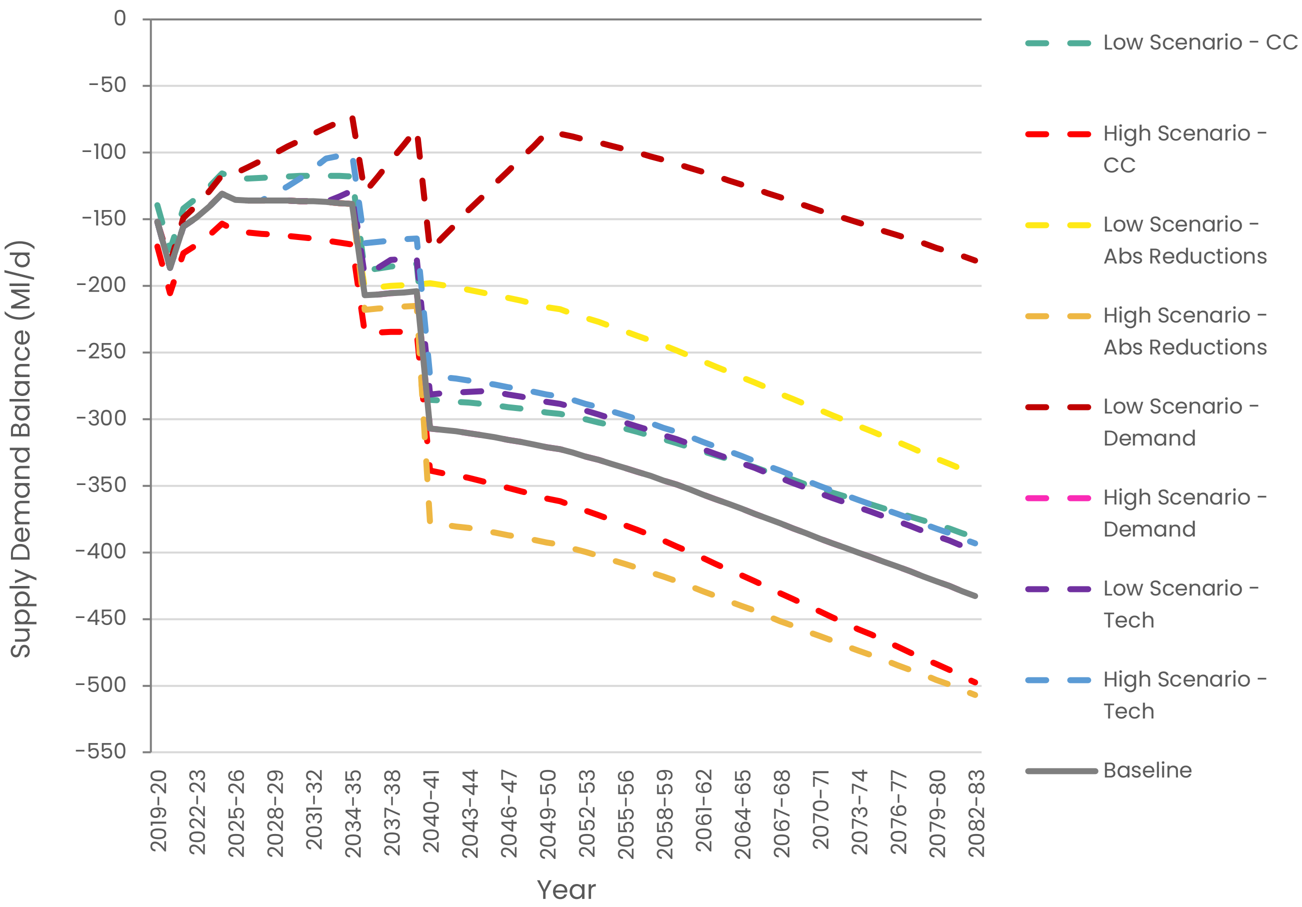
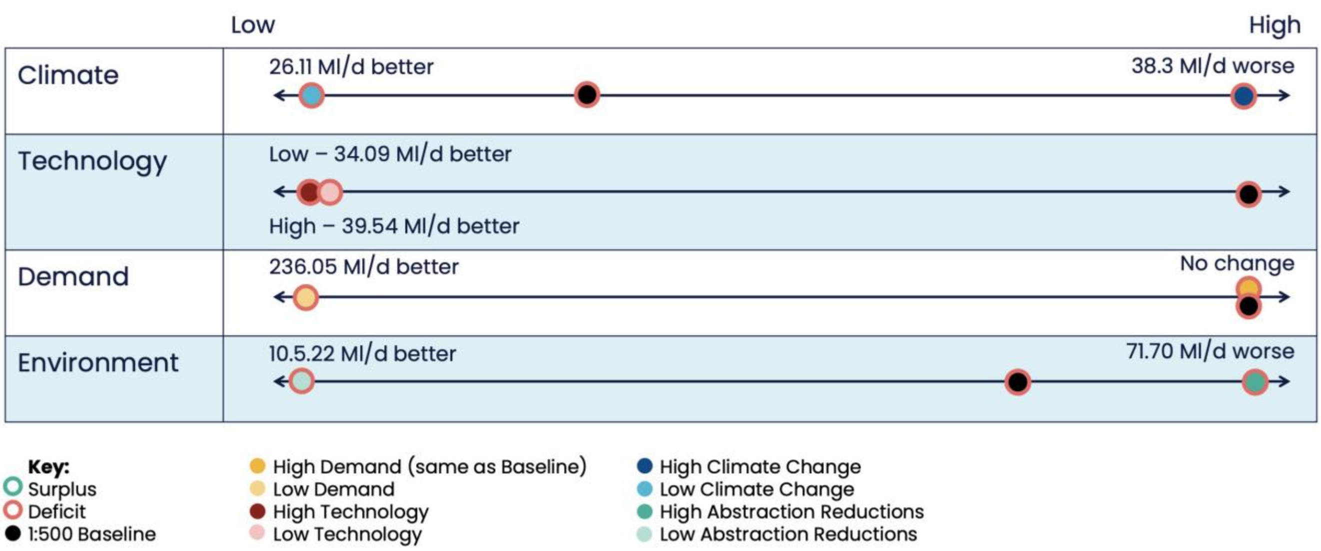


Figure 7.9: Grid zone scenarios Vs baseline in 2049/50



8 Options appraisal

This section describes the options we have considered to meet the Grid SWZ deficit and the process we have carried out to appraise the options and collate a feasible list of options to be taken forward to the best value plan assessment.

To close the deficit identified in the Grid SWZ, we need to invest in schemes that will either reduce future demand or provide additional supply. To select an appropriate solution to the deficit we consider the types of options available and determine which are feasible for the risks we need to address. This is the options appraisal part of our decision-making process. We then carry out a best value plan decision-making assessment to determine the combination of feasible options that we include in our WRMP as the best value solution to the deficit.

Our options appraisal was carried out in accordance with:

- Environment Agency WRPG (2001);
- The economics of supply and demand (UKWIR, 2002a);
- The UKWIR Water resources planning tools 2012: summary report;
- UKWIR WRMP 2019 methods - Decision Making Process: Guidance.

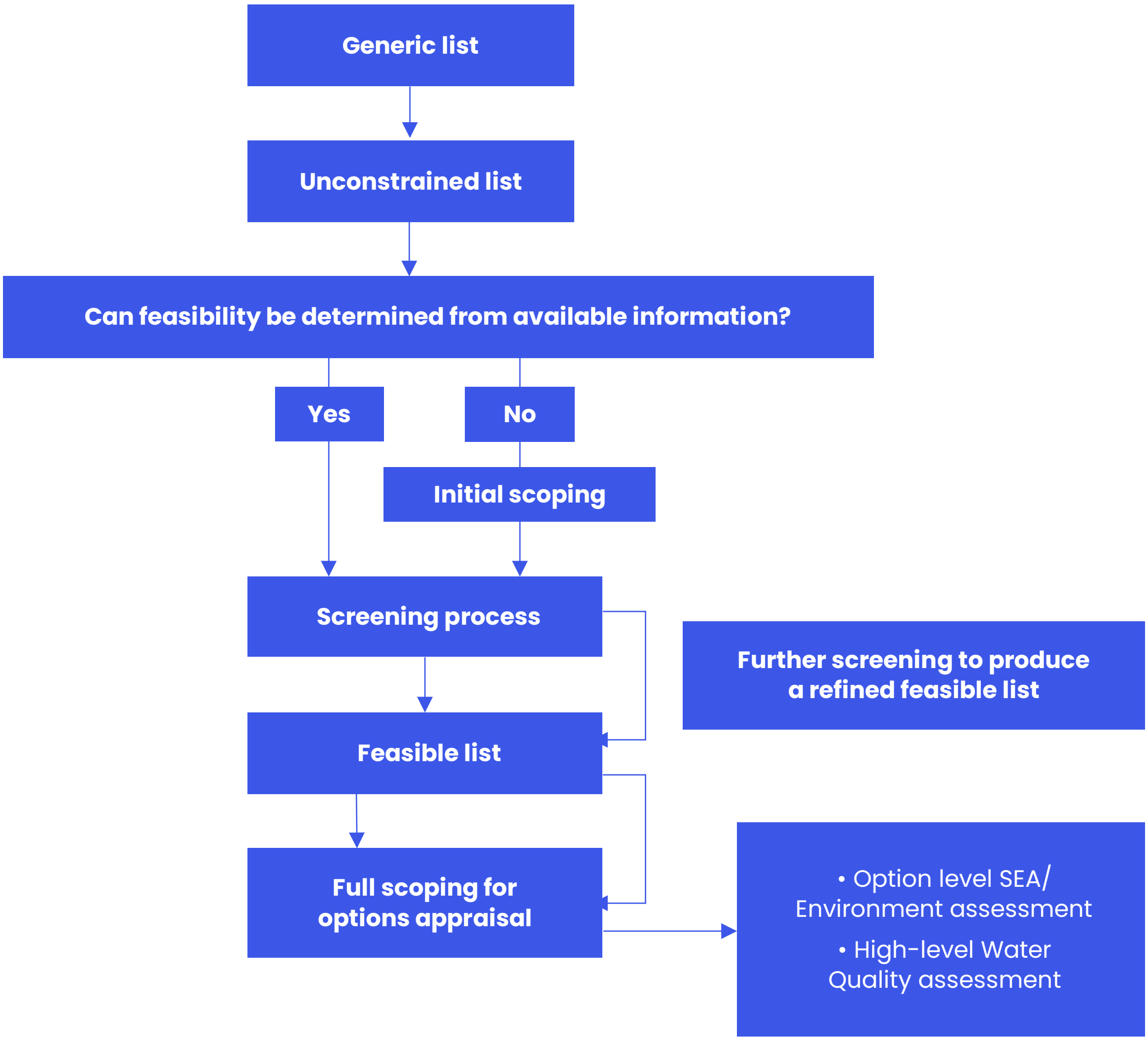
In line with the UKWIR *WRMP 2019 methods - Decision Making Process*: *Guidance*, at the start of the planning process we carried out a problem characterisation assessment for our two water resource zones. This was based on our WRMP19 and any known changes since our last plan (see Section 2.9). The East SWZ baseline problem characterisation concluded that the zone was not at risk of deficit, which was confirmed by the WRMP24 supply-demand balance. Therefore, an options appraisal has not been carried out for the East SWZ and this section focuses on our Grid SWZ, which does show a risk of deficit.

8.1 Options appraisal process

Figure 8.1 summarises the steps taken during the options appraisal process. To begin with we identify a list of unconstrained options and assess which are feasible for meeting the deficit in the Grid SWZ. We then determine the costs and impacts of each feasible option. This includes quantifying the capital, operating, carbon, environmental and social costs to produce six capitals data at an individual option level. A Strategic Environmental Assessment (supported by a Water Framework Directive and Habitats Regulations assessments) of all feasible options was carried (see Section 9 and 10).

For our WRMP24 we have carried out a second screening of the feasible options. This was to ensure the options we included in the best value plan assessment (see Section 10) were appropriate for the risks we needed to solve in the Grid SWZ. This was mainly to avoid any supplementary risks e.g.; we constrained out any sources that are currently under a WINEP investigation and others that provided a benefit that was disproportionately low compared to the need.

Figure 8.1: Options appraisal process summary



8.1.1 Further options identification post draft WRMP24

The Regional Plan and WRMP24 process started in 2020 and the unconstrained and feasible options lists were collated as part of this process. At this time, and up until spring 2022, the known risks in our supply area were very different to those presented in this draft WRMP24. WRMP19 identified that supply would reduce as a result of climate change, but this was not driving a deficit until the mid-2030s. The WReN emerging Regional Plan published in January 2022 set out the supply-demand needs of our Grid SWZ. This included a deficit driven by the impact of climate change on supply and potential options for back filing the loss of the Severn Trent Water (STW) transfer. However, the most likely scenario assumed the transfer would continue throughout the planning period. The baseline environmental destination assumed no loss or reduction in available licences and was therefore zero, as discussed and agreed with our local EA as part of the WReN Regional Plan discussions.

For the emerging regional plan, our focus was on meeting the climate change driven deficit through adhering to demand reduction policy requirements. This included the potential for some small localised new supply schemes that would provide additional resilience in our Grid SWZ during critical periods. We developed options for ensuring there was an alternative supply to the STW transfer if required and assumed the date of termination was 2040.

Since publishing the emerging WReN Regional Plan, the situation has changed significantly. It is now confirmed that STW will terminate the transfer in 2035 (since the draft WRMP24 submission). In addition, the baseline (BAU+) environmental destination that we are required to plan for in our WRMP24 includes for licence reductions in 2035 and, most significantly, in 2040 when there is a risk, we will lose a large proportion (110Ml/d) of our River Derwent abstraction licence. This licence is significant to our grid network in terms of both scale and strategic flexibility. The loss of this licence, combined with the loss of the STW transfer and the climate change impacts, increases the scale of the deficit and creates new risks that were not apparent until very late in the process of building our WRMP24. These risks create a need for schemes that provide a larger benefit, and they cannot be met by demand reduction alone.

Our WRMP24 presents a plan for closing the deficit, however we recognise that the scale of the deficit drives a need for further option assessment. We will start this work in AMP7 and develop any new feasible options in good time for inclusion in the next iteration of our plan (WRMP29).

8.1.2 Types of options available

Our WRMP24 unconstrained options list considered the potential for:

- closing the deficit in the Grid SWZ supply-demand balance
- meeting other sector needs or providing an export to another water company
- addressing government expectations or concerns identified by customers and / or local stakeholders
- ensuring the efficient use of water.

In general, we classify WRMP options as new supply or demand reduction options, but they can be split further by the type of supply or demand options. They are grouped into the following categories:

- **Resource options** - options that increase deployable output through new supplies or increasing our ability to use existing supplies
- **Bulk transfer options** – these are a type of resource option that involve new supply agreements with other water companies
- **Production management options** - options targeted at activities between abstraction and distribution input and designed to reduce process losses
- **Distribution management options** - options targeted at activities between distribution input and the point of consumption i.e., leakage reduction
- **Customer side management** - options to reduce customers' water use or supply pipe losses.
- **Third party options** – includes options delivered by third parties on our behalf, licenced volume trades with non-PWS abstractors and opportunities for collaboration to develop new supplies or deliver demand reduction schemes. Third parties can submit an option bid through our bid assessment process[43].

[43] https://www.yorkshirewater.com/about-us/water-bidding-market/

8.1.3 Development of potential options

For each WRMP we review the potential options available to meet a supply-demand deficit and compile an "unconstrained" list of options. Unconstrained options include all options that could technically be used to meet the deficit. To compile the unconstrained list of options for this plan we carried out the following activities:

- Reviewed the WRMP19 list of options to determine if they are still technically feasible or should be constrained out.
- Reviewed the options suggested in the WR27 Water Resources Planning Tools, UKWIR 2012 report.
- Reviewed bulk transfer opportunities in consultation with other water companies as part of the regional planning process. This included both intra-region and inter-region transfer.
- Consulted third parties to review existing third-party options and identify new options.
- Consulted Yorkshire Water staff with knowledge of our supply system and operations, water production planning and service delivery.
- Reviewed learning from the dry period of 2018 and investigated which areas of our grid network were under stress (links to the critical period scenario).
- Created a water system supply strategy which reviews the system constraints and associated risks to our network. This project identified resilience risks that are not apparent through the WRMP supply and demand component forecasts but have potential to be solved by the same options.
- Commissioned Artesia Consulting to carry out a review of demand reduction options (excluding leakage) for our draft WRMP24 and we have undertaken a further review with RPS Consulting for our revised draft WRMP24 submission.
- Created a Water Network Strategy for reviewing existing and identifying new leakage reduction techniques and network improvements for driving leakage down.

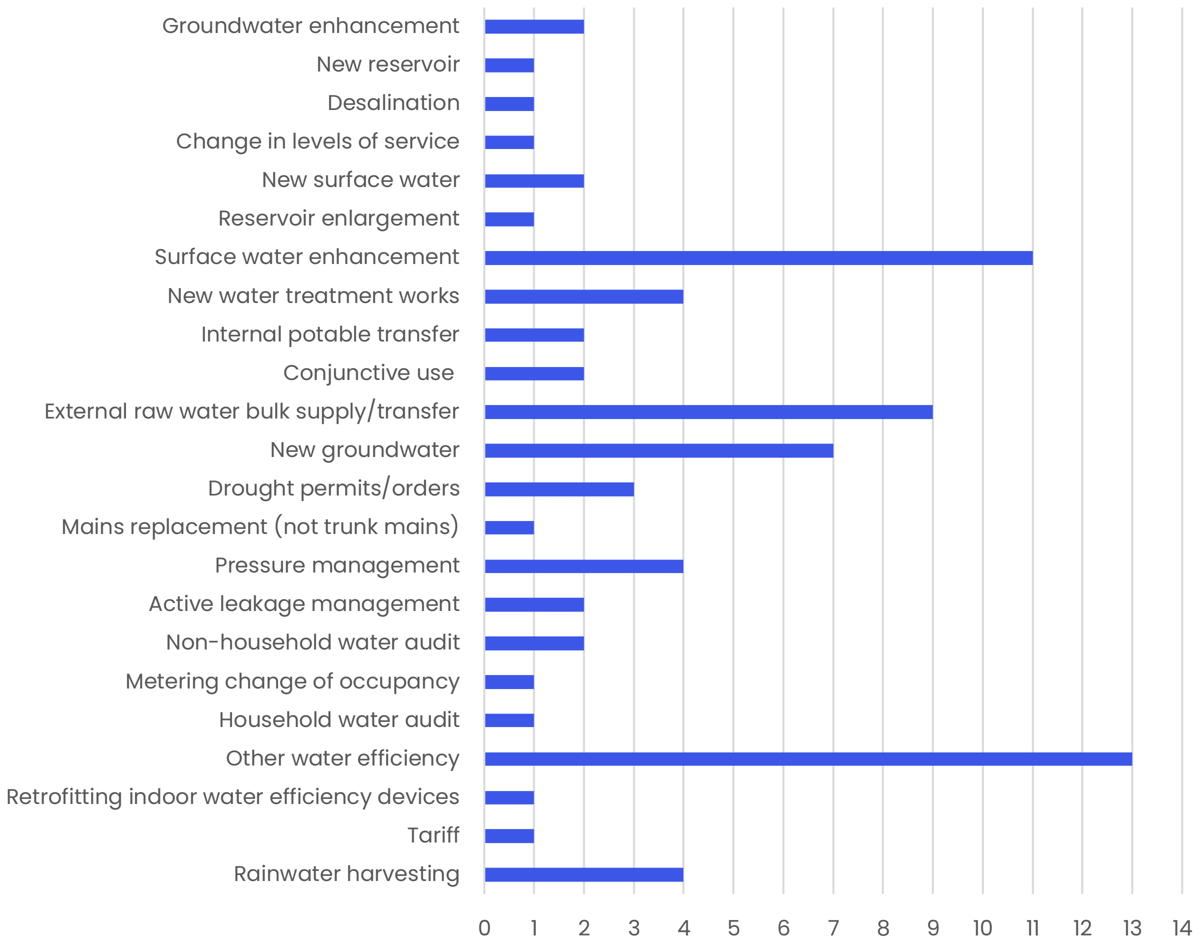
We assess the initial list of options to understand which are technically feasible and should be developed further. We assess demand and resource options differently. The criteria used to assess resource options includes impacts that are not relevant to demand options (for example, planning approvals and biodiversity net gain) and are resource specific. Demand option criteria is usually evidence based and we will draw on our own data, other companies' studies, and industry experts to assess the feasibility of demand reduction options.

Any options that are submitted by third parties through our Bid Assessment Framework, under the water bidding market, are subject to the same criteria as our own options. We have a markets team who are responsible for assessing the options using the WRMP criteria. Any options identified as feasible will be scoped to the same standard as our own WRMP options.

If we identify a reason why an option is not deliverable, it is constrained out and we are left with a 'constrained' or 'feasible' list of options. The unconstrained list, which is all the potential options we considered, is presented in Appendix A.1. The feasible list is provided in Appendix A.2 with a brief description of each option.

The types of options we have considered, and the number of each type identified as feasible is presented in Figure 8.2.

Figure 8.2: Summary of WRMP24 feasible option numbers to meet the Grid SWZ deficit



* Note some supply options are variations on the use of a source of water and are mutually exclusive

8.2 Resource options

There are various types of resource options we consider, including new groundwater and surface water abstractions, additional connections (interconnectors) that increase WAFU, bulk transfers, desalination, and new reservoirs. To identify which of the resource options included in the unconstrained list should be investigated further, we reviewed the technical, environmental, carbon and social attributes of each option at a high level.

The technical attributes considered were source yield increase and / or the demand decrease; construction and delivery costs; time to implement; asset life of infrastructure; and resilience benefits. This information was used to assess the schemes against the criteria summarised in Table 8-1. The detailed screening criteria is presented in Appendix B. The answers to the criteria were used to determine if the options were suitable to take forward for inclusion in the best value plan decision-making or if there was a reason for constraining out at this early stage of the process.

Table 8-1: Summary of resource option feasibility screening criteria

Screening criteria	
Benefit	Does the scheme provide a benefit under the scenario conditions identified?
Environmental acceptability	Does the option avoid breaching any unalterable constraints that makes it unsuitable for promotion
Regulatory acceptability	Is the option promotable / does it meet regulatory and stakeholder expectations?
Risk of failure	Is the risk of the option failing acceptable?

The options included in the feasible list were assessed through desktop studies. We collated all the available information to create a scope of the option details, including location of resource, treatment requirements, pipeline routes, land purchase assumptions and pumping capacity. This information is used to create option specific cost elements and passed on to our Costing Team who derive the costs from our cost models. Each feasible option and the relevant cost elements are entered into our Decision-Making Framework optimisation model. Our cost models are linked to our optimisation model, and this ensures that the WRMP feasible options are based on the latest cost model data and inflation is applied regularly.

For WRMP24 we have carried out a second screening on the feasible options. The options that were constrained out at this stage are included in Appendix A.2 as feasible options and noted as screened out at second screening. This was to ensure the options taken through to the best value plan were deliverable and appropriate for closing the deficit.

Criteria for screening out options included any supply options below a 5Ml/d de-minimis as disproportionate to our need. In most cases there were additional reasons for excluding, such as unacceptable impacts on biodiversity, disrupting a built-up area or the option's location not being strategically beneficial. One option that is below the 5Ml/d (R3a) was retained as the benefit would be higher (15Ml/d) for short periods and it provides a resilience benefit during periods of peak demand.

We have two options that increase the use of groundwater licences which are currently under ongoing WINEP investigations due to be completed in 2025. We cannot plan to increase the use of these licences as there is a potential the abstractions are detrimental to the environment and the permitted abstraction could be reduced. We have therefore constrained the options out of WRMP24 but, depending on the outcome of the investigations, they could be considered in WRMP29.

More widely with regard to lead times for groundwater options, these have been assigned a minimum 3 year lead time, however the optimisation model is utilised to ensure that where a feasible option is selected, we have reviewed the viability of the option lead time in correlation with the likely licencing risks for that specific option. This is described later in Section 10 with regard to those groundwater options that are selected in the period 2025 – 2030.

8.2.1 Drinking Water Quality

We have described our approach to ensuring that this WRMP meets obligations in relation to drinking water in Section 3.14. To help inform this, for the supply options considered in this plan, a high-level review of option type was completed. Where the option involves making greater use of an existing raw water source, water quality risks for that specific source are already well understood through existing Drinking Water Safety Plans. Where the option could make use of a new raw water source, we have a good understanding of the generic types of risk that are likely to exist for that source as we found that they were likely to be similar to those from other sources of the same type (reservoir, river, or groundwater). During the delivery of new supply schemes water quality sampling will be carried out and all necessary permissions sort, including approval for use under Regulation 15 of the Water Supply (Water Quality) Regulations, before any decisions are made to bring new sources into supply.

8.2.2 Third party options

When compiling our list of potential options, we consult with third parties who could provide potential solutions. Third party options include bulk transfer schemes between two or more water companies, licence trading with non-PWS abstractors, collaborative development of resource schemes and upstream services such as the provision of water, leakage detection and demand management.

Our unconstrained list of options is available for consideration against non-PWS needs as well as PWS and we are open to collaborating with other sectors on developing new shared options. However, the needs of other sectors in our region are still being developed and no non-PWS options are included in our WRMP24. This will be considered further in future iterations of our plan.

We have published water resources market information on our website alongside our WRMP24, using a data template provided by Ofwat. This will enable third parties to identify opportunities to provide new water resources and demand management and leakage services. For Yorkshire Water, this will allow us to engage further with third parties and encourage development of potential options. We have also made our market information available, and more accessible, via the Wheatley Watersource Market Information Explore platform. This provides a geographical visualisation of the data contained within the market information tables, by water resource zone. Presenting the information in this way is intended to make it easier for market entrants to understand the data and hence make offers through the water bidding market. To date, we have had one formal submission made through the market information portal, although this was received too late to be included within our options assessment process for WRMP24. This option will be considered as part of our early start optioneering for WRMP29.

Neighbouring water company options

For WRMP24 we have engaged with our neighbouring water companies to consider bulk transfer options as part of the regional planning process. New exports and imports were discussed with Northumbrian Water (NWL), United Utilities (UU), Anglian Water (AWS) and STW. Our feasible options include bulk transfers from NWL, and we have one export option that could provide a supply to STW. Further options were considered through the regional planning process but at this stage no additional bulk transfers were identified as feasible.

Our discussion with NWL identified options to import water from the River Tees, with variations on how the water could be transferred. There are no options available for us to export water to NWL. Our feasible options for importing water from NWL include options to transfer to the Yorkshire Dales, York, or South Yorkshire. The transfer volumes vary from 15Ml/d to 140Ml/d.

All options require pre-treatment to avoid INNS risks before the water can be transferred out of the Tees catchment. Any transfers above 50Ml/d would require a new pump and electricity supply to be installed to transfer water from Kielder Water to the River Tees to support the export. NWL's spare licence capacity is limited to 50Ml/d at most, and larger volume transfers would require new licence permissions to be granted by the Environment Agency. Our discussions with NWL confirmed it has potential to provide a transfer, but the terms and the exact volume would need to be determined through a bulk transfer agreement, with Yorkshire Water funding any additional infrastructure requirements. We have proposed to include the Tees transfer option variants as part of a Kielder SRO in AMP8, which will be delivered in collaboration with UU and NWL.

Our discussion with UU identified two potential import options however, they are low volume supplies (1 to 2Ml/d) and do not provide a sizable benefit for the deficit we need to meet. They have therefore not been taken forward as feasible options for WRMP24. A potential YW to UU transfer from the River Ouse near York was discussed. The option was infeasible as it considered the use of watercourses to transfer the water, and this was not technically feasible. The surplus licence capacity available is also needed to close the deficit in our own area.

Discussions with STW identified one export and no import options. Our export would transfer up to 20Ml/d of treated water from South Yorkshire to STW via a new pipeline. Discussions with AWS did not identify any imports or exports for WRMP24. We do have spare licence capacity potentially available to either UU or STW in the Doncaster area, but the licences are under WINEP investigations, and we cannot assume that this capacity will be available in the future.

The outcome from these discussions is that there has been no requirement from other water companies for new transfers from our supply area for WRMP24 (through collaboration including both WReN and other regional groups). The outcome of the regional planning reconciliation process[44] (RCG, 2023) was that STW plans to terminate the existing transfer it currently provides to our South Yorkshire area. We have investigated options for offsetting this loss and discuss this below.

We are committed to exploring the potential for developing technically feasible (but currently resourced constrained) transfers as part of the next round of planning. This activity will form a re-assessment of water available for intercompany transfer following resource investigations and the outcomes of WRMP24 (as part of the option identification case for WRMP29).

8.2.3 Alternative STW transfer options

We have investigated options to replace the existing STW to YW raw water transfer from the Derwent Valley reservoirs. The existing contract end date is 2084, however it could terminate in 2035 if either STW or Yorkshire Water gave notice to the other party by no later than 2030.

At the time of publishing our draft WRMP24, Yorkshire Water and STW were jointly developing an SRO that would increase the reservoir capacity in the Derwent Valley. However, following concerns by regulators and stakeholders on the impacts of the reservoir expansion scheme, STW has confirmed that it will not progress with this option. In an update to its draft WRMP24, STW has also confirmed that cessation of the existing transfer will be included in its preferred plan from 2035. We have aligned our plan with this outcome and there is no planning scenario in which the transfer could continue.

Alternative supply options were identified through studies carried out on our behalf by Stantec consultants as part of the WReN regional planning process. In line with the WRMP options identification process we identified an unconstrained list of options. We assessed them against the screening criteria listed in Appendix B to determine a feasible list of options for meeting this specific need. The unconstrained list and feasibility outcome is shown in Table 8-2.

We have aligned with the WReN principle that a 5Ml/d de-minimis should be applied to strategic needs. The loss of the STW transfer initially increases the deficit in the Grid SWZ by 46Ml/d. To include very low volume schemes would not negate the need for larger schemes and so the de-minimis is applied.

[44] Inter-regional Reconciliation 3: Summary report (https://www.waterresourcesnorth.org/globalassets/wrmp/wren/inter-regional-reconciliation-3---summary-report---v1.0---final-for-publication.pdf), noting particularly Section 5 & 7 as relevance to Yorkshire Water.

Table 8-2: Unconstrained list of alternative options to the STW transfer

Option Ref.	Option name	Outcome
DV1 & DV2a	Increase / expand South Yorkshire reservoir existing supply	Constrained out. Low benefit (below 5Ml/d de-minimis)
DV2b	Additional storage at or near South Yorkshire WTW	Constrained out. Low benefit (below 5Ml/d de-minimis)
DV3	Magnesium Limestone (South Yorkshire area) new GW supply	Feasible but limited resource available (5Ml/d)
DV4	Barnsley BH	Constrained out. Low benefit (below 5Ml/d de-minimis)
DV5	Expand Derwent Valley reservoirs	This was in development as an SRO in collaboration with STW but due to environment and heritage concerns the SRO will not be progressed any further.
DV6	NWL import from R Tees to South Yorkshire (direct)	Feasible provided pre-treatment installed at source to address INNS risk (50-140Ml/d)
DV7a	NWL import from R Tees transfer via grid	Feasible provided pre-treatment installed at source to address INNS risk (50-140Ml/d)
DV8(iv) & DV8(iv)A*	North to south internal transfer connection – various routes considered	Feasible – enables water to be transferred via a new interconnection but no associated yield benefit
DV8(v) & DV8(v)A	Expand existing or build new WTW (York) supplied by the River Ouse	Feasible – transfer existing licensed resource to new WTW adjacent to an existing treatment site
DV9a & DV9b	Doncaster supply to South Yorkshire – treated or raw	Constrained out. Source of supply is under WINEP investigation
DV9c	Doncaster supply to STW	Constrained out. Source of supply is under WINEP investigation
DV10	Transfer existing South Yorkshire Reservoir supplies to Sheffield WTW receiving the Derwent Valley import	Constrained out. This does not provide a new resource and although could provide a resilience benefit it would not close the deficit
DV11a (R1c)	Increase grid supplies to South Yorkshire - treated	Feasible – this option has been taken forward as WRMP option R1c
DV11b	Increase grid supplies to South Yorkshire - raw	Constrained out. INNS risk
DV11c/d	Increase grid supplies to South Yorkshire – raw river/canal/pipeline	Constrained out. INNS risk
DV12	Sheffield WTW new local sources	Constrained out. Low benefit (below 5Ml/d de-minimis)
DV12a	River Trent	Initial investigations have not identified a feasible option, but we consider there could be some potential on further investigation
DV12b	River Don	Constrained out. Water only available at low reliability
DV13	West Yorkshire	This is a feasible option and has been developed as WRMP R86

* This could be supported by WRMP options included in the wider list (Appendix B) either directly or by displacement

We identified a total of 18 unconstrained options, although it should be noted that some presented alternative uses of the same source and are mutually exclusive. A number of the options investigated could provide an alternative raw water source to the South Yorkshire WTW that treats the Derwent Valley import. However, to address INNS risks if the alternative raw water source is within a different catchment to the receiving works, pre-treatment would be required before transferring. There were no feasible options identified in the same catchment as the works that treats the import.

Of the 18 unconstrained options, only five were determined to be feasible. As there was limited new supplies available close to the South Yorkshire demand area, it was concluded that the WRMP24 solution would need to include the DV8(iv) or DV8(v) option. This is new internal transfer from York to South Yorkshire and alternative routes have been considered. This option does not provide a benefit but enables the South Yorkshire demand to be met by sources in the North Yorkshire area, which increases total WAFU in the Grid SWZ.

A combination of new water treatment (DV8(iv)A) and internal transfer (DV8(v)A) options is referred to as DV8B. To ensure that we can maintain supplies once the Upper Derwent Valley transfer ceases in 2035, we must progress with the development of option DV8B through the SRO process and will agree a programme for this with RAPID following publication of our final WRMP. In addition, we will carry out further option identification studies in AMP8 before the transfer termination decision date of 2030. We shall also consider the future of the South Yorkshire WTW that treats the imported supply. In addition to the import, we feed water from local reservoirs to the site, but the volume is limited to 10 to 15 Ml/d; the works is designed to treat a minimum flow of 35Ml/d and maximum of 75Ml/d. The works will need to be reconfigured to treat a lower volume or supplied by alternative sources. For example, water from YW reservoirs in the area that are treated at local WTWs could be rediverted to the South Yorkshire WTW.

8.3 Options for reducing outage and increasing resilience

We have considered options for both short term outage reduction, as well as addressing larger scale supply resilience needs. Our approach in each case is outlined below.

8.3.1 Outage options

Our outage assessment includes risks based on previous outage events and provides an allowance for short term losses of supply. We have an outage performance commitment for reducing unplanned outage this AMP. We also consider outages in our drinking water supply strategy and whether our existing treatment practices require modifications or refurbishment to treat water that has deteriorating water quality and so causes outages. Outage reduction is considered for our PR24 business plan, and any benefit of planned capital schemes built into our WRMP24 outage allowance.

Our Drinking Water Safety Plan is submitted to the DWI and identifies investment to mitigate outage risk. This includes a need to replace an existing borehole at North Yorkshire 1 to avoid water quality risks. Past outages at the site due to poor water quality have followed heavy rainfall events and have not posed an outage risk in WRMP terms as there has been sufficient alternative supplies. However, there is a resilience risk especially during high demands if the alternative sources could not fully compensate for the outage at North Yorkshire 1.

To ensure deteriorating water quality at the site is not a risk to future supply, a drinking water quality scheme will relocate the borehole and is due to be delivered in AMP8. Historically we have not fully utilised the licence that permits the borehole abstraction. By relocating the borehole to an area that avoids the water quality risk we create an opportunity to increase the use of the resource. A WRMP option has been developed that includes additional infrastructure that would link the borehole to the North Yorkshire 2 WTW. This would provide an additional supply but would only be utilised during outages at the North Yorkshire 2 WTW, during times when the flow in the River Ouse, which supplies the works, is low. This would increase the Grid SWZ WAFU by 5Ml/d in the DYAA scenario and is included as option R91 New internal transfer to North Yorkshire WTW 2.

8.3.2 Resilience options

Our WRMP19 considered the resilience benefits of our WRMP options. Our Asset Planning team identified the water treatment works in our area that are key to our conjunctive use system and would severely limit supply if out of service, or if the output was severely reduced due to extreme weather conditions or other events. This work considered unprecedent outage events with more extreme risks than the WRMP outage assessment identifies. Current resilience of the sites was assessed by considering the ability to maintain supply through on-site storage and support from alternative water treatment works. Vulnerability was assessed against the number of properties that could be affected by extreme outage events.

For our PR24 Business Plan, we have expanded on this work through our Water Supply Systems Strategy (WSSS) project. Our WSSS project reviews the combined risk of extreme weather events and areas of our network where the constraints are testing our ability to supply customers. During extreme weather events (summer and winter) we experience short daily peaks in demand (greater than our DYAA or critical period demands) and network constraints can mean some areas, particularly if over reliant on a single WTW, are at risk of outages. In most circumstances, we have sufficient storage or alternative resources to ensure these outages do not impact on our levels of service. Our business plan will consider where risks can be mitigated though additional service reservoirs or enhancing water treatment works. Further details are provided in section 3.6.1.

In our WRMP24 options appraisal, we have considered the risks identified in our WSSS and which of our WRMP options could meet a supply-demand balance need and a WSSS need. WRMP critical period scenarios typically consider peak demands that are experienced during a period of seven days or more. For our Grid SWZ, the critical period is a four-week summer demand increase. The non-drought resilience work in our WSSS considers system constraints during shorter duration peak periods where the constraint is not the resource. In some circumstances there is a resource and a system constraint need and WRMP options could meet both needs. These options are classed as resilience options as well as WRMP options and we have included a best value metric in our decision-making process which assigns a value to options that meet resilience needs, including outage risks.

Table 8-3 summarises the links between our the WSSS areas that were completed in time to feed into this WRMP and the WRMP options.

Table 8-3: WSSS risks that could be addressed by WRMP options

Water Supply System	Summary of strategic risks	WRMP Options that could resolve the risk
North Yorkshire / Dales	The North Yorkshire area is reliant on a WTW in the Dales area. The works can struggle to meet daily peak demand particularly during the summer or freeze thaw and the area is vulnerable during critical periods. The WTW meets around 60% of the demand. This means the area lacks resilience to unplanned outages. Its estimated survival time (outage duration beyond which significant supply interruption is likely) is only 15 hours. In addition, the area is subject to demand growth, including significant non-household growth associated with a drinks manufacturer that is locating a new production plant in North Yorkshire. Other commercial and residential growth in the A1 corridor is exacerbating the risks. The area could benefit from either new links to the grid network or new resources that reduce the reliance on the WTW. A new resource would also reduce drought risks and benefit the Harrogate area as the Harrogate and the Dales 'share' a reservoir supply.	Northern Grid Extension (R1d -also requires R1a as a pre-requisite) Tees to Dales import from NWL (R49 and R51) Sherwood groundwater sources (R8c, R8g) Northallerton WTW (R87) Convert Wensleydale springs to boreholes (R89)
Howardian Hills	The Howardian Hills system has limited connectivity to the grid network (it can import some water from York). There are five relatively small treatment works within the system which can provide limited support in the event of an outage at any one of those works. The most vulnerable works is North Yorkshire 2 WTW, which receives raw water abstracted from the River Ouse. The river is subject to frequent periods of high turbidity, which due to the configuration of the raw water lagoons and pipelines cannot be prevented from reaching North Yorkshire 2 WTW. At times, this raw water cannot be treated effectively leading to outages, which have come close to causing supply interruption to around 8,000 properties. There is also a risk of supply interruption to around 14,000 properties in the event of an unplanned outage at another WTW in this area, and a PR24 scheme is being developed to improve the WTW's resilience.	Northern Grid Extension (R1e also requires R1a as a pre-requisite) Sherwood Sandstone and Magnesian Limestone Boreholes option 2 (R8b) New groundwater (Sherwood Sandstone) supply to existing North Yorkshire WTW (R8h) Increase storage at an existing WTW in North Yorkshire (R88)

York	The York system is supplied in roughly equal proportions from two WTWs. In the event of an outage at York WTW 1, York can be supplied by increasing the supply from York WTW 2 but if the supply from York WTW 2 is lost, York WTW 1 cannot support the York demand on its own. This would leave around 42,000 properties at risk of supply interruption. An unplanned outage at York WTW 2 exceeding 20 hours could cause such an outage, as could the failure of the (single) trunk main which supplies York from York WTW 2. There is a critical section of this main which crosses the A64 at significant depth which would not be repairable in time to prevent the supply interruption.	Northern Grid Extension (R1g also requires R1c as a pre-requisite) New WTW (York) supplied by the River Ouse (DV8(v) and DV8(v)A)
Bradford	Bradford's raw water supply can come from a combination of 3 aqueducts. The loss of either of the two main aqueducts for a short period of time can be tolerated without risk of loss of supply (would require some introduction of alternative supplies and minimisation of exports). In a longer-term outage (weeks to months) the risk of supply interruption would increase given the potential for outages elsewhere to reduce the availability of alternative supplies or increase need to resume exports. There are critical sections of the largest aqueduct where asset failure could result in loss of raw water supply for several months.	New Abstraction from the River Aire (R37b(ii) River Aire Abstraction option 4) New (R86 West Yorkshire new WTW)
South Eastern Grid	The South eastern area of our grid system is dependent on support from the grid network to maintain supply during high demand periods. Existing grid connections can support South East WTW 1 or South East WTW demand areas at times of high demand but not both. Supplies to the South East WTW 1 WSS are vulnerable to outages at local WTWs and this vulnerability has increased as a result of Regulation 26 compliance protocols increasing the risk of supply interruptions, which could affect around 2,000 properties. There is very limited storage available for South East WTW 2 resulting in minimal survival time in the event of an outage with a risk of supply interruptions to around 45,000 properties for outages exceeding 16 hours. This limited storage also means that it is not possible to take South East WTW 2 out of service for sufficient time to carry out adequate maintenance, thereby compounding the risk of future unplanned outage. The system currently requires South East WTW 2 to operate at full capacity and future growth in the Doncaster area will increase the pressure on this works.	Rebuild Kirklees WTW (R85)

Harrogate	The Harrogate area is showing some signs of pressure during peak production and linked to local growth. This area shares a resource with the Dales area and new resources in this area could provide resilience benefits to support the Dales as well as in the Harrogate area.	Sherwood Sandstone groundwater supplies (R8)
Doncaster	The Doncaster area is experiencing local growth and is being supported by our grid network. In the future increased grid support maybe required at peak times or during outages. A bidirectional link could allow support to the grid when other areas experience outages.	South Yorkshire Groundwater Option (R6c and d)
Flood alleviation	Flood alleviation was not considered in the WSSS, but it has been considered as a resilience need. We have a reservoir in West Yorkshire that has been used for flood alleviation as part of a trial in collaboration with the EA where the reservoir has been drawn down. We will continue to work with the EA to determine if using these reservoirs for flood storage could provide flood protection without risks to water supplies, following the Operating Framework published by the EA in 2023 (Environment Agency, 2023)	New Abstraction from River Aire (R37b(ii)) or a new West Yorkshire WTW (R86) could support this scheme, but further assessments would be required to confirm this.

8.4 Demand management options

Our demand management options reduce distribution input and mean we are required to put less water into supply on average each day. This helps offset demand growth which conversely increases the volume we are required to put into supply. Depending on the driver of supply-demand deficits, demand reduction can also reduce the need for new supplies which benefits the environment. We have considered demand reduction options for:

- **Leakage** – reducing the volume of water we lose between the point of distribution and customers' properties
- **Metering household and non-household properties** – metered properties tend to use less water on average.
- **Water efficiency** – enabling our customers and businesses to use less water on average in their homes and places of work.

8.4.1 Leakage options

Our WRMP19 included a challenging leakage target to reduce leakage by 15% in the first five years of the plan (2020 to 2025) and to continue to reduce leakage to achieve a 40% reduction by the 2030s. For WRMP24 the water industry has been set a target to collectively reduce leakage by 50% compared to 2017/18 levels by 2050. This objective aligns with our WRMP19, and we have reassessed our leakage options for our WRMP24.

In 2017/18 our total leakage level (Grid SWZ and East SWZ combined) was 323Ml/d. To achieve the policy requirement, we have created a glidepath to reduce leakage to 161Ml/d by 2050. The benefit of achieving the target has been allocated to our Grid SWZ as the zone is in deficit and includes the majority of our region. The East SWZ total leakage has been maintained at 1.44Ml/d across the planning period.

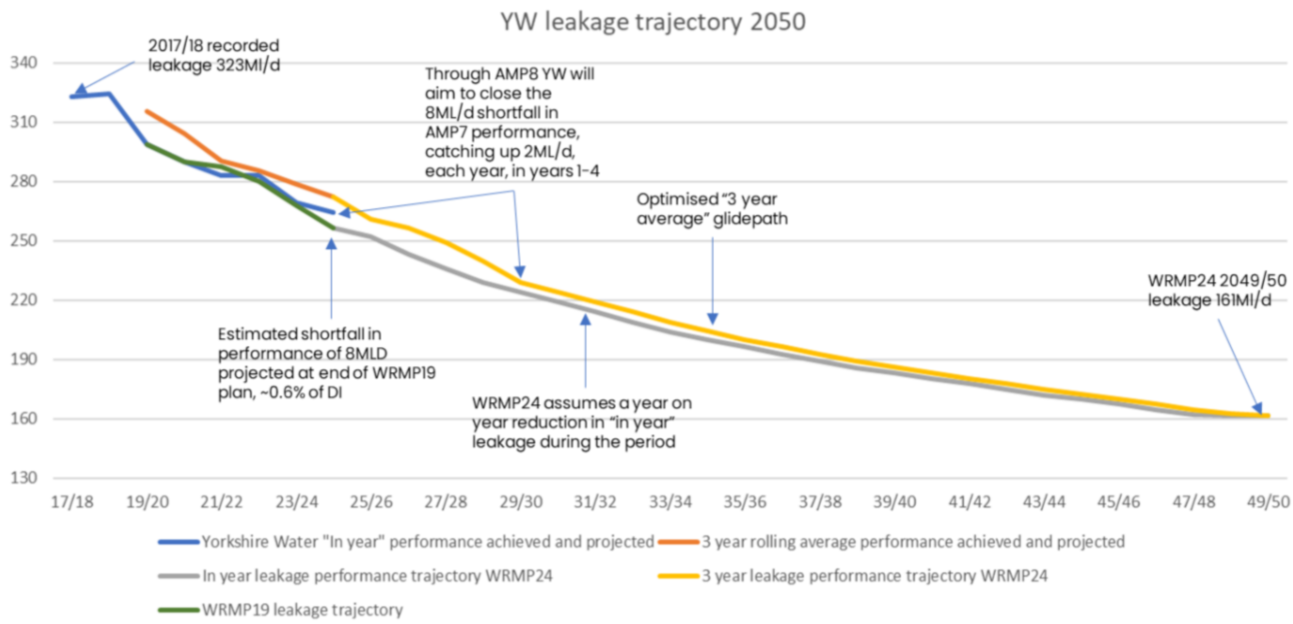
The current leakage target is an Ofwat performance commitment that has been set for AMP7 as a three-year rolling average target. To achieve the policy requirement, we have therefore created a three-year rolling average target for the period from 2025 to 2050. The three-year rolling average has been converted to year-on-year projection that is aligned with the three-year rolling average target. However, the in-year values for some years increase compared to the previous year, accommodating extremes of climatic conditions adverse to leakage management and improvement in some years. The WRMP however, forecasts leakage reduction annually and does not plan for increases in total leakage.

The full leakage trajectory from 2017/18 is shown in Figure 8.3. Yorkshire Water has achieved its in year Defra leakage targets for the first 2 years of AMP7, with a small shortfall in performance in year 3 of the plan. The 3Ml/d shortfall in year 3 of the plan is largely due to adverse in year conditions, with an exceptionally hot dry summer causing ground slumping and higher levels of leakage than expected, whilst a colder than average winter, also resulted in leakage breakout above historic averages.

The industry has a metric to measure the amount of leakage a company has to find and fix to maintain a static leakage level; this is called the natural rate of rise (NRR). The adverse summer and winter conditions resulted in 91.3Ml/d of additional leakage activity to maintain performance in 2022/23 compared to the 7 year average of NRR. Without the high NRR experience in year 3 of the plan, Yorkshire Water project that they would have achieved the year 3 leakage plan target for Defra. NRR is a metric which Yorkshire Water will be monitoring closely in the lead up to WRMP29 as climate change may impact the level of activity to maintain a leakage level, making reductions in leakage more challenging to achieve.

By the end of AMP7 Yorkshire Water are aiming to achieve an in-year performance of 256Ml/d, however current projections of actual performance may be up to 8Ml/d behind the WRMP19 plan, due to a shortfall in investment to achieve frontier levels of leakage. To address this approximate 0.67% shortfall in distribution input (DI) reduction, Yorkshire Water are looking to achieve an 8Ml/d "catchup" over the first 4 years of AMP8, resulting in achieving and aligning to the WRMP leakage target in year 5 (2029/30) of the plan.

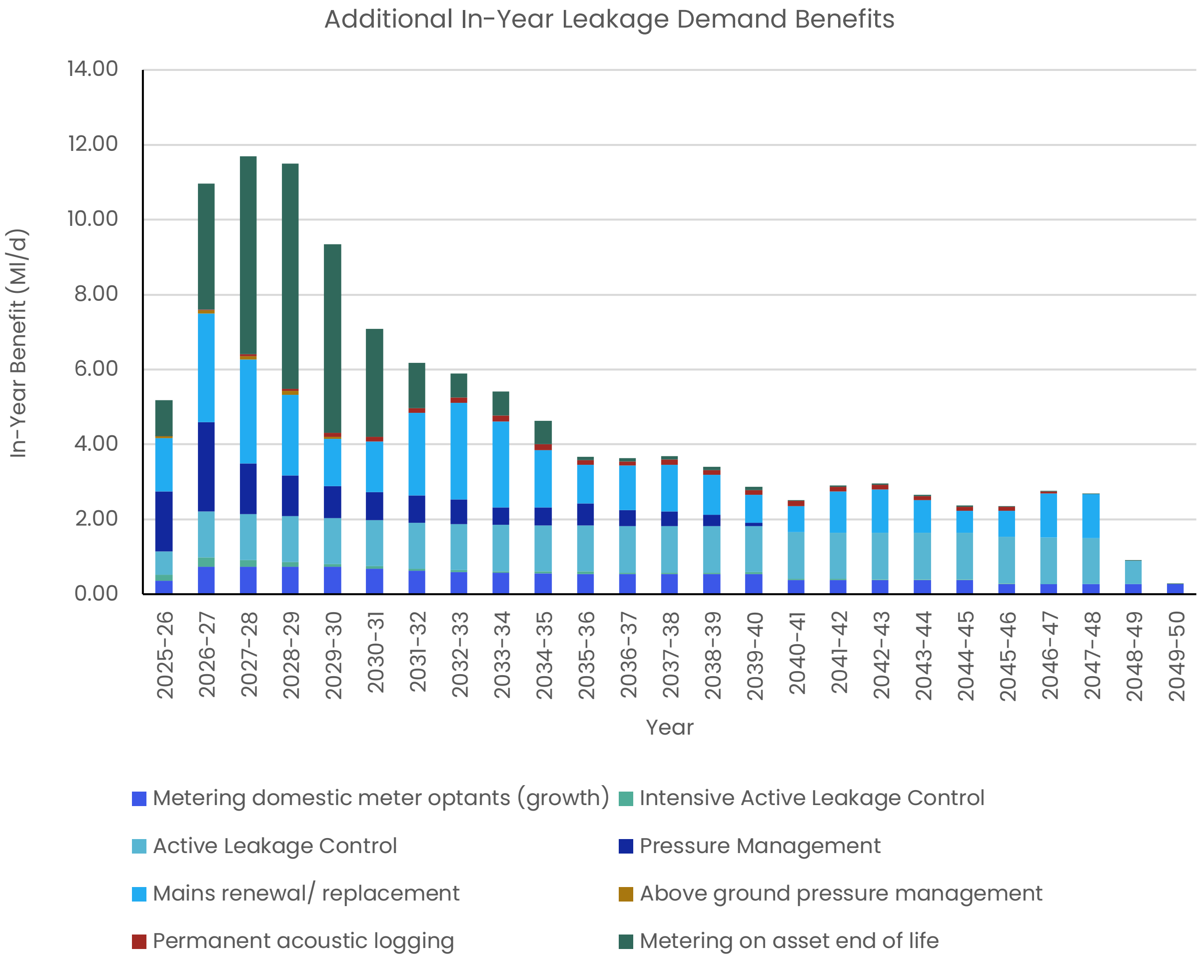
Figure 8.3: Three year rolling average and annual leakage reduction glidepaths to achieve the 2050 leakage target



Yorkshire Water's optimisation process has considered a bottom-up build of leakage intervention costs and benefits, including all options in Table 8.4. Unconstrained lowest cost optimisation runs have required a 50% reduction in leakage to achieve the required supply demand resilience during the period. Yorkshire Water has built 30%, 40%, 50% and 60% reduction strategies, in a bottom-up build and optimisation process, including variants for policy constraints such as smart metering and mains renewal. As such, the 50% leakage reduction target will take precedence, aligned to the supply - demand resilience need and regulatory regime ambition. The 50% leakage reduction target will be incorporated into our preferred plan for WRMP24. Scenarios have been built to consider higher levels of leakage reduction up to 60%. The Yorkshire Water demand scenario is such that a 60% scenario is not required to achieve a supply - demand balance. The incremental increase in unit cost to achieve more challenging frontier levels of leakage, mean that it is not cost beneficial to customers to target levels of leakage reduction greater than 50%. Through subsequent WRMP cycles as technology and innovation brings the cost of leakage down, this long-term target will be reviewed.

The leakage trajectory detailed in Figure 8.3 is a result of optimisation of the leakage investment options detailed in Figure 8.4 below, which is an output of the optimised 50% leakage reduction plan from SoLow including a metering and mains replacement policy constraint.

Figure 8.4:Yorkshire Water 25 year leakage trajectory and optimised investment glidepath



The investments regime above will deliver leakage benefits as forecast in Figure 8.4. These initiatives have been included in the 2050 glidepath but with benefits phased over 2 years, the year of initial investment / commissioning and the following year. This phasing is to accommodate the way by which leakage is calculated. Leakage is calculated as an annual average value (each day accruing 1/365th of the total reported value), the benefits from the intervention have been phased over 2 years as interventions commissioned at the end of the year will realise most of the benefit in the second year. As such we have modelled that a programme of delivery would have an even benefit regime meaning 182.5/365ths of benefit would be realised in year 1, with the remaining benefit occurring in year 2.

The blended programme above will result in 33.26Ml/d of leakage reduction from customer smart metering. This programme of work is underpinned by a Smart as Standard Strategy from 2023, where all new meters being installed within Yorkshire Water will operate as smart. This includes DMO, new developments and broken meter exchanges. An end-of-life meter exchange programme will start in AMP8 replacing 1.38million meters and completing in AMP9, at which point all the customer meter asset base will be smart. The preferred plan has not included policies to increase meter penetration through compulsory metering, however this will be reviewed, and customer support understood as part of the WRMP29 process. The smart meters will detect continuous flows in near real time and target the circa 72Ml/d of customer side leakage through proactive engagement with customers to limit water wastage.

Mains asset renewal will deliver 28.45Ml/d of leakage reduction. Utilising the RPS SoLow optimiser and associated industry benefit models, Yorkshire Water will target enhanced levels of mains replacement in DMAs with high levels of mains failure and high levels of background leakage. This plan will deliver 0.66% mains renewal for a 10 year period, before reducing the renewal percentage to sustain asset health metrics.

Pressure management and active leakage control will deliver 16.29Ml/d of leakage reduction. Yorkshire Water has recognised its higher than national average, average zonal pressure and night pressures, and has undertaken significant strides in AMP7 to reduce pressure and increase the maturity of network pressure management in AMP7. This will continue in AMP8 with city wide pressure management schemes, network optimisation and completing the installation of advanced pressure control on our pressure reducing valves (PRVs) and advanced controls on variable speed drives (VSDs) for our pumped systems. Yorkshire Water has embraced digital twin technology and will undertake intensive leakage control activities on the worst performing DMAs to understand the root cause of asset performance and improve leakage performance.

This blended programme of work is more aggressive in the early years of the plan to bridge the supply demand gap. Yorkshire Water will iterate the plan in subsequent WRMP submissions as the evidence base of costs, benefits and remaining opportunity improves, and the active monitoring programme for adaptive pathways determines whether a different blend of investments is required to achieve a cost-effective outcome for customers.

The initiatives within the programme are all solutions which Yorkshire Water has historic experience in delivering, albeit in AMP8 the solutions may have enhanced maturity (such as intensive / advanced active leakage control or advanced pressure management), or at a scale which has previously not been undertaken (such as 0.66% mains renewal or 1.4 million meter exchange). As such the deliverability of the programme is high, with the mains risks to achieving the outcomes for leakage reduction being related to correct projection of benefit and the costs of the solutions in a volatile international supply chain and high levels of inflation. Both of these risks will be part of the adaptive planning monitoring programme detailed in section 10.3.

8.4.2 Metering strategy supporting leakage, PCC and non-household demand reduction

Yorkshire Water has considered seven options regarding meter investment, against a backdrop of an asset base largely at the end of its operational life during AMP8 detailed in Table 8.4 below.

A long list of options has undergone modelling to confirm suitability to include in the WRMP for delivery within the WRMP24 plan. The modelling prior to inclusion in scenario optioneering in the WRMP Optimiser includes consideration of the following factors:

- The level of service improvement in relation to cost to achieve.
- The cost of "regret spend". This would include early capital write off or enhancing operational costs to mitigate decreases in efficiency due to assets being end of life.
- The design of an efficient smart meter roll-out programme, allowing for volume and workforce efficiencies
- The deliverability of the programme, ensuring supply chain and people resources can cope with the scale of the investment.
- Dependencies between policies, impacting the trajectory to "full smart metering".
- The blend of technologies required to achieve "full smart metering".

For each of the factors above there will be an impact on the following service / efficiency areas:

- Per capita consumption
- Non household demand
- C-MeX
- BR-MeX
- Leakage targeting
- Customer side leakage

Table 8.4 below sets out a variety of strategy scenarios considered by Yorkshire Water within the WRMP for our metering assets. It demonstrates that Yorkshire Water do not have the option to spread this investment over multiple periods, because asset performance is limited by the life of battery powered components and life of metrology. If we don't invest in life expired assets in AMP8 to maintain service, significantly higher opex would be required to perform manual meter reading activities and risks of meter under registration and data integrity and accuracy would increase. Additionally, it would erode benefits from leakage, PCC, and non-household demand reduction, putting at risk the resilience of the Yorkshire Water supply demand balance within the WRMP. Further additional miles driving to manually read meters, would impact Yorkshire water's Net Zero Carbon Strategy and impact accuracy of billing, causing a regression in customer satisfaction.

Table 8.4 below, details the scenarios which were carried forward for optimisation within the WRMP. The "Cost Delta" column demonstrates the totex change in investment over the next 15 years compared to a baseline of replacing AMR like-for-like at the end of asset life. A negative figure demonstrates a reduction in costs, a positive figure demonstrates an increase in costs.

Benefits impacts are shown as a red, amber, or green status across key performance commitments. Red indicating a negative impact, amber as marginal impact and green being a positive impact. An estimated, quantified leakage benefit is shown in the Benefit Delta box.

Within our AMP8 programme, no investment is being proposed to be brought forward from AMP9. Approximately 100,000 AMR meters are due to be replaced as end of life in AMP9. These have not been brought forward due to risks to deliverability increasing the AMI further beyond that proposed in AMP8.

Table 8.4 below shows £0 base totex as the assumption within WRMP, this assumes that a Cost Adjustment Claim would be successful allowing funding the base element of the smart metering programme, with enhancement funding supported by the WRMP to provide the upgrade from AMR to AMI and releasing the benefits from smart metering.

For WRMP24 scenario 4 has been constrained into the plan, given the need to replace the metering asset base, the 'no regret' spend impact of transition over one AMP period, the lowest cost to customers to transition now and multiple benefits realised.

Scenarios 6 and 7 have been considered within the optimisation process, with Change of Occupancy policy (scenario 6) being selected in the lowest cost plan. Given the risk of successfully delivering a Change of Occupancy policy, in addition to the 1.4 million meter exchanges and 160,000 new meter installs, the Change of Occupancy policy has not been included in the plan, allowing for ratification of cost benefits and further engagement with customers in AMP8, to subsequently inform WRMP29.

Table 8-4: Summary of shortlisted metering strategy options for WRMP24

Scenario No	Investment Scenario		Cost Delta (Millions, 1st investment cycle 0-15 years)	Benefit Delta DI MLD (AMP8)	Outcome	
1	No AMR meter Replacement- Revert to visual Read		Base Totex: – £64.00 Enhancement Totex: £0	- 8 MLD, regression	**Rejected**: Regression in service is not aligned with strategic requirement to reduce Water Demand	
	Description: Allow AMR solution batteries to fail and do not replace with new AMR. Attempt to maintain 6 monthly reading cycle with increased meter reading resource. Lose capability to understand AMR alarms, such as continuous flow leak alarm, limiting capability to target customer side leakage.					
	Customer Side Leakage impact	Leakage Targeting impact	Per Capita Consumption impact	Non Household Demand impact	C-Mex impact	BR-Mex impact
2	AMR for AMR replacement end of life		Base Totex: £0 Enhancement Totex: £0	0 MLD	**Progressed**: Included as the baseline assumption for WRMP scenario modelling	
	Description: Replace end of life AMR meter, with an new AMR meter. Service levels and capabilities will be maintained as BAU service.					
	Customer Side Leakage impact	Leakage Targeting impact	Per Capita Consumption impact	Non Household Demand impact	C-Mex impact	BR-Mex impact
3	AMR for AMR replacement, smoothed AMP impact		Base Totex: £36.00 Enhancement Totex: £0	-4 MLD, regression	**Rejected**: Regression in service to attain a reduction in Water Demand and higher whole life cost to customers.	
	Description: To mitigate bill impact of large AMR meter replacement programme in 1 AMP, replace ½ the AMR meters in AMP8 and the second half in AMP9. Attempt to maintain 6 monthly reading cycle with increased meter reading resource, for meters with end of life AMR's. Half of meters lose capability to understand AMR alarms, such as continuous flow leak alarm, limiting capability to target customer side leakage. Performance would recover during 2nd AMP with AMR EOL replacement.					
	Customer Side Leakage impact	Leakage Targeting impact	Per Capita Consumption impact	Non Household Demand impact	C-Mex impact	BR-Mex impact
4	AMR for AMI replacement End of life		Base Totex: £0 Enhancement Totex: £80.0	19.3 MLD DI reduction	**Progressed**: Included as option for delivering service improvement and long term DI target attainment.	
	Description: Replace end of life AMR meter, with an new AMI meter. IT systems, process, customer communications, maintenance, future DMO and New Developments all Smart. Note enhancement costs include cost delta for DMO & New Developments vs AMR.					
	Customer Side Leakage impact	Leakage Targeting impact	Per Capita Consumption impact	Non Household Demand impact	C-Mex impact	BR-Mex impact
5	AMR for AMI replacement, smoothed AMP impact		Base Totex: £36.00 Enhancement Totex: £80.0	5.65 MLD DI reduction	**Rejected:** Over a 15 year Whole life cost, this model is more costly, impairing AMP8 performance improvements and regressing service levels in areas of delayed AMR replacement.	
	Description: To mitigate bill impact of large AMR meter replacement programme in 1 AMP, replace ½ the AMR meters in AMP8 and the second half in AMP9. Attempt to maintain 6 monthly reading cycle with increased meter reading resource, for meters with end of life AMR's. Half of meters lose capability to understand AMR alarms, such as continuous flow leak alarm, limiting capability to target customer side leakage. Benefits for ½ of region with AMI replacement would be eroded against less ability to respond to continuous flow alarms which would no longer be generated from AMR's with expired batteries. Note enhancement costs include cost delta for DMO & New Developments vs AMR.					
	Customer Side Leakage impact	Leakage Targeting impact	Per Capita Consumption impact	Non Household Demand impact	C-Mex impact	BR-Mex impact
6	AMR for AMI, Change of Occupancy metering		Base Totex: £0 Enhancement Totex: £74.25	13.00 MLD DI reduction	**Progressed:** Included due to strategic alignment and service improvement acceleration option. Required to achieve "full Smart metering".	
	Description: When a new occupier contacts Yorkshire Water to become the bill payer, Yorkshire Water would install a meter at that property for billing purposes. This would speed up the transition to Full Smart Metering, but increasing the number of unmetered properties per which would switch to Metered charging, enabling all the benefits of water efficiency to be realised through a link to the customer bill. This has a dependency on scenario 4 which would deliver the capabilities to realise a service improvement. In the first AMP of adopting this policy circa 167.7K properties would have a meter installed through this policy change. If selected, constraint may be required to start in AMP9, as delivery of AMP8 programme may be overambitious to include this additional volume of meters.					
	Customer Side Leakage impact	Leakage Targeting impact	Per Capita Consumption impact	Non Household Demand impact	C-Mex impact	BR-Mex impact
7	AMR for AMI, enhanced Domestic Metering Programme		Base Totex: £0 Enhancement Totex: £14.38	2.32 MLD DI reduction	**Progressed:** Included due to strategic alignment and service improvement acceleration option. Required to achieve "full Smart metering".	
	Description: Through proactive campaigns and targeting, enhance the number of customers opting to have a meter installed. This would equate to 31.5K properties in AMP8 and 24.5K properties in AMP7. This has a dependency on scenario 4 which would deliver the capabilities to realise a service improvement. This option has a relationship with scenario 6, both policies are not to be selected together as the overlap in customers targeted is too great. If chosen, scenario 6 would take precedent.					
	Customer Side Leakage impact	Leakage Targeting impact	Per Capita Consumption impact	Non Household Demand impact	C-Mex impact	BR-Mex impact

8.4.3 Per capita consumption (PCC) reduction

Our WRMP19 included a challenging PCC target to reduce PCC by 8.9% in the first five years of the plan (2020 to 2025) and to continue to reduce PCC to achieve 110l/h/d by the 2050. For WRMP24 the water industry collective target of achieving 110l/h/d is still in place and we have assessed our WRMP24 water efficiency options to ensure our glidepath achieves our 2050 PCC target.

Demand reduction initiatives aimed at helping our customers reduce water use in their homes is already part of our base demand reduction activity. We also have an initiative to identify customers who might benefit from a metered supply, and we pro-actively contact such customers to encourage them to consider opting for a meter.

Our demand forecast model accounts for future influences on costumer use, including metering and water efficiency activity in our baseline projections. The aggregated assumed savings are reflected in the baseline demand forecast and the output is a year-on-year reduction in household demand.

This forecast shows by 2050 average PCC will be 116.9l/h/d in the DYAA and 114.5l/h/d in the normal year scenario, as shown in Table 8-5. This reduction assumes no additional household demand reduction interventions beyond base activity.

Table 8-5: Summary of baseline normal year and dry year annual average PCC forecast by AMP period

	2019/20 (end AMP6)	2020/21	2021/22	2022/23	2023/24	2024/25 (end AMP7)	2029/30 (end AMP8)	2034/35 (end AMP9)	2039/40 (end AMP10)	2044/45 (end AMP11)	2049/50 (End of AMP12)
Regional DYAA PCC with Covid impact (l/h/d)											
Measured Household - PCC	108.71	120.98	113.08	109.94	109.78	109.62	109.38	109.19	108.99	108.87	109.01
Unmeasured Household - PCC	154.52	172.01	160.81	156.36	156.12	155.9	155.2	154.5	153.9	153.4	153.2
Average Household - PCC	130.39	144.37	134.14	129.65	128.72	127.79	124.2	121.5	119.4	117.8	116.9
Regional NYAA PCC with Covid impact (l/h/d)											
Measured Household - PCC	106.47	118.49	110.76	107.68	107.53	107.37	107.13	106.95	106.75	106.63	106.77
Unmeasured Household - PCC	151.34	168.5	157.5	153.1	152.9	152.7	152.0	151.4	150.8	150.2	150.1
Average Household - PCC	**127.7**	**141.4**	**131.4**	**127.0**	**126.1**	**125.2**	**121.7**	**119.0**	**116.9**	**115.4**	**114.5**

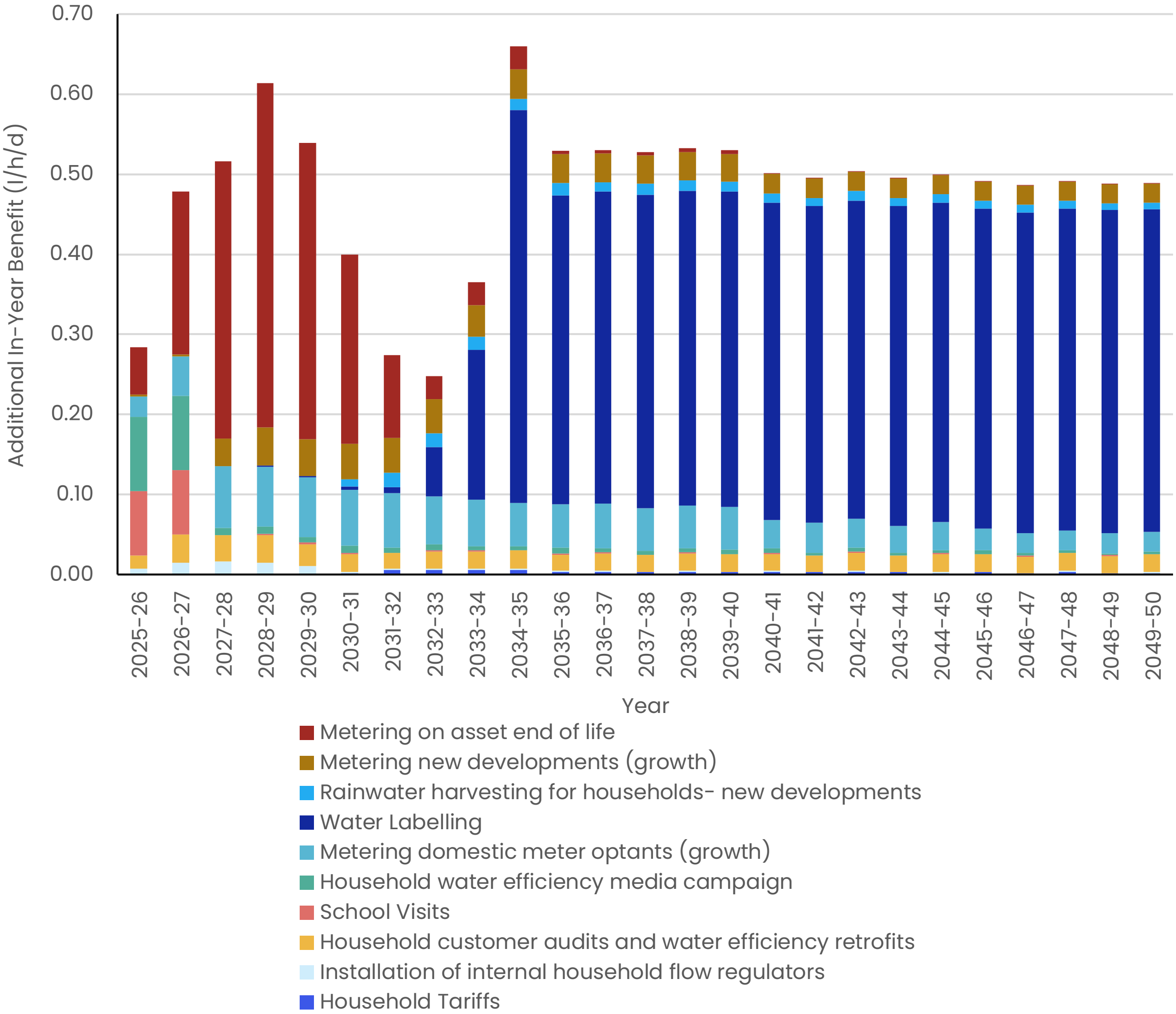
Our WRMP24 has an objective to achieve the demand reduction national policy requirement to reduce PCC to an average of 110l/h/d by 2050 in a DYAA scenario. To achieve the target, we must enhance our existing demand reduction activity and find new ways of supporting our customers in reducing their water use by an average 6.9 l/h/d by 2050 in a dry year.

We have considered the demand reduction options available to us and reviewed the options we identified for our previous plan. For our revised draft submission, we commissioned RPS to assess the feasibility of demand options and provide costs and benefits. The outputs of the project have provided a revised list of household water efficiency options that we have included in our decision-making process.

The PCC reduction options we included as feasible options in our optimiser model for household are outlined in Appendix A.2 and feature initiatives to encourage customers to reduce their usage through targeted media campaigns, the implementation of flow regulators and completion of water efficiency audits.

The PCC reduction glidepaths for the options within the best value plan are given in Figure 8.5 below. This is an output of the EDA optimisation process detailed further in Section 9.1 of this report.

Figure 8.5: Per capita consumption (PCC) program glidepath to 2050



The program listed above will deliver PCC benefits that will help us achieve our 2038 and 2050 targets of 122 l/h/d and 110 l/h/d. The benefits presented in the above figure were initially calculated through a blend of modelled output from RPS and information calculated from ongoing trials.

These schemes will result in a cumulative PCC reduction of 11.97 l/h/d from our end of AMP7 position. This PCC reduction profile is reliant on benefits from smart metering, water labelling and a customer awareness and education program. The benefits of water labelling are largely unknown at this point in time which is why our water labelling benefits do not meaningfully materialise until the beginning of AMP9. The approach taken to calculate these is described below in Section 8.4.4.

8.4.4 Government initiatives

During the life of our plan there is potential for Government initiatives to reduce PCC. We have created two Government initiatives options that represent scenarios provided in the Defra 2022 *Consultation on Mandatory Water*[45]. Option C30a Water labelling- baseline is derived from Scenario 1 in the consultation and option C30b Water labelling- low demand common reference represents scenario 2 (Table 8-6).

Table 8-6: Assumed benefits of Government water saving initiatives

	Scenario 1 – water labelling (no minimum standard)	Scenario 2 – water labelling (with minimum standards) and building regulation
Litres saved per capita per day	0.75 (1.5)	6.3
Litres saved per capita per day	6.5 (13)	31.4

* Volumes in brackets are the savings proposed by the Defra 2022 consultation.

Water efficiency labelling is a government-led initiative to reduce PCC that will be introduced through legislation. The introduction of water labelling would instigate a slow change to more efficient white goods that would reduce PCC over time. In addition, there is potential the government will introduce mandatory standards to limit water using appliances in new build and retrofit properties that could reduce PCC further.

Scenario 1 assumes a benefit from water labelling of white goods will start in 2025 and increase over the next 25 years. In this scenario there are no minimum standards applied to the labelling, which limits the potential savings. In scenario 2 minimum standards for white goods are assumed and incorporated into building regulations and a higher benefit is assumed.

A Water UK/Defra project[46] (2019) developed a number of demand management scenarios based around the potential impact of government-led interventions on per capita consumption (PCC). A scenario for water labelling (without minimum standards) was suggested to achieve 11 l/h/d by 2050. A WRSE study in 2022[47] reviewed the outputs and the predicted benefits. The WRSE study reviewed evidence in Australia and concluded the benefits from water labelling could not be disaggregated from benefits of other initiatives running at the same time. A more conservative water labelling benefit of 6 l/h/d was proposed.

We have built a 6.5 l/h/d benefit by 2050 into C30a Water labelling- baseline option. We do not consider the 13 l/h/d to be realistic for our area, which already has one of the lowest average PCCs in England. We consider 6.5 l/h/d more appropriate as our baseline forecast includes benefits of improved technology and there is a risk of double counting these benefits. We also consider labelling to have high uncertainty, higher than other demand reduction initiatives. Although we have assumed the benefit in our Grid SWZ final scenario we have created a plan that does not rely on this benefit in the near term.

The C30b Water labelling- low demand common reference option has been created for the low demand, high benefit scenario. This option is aligned with the Defra 2022 consultation as the scenario represents an unlikely but plausible future and we have applied the full benefits.

[45] Consultation on mandatory water efficiency labelling (defra.gov.uk)

[46] Water UK 'Pathways to Long-Term PCC Reduction' 2019

[47] Water UK 'Pathways to Long-Term PCC Reduction'

8.4.5 Tariffs

We have considered the use of tariffs as a potential demand management option. We have investigated the use of social tariffs but this impacts on the 'retail' element of the bill and is not based on varying tariffs for different levels of water use.

Use of tariffs for demand management would require properties to be metered to allow a financial benefit for reduced water use. Current meter penetration in Yorkshire is just over 50%, and therefore we consider the use of tariffs for demand management to be an unfeasible option at this stage.

We also have insufficient information to quantify the potential water savings from tariff schemes for WRMP19.

8.4.6 Non-household water efficiency

Non-household reduction is a new performance commitment from AMP8 and we have outlined in Section 5 our new demand management strategy. The target for non-household reduction as defined by Defra (Environment Improvement Plan 2023 (Defra, 2023) is a 9% reduction in non-household usage from the 2019/20 3-year rolling average baseline by 2037/38 and a 15% reduction by 2050.

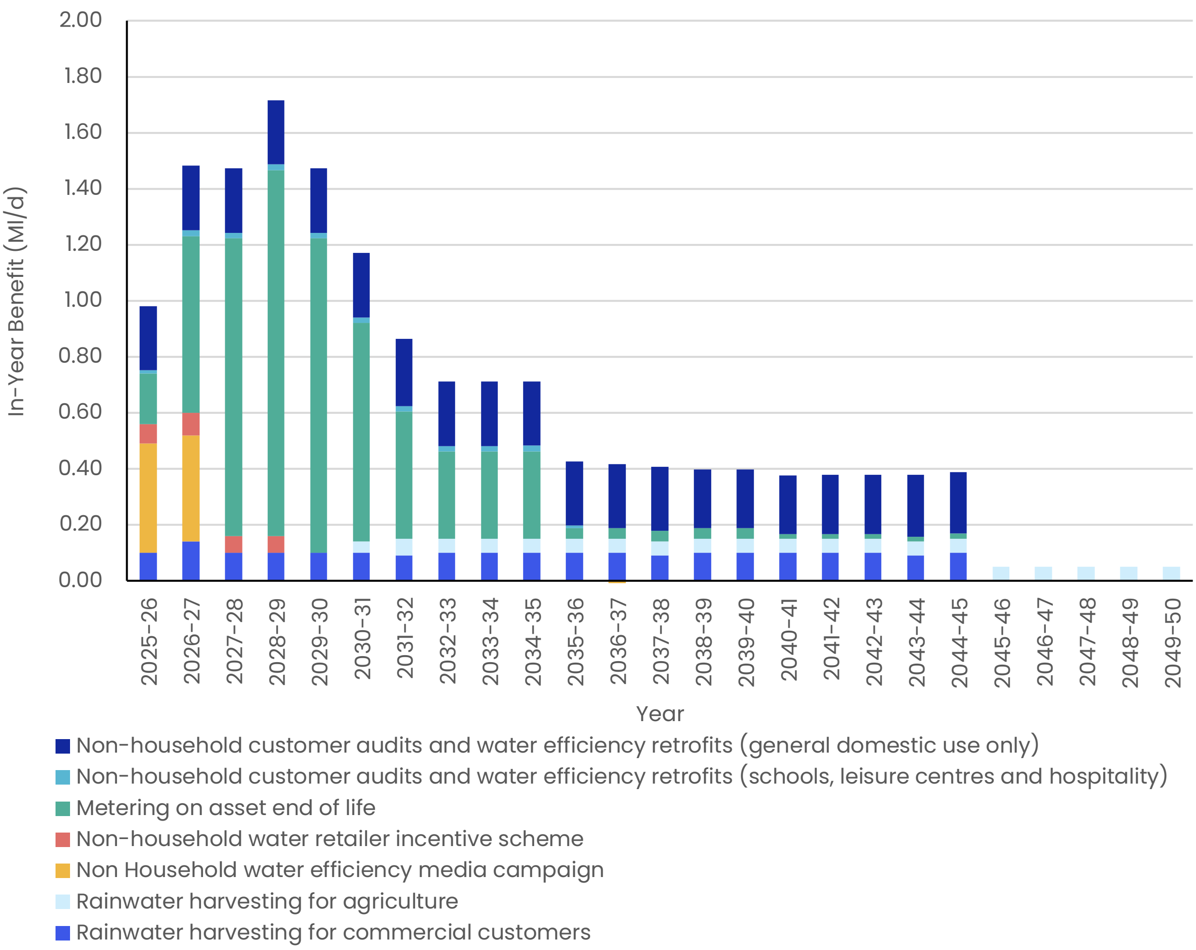
We have considered the demand reduction options available to us and for our revised draft we commissioned RPS to assess the feasibility of demand options and provide costs and benefits. The outputs of the project have provided a revised list of household water efficiency options that we have included in our decision-making process.

The non-household reduction options we included as feasible options in our optimiser model for non-household are outlined in Appendix A.2 and feature initiatives to encourage non-households to reduce their usage through targeted media campaigns, completion of water efficiency audits for schools, leisure centres and hospitality, completion of water efficiency audits for business "domestic type" use, for example, kitchens toilets, showers, rainwater harvesting for large users and water efficiency incentives.

Our smart metering programme will replace about 104,000 unmetered properties in AMP8 with AMI smart meters, the remaining AMR meters on non-household will be replaced in AMP9. We will continue to review policies to increase meter penetration in our non-household customers. All our large and medium non-households will be AMI smart metered through AMP8 in line with our continuously logged user policy.

The non-household reduction glidepaths for the options within the best value plan are given in Figure 8.6 below. This is an output of the EDA optimisation process detailed further in Section 9.1 of this report. The program shown below will allow us to achieve our non-household demand reduction interim target of 9%. This target is met when excluding growth from a three-year average baseline from 2019/20 in alignment with the Business Demand performance commitment. The benefits presented in Figure 8.6 were initially calculated through a blend of modelled output from RPS. These schemes will result in a cumulative non-household demand reduction of 15.47 Ml/d from our end of AMP7 position.

Figure 8.6: Non-household demand reduction glidepath



8.4.7 Drought measures

Our baseline forecasts for both the DYAA and critical period scenario make no assumptions for drought measure benefits. We include level 1 to 3 drought measures as options available for selection to close a deficit. As the East SWZ does not show a surplus we have only developed drought measure options for the Grid SWZ. There are three types of drought measure options:

- Supply rivers drought permits
- Supply reservoir compensation drought permits
- Drought demand reduction

The benefits of the drought measures change if the level of service changes. In Section 9 we discuss scenarios for achieving the 1 in 500 year level of service requirement. In each scenario the drought measure option benefits are aligned to level of service presented in the supply-demand balance scenario for each year. In all scenarios the benefits of drought measures cease after 2038/39 as the objective is to be resilience to drought without the use of drought measures.

The drought demand reduction measures include voluntary calls for restraint (level 1 measures), as well as leakage reduction, TUBs (level 2 measures) and NEUBs (level 3 measures). The supply river and reservoir drought permits are both level 3 measures (although some may be considered as level 2 if applied in the winter, we have assumed the worst-case position of summer permits which would be level 3), which would be used in the first or second year of a drought. We include long term drought measures (also level 3) in our Drought Plan 2022, but have not considered those benefits as options in this WRMP, as our long term drought options are also WRMP options, and are more appropriately considered in this context. These drought options and levels are described in our Drought Plan 2022.

8.4.8 Level of service

Our critical period is not linked to levels of service and therefore the benefit of planning to a reduced level of service is not an option. Our baseline DYAA forecasts is based on a 1 in 500 level of service. For our final plan we have included a reduced level of service as a potential option and assessed the impact on the supply-demand balance with and without the benefits.

8.4.9 Water market

We recognise that the use of third-party options and a water resource market could help us deliver resilience, cost efficiency and innovations.

We are therefore currently encouraging a water bidding market and plan to stimulate this market through early engagement with potential participants and have created a dedicated water bidding market page on the Yorkshire Water website www.yorkshirewater.com/about-us/what-we-do/become-a-supplier-of-yorkshire-water/water-bidding-market/.

We have met with a specialist licence trading consultant to understand available water resources and potential opportunities for our region. We also plan to help strengthen and protect national resilience in the longer term by understanding the need for and approach to transporting water around our country. This will be facilitated through the Water Resources North group.

As part of our initiative to explore the water resources market, we have developed a geographic information system (GIS) tool which shows all third-party and our own abstraction points in Yorkshire. This tool makes potential trades more visible and helps us to identify locations where we may be able to optimise the use of existing third-party water abstraction licences.

We will pursue trades where they make us more efficient or resilient, meeting the needs of our customers, stakeholders, and the environment.

Our aim is to improve regional and national resilience, reduce waste and support innovation through three initiatives: pursue increased trading to deliver efficiency and reduce the need for capital expenditure; utilise experts to introduce improved approaches and technology; and collaborate to do more than we could alone.

Our Water Bidding Market webpage will list all opportunities for the water management market, including water resources, demand management and leakage services. The webpage allows us to share trade opportunities quicker than the published Market Information requirements as it will enable:

- Communication between us and other water companies or third parties, including the ability to submit bids;
- Engagement with the market when we want to understand potential solutions before starting procurement (market testing); and,
- A route for the market to submit prospective solutions unrelated to a specified requirement.

The webpage is supported by our Trading and Procurement Code, Bid Assessment Framework and a proportional procurement process. We are currently investigating any perceived barriers to entry.

Developing the market and bilateral trading market

We are reaching out to participants to stimulate interest, and our published Market Information is the first step in this process. We have also asked third parties to tell us what other market information they need to help us drive resilience, innovation, and efficiency into water resources. All market participants will be able to review and comment on our approach and systems before we go live.

8.5 Strategic Environmental Assessment, Habitats Regulation Assessment and Water Framework Directive

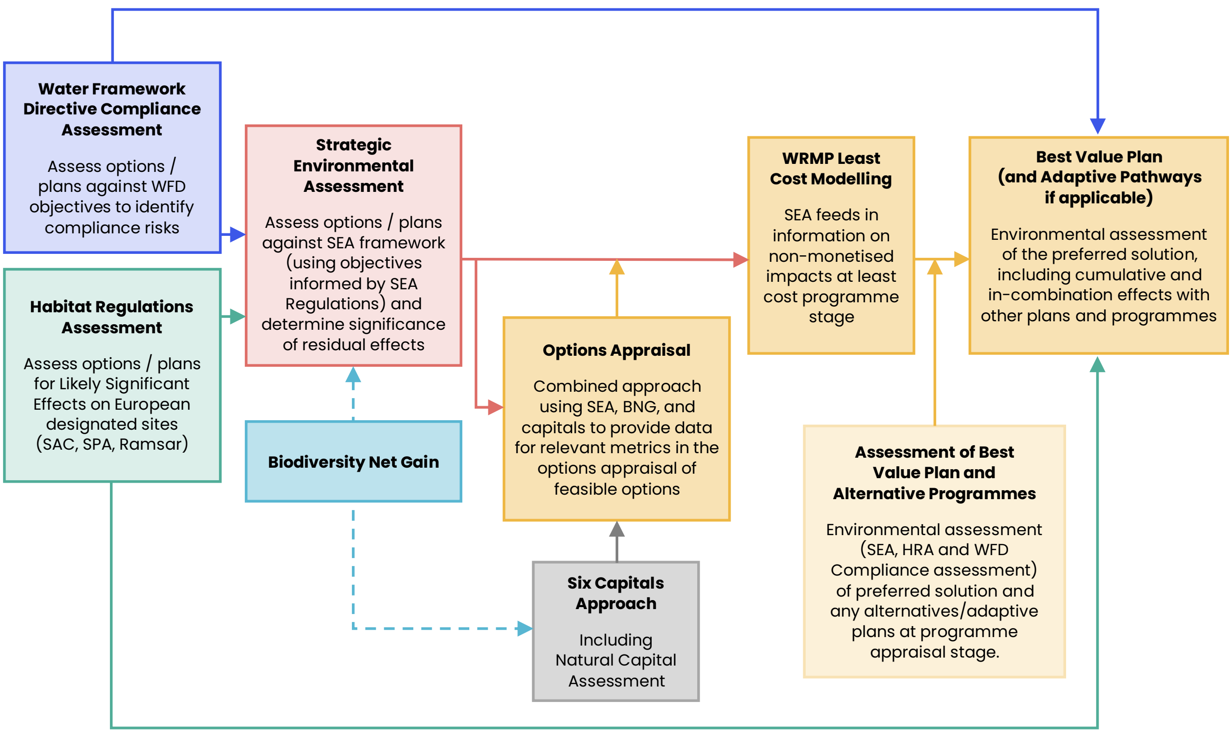
The non-monetised environmental, social and carbon impacts of each option have been considered in a Strategic Environmental Assessment (SEA). The full output of the SEA is provided in an Environmental Report, which is published on our website alongside this document.

We have reviewed all available guidance: *A Practical Guide to the Strategic Environmental Assessment* (ODPM, 2005), *Environmental Assessment Guidance for Water Resources Management Plans and Drought Plans* (UKWIR, 2021), the updated *Final Water Resources Planning Guideline* 'WRPG' (Environment Agency, 2021) and supplementary guidelines on *Best Value Planning and Environment and Social Decision Making* (Environment Agency, 2021d). This review concluded that the WRMP falls under the SEA. Notably, this is because the WRMP will include schemes that will likely require an Environmental Impact Assessment (EIA).

The SEA and the WRMP options appraisal have been informed by a Habitats Regulations Assessment (HRA) Screening Report. The WRPG states that water companies must take account of the requirements of the WFD regulations when considering the preferred plan, including objectives outlined in the River Basin Management Plans (RBMPs). A WFD Compliance Assessment has therefore been carried out to inform the SEA and assess the impact of the best value plan on WFD requirements for no deterioration to waterbodies.

The SEA, HRA and WFD assessments are used in the options appraisal to help determine a preferred solution that reduces the risk of detrimental impact to the environment. Figure 8.7 outlines the process for integrating the SEA, HRA and WFD into the options appraisal. Further information on how the SEA has influenced the development of the WRMP is available in Section 7.5 of the SEA Environmental Report, which accompanies this Technical Document.

Figure 8.7: Integration of SEA, HRA and WFD in the WRMP Process



The SEA can add value to the options appraisal process by identifying a wider range of impacts that cannot be monetised. It considers both adverse and beneficial potential environmental and social effects of feasible options and identifies the cumulative effects of a supply-demand solution. Biodiversity Net Gain (BNG) has also been incorporated into the SEA framework through the inclusion of a specific SEA objective.

The combined approach to including SEA, BNG and the Six Capitals will provide data for relevant metrics in the optional appraisal system (i.e., environment performance metric and the human and social wellbeing metric). The natural, social, and human capitals overlap with the SEA objectives which creates a risk of double counting any costs and benefits. At the end of the option appraisal process, an assessment was made of the environmental and social impacts of the best value plan to identify if any double counting could be a factor.

A cumulative, or in-combination, assessment has been undertaken on the preferred plan. This involved examining the potential impacts of each of the water resources management options in combination with each other, as well as in combination with the implementation of other relevant plans and programmes.

The overall findings of the SEA describe the extent to which objectives for eight environmental topics are met by each of the WRMP options. Table 8-7 summarises the topics and associated objectives.

Table 8-7: SEA topics and objectives

SEA Topic	Ref.	SEA Objectives
Biodiversity, flora and fauna	1.1	To protect and enhance biodiversity, ecological functions, capacity, and habitat connectivity within Yorkshire Water's supply and source area.
	1.2	To provide opportunities for habitat creation or restoration and a net benefit/gain for biodiversity.
	1.3	To protect, conserve and enhance natural capital and the ecosystem services from natural capital that contribute to the economy.
	1.4	To avoid introducing or spreading invasive non-native species (INNS).
Population and human health	2.1	To protect and improve health and well-being and promote sustainable socio-economic development through provision of access to a resilient, high quality, sustainable and affordable supply of water over the long term.
	2.2	To protect and enhance the water environment for other users, including recreation, tourism, and navigation.
Material assets and resource use	3.1	To reduce, and make more efficient, the domestic, industrial, and commercial consumption of resources, minimise the generation of waste including leakage from the water supply system, encourage its re-use and eliminate waste sent to landfill.
Water	4.1	To maintain or improve the quality of rivers, lakes, groundwater, estuarine and coastal waterbodies.
	4.2	To avoid adverse impact on surface and groundwater levels and flows and ensure sustainable management of abstractions.
	4.3	To reduce and manage flood risk, taking climate change into account.
	4.4	To increase awareness of water sustainability and efficient use of water.
Soil, geology and land use	5.1	To protect and enhance geology, geomorphology, and the quality and quantity of soils.
Air and climate	6.1	To maintain and improve air quality.
	6.2	To minimise greenhouse gas emissions.
	6.3	To adapt and improve resilience to the threats of climate change.
Archaeology and cultural heritage	7.1	To conserve and enhance the historic environment, heritage assets and their settings and protect archaeologically important sites.
Landscape and visual amenity	8.1	To protect and enhance designated and undesignated landscapes, townscapes and the countryside.

A ten-point impact assessment scale was used, using the effect categories: major adverse; moderate adverse, minor adverse; negligible adverse; no adverse effect, no beneficial effect, negligible beneficial, minor beneficial; moderate beneficial and major beneficial. This report considers the outputs of the SEA on the least cost solution and the preferred plan. The SEA outputs for all the feasible options can be found in the SEA Environmental Report which are submitted alongside this final WRMP.

8.6 Customer views on options

Working in partnership with Northumbrian Water and Hartlepool Water, through Water Resources North, we carried out research into customer preference and prioritisation of the different investment options available.

This programme comprised deliberative research across 16 groups including a mix of household customers, future customers and citizens, and a range of non-household customers. The non-household sessions were held with a mixture of water dependent businesses (such as farmers) and non-water dependent businesses. Whilst this type of approach typically engages a lower number of customers than quantitative survey approaches, it benefits from a much greater dialogue and opportunity for those involved. It enables customers to better understand the nuances of water resources management, allowing for a more educated decision on their priorities for future plans. Reconvening workshops allowed for a more in-depth discussion with respondents who became more informed as the workshops progressed.

As part of the process Customer Challenge Groups (CCGs) were engaged in the research and process. All materials, including discussion guides, were developed in conjunction with the Water Resources North companies and the opportunity for feedback on these materials was provided to stakeholders such as CCGs. A total of 16 workshops were conducted across the usual demographics within the three water regions Yorkshire Water, Northumbrian Water and Hartlepool Water.

Workshops were constructed based on a number of demographic criteria including age, marital status, gender, income (including low income), vulnerability, household and business customers and citizens. They included some engaged water dependent business customers with a mix of SMEs with a mix of urban and rural business locations. Business customers were recruited from across a number of sectors including agriculture, retail, service and hospitality. The groups were organised in such a way as to allow results for individual water companies to be disaggregated from the overall Water Resources North picture, to help companies use this data to inform their WRMP24s alongside the Regional Plan.

Pre group and post group questionnaires were utilised to collect information from the groups and to explore other avenues that time didn't allow for within the sessions themselves.

Two sessions per workshop, lasting up to 1.5 hours' duration each, were undertaken. The first session included educational information via the use of 3 films to cover the customer engagement process, how water companies provide customers with water, an introduction to Water Resources Planning, the shift to regional planning, putting customers at the heart of plans and water trading. The second session was used to explore WRMP and Drainage and Wastewater Management Plan (DWMP), environmental ambition, best value plan metrics and WRMP objectives. The research was conducted in June 2021.

Customers were asked to rank WRMP and DWMP options individually, and then asked to rank their combined WRMP and DWMP options. The aim of testing WRMP and DWMP directly was to understand customers' relative priority areas for investment, rather than them being driven by options tackling the same needs or challenges.

For WRMP options, customers were most concerned about leakage, and this was true across the region as a whole as well as with both Yorkshire Water and Northumbrian Water customers (Hartlepool Water customers placed leakage second after water efficiency). Customers consistently ranked increased abstraction last. Within discussions, it was felt that customers wanted to see water companies implement options that improved the efficiency of existing systems and resources, rather than increase abstraction.

Customers felt that if leakage was 'solved', then the whole system would be more efficient. Water efficiency (and relatedly consumption data) was also key priority to customers because they believed that if consumers could reduce the amount of water they used, it would in turn lead to less pressure on the environment.

Overall, within follow up discussions, many options overlapped in customers' minds such as meter optants and metering on change of occupancy which they felt was related to water efficiency, and leakage being connected to mains replacement and supply pipe renewal.

Generally, customers and citizens wanted reservoirs to be enhanced rather than new ones created, as this was perceived to be less damaging to the environment. The options that appeared last on the list included increased abstraction and desalination. These were seen as a last resort.

Table 8-8Table 8-8 shows the ranked output for Yorkshire Water's WRMP options.

Table 8-8: Ranked output of WRMP options

Ranking	Option
1	Leakage
2	Water efficiency (providing water saving products)
3	Meter optants
4	Commercial (that is, NHH) water efficiency
5	Supply pipe renewal
6	Mains replacement
7	Reservoir desilting
8	Reservoir (dam or embankment raising)
9	Consumption data
10	Metering on change of occupancy
11	Water transfers
12	Desalination
13	Extension of existing water treatment works
14	Increased abstraction

We have taken account of customer preferences when developing the metrics used to optimise our preferred plan. Delivering against policy objectives to reduce demand clearly aligns with the ranking shown in Table 8-8. However, when it comes to supply options, we find that other metrics are more influential in determining the plan outcome than customer views.

9 Decision-making

The outcome of our WRMP24 should be a best value plan for our customers and stakeholders, which achieves our stated objectives. This section explains the decision-making process for creating our preferred plan to meet the WRMP24 objectives.
Our objectives are aligned with the WReN Regional Planning process, the Water Resources National Framework and WRPG. A summary of the WReN objectives mapped to YW WRMP24 objectives is provided in Figure 9.1. We have developed our WRMP24 in parallel to the WReN Regional Plan to ensure the two plans are fully aligned. Our WRMP24 objectives focus on the public water supply (PWS) WReN objectives with the key decisions made in the context of the broader regional plan objectives.

The WReN Regional Plan describes the strategy for meeting the non-PWS components of the objectives and the combined contributions of all three water companies to the regional objectives. Our WRMP will continue to be developed in parallel to the WReN Regional Plan as we deliver the outputs and produce future iterations of both plans. As the Regional Plan is developed further and non-PWS needs quantified, we will consider multi-sector options and if we can co-deliver solutions with other sectors within our supply are9a.

The WReN objectives were developed by the WReN stakeholder steering group to align with regulatory requirements and policy aspirations, customer preferences and stakeholder feedback. The strategy for addressing the Regional Plan objectives is described in the WReN Regional Plan. Our WRMP24 describes how we will meet the public water supply future needs in our area, which are listed in Figure 9.1 as Yorkshire Water WRMP24 objectives.

Each objective has been assigned a planning status to describe how the objective will be considered in the options appraisal process. The planning status categories are summarised as:

Achieve or enhance:
There is a mandatory requirement, but our options appraisal could result in programmes that exceed (enhance) the mandatory requirement if feasible options are available. This applies to Yorkshire Water objectives 2 and 3.

Optimise:
We develop solution programmes using a WRMP optimisation model and measure performance against our objectives (using metrics) at a programme level. The optimised programmes provide a portfolio of options to consider for inclusion in the preferred plan and adaptive pathways. There will be trade-offs between metrics, as we cannot optimise all metrics. This applies to Yorkshire Water objectives 1 and 5.

Scenario constraint:
The objective must be constrained into a planning scenario in order for them to be achieved in the solution programme. This applies to Yorkshire Water objectives 4, 6, 7 and 8.

Environmental objectives:
Use of water resources for public and non-public water supply has a significant impact on the environment therefore, environmental impact and mitigation is an essential component of regional plans and WRMPs. The Strategic Environmental Assessment (SEA), Habitats Regulations Assessment (HRA) and Water Framework Directive (WFD) assessments, including Invasive Non-Native Species (INNS) are a statutory requirement of water companies' planning processes when considering options. Each option is assessed against SEA objectives and, where applicable, HRA and WFD requirements are assessed independently of the best value plan approach.

The SEA influences the selection of the best value plan by providing an option level assessment for each objective that we use to assess the supply-side options included in a solution programme. We assess the environmental impacts of the individual options and the combined impacts of the whole programme. If there is potential to avoid any adverse or major adverse impacts, we may remove an option from the programme and select a less adverse option instead. However, for the programme to close the deficit it is not always possible to avoid adverse impacts completely and we must identify mitigation measures instead.

Figure 9.1: WReN Regional Plan and Yorkshire Water WRMP24 objectives

WReN objectives

1. Meet the future PWS and non-PWS needs in our region
2. Meet and maintain a PWS drought resilience level of service of 1 in 500-years for level 4 restrictions no later than 2039
3. Contribute to the Government's ambition in the 25 Year Environment Plan to 'leave the environment in a better state than we found it'
4. Achieve the WReN environmental destination and River Basin Management Plans (RBMP) objectives (sustainability reductions) taking a catchment wide approach
5. Meet demand management policy requirements to reduce leakage and per capita consumption as defined in the Water Resources National Framework
6. Identify WReN's potential to contribute to national resilience
7. Incorporate Strategic Environmental Assessment (SEA) outputs and other relevant environmental legislation (e.g., habitats regulations assessment) in decision making
8. Achieve multiple benefits (including non-drought resilience)
9. Produce a plan that supports the views of regional stakeholders and water companies' customers and is not detrimental to social wellbeing
10. Create a plan that is affordable and sustainable over the long term

Yorkshire Water WRMP24 Objectives

1. Close the supply demand balance deficit
2. Reduce leakage by 50% compared to 2017/18 levels by 2050
3. Achieve an average PCC of 110 l/h/d by 2050
4. Become resilient to 1 in 500-year drought events without reliance on drought measures
5. Increase resilience in the Grid SWZ and localised growth hot spots
6. Offset the environmental destination BAU+ groundwater abstraction loss
7. Offset the STW transfer termination
8. Offset the environmental destination BAU+ surface water abstraction loss on the River Derwent

As the SEA, HRA and WFD assessments, including INNS, are a key requirement of WRMPs they are included as a key objective in the Regional Plan (WReN objective 7). Although SEA objectives are used to shape the best value plan, they do not create a defined scenario or an individual metric for inclusion in the decision-making. Instead, they provide data for delivering the process at both the option appraisal and decision-making stages that is in addition to the metrics. SEA objective data has been used to score three of the metrics, however this is because the SEA data is representative of those metrics and the approach is not attempting to represent the full SEA objectives in the metric analysis.

Another key objective of the WReN Regional Plan is meeting the environmental destination and RBMP (objective 4). The approach to environmental destination is described in section 3.8. Our approach includes the environmental destination and RBMP objectives as scenarios that we use to assess the impact of any potential changes to abstraction permissions on the supply-demand balance. Our baseline scenarios included the most likely impacts and we consider alternative high and low scenarios in the stress testing.

The environmental destination and RBMP objective could also be included under the objective to contribute to the government's ambition in the 25 Year Environment Plan to 'leave the environment in a better state than we found it'. Initiatives such as the environmental destination and RBMPs will help meet this ambition by improving waterbodies or removing the risk of deterioration in the future. However, as it is a key component of regional and company planning, we have classed it as a key objective in its own right.

9.1 Decision-making approach

As part of the Grid SWZ problem characterisation assessment we reviewed the methods available to determine the best value solution for closing the deficit and developed our approach using the following guidelines:

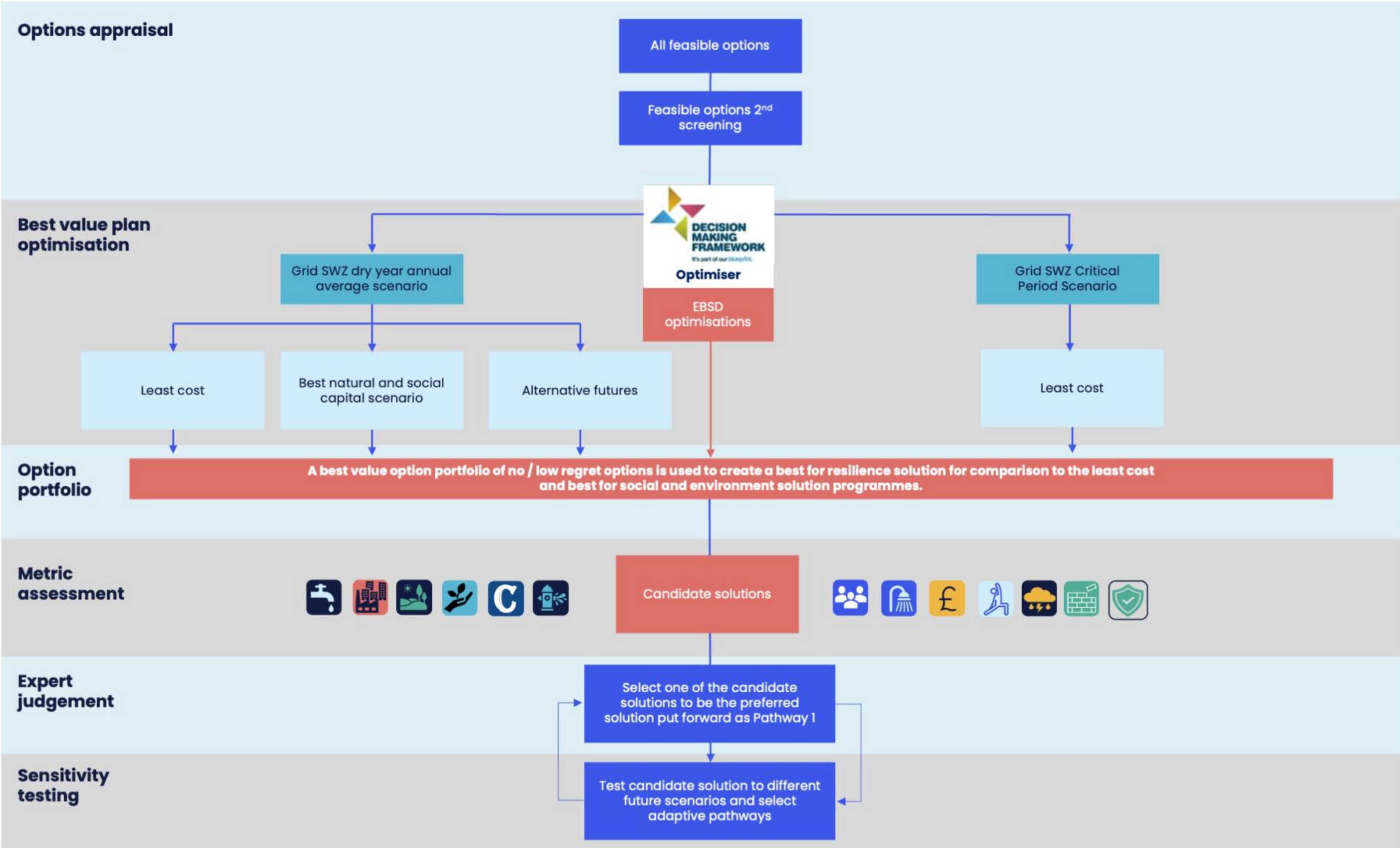
- Environmental Improvement Plan 2023. First revision of the 25 Year Environment Plan (Defra, 2023)
- WRMP24 WRPG (EA, 2021);
- PR24 and beyond: Final guidance on long-term delivery strategies (Ofwat, 2022).
- The economics of balancing supply and demand (EBSD; UKWIR, 2002a);
- UKWIR WRMP 2019–methods - Decision Making Process: Guidance (2016d);
- UKWIR WRMP 2019–methods - Risk Based Planning: Guidance (2016e); and
- UKWIR Deriving a Best Value Water Resources Management Plan UKWIR, 2020).

The outcome of our problem characterisation was that we would use an EBSD approach extended to include multi-criteria analysis (MCA). The traditional EBSD approach creates a single least cost plan to closing the deficit. The MCA approach creates several alternative programmes for closing the deficit and we compare these using metrics in addition to cost.

We used our WRMP optimiser model to produce solution programmes to meet a range of plausible alternative futures using the EBSD methodology. Across the range of scenarios, we set optimisation constraints to ensure demand policy requirements and the loss of the STW transfer would be met. The outputs of the optimised scenarios provided candidate solution programmes for meeting the baseline deficit. We compared the solution programmes using the MCA approach to assess the trade-offs before selecting our preferred plan to closing the baseline deficit.

Our best value plan process is summarised in Figure 9.2. The first steps, collating the feasible options and second screening, are described in Section 8. This section describes the process for selecting the preferred plan and stress testing the plan to alternative futures. The adaptive pathways are explained in Section 10.

Figure 9.2: Best value plan process



9.1.1 WRMP24 Optimiser model

Our optimiser model is part of our Decision-Making Framework (DMF) and has been developed in-house specifically for the WRMP24. Enterprise Decision Analysis (EDA) is the software that supports the DMF, and it has a bespoke WRMP optimisation platform that is linked to our business plan cost models, service measures and six capital costing. This helps ensure the cost and benefits data is kept up to date and aligned with our business plan. All feasible options and the associated assets, infrastructure and operating elements have been entered into the WRMP24 optimiser model. The costs and benefits for each feasible option are calculated in accordance with Section 8 of the WRPG.

The WRMP24 model inputs include the following data for each individual option:

- Ml/d benefit as a supply increase or a demand reduction, taking into account how this is delivered (for example, additional resource and leakage reduction);
- Other impacts associated with the option such as land use impacts and security of supply from building an additional supply resource;
- Benefit ramp up that is, benefit available each year until 100% is achieved;
- Time to benefit that is, first feasible year of benefits following construction where applicable;
- Capital costs, these include build and replacement costs where applicable divided into civil, instrumentation and automation (ICA), land and mechanical and electrical (M&E) categories, aligned with but not perfectly matched to the categories provided by the EA for Table 5b of the WRP tables;
- Cost for achieving biodiversity net gain (BNG) where applicable. This applies to the supply-side options that require planning consent and we would need to offset the biodiversity impacts of the options with a 10% net gain;
- Build profile that is, percentage of capital cost invested each year before and after the first year of utilisation;
- Operational costs that are, fixed and variable operating costs such as cost of energy, chemical use and labour. This also includes any opex savings related to demand reduction such as leakage reduction;
- Embedded and operational carbon volume and costs related to the capital and operational costs;
- Prerequisite option – link to another option that must be selected before the option can be in use and the "lag" time between implementation where applicable; and
- Mutual exclusions / option dependencies – option selection is dependent on the selection of another option(s), for example, we may have more than one option available to utilise an individual river or groundwater resource, but can only utilise one of the potential schemes.

The WRMP24 optimiser model uses the above information entered for individual options to identify a solution that ensures supply can meet demand plus target headroom for each year of the 60-year planning scenarios. It optimally schedules investment to meet the projected deficit, optimising for one or more of the capitals as defined by the model parameters. For the least cost solution optimisation is based on the minimum net present cost (NPC).

The time to benefit (or lead in time) for the supply options is provided by the optimiser model using assumptions linked to the cost models. For larger schemes that will require lengthy planning periods and environmental investigations we have overridden the cost model time to benefit with a longer time period. This is relevant to the options for importing water from Northumbrian to either the York area or South Yorkshire, the Severn Trent import loss backfill option, desalination and the tidal abstraction option.

Since the draft submission we have updated the supply-side option costs to include costs of delivering 10% BNG where applicable. BNG costs are not known until an environmental impact assessment (EIA) is carried out at the point of implementing the scheme when BNG is accounted for in the detailed design. In the absence of any specific scheme BNG data we have assumed 100% of the gain would be offsite and applied a default BNG unit tariff of £20,000 per unit (set by the Local Authorities in our area).

The optimiser model utilises a linear / integer programming approach, as described in the report, *The Economics of Balancing Supply and Demand* (Environment Agency and UKWIR, 2002a). The integer programme technique selects a schedule of options that will, in aggregate, meet any projected deficit in each year, from the base year to the end of the planning horizon.

The output from the model includes average incremental cost (AIC), net present value (NPV) as defined in the EBSD report, based on the output of the scheme. In addition, it provides outputs for WRP tables 4, 5a and 5b including the best value metric data linked to natural capital.

Monetised costs and benefits are discounted over a 100-year period as this is the lifetime of the longest lasting asset. The model uses discount rates and net present value calculations on the criteria specified in the WRPG. For each feasible option, it calculates the profile of the costs over 100 years, split into capital (including maintenance and replacement costs) and operational (both fixed and variable costs) expenditure. Capital expenditure values are transformed into financing costs, where the approach is based on the Regulated Capital Value and Net Book Value as per the detail provided in WRP table 5c. The depreciation is based on each individual option's asset life, and the weighted average cost of capital (WACC) applicable to Yorkshire Water from the PR19 Competition and Markets authority (CMA) determination is used.

All monetised costs and benefits have been discounted using the HM Treasury Green Book standard declining long-term discount rate (HM Treasury 2022). This discount rate is 3.5% for years 0 to 30 of the planning period, 3.0% for years 31 to 75 and 2.5% for years 76 to 125. The WRPG state all cost information should be maintained in a price base of 2020/21 throughout the draft plan, final plan and all tables. Our WRMP optimiser is also used for business planning and has a cost base of 2022/23 to align with the Ofwat PR24 guidelines. We have therefore applied a deflation factor to the WRMP costs.

The carbon impacts of the WRMP options are associated with capex and opex of individual schemes. Capex is associated with a volume of capital or embedded carbon during construction and opex is associated with a volume of operational carbon during asset utilisation. Capital carbon volume is estimated via carbon models associated with our unit cost models or via generic carbon models. By comparison, operational carbon volume is estimated via multipliers which estimate a carbon volume given per £1 unit of expenditure on different opex categories (e.g., chemicals, energy). This approach follows the methodology developed for the YW Whole Life Cost (WLC) Calculator. Any reduction in the average volume of water supplied (e.g., due to leakage or demand management) is also reflected as a reduction in operational carbon.

The WRMP optimiser model uses a value of £354.67/tCO2e. This is derived from the central carbon values per tCO2e in 2020 prices in pounds per tonne of CO2 as per Annex 1 in the Department of Business, Energy and Industry Strategy (BEIS) approach published in September 2021 on the valuation of greenhouse gas emissions[48]. The BEIS approach provides costs up to 2050 and recommends applying real annual growth rate of 1.5% to derive the carbon cost post 2050. As we can only use a single cost of carbon in this calculation, we use a 41 year (2022 to 2062) average central carbon price adjusted to 2022 prices. We then apply the HM Treasury Green Book standard declining long-term discount rate to produce the net present value of carbon for the solution.

[48] https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation

9.1.2 Metrics

The best value metrics we used to compare our candidate solutions were developed through the WReN regional planning process with the exception of the resilience metric, which is bespoke to the Yorkshire Water WRMP24 (see Section 8.3). The metrics are summarised in Table 9-1.

We compare the metric performance of candidate solution programmes to assess the impacts of moving away from a least cost solution and to identify where metric trade-offs are needed. The metrics represent a range of criteria each measured by a qualitative unit or a quantitative scale that is appropriate for that particular criterion. This makes it difficult to compare programme metric scores using the measured values as they are not consistent, therefore we have normalised the values to a scale from 0 to 100 to provide consistent units.

A score of 100 is the most optimal value for all metrics. When comparing solution programmes, a score of 100 will be applied to the programme that presents the best value for an individual metric. The normalised scores were relative to the programme outputs or a predefined range for an individual metric score. This was dependent on the metric and whether a pre-defined range could be applied.

The option data for SEA objectives has provided data for three of the metrics (flood risk management, multi-abstractor benefit and human and social well-being), but not all SEA objectives are represented as metrics. The metrics have been developed independently to the SEA objectives and focus on key decision-criteria that are relevant to the objectives listed in Figure 9.1 and therefore influences our WRMP. The SEA objectives have been derived from environmental objectives established in law, policy or other plans and programmes, and from a review of the baseline information. Where there is a clear overlap between the decision-making metrics and the SEA objectives, the SEA outputs can provide the data for measuring the metric.

Separate to the metric analysis, the SEA outputs for potential solutions are considered and incorporated into the final decision making and the preferred plan delivery (for example, mitigation measures). This allows SEA objectives that represent metrics to be assessed as part of the decision-making approach to developing a best value plan, whilst ensuring we are compliant with the SEA process.

Table 9-1: WRMP24 decision making metrics

Metric	How we measure the metric
PWS Drought resilience	Number of years over the 2025 to 2050 period the PWS drought resilience objective is achieved.
Biodiversity	The change in biodiversity metric units is based on assumptions related to change to land use/habitat due to the option and its footprint relative to the baseline. Natural England's Biodiversity Metric Tool version 3.0 was used to calculate the biodiversity unit impacts of the options.
Natural Capital	Monetised (£NPV) impact of the option on natural capital for example, change to land use, recreation.
Leakage reduction	Volume of leakage reduction achieved over the planning period (Ml/d).
PCC reduction	Volume of PCC reduction achieved over the planning period (litres/head/day).
Flood risk management (non-drought resilience)	Qualitative assessment based on SEA objective 4.3: To reduce and manage flood risk, taking climate change into account. Options will be graded -4 to +4 and the programme score based on the average grade.
Multi-abstractor benefit	Qualitative assessment based on SEA objective 4.1 To maintain or improve the quality of rivers, lakes, groundwater, estuarine and coastal waterbodies and 4.2 To avoid adverse impact on surface and groundwater levels and flows and ensure sustainable management of abstractions. Options will be graded -4 to +4 for each objective and the programme score based on the average grade.
Carbon	Capital/embedded and operational total tCO_2e of programme.
Customer preferred option type	Options to be ranked 1 to 3 based on customer preferences from the outputs of the WReN Customer Research June 2021 (Appendix 7). (Leakage and water efficiency score 3, enhancement of existing supply options score 2 and new supplies such as desalination and increased abstraction score 1.) Programmes will be compared by the benefit (Ml/d) provided by each of the 3 categories.
Human and social well-being	SEA objectives associated with human and social well-being: 2.1 To protect and improve health and well-being and promote sustainable socio-economic development, 2.2 To protect and enhance the water environment for other users, 6.1 To maintain and improve air quality, 6.2 To minimise greenhouse gas emissions, 7.1 To conserve and enhance the historic environment, heritage assets and their settings and protect archaeologically important sites and 8.1 To protect and enhance designated and undesignated landscapes, townscapes and the countryside. Options will be graded -4 to +4 and the programme score based on the average grade.
Financial Cost	Total cost (Totex) of the programme £NPV.
Option Deliverability	Individual options will be scored (1 to 5) for deliverability / cost confidence. The programme score will be based on the average score for all options included in the solution.
Programme Resilience	Individual options were scored 1 (yes) or 0 (no) depending on whether or not they had been identified through our water system supply strategy as meeting a defined resilience need. The programme score sums the number of resilience needs met and is calculated so that a programme can only score 'yes' for a resilience need once.

Alignment to Ofwat public value principles

Our WRMP24 MCA approach and our PR24 Business plan are aligned with the Ofwat public value principles (Table 9-2) [49]. There are six public values, as shown below with a brief explanation outlining consistency between each principle and our best value plan approach.

Table 9-2: Ofwat's public value principles

The Principle	
Principle 1	Companies should seek to create further social and environmental value in the course of delivering their core services, beyond the minimum required to meet statutory obligations. Social and environmental value may be created both in direct service provision and through the supply chain.
Principle 2	Social and environmental benefits should be measurable, lasting and important to customers and communities. Mechanisms used to guide activity and drive decision-making should support this, for example through setting and using company purpose, wide external engagement and explicit consideration of non-financial benefits.
Principle 3	Companies should be open with information and insights on operational performance and impacts (both good and bad). This will support stakeholder engagement, facilitate collaboration and help identify opportunities for delivering additional social and environmental value.
Principle 4	Delivery of social and environmental value outcomes should not come at greater cost to customers without customer support.
Principle 5	Companies should consider where and how they can collaborate with others to optimise solutions and maximise benefits, seeking to align stakeholder interests where possible, and leveraging a fair share of third-party contributions where needed. Companies' public value activities should not displace other organisations who are better placed to act.
Principle 6	Companies should take account of their capability, performance and circumstances in considering the scope for delivering greater social and environmental value.

- Our metrics include for delivery of greater social and environmental value between solutions (Principles 1, 6).
- We have completed engagement to consider what is important to customers, citizens and stakeholders in developing the plans (Principle 2).
- Where the requirements or benefits are uncertain at this time, for example around future environmental solutions, we have set out the need for further investigations or studies e.g., in the SEA (Principles 2, 4).
- We have actively engaged with neighbouring water companies as part of our regional planning work (WReN) including where we have collaborated on joint shared solutions (Principle 5). We have also worked closely with local or catchment stakeholders, as appropriate, around environmental delivery (Principles 3, 5).
- We considered and explored the impacts of going beyond the BAU+ 'minimum' environmental destination scenario (Principles 6, 4).
- It is also worth noting that acute potential trade-offs and/or wider impacts have been identified from adopting higher levels of environmental protection as part of the plan development process. For example, in the case of the River Derwent CSMG targets and associated potential removal of existing river structures, this could potentially cause flooding of surrounding countryside and villages (negative social impacts). This shows the importance of continuing further work to weigh up the pros and cons of different interventions beyond the current round of plans as part of the ongoing process to achieve outcomes in line with Ofwat's principles.

[49] https://www.ofwat.gov.uk/wp-content/uploads/2022/03/Ofwats-Final-Public-Value-Principles.pdf

9.1.3 Optimiser model constraints

Some of the WRMP objectives cannot be met or tested by the optimiser model parameters, and we must apply constraints to the model to ensure these are achieved. These constraints are discussed below.

Demand policy reduction constraints

In our best value plan, we want to meet the leakage and PCC policy targets as a minimum. We also want to meet the non-household policy target, however at the time of creating our WRMP24 there are insufficient feasible options available to us for achieving the 15% reduction by 2050. We have sufficient options to achieve the interim target for a 9% reduction in non-household use by 2038 (excluding growth). We will continue to review and develop non-household options for consideration in the next iteration of our plan and to build a strategy to achieve the 15% reduction by 2050.

The optimiser model will create a solution programme for closing a defined deficit based on predetermined parameters that optimise on one or more of the six capitals. The solution programme will include options that close the deficit however, it is not possible to define the demand reduction levels the optimiser must meet. To ensure the demand reduction policy requirements are met in the optimised solution, we must constrain the individual options into the solution programme and allow the optimiser to select from the remaining options.

To test the level of unconstrained demand reduction achieved when optimising on cost, we created two 1 in 500-year drought level of service runs without demand reduction options constrained in. In all subsequent runs the policy related demand options were constrained into the solution programme to ensure these were met as a minimum. Further demand reduction options were available for selection by the optimiser creating the potential to overachieve the policy requirements.

The non-household demand reduction options constrained into the runs are listed in Table 9-3.

The leakage and PCC targets are met by a combination of leakage reduction activity, smart metering and smart networks. We have created individual leakage reduction and smart metering options for achieving the policy requirements as a minimum. These are listed in WRP table 4. To ensure sufficient options to achieve the leakage and PCC policy requirements for 2050 are achieved in the best value plan, we have constrained in the glidepath described in Section 8.4. The glidepath was set as a must do in the optimisation runs and additional leakage and PCC reduction options were available for selection.

The optimiser includes options linked to Government initiatives for reducing household water use. We have constrained the C30a Water labelling option into all the runs except for two 1 in 500 scenarios, the high demand scenario (which assumes no Government initiative benefits), and the low demand scenario which includes the higher benefit C30b Water labelling- low demand option.

We have not constrained any household water efficiency options into the runs. The PCC target can be met through the benefits of smart metering, smart networks and water labelling without any household water efficiency initiatives. However, household water efficiency options were available for selection in the runs, as were leakage options in addition to those needed to achieve the 50% reduction. This ensured the optimiser model could select options to overachieve the targets but could not underachieve.

Table 9-3: Non-household water efficiency options to achieve the 9% reduction target by 2038

Option reference	Option name	Benefit (Ml/d) 2049/50
C6a	Non-household customer audits and water efficiency retrofits (schools, leisure centres and hospitality)	0.2
C12a3	Rainwater harvesting for commercial customers	2.0
C34a	Non-household water efficiency media campaign	0.8
C35c	Non-household water efficiency incentive scheme	0.3
C6a(ii)	Non-household customer audits and water efficiency retrofits (general domestic use only)	4.5
C23b1	Rainwater harvesting for agriculture	1.0
Total		**8.7**

The leakage and PCC targets are met by a combination of leakage reduction activity, smart metering and smart networks. We have created individual leakage reduction and smart metering options for achieving the policy requirements as a minimum. These are listed in WRP table 4. To ensure sufficient options to achieve the leakage and PCC policy requirements for 2050 are achieved in the best value plan, we have constrained in the glidepath described in Section 8.4. The glidepath was set as a must do in the optimisation runs and additional leakage and PCC reduction options were available for selection.

Option constraints to offset the loss of the STW transfer

The Derwent Valley transfer from STW into South Yorkshire will terminate in 2035. This has a significant impact on our supply-demand balance, and the loss of supply must be offset by an alternative supply to ensure our customers in South Yorkshire have a reliable water supply.

We have constrained the DV8B New York WTW and Dual Main South Yorkshire Pipeline option into the majority of runs. There are two parts to this option. The dual main is an interconnector that ensures water can be supplied to the South Yorkshire area once the STW transfer ceases. The New York WTW 2 supply option provides the water resource benefit. Without the main the water could not be transferred, and the New York WTW 2 benefit would only be 10.28Ml/d, whereas with the main there is a 50Ml/d annual average benefit. We have therefore allocated a benefit of 39.72Ml/d to the interconnector.

The New York WTW 2 is the only supply option with potential to provide the required yield by 2035. We already hold a licence to abstract the volume and would not need to apply to the EA for a new licence. The River Ouse licence is currently subject to a WINEP investigation, which creates a risk to the success of the scheme, however, for WRMP24 we have assumed in our preferred plan the licence will be retained. We consider the risk to this licence in Section 10.1.2.

Although other resources could potentially make up the loss, they could not be delivered by 2035 as licence applications, including associated environmental monitoring, test pumping and analysis, would need to be completed and permissions granted before we could start implementation. Any alternative supply option(s) would be in a different location to the Ouse licence and alternative network enhancements to the dual main interconnector would be required to ensure the water can be transferred to South Yorkshire. We will continue to investigate alternative options ahead of 2025 in case the River Ouse surplus licence is revoked or reduced when the WINEP investigation concludes. This would be a significant risk to our plan and whether the STW transfer loss could be backfilled in time to meet the 2035 cessation date.

Supply-demand balance

The WRMP24 optimiser selects options for closing deficits over the 60-year planning period from 2025/26 to 2084/85. The deficits are defined by supply-demand balance scenarios which are entered into the model for each year of the planning period. During scenario testing the supply-demand balance input data is altered to represent an alternative scenario and the model rerun. Each run provides a solution programme for a single scenario.

Level of service

The baseline supply-demand balance deficit is based on a supply forecast scenario with a 1 in 500-year drought return period. Our feasible options include an option to plan to a reduced level of service (1 in 200-year drought return period) initially, prior to improving to a 1 in 500-year level of service later in the planning period. This option requires a change to the deployable output and is applied as an adjustment to the supply-demand balance scenario, which reduces the deficit in the years the level of service is lower. It is not an option that the optimiser can select and must be pre-defined.

9.2 Least cost benchmark

We have created a DYAA least cost solution programme to use as a benchmark when determining our preferred plan and to identify trade-offs from moving from least cost to best value. The least cost scenario deficit changes depending on the year we move from a 1 in 200 to a 1 in 500-year level of service. We have tested the plan to alternative years for meeting the level of service improvement to identify the most cost-effective scenario that should represent the least cost benchmark.

The deployable output in WRP table 3a represents a 1 in 500-year level of service and the National Framework for Water Resources objective is to meet this level by 2040. The Grid SWZ is in deficit at the start of the planning period and reducing the level of service requirement in the early years will allow time for options to be delivered and potentially reduce the total cost of the plan. This is particularly important when considering demand option benefits as they will increase over time and on full completion could make supply options delivered early in the programme become redundant assets.

We initially created three variations of a least cost solution for meeting the 1 in 500-year level of service supply-demand balance deficit presented in Table 3a of the WRP tables. We then reran the optimiser for a range of years (2035, 2040 and 2045) when the 1 in 500 level of service requirement would be met later in the planning period.

9.2.1 One in 500-year level of service optimisation runs

We ran two 'unconstrained runs' to meet the Grid SWZ DYAA baseline 1 in 500 supply-demand balance scenario. The difference between the two runs was the inclusion and exclusion of level 1 to 3 drought options. We created the unconstrained runs to test:

- **The potential to close the baseline 1 in 500-year deficit:** The Grid SWZ 1 in 500 level of service supply-demand balance shows a deficit throughout the planning period. If the level of service is reduced to 1 in 200, without any intervention, the deficit is reduced, but the zone is still in deficit. We have produced unconstrained optimisations for the 1 in 500 baseline scenario to assess the costs and impacts, and the earliest year the 1 in 500 level of service could be met.
- **The inclusion of level 1 to 3 drought options:** The feasible options include level 1 to 3 drought options for restricting water use and increasing supply from rivers and reservoirs. Our preference is to reduce our reliance on these actions, and we have run the optimiser with and without drought options available for selection to assess the costs and impacts.
- **Selection of the solution for backfilling the loss of the STW transfer:** The draft WRMP24 put forward a backfill solution that included a new interconnector from York to South Yorkshire (DV8(iv)). The supply to the interconnector was from an existing abstraction licence on the River Ouse that would be treated at an existing works (DV8(v) Increase York water treatment works capacity) with investment to increase the output of the works. In our final plan we have altered the backfill option and included a dual main interconnector and a new WTW in place

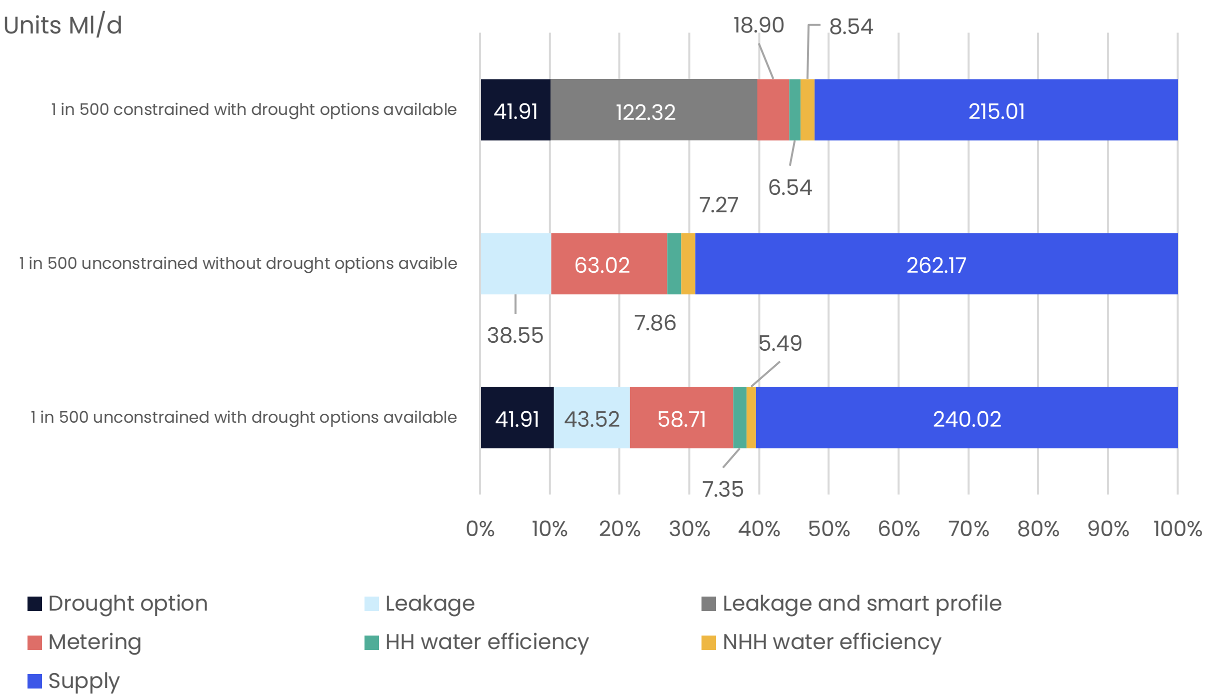
of the extension to the existing works. As discussed above, in the majority of our optimisations we constrain the STW backfill option into the solution. For the two unconstrained runs we did not constrain this option into the optimiser in order to test if the DV8B SRO Backfill- York WTW and Dual Main option would be selected.

The option presented at draft to increase the water treatment works capacity is still a feasible option, but would create a high resilience risk if it was expanded and an outage occurred at the site. Increasing the footprint of the existing works to treat the River Ouse surplus would also use land at the site that is needed for the DV7a(vi) Tees transfer option as this water would need to be treated at the same works. We have therefore selected the DV8(v)A York 2 WTW option in preference to the DV8(v) Increase York water treatment works capacity as it is a more resilient option and does not invalidate the feasibility of the Tees transfer.

- **The volume of demand reduction activity the optimiser selected when Government policy requirements were not a constraint.** The two unconstrained runs did not constrain any demand reduction options into the solution. This allows us to assess the volume of leakage, household and non-household demand reduction that is selected if the only objective is to minimise cost, and to see if the baseline deficit drives demand activity that is higher or lower than the policy requirements.

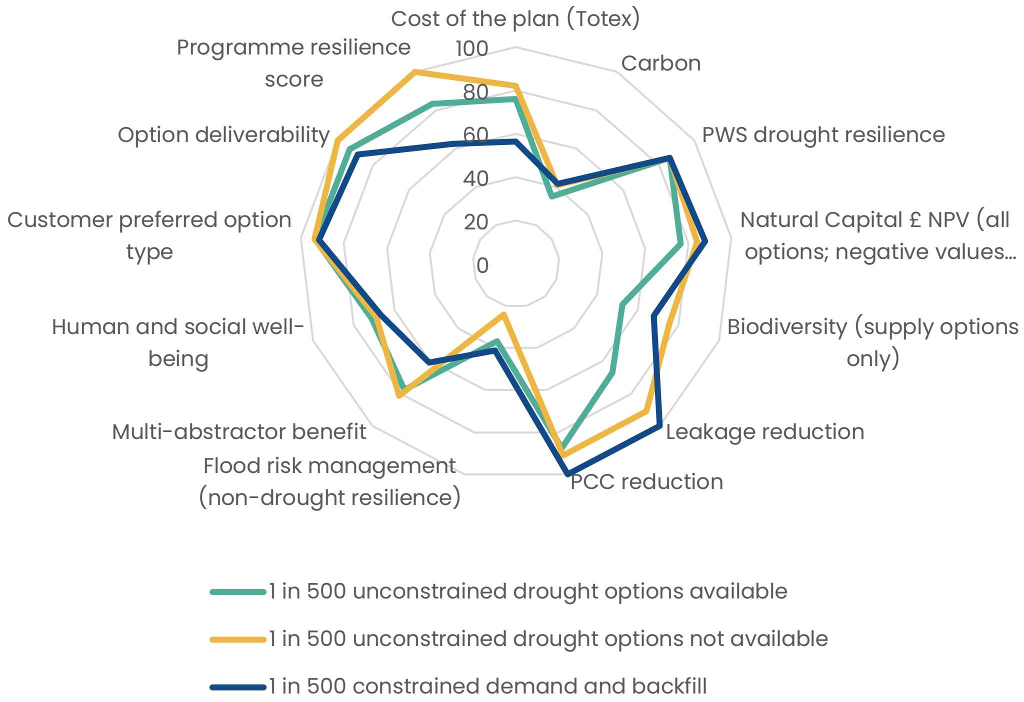
A third 1 in 500 run was produced with both the demand policy and backfill options constrained into the solution. Drought options were available for selection in this run. The demand policy and need to offset the loss of the STW transfer are key objectives for our plan and we have compared the impacts of the constrained run to the unconstrained runs. The options selected in each of the three 1 in 500 scenario runs are provided in Appendix C.1. A summary of the benefits is shown in Figure 9.3. This shows the percentage contribution each option category makes to the solution programmes and the total benefits (Ml/d) as labels on the bars.

Figure 9.3: Summary benefits of 1 in 500-year baseline scenarios



We have compared the outputs using our best value metrics, see Figure 9.4. The metric comparison compares the three 1 in 500 runs using normalised metric scores. These scores allow comparison across the metrics, which each have different units of measure. The normalised scores have been calculated using a range of scenarios (including alternative supply-demand balance scenarios).

Figure 9.4: Normalised metric results comparison: 1 in 500 baseline scenarios



The supply-demand deficit not met in any of the optimised runs until 2029/30. The DYAA deficit is 135.37 Ml/d in 2025/26 and there is insufficient time to implement schemes to close the gap in the first four years of the plan. Drought options were selected when made available as they provide a significant benefit from the first year of the plan. However, they are subject to permit applications being granted and the benefits will vary depending on the exact drought conditions. The backfill option was selected in the unconstrained run with drought options selected (green line in Figure 9.4) and was not selected when drought options were not available (blue line in Figure 9.4).

Neither of the two unconstrained runs met the 50% leakage reduction by 2050 objective. With drought options available a 15% reduction was achieved and without drought options this increases to a 28% reduction by 2050. Both the unconstrained runs reduced PCC below the DYAA 110 l/h/d target.

The metric scores show the unconstrained scenario without drought options available to score best on cost as there is an annual cost incurred to deliver the drought options from 2025/26 to 2038/39 when the option is selected. There are also benefits to biodiversity and natural capital if we do not rely on level 1 to 3 drought options. Option deliverability and programme resilience are improved as the drought option benefits have high uncertainty and more supply schemes are brought in when they are not available for selection. However, an increase in the number of supply-side options has a negative impact on the flood risk management metric.

Once the demand reduction activity for meeting policy requirements and the STW backfill option are constrained into the solution the cost score is reduced. However, the flood risk management score is improved and this solution scores best for natural capital.

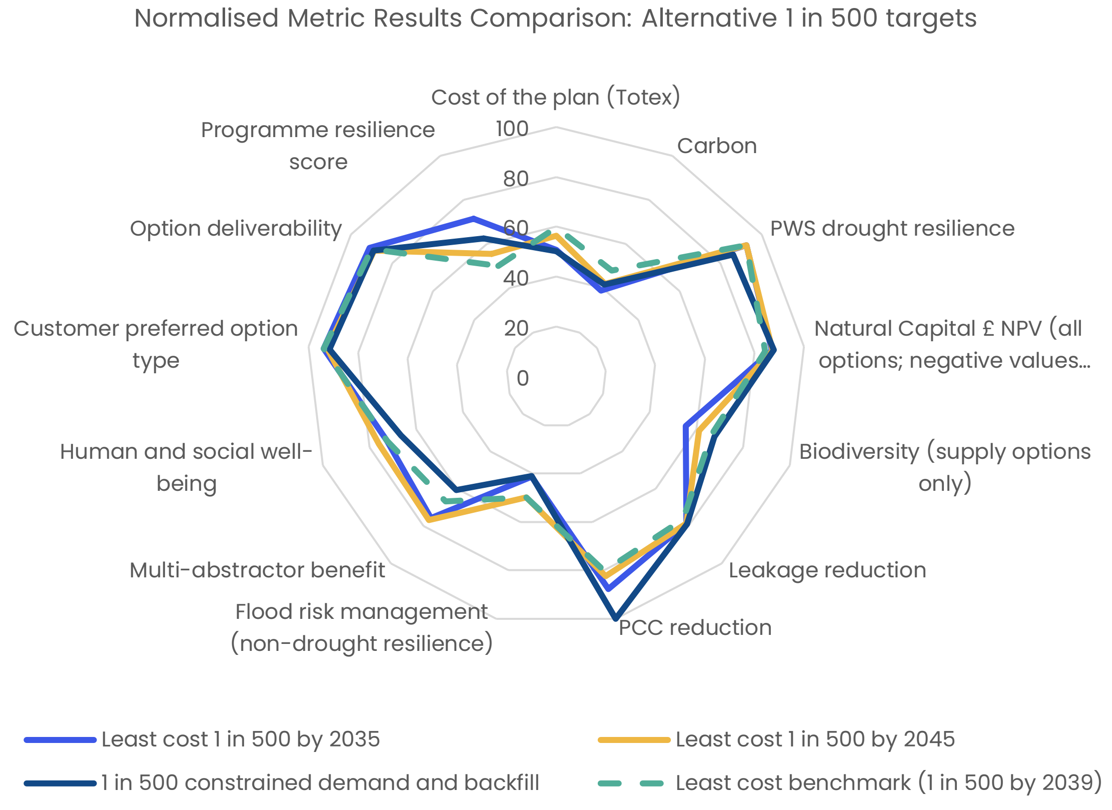
9.2.2 Level of service sensitivity testing

The Grid SWZ baseline supply-demand balance (WRP table 3a) is based on a 1 in 500-year drought return period for the full planning period, in line with the WRPG. Whereas the National Framework for Water Resources requirement is to be resilient to a 1 in 500 drought by 2040. The earliest year we could move to a 1 in 500 level of service in the 1 in 500 runs is 2029/30. By delaying the year in which we achieve the 1 in 500 drought resilience we can reduce the cost of the plan and potentially deliver a more sustainable plan over the longer term as demand reduction options offset the need for new supplies.

We have run the optimiser to meet supply-demand balance scenarios that represent different years for when the 1 in 500 drought resilience objective is achieved. These are 1 in 500 by 2035, 2040 and 2045. All runs were optimised on cost, with level 1 to 3 drought options available for selection and both the STW backfill and the demand reduction policy options being constrained into the solution programmes. Drought options were selected in each scenario as they provide a benefit from year 1 of the planning period.

The key difference between the options selected in the level of service runs is the year in which the DV7a(vi) Tees to York Pipeline - NWL import option providing 140 Ml/d benefit is selected. Any run with a change in level of service post 2040 delays the need of this scheme. However, in the baseline (most likely) scenario the BAU+ environmental destination leads to a point source reduction from the River Derwent in 2040/41. If we delayed the Tees transfer scheme, we would not be able to make up for the River Derwent loss.

Figure 9.5: Normalised metric results comparison: alternative years for achieving the 1 in 500 level of service.



The outputs are compared to the 1 in 500-year constrained scenario in . The lowest cost solution is the scenario to achieve the 1 in 500-year drought resilience objective by 2039/40. However, this scores lowest for programme resilience and PCC reduction.

Reducing the target level of service to 1 in 200 years at the start of the planning period improves the PWS drought resilience score, which increases from 86 to 93. Each of the alternative programmes for achieving the 1 in 500 year drought resilience result in the deficit being closed by year 3 (2027/28) as we are planning to a reduced drought resilience of 1 in 200-years at the start of the planning period. In years 1 and 2, even when planning to a 1 in 200-year drought, it is still not feasible to close the deficit in the time available for implementing options. This means for the first two years of the plan the level of service we can provide is lower than 1 in 200-years. We consider this further in Section 9.5.

Based on this comparison, the 1 in 500-year drought resilience by 2039/40 is the lowest cost solution and the output of this run has been used as the 'least cost benchmark'. The benchmark supply-demand balance differs to the WRP table 3a Grid SWZ baseline due to the reduction to a 1 in 200-year target level of service from 2025/26 to 2038/39. All alternative candidate solutions will need to meet the 1 in 500 by 2039/40 supply-demand balance objective as a minimum and this scenario represents the **'most likely'** pathway.

This least cost benchmark solution programme is a candidate solution for meeting the Grid SWZ most likely pathway and is compared to alternative solution programmes in Section 9.4.

9.3 SEA of least cost solution

Table 9-4 provides a summary of the SEA outputs for the least cost solution. There are some major and moderate adverse impacts as well as several minor adverse impacts associated with supply schemes.

DV7a(vi) – Tees to York Pipeline - NWL import 140 Ml/d and DV8B New York WTW and Dual Main South Yorkshire Pipeline have major adverse impacts across a number of SEA objectives, including biodiversity.

There are potential risks to WFD compliance associated where abstractions may result in flow reductions that may exacerbate water quality pressures in the affected water bodies. There is uncertainty associated with potential groundwater and surface water interactions which leads to uncertainty over the hydrological impact on dependent surface water bodies and over how some of the schemes may impact pollution pathways in groundwater bodies. Additional uncertainties appear where details of the operational regime are yet to be confirmed and there are unknowns regarding how options will operate alongside existing licences. In the context of WFD compliance assessment and removing uncertainties, further information would be required, and, in some cases, further investigations would need to be carried out to confirm the impacts identified before we could be confident the schemes could be implemented.

We have also reviewed the SEA results of all the selected options to consider the actions we can take to mitigate the environmental and social impacts. It is not always practical to constrain out all schemes where there are potential negative impacts, as the remaining schemes may not meet the deficit and the cost could be disproportionately high.

Our preference is to constrain out options classified in the SEA as having a major adverse impact on the environment. However, if these options were selected as part of the solution, we would consider the wider benefits of the schemes and how we might mitigate the impacts before constraining out.

If the SEA highlights an adverse impact that is not classed as major adverse but presents an impact that is disproportionate to the yield gain or a risk that could increase in the future, we will consider constraining out the option.

The demand options within the least cost solution do not raise any moderate or major adverse impacts. Most minor adverse impacts relating to the leakage and customer management options are temporary and relate predominantly to the intermittent increases in vehicle movements associated with each scheme and the potential temporary health effects associated with dust, noise, and vibration from installation of equipment on public rights of way and roads. The minor and major beneficial effects identified are in relation to sustainable and efficient use of water resources. Water savings brought by these options would support population health and economic development and improve climate change resilience.

Table 9-4: SEA outputs of Grid SWZ least cost solution

Scheme	Adverse																		Beneficial																
	1.1	1.2	1.3	1.4	2.1	2.2	3.1	4.1	4.2	4.3	4.4	5.1	6.1	6.2	6.3	7.1	8.1		1.1	1.2	1.3	1.4	2.1	2.2	3.1	4.1	4.2	4.3	4.4	5.1	6.1	6.2	6.3	7.1	8.1
C1d Household customer audits and water efficiency retrofits		None		None		None						None				None	None					None		None						None				None	None
C4 Metering on change of occupancy		None		None		None						None				None	None					None		None						None				None	None
C6a Non-household water use audit and retrofit				None								None				None	None					None								None				None	None
C6a(ii) Non-household domestic water use audit and retrofit				None								None				None	None					None								None				None	None
C12a3 Rainwater harvesting for commercial customers		None		None		None						None				None	None					None		None						None				None	None
C13c Household tariffs				None		None						None				None	None					None		None						None				None	None
C15d Installation of internal household flow regulators				None		None						None				None	None					None		None						None				None	None
C23b1 Rainwater harvesting for agriculture				None		None						None				None	None					None		None						None				None	None
C27d School Visits		None	None	None		None						None				None	None				None	None		None						None				None	None
C30a Water labelling			None	None								None				None	None				None	None								None				None	None
C32c Household Rainwater Harvesting- New Development				None		None						None				None	None					None		None						None				None	None
C34a Non-household media campaign	None			None		None						None	None	None		None	None					None		None						None	None	None		None	None
C35c Non-household water efficiency incentive scheme			None	None								None				None	None				None	None								None				None	None
LSM Leakage reduction and smart metering				None																		None													
DO03 Supply rivers drought permits- ends in 2038- DYAA		None	None		None	None	None			None	None	None	None	None	None	None			None	None		None			None	None	None		None	None	None	None		None	None
DO13 Drought demand reduction- ends in 2038- DYAA	None	None				None	None	None	None	None	None	None	None	None						None		None			None					None	None	None			
DO08 Supply reservoir compensation drought permits- ends in 2038- DYAA		None	None		None	None	None			None	None		None	None	None	None			None	None		None			None	None	None		None	None	None	None		None	None
DV3 - Magnesium Limestone new GW supply				None							None																		None						
DV7a(vi) - Tees to York Pipeline - NWL import 140 Ml/d				None							None																		None						
DV8B - New York WTW and Dual Main South Yorkshire Pipeline											None																								
R37b(ii) - River Aire Abstraction option 4											None																		None						

Key		No effect		Negligible adverse		Minor adverse		Moderate adverse		Major adverse		Negligable beneficial		Minor beneficial		Moderate beneficial		Major beneficial

9.4 Building the preferred plan

We have produced multiple potential solutions for meeting the Grid SWZ deficit using our WRMP optimiser model. In total we produced 26 optimisation runs for a range of plausible scenarios including the baseline scenario (1 in 500-year level of service), alternative levels of service, the Ofwat common reference scenarios and YW bespoke scenarios. We also tested the plan using alternative optimisation parameters for meeting the DYAA deficit in the most likely pathway.

For each scenario the optimiser was run with all feasible options that had passed the second screening available for selection. Options for meeting key objectives (see section 9.1) were constrained into the runs. Each scenario covered a 60-year planning period from 2025/26 to 2084/85. Table 9-5 lists the runs.

We produced four optimised solutions for closing the deficit in the DYAA most likely pathway which are variations on the least cost benchmark. This run was created with and without the STW backfill options constrained into the plan. We have variations on these runs as late in the process an error was found in the supply-demand calculation, which was not material to the plan, but the deficit had been overestimated. The WRP tables have been updated, but it was too late to rerun all the scenarios in the optimiser model. However, the least cost most likely scenario was rerun (with and without the backfill option constrained in) and the rerun version with the backfill options constrained in has been used as the benchmark.

Figures and tables shown in this section displaying alternative pathways represent scenarios used within the optimisations. These figures/ tables do not contain adjustments that were made post-optimisation such as NAV adjustments (See Section 3.13.3) and the error discussed above.

We have created two critical period solution programmes. As the DYAA scenario has a greater deficit than the critical period this has been the focus of the decision making and any solution to the DYAA will close the critical period deficit.

Table 9-5: Optimised Grid SWZ supply-demand balance scenarios

Scenario	Level of service	Optimisation objective	Demand policy options	STW transfer backfill	Level 1 to 3 drought options
1 in 500 unconstrained drought options available	1 in 500 all years	Minimise cost	Unconstrained	Unconstrained	Not available
1 in 500 unconstrained drought options not available	1 in 500 all years	Minimise cost	Unconstrained	Unconstrained	Until 2039
1 in 500 constrained demand and backfill	1 in 500 all years	Minimise cost	Constrained	Constrained	Until 2039
Least cost (1 in 500 by 2039) without backfill v1	1 in 500 by 2039	Minimise cost	Constrained	Unconstrained	Until 2039
Least cost benchmark (1 in 500 by 2039) with backfill v1	1 in 500 by 2039	Minimise cost	Constrained	Unconstrained	Until 2039
Least cost (1 in 500 by 2039) without backfill v2	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
Least cost benchmark (1 in 500 by 2039) with backfill v2	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
Least cost 1 in 500 by 2035	1 in 500 by 2035	Minimise cost	Constrained	Constrained	Until 2035
Least cost 1 in 500 by 2045	1 in 500 by 2045	Minimise cost	Constrained	Constrained	Until 2045
Best for natural capital	1 in 500 by 2039	Maximise natural capital	Constrained	Constrained	Until 2039
Best for social and natural capital	1 in 500 by 2039	Maximise social & natural capitals	Constrained	Constrained	Until 2039
Best for carbon	1 in 500 by 2039	Minimise carbon	Constrained	Constrained	Until 2039
Best for all capitals	1 in 500 by 2039	Maximise 6 capital benefits	Constrained	Constrained	Until 2039
Hydrogen	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
High climate change	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
Low climate change	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
High demand	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
Low demand	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
High technology	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
Low technology	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
Low Environmental Destination	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
High Environmental Destination	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
1 in 500 by 2039 intergenerational test	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039
Critical Period without drought options	n/a	Minimise cost	Constrained	Constrained	Full period
Critical Period with drought options	n/a	Minimise cost	Constrained	Constrained	Not available
Underachieve demand	1 in 500 by 2039	Minimise cost	Constrained	Constrained	Until 2039

Alternative futures

Our preferred plan has not been based on one optimised output for a single supply-demand balance scenario. To ensure the plan is resilient to risks and flexible to alternative scenarios our preferred plan includes options that can be considered no or low regrets across a range of plausible futures. We have identified the no / low regrets options through scenario testing.

We have created alternative future supply-demand balance scenarios that align with the Ofwat common reference scenarios. We have also created bespoke scenarios to address risks not captured by the common reference scenarios. These include a scenario to represent the risk of a new non-household need for hydrogen in the Hull area (hydrogen scenario) and a scenario where the demand reduction options constrained in to meet the policy requirements only achieve half the assumed benefits (half demand benefits scenario).

We have included the hydrogen scenario as hydrogen has been identified as a future source of energy to help achieve the Government's target for future CO2 emissions. To achieve these targets there are several projects throughout the UK, known as Hydrogen Hubs. One of these hubs is the Humberside Zero Project, which will produce hydrogen to be used in power generation and could have a large impact on water use for the Yorkshire region in the Hull area. We estimate a need for 7Ml/d, however, it is possible this could be much higher, and we have assumed a 15Ml/d need from 2027/28 onwards in this scenario.

Future water needs for hydrogen energy is highly uncertain and dependent on policy delivery uncertainty. This impacts the technology chosen, which in turn impacts the volume of water use. There is also uncertainty where hydrogen production may be located and when production may start. Hydrogen water needs will be a focus of the next round of regional plans to improve understanding of the growth in hydrogen energy and what it will mean in terms of competing requirements for water resources. This will inform our WRMP29.

The half demand benefits scenario has been included to represent a risk that the full benefits from the options to achieve the demand policy reductions is not achieved. We have assumed as an extreme plausible scenario only 50% of the benefits assumed for each year of the planning period are achieved. This is aligned with scenario testing used in the regional planning reconciliation process.

Solution programmes for each of the alternative futures were produced using the optimiser model. Each scenario represents a plausible future that is (at the time of producing this WRMP24) considered less likely than the DYAA baseline (most likely) scenario. We have not combined any scenarios (for example, high climate change and high demand) as the individual alterative futures are considered extreme. Compounding extreme scenarios would result in deficits not considered plausible and could result in extreme under or over investment.

The alternative scenarios and a brief description are listed in Table 9-6. Each scenario is classed as adverse or benign depending on whether it worsens or improves the deficit in the baseline scenario[50]. All scenarios include a supply objective to meet the 1 in 500 years level of service by 2039/40 to ensure comparable to the most likely scenario.

[50] Note that this is different from the baseline supply-demand balance position as presented in Section 7, which utilises a 1 in 500 year drought resilience position. The baseline in this case reflects a re-baseline for the purpose of the optimisation runs, including a 1 in 200 year drought resilience position prior to 2039/40.

Table 9-6: Alternative future scenarios

Scenario	Description (change to baseline)	Adverse / benign	2029/30 BL Difference	2049/50 BL Difference	2084/85 BL Difference
High climate change	Climate change impact on supply (deployable output) based on carbon emissions RCP8.5	Adverse	-28.34	-38.30	-66.47
Low climate change	Climate change impact on supply (deployable output) based on carbon emissions RCP2.6	Benign	17.47	26.11	45.31
High demand	The baseline local authority plan-based growth scenario meets the Ofwat classification for high demand growth. Therefore, there is no change to baseline demand forecast. However, this scenario assumes there is no benefit from the Government water labelling initiative and the C30a water labelling option is not available for selection	Adverse	0	0	0
Low Demand	A lower demand growth scenario is represented by an ONS trend-based growth projection instead of the local authority plan-based scenario. A higher building regulations and product standards benefit option (C30b) is constrained into the SDB which reduces the deficit compared to baseline. This difference from baseline is represented in brackets.	Benign	23.21 (40.52)	47.30 (236.05)	50.27 (252.79)
High technology	This scenario is the same as the baseline however, the leakage and metering benefits are based on smart water supply network and full smart meter penetration achieved by 2035.	Benign	0	0	0

Scenario	Description (change to baseline)	Adverse / benign	2029/30 BL Difference	2049/50 BL Difference	2084/85 BL Difference
Low technology	This scenario is the same as the baseline however, the leakage and metering benefits are based on smart water supply network achieved by 2040 and full smart meter penetration by 2045.	Adverse	0	0	0
Low Environmental Destination	There are currently no known legal requirements for abstraction reductions in our area and this scenario assumes no licence reductions over the planning period.	Benign	0	105.22	89.96
High Environmental Destination	This scenario is the same as the EA enhanced ED scenario (see section 3.8.3) and assumes more significant licence reductions are applied to the groundwater sources in 2035 and the River Derwent surface water abstraction in 2040.	Adverse	0	-71.7	-74.40
Hydrogen	This option assumed a 15Ml/d new non-household need in 2027/28 for hydrogen energy	Adverse	-15	-15	-15
Half demand benefits	The supply-demand balance is the same as the baseline. However, the solution assumes the year-on-year combined benefits from leakage, metering and water labelling initiatives will be underachieved by 50%	Adverse	0	0	0

9.4.1 Sensitivity testing

It is important that our plan considers cost and that we aim to meet this objective to produce a plan that is affordable and sustainable over the long term. However, the least cost solution may not provide best value for meeting other WRMP objectives. The WRMP optimiser model has functionality to optimise on one or more of the six capitals and we have used this to create solution programmes optimised on factors other than cost.

We have also rerun the optimiser with a reduced long-term discount rate (which excludes pure social time preference) to sensitivity test the plan against the standard declining long-term discount rate as recommended in the HM Treasury Green Book. The difference between these two figures provides an estimate of the wealth transfer that is attributable to pure social time preference. This helps us test the intergenerational impact of the plan.

Each solution programme was created to meet the most likely supply-demand balance scenario. The objectives for the alternative optimisation solution programmes are listed below:

1. Minimise carbon impact on the solution.
2. Maximise the natural capital and social benefits of the solution.
3. Maximise natural capital benefits of the solution.
4. Provide a solution that is best value for the 6 capitals combined.
5. Reduced long term discount factor.

The minimum carbon run is based on minimising the carbon costs associated with emissions from capital and operational expenditure of WRMP options to meet supply-demand balance requirements. A maximised environmental and social benefit run is based on maximising the monetised natural and social capital values due to the yield benefit and other impacts from the WRMP options (for example, change in land use) to meet supply-demand balance requirements. There may be cases where the natural and social capital impact represents a 'cost' rather than a benefit (for example, due to a loss of a habitat type from building the option). Due to this, the maximisation of a benefit is also associated with minimising a negative natural and social capital impact. We refer to these runs as "best value optimisations". They do not give the final preferred best value plan but do provide alternative optimisations based on factors other than financial costs that we considered in formulating our best value plan.

The outputs of these runs are presented in Appendix C.2. The solution programmes are very similar at the start of the planning period until 2039/40 when the DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d option is selected at the end of AMP10. This option provides surplus until post 2050 when further supply side options are selected. At this point the programmes start to diverge.

9.4.2 Best plan for social and environment

The EA guidelines require a best plan for society and environment plan to be considered. The programme costs and benefits to society and the environment are complex and can be represented in several different ways. Within our decision-making we have considered social and environmental factors as:

- **Metrics** – the MCA approach includes environmental and social related metrics, which are natural capital, biodiversity, and social and human wellbeing.
- **Optimisation** – As part of our sensitivity testing, we have created a solution programme to meet the most likely supply-demand balance scenario optimised to maximise benefits of the natural and social capital values.
- **Scenarios** – the high (enhanced) ED includes a greater level of abstraction reduction than our most likely pathway, which is based on the BAU+ ED. The environment destination objective benefits to the environment of this scenario are greater than the most likely scenario as the environment could potentially benefit from a more naturalised flow regime.

As the three approaches are addressing social and environmental factors differently there are some conflicts. The high ED scenario results in a better outcome for the water environment which has an associated social benefit. However, it leads to a greater deficit and more supply options selected; there are positive and negative environmental and social impacts of this. We have therefore considered both the optimised best for natural and social capital values and high ED solution programmes as candidate solutions for the best value plan. These can be compared to the least cost benchmark solution programme and the metrics are used to support the final decision making and consider the trade-offs.

Critical period

Although the main driver of the solution is the DYAA scenario due to the larger deficit, we have produced two optimisation runs for the critical period scenario. The supply-demand balance is the same for both runs and as presented in the Grid SWZ WRP table 3d. The difference between the two runs is the availability of drought options. In the critical period level 1 to 3 drought options are available throughout the planning period. We have produced solution programmes both with and without drought options available for selection.

In the critical period scenario runs we have made a change to the R3a River Ouse licence variation 1 option and increased the benefit from 0.3Ml/d to 15Ml/d. This option is a licence transfer to take more water during low flows and the benefit is greater in the critical period when the river is more likely to be in the lower flow band.

9.4.3 Best for resilience

The results from the optimisation runs were used to create a 'best for resilience' plan for closing the most likely Grid SWZ DYAA deficit. The modelled outputs provide important information on which to base our decisions, but the optimised solution programmes do not meet all the WRMP24 objectives or provide flexibility for the future. The best for resilience solution programme is not an output from the optimisation model. However, the option selection frequency from the optimised programmes have been used to create a 'best value' portfolio that we have used to build the best for resilience plan.

Options that were selected most frequently across the range of plausible futures and using alternative optimisation parameters can be considered no or low regrets. shows the number of times individual options were selected across all 26 optimised solution programmes. The options to meet demand management objectives and offset the loss of the STW transfer were constrained into the majority of the programmes and are not included in the chart.

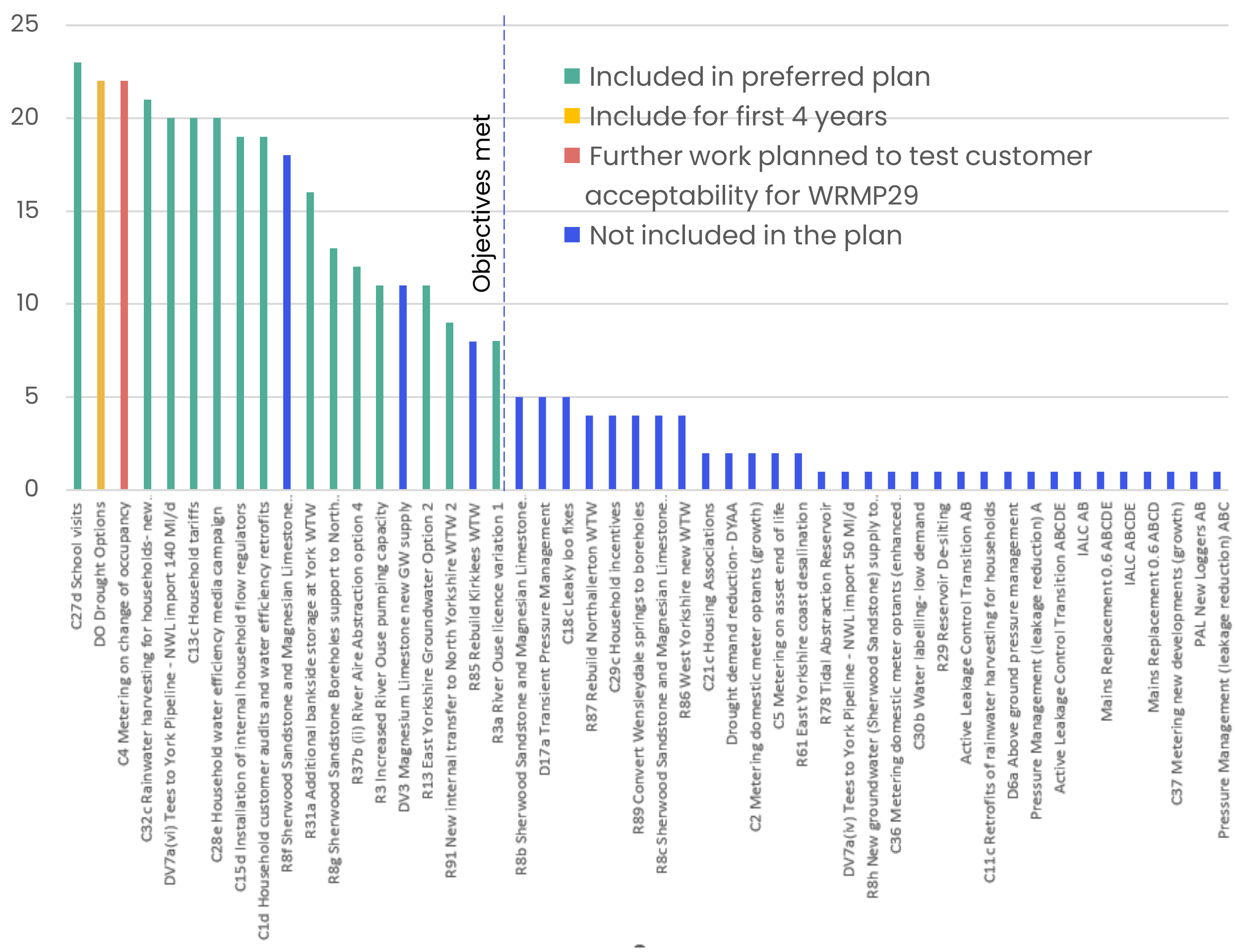
The options selected in the model runs create a portfolio of options that we consider to be best value. In total there are 95 feasible options available for selection (including options that rely on the same source and are mutually exclusive) and 17 were not selected in any of the optimisation runs. These options cannot be considered no or low regret options and are therefore excluded from the best value portfolio.

During this phase of the decision-making process, we have applied 'expert judgement' in creating the best for resilience solution programme and have considered:

- **A twin track approach that invests in both new supplies and demand reduction.** We have ensured our plan is contributing to the Government's Environment Plan demand reduction targets by constraining demand options into the candidate solutions. However, if the required demand reduction is not achieved this creates a risk to security of supply for customers. Our preference is to invest in both demand reduction and new supply schemes early in the planning period (AMP8) to ensure we are not overly reliant on demand reduction.
- **The SEA assessment at the option level.** If an option is selected frequently but poses a greater risk to the environment than an option selected less frequently, we consider if the environmental impacts of the option override the frequency score. This partly depends on the scale and size of the deficit as we cannot always avoid options that are scored as adverse. We consider the wider benefits of the schemes and how we might mitigate the impacts before constraining out.
- **The resilience benefits of the supply-side options.** In compiling our best value plan, we have considered the resilience benefits of options and if there is justification for these benefits overriding the frequency score. As a number of options support our WSSS they achieve benefits in addition to drought resilience as listed in Table 8-3. We have discussed the resilience needs with operational teams to understand their priorities and included options that align with other strategies as well as being selected in several plausible futures.

- **Alternative futures.** The best value plan is not a plan for meeting a single supply-demand balance scenario. It is a plan that meets the most likely scenario and ensures flexibility for the future if we deviate to an alternative scenario. The alternative future scenarios highlight key risks in the medium to long term that could drive a change to the solution programme. They show that there is a risk that the deficit could be greater than the most likely in the short term (2025-2035). This risk is present in the high climate change, high ED and hydrogen scenarios. Any risk in the near term requires options to be developed in AMP8 to allow for the time to deliver. We have balanced this through inclusion of solutions to achieve a benefit in AMP8 and enabling work for solutions that could need to be brought forward if we deviate to an alternative pathway.
- **Drought resilience.** We have an objective to be resilient to a 1 in 500-year drought return period by 2039/40 and we balance this with the cost and time needed to deliver options. We also want to reduce reliance on level 1 to 3 drought measures to provide a more secure supply of water to our customers and avoid the risk of detrimental impacts to the environment through drought actions. Our best for resilience plan aims to meet the 1 in 500-year drought objective by 2040 and goes further by planning to reduce reliance on level 1 to 3 drought actions in advance of 2040.

Figure 9.6: Option selection frequency based on optimisation runs



The options included in the best for resilience plan are highlighted in . The options selected include level 1 to 3 drought actions from 2025/26 to 2028/29. The 1 in 200-year drought return period deficit is not fully closed until 2027/28[51]. From 2028/29 onwards the deficit is closed without the use of drought options by bringing forward supply-side options to provide a twin track solution. This provides non-drought resilience for our conjunctive use system, helps mitigate the risk of not achieving demand reduction and provides resilience against more adverse pathways, which we would struggle to adapt to in the future if we did not invest in new supplies early in the planning period.

The first consideration for inclusion is frequency of selection, however, for some options the frequency has been overridden and we have excluded the following options from our best for resilience plan:

- C4 Metering on change of occupancy – this option would install a meter into household properties when a new occupier moved in. This would accelerate meter penetration and benefit demand reduction. Meter penetration in the baseline scenario achieves 86% by 2050. Change of occupancy metering would achieve 90% by 2050, and from 2030 to 2050 there would be a benefit to the supply-demand balance from achieving the higher percentage and by escalating the conversion rate. However, this option would mean customers would not be given a choice in receiving a metered supply. We shall carry out customer surveys to assess the acceptability of this option for further consideration in WRMP29.
- R8f Sherwood Sandstone and Magnesian Limestone Boreholes option 6 – this option shows major adverse impact on biodiversity and flora. To meet the majority of futures we can avoid this impact by including an alternative option. Our preference is the R8g Sherwood Sandstone Boreholes support to North Yorkshire as it provides additional resilience for the Dales area. This option has no major or moderate adverse impacts. In the higher deficit scenarios, the R8f option is still required, and we would need to mitigate the adverse impacts, the details of which would be finalised during project planning.
- DV3 Magnesium Limestone new GW supply – this option is in the Doncaster area. There is a PR24 scheme to improve resilience in the area and therefore this option would have reduced utilisation. However, in higher deficit scenarios the utilisation would increase, and this option could be required for the more adverse pathways.
- R85 Rebuild Kirklees WTW – this option has not been included in our best for resilience plan as the next most frequently selected option is the R3a River Ouse licence variation 1. The R3a option is a licence variation that would have provided drought resilience in the 2022 drought. The benefit in the DYAA scenario is marginal at 0.3Ml/d, but in a critical period scenario the benefit is 15Ml/d. The option has no construction cost, which means the lead in time is short. However, the River Ouse WINEP investigation has yet to complete, and the licence variation would need to be approved by the EA and the Canal & River Trust (CRT).
- Options R3, R3a, R13 and R91 have been scheduled ahead of supply options with a higher frequency ranking (R8g and R37b(ii)) due to the shorter lead in times. . The lead in time for options R8g and R37b(ii) includes a greater level of investigation and construction than the R3, R3a, R13 and R91 options. Therefore, we have selected the options that are expected to be deliverable in a shorter timeframe to provide a benefit sooner and help close the near-term deficit.

[51] In all candidate solution programmes, including the best for resilience, the 1 in 200-year level of service cannot be met until 2027/28 as there is insufficient time to implement schemes and we are therefore planning to a level of service lower than 1 in 200 years in the interim period. This is discussed in Section 9.5.

9.4.4 Candidate solution programmes

The following solution programmes have been considered as candidate solutions for the preferred (best value) plan:

- **Least cost benchmark** optimised solution to most likely scenario to achieve 1 in 500-year drought resilience by 2039/40. Relies on level 1 to 3 drought options until 2038/39.
- **Best for social and natural capital** optimised solution to most likely scenario to achieve 1 in 500-year drought resilience by 2039/40. Relies on level 1 to 3 drought options until 2038/39.
- Least cost optimised solution to **high ED** scenario to achieve 1 in 500-year drought resilience by 2039/40. Relies on level 1 to 3 drought options until 2038/39.
- **Best for resilience** plan to most likely scenario to achieve 1 in 500-year drought resilience by 2039/40. Relies on level 1 to 3 drought options until 2028/29.

The options included in each programme are listed in Appendix C.3. Each solution programme will meet the DYAA most likely pathway deficit and close the critical period deficit. The high ED solution will meet the higher deficit scenario and includes more options than the other candidate solutions.

The best for resilience plan includes more supply-side options compared to the least cost benchmark and best for natural and social capitals. This is to provide resilience by not relying on demand management alone and to increase the water supply system resilience benefits of the solution. A number of supply-side options are included in the AMP8 period, which means from 2029/30 onwards the deficit could be met without the need for drought options.

We have compared each plan using the best value metrics. In selecting our final best value (preferred) plan, we considered the metric values, the SEA, and the resilience benefits of each option. The metric values for each programme are compared in Table 9-7shows the metric comparison for the candidate solution programmes. The metric scores for the least cost benchmark solution show it to be a good value solution scoring highest for eight of the metrics – carbon, natural capital, leakage, PCC flood and risk management, multi abstractor, human and social well-being and customer preference. However, the option deliverability and programme resilience scores are lowest. The plan includes the STW backfill option and the Tees transfer, but there are no further supply-side options.

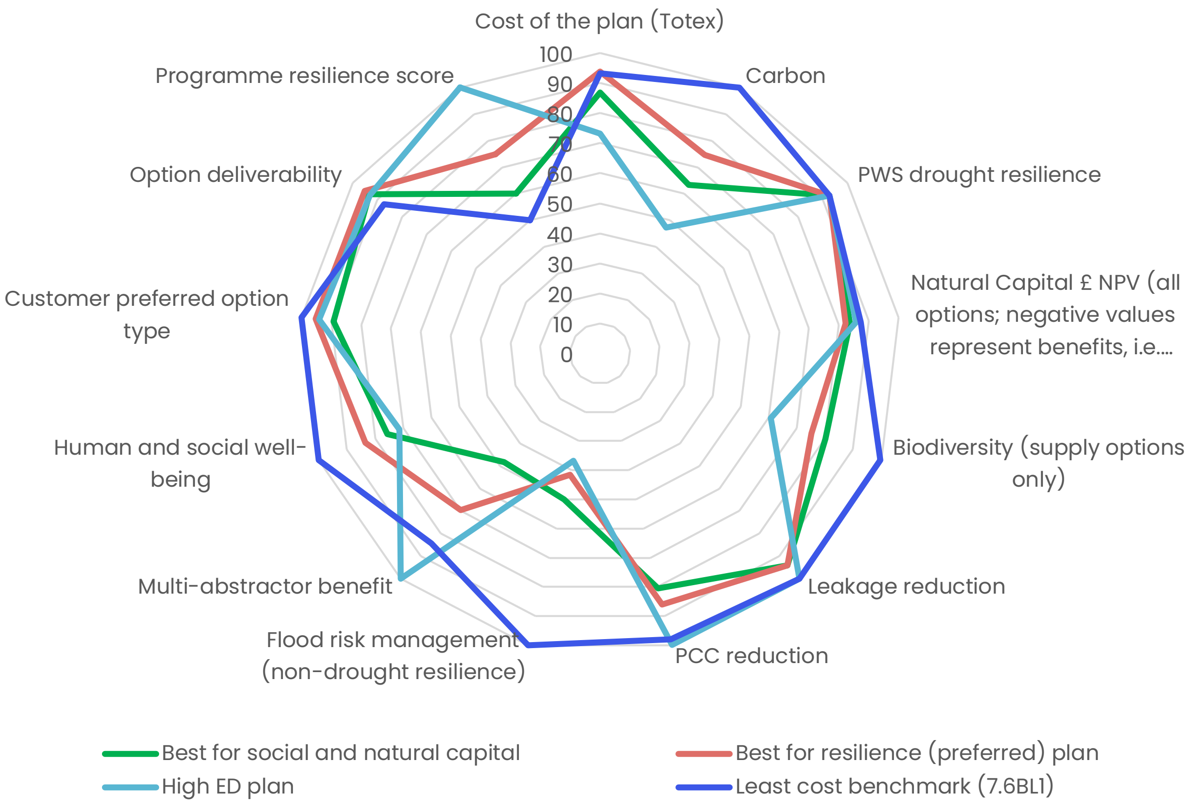
Table 9-7: Candidate solution programme best value metric values

Solution programme	Least cost benchmark (1 in 500 by 2039)	Best for social and natural capital	High ED	Preferred plan (best for resilience)
Cost of the plan £M NPV (Totex)	1630	1750	2047	1620
Carbon 000s tCO_2	2949	4647	5879	3944
PWS Drought resilience	23	23	23	23
Natural Capital (£M NPV)	-653.74	-614.95	-589.9	-599.2
Biodiversity (supply options only)	-2257.15	-2804.86	-3619.85	-2988.93
Leakage reduction Ml/d	100.96	94.64	94.61	94.61
PCC reduction l/h/d	13.96	10.79	11.93	11.93
Flood risk management (non-drought resilience)	0.1	0	-0.10	-0.04
Multi-abstractor benefit	-0.29	-0.5	-0.40	-0.35
Human and social well-being	-0.25	-0.33	-0.37	-0.3
Customer preferred option type	2.43	2.14	2.10	2.31
Option Deliverability	2.81	3.05	3.20	3.12
Programme resilience score	0	1	0	2

The high scores are a result of the solution including fewer supply options compared to the alternatives. All of the candidate solutions include the backfill option and the Tees transfer, and these options are critical to offset the STW transfer loss and potential River Derwent abstraction reduction respectively. There are two further supply-side options in the least cost benchmark programme, but not until the 2070s. This would mean there would be no new resources available to close the deficit driven by climate change and population growth. If in the future we diverted to an alternative pathway with a higher deficit (high climate change, hydrogen cluster or high ED) it would be too late to deliver new resources.

The least cost plan is optimising on cost to meet a single (most likely) scenario deficit. If we remain on the most likely pathway and achieve the demand reduction, this plan will meet the deficit with minimal surplus. However, the trade-off to this is that the plan has limited flexibility to the alternative futures and there is no resilience if demand management is not achieved. It scores lowest for option deliverability and programme resilience due to the risk of relying on an ambitious demand management programme.

Figure 9.7: Candidate solution programmes metric comparison



The best for social and natural capital programme includes four supply-side options in addition to the STW backfill and Tees transfer options, however these are later in the programme (2068 onwards) and similar to the least cost benchmark this solution would make us vulnerable to near term risks. The scenario also results in lower metric scores for each metric compared to the least cost benchmark and we can conclude that it is not the best performing plan in the context of the WRMP objectives.

Table 9-8 compares the benefits of the three remaining candidate solutions (least cost, high ED and best for resilience) by option category. A cost comparison including bill impacts is provided in Table 9-9.

The high ED solution programme provides a plan for meeting a more extreme deficit. Compared to the least cost benchmark it performs better on option deliverability and programme resilience as it is selecting a greater number of supply-side options, some of which are selected within the first 25 years of the plan. It also equals the leakage score of the least cost plan and marginally improves on the PCC score. The trade-off to this is that it performs worst for biodiversity, carbon, flood risk management, human and social well-being and cost. It includes 10 new supply options compared to four in the least cost benchmark. However, it is also relying on demand reduction in the near term.

The best for resilience plan scores the same as the least cost benchmark for the cost metric. It has lower scores for carbon, biodiversity, leakage, PCC flood risk management, human and social well-being and customer preference. However, it includes a greater number of supply-side options and improves on the cost, carbon and biodiversity metrics when compared to the high ED.

As shown in Table 9-9 the cost for the best for resilience plan are higher than the least cost but lower than the high ED. This is due to the number of supply-side options each plan provides.

Table 9-8: Candidate solution programmes option benefits by category

Least cost plan benefits

Option type	AMP8	AMP9	AMP10	AMP11	AMP12	AMP13	AMP14	AMP15	AMP16	AMP17	AMP18	AMP19
HH WE	2.06	7.51	19.85	32.59	45.62	46.06	46.14	46.14	46.14	46.14	46.14	46.14
Leakage & metering	59.38	96.49	115.02	130.39	141.03	141.03	141.03	141.03	141.03	141.03	141.03	141.03
NHH WE	2.59	4.59	6.46	8.26	8.73	8.73	8.73	8.73	8.73	8.73	8.73	8.73
Resource	41.69	41.43	190	190	190	190	190	190	190	195	228.5	228.5
Total	105.72	150.02	331.33	361.24	385.38	385.82	385.9	385.9	385.9	390.9	424.4	424.4

Best for resilience plan benefits

Option type	AMP8	AMP9	AMP10	AMP11	AMP12	AMP13	AMP14	AMP15	AMP16	AMP17	AMP18	AMP19
HH WE	3.2	8.84	21.34	34.2	47.32	47.76	47.85	47.85	47.85	47.85	47.85	47.85
Leakage & metering	46.47	77.79	96.32	111.69	122.33	122.33	122.33	122.33	122.33	122.33	122.33	122.33
NHH WE	2.82	4.82	6.67	8.48	8.73	8.73	8.73	8.73	8.73	8.73	8.73	8.73
Resource	21.3	21.3	86.3	226.3	226.3	226.3	226.3	226.3	226.3	259.8	259.8	270.4
Total	73.79	112.75	210.63	380.67	404.68	405.12	405.21	405.21	405.21	438.71	438.71	449.31

High ED plan benefits

Option type	AMP8	AMP9	AMP10	AMP11	AMP12	AMP13	AMP14	AMP15	AMP16	AMP17	AMP18	AMP19
HH WE	9.74	5.93	7.48	7.69	9.66	3.45	3.45	3.45	3.45	3.45	3.45	3.45
Leakage & metering	90.65	36.30	46.28	216.63	62.12	122.45	29.31	19.85	19.85	19.85	19.85	19.85
NHH WE	21.17	27.91	31.25	31.66	32.54	23.71	23.71	23.71	23.71	23.71	23.71	23.71
Resource	131.17	436.31	315.34	229.51	231.43	235.38	231.47	322.70	329.11	359.33	279.13	278.12
Total	252.72	506.45	400.35	485.48	335.75	384.98	287.93	369.70	376.11	406.33	326.13	325.12

Table 9-9: Cost comparisons for the least cost, best for resilience and high ED plans (costs shown in CPIH 20/21 price base)

	Totex							Average Bill increase per annum					
	AMP 7	**AMP 8**	**AMP 9**	**AMP 10**	**AMP11**	**AMP12**	**Total investment**	**AMP 7**	**AMP 8**	**AMP 9**	**AMP 10**	**AMP11**	**AMP12**
Best for resilience	-	254.7	377.05	206.2	232.76	244.23	1,314.93	-	5.63	14.1	22.59	25.09	22.74
Least Cost	-	287.52	320.85	200.43	227.56	227.74	1,264.11	-	5.89	13.53	21.23	24.11	22.04
High Ed	-	245.3	474.13	356.28	281.39	293.07	1,650.16	-	5.43	14.58	24.88	33.37	30.59

9.5 Yorkshire Water preferred plan

The best for resilience plan is our preferred plan as it provides resilience in the near-term through inclusion of supply side options for a similar whole life cost as the least cost solution. This provides flexibility to alternative futures, which is not achieved through following the least cost plan. It does require trade-offs on other metrics but overall performs better than the high ED by not committing to the higher deficit, whilst ensuring we can deviate to this pathway in the future.

The best for resilience plan has been created to provide a twin track approach to meeting the deficit, which provides resilience if the demand reduction is not achieved and if an adverse pathway is triggered within the first five years of the planning period. It includes four new resource schemes that will be delivered in AMP8.

Two of the schemes make use of licenced abstractions we are permitted to take on the River Ouse, but current infrastructure limits utilisation. The third option, R13 East Yorkshire Groundwater Option 2, relocates a borehole and a licensed abstraction that is out of service due to water quality risks. This will require a variation of the existing abstraction licence. This option was included in our WRMP19 for resilience purposes and not directly linked to the deficit in our previous plan, which was not until the mid-2030s. The early deficit in WRMP24 reinforces its need and delivery will start in AMP7.

In the best for resilience plan we would implement a new borehole scheme in the Sherwood Sandstone aquifer in North Yorkshire to be available for 2035. Two further supply schemes close the longer-term deficit, the R37b(ii) River Aire Abstraction option 4 and R31a Additional bankside storage at York WTW in 2073 and 2082, respectively.

The key objectives for WRMP24 are summarised in Table 9-10 with a brief description of how the preferred plan meets the objectives.

Table 9-10: WRMP24 public water supply objectives and high-level solutions

Objective	Benefit year(s)	Solution	Justification of need
1. Objective: Close the supply-demand deficit (25 years minimum)	2025-2082	• The twin track approach to reduce demand and increase supply will close the deficit and enable deviation to more adverse pathways if triggered	Early interventions are needed to mitigate the risk of deficit in the short term and ensure the zone is in surplus in the final plan.
2. Objective: Reduce leakage by 50% compared to 2017/18 levels by 2050	2025-2050	• An optimised leakage delivery plan that achieves the 50% reduction	Policy requirement and reduces water taken from the environment.
3. Objective: Achieve an average PCC of 110 l/h/d by 2050	2025-2050	• Smart metering and household water saving initiatives, including water labelling	Policy requirement and reduces water taken from the environment.
4. Objective: Become resilient to 1 in 500 drought events without reliance on drought measures	2025-2039	• East SWZ at 1 in 500-year resilience in the base year • In the Grid SWZ achieve 1 in 200-year level of service (DYAA scenario) by 2027/28 and 1 in 500 year by 2039/40. • Reduced reliance on level 1 to 3 drought options.	The Grid SWZ DYAA and DYCP scenarios show an immediate risk of deficit. Early interventions are needed to mitigate this risk and achieve 1 in 200 year drought resilience as soon as feasibly possible. In the medium term there is a policy requirement to be resilient to a 1 in 500-year drought by 2039/40.
5. Objective: Increase resilience in the Grid SWZ and localised growth hot spots	2025-2035	• Invest in both supply and demand options. • Include supply options that have non-drought resilience benefits in local areas.	In our solution we have considered areas of the Grid SWZ that would benefit from new supplies to meet short term resilience risks or offset the impact of growth in localised areas.
6. Objective: Offset the ED BAU+ Groundwater loss	2035	• The BAU+ groundwater loss is offset by the twin track approach in the early part of the preferred plan	Environmental Destination BAU+: risk of reduced licence availability from groundwater sources by 2035 (11Ml/d in total).
7. Objective: Offset the STW transfer termination	2035	• Invest in DV8(iv)B New north to south internal transfer connection and DV8(v)B New WTW in York supplied by the River Ouse	The internal transfer is required to connect new supplies to the South Yorkshire demand area that is currently supplied by the STW transfer. The York WTW option will provide an additional source of water to substitute the loss of the transfer.
8. Objective: Offset the ED BAU+ Surface water loss on the River Derwent	2040	• This should be met by the DV7a(vi) Tees to York SR - 140Mld	Environmental Destination BAU+: licence reduction on the River Derwent by 2050 to address a CSMG target.

9.5.1 Preferred plan level 4 drought resilience

The Grid SWZ preferred (best for resilience) plan benefits (in Ml/d) are represented in and compared to the DYAA and DYCP baseline scenarios. This shows the reduced level of service scenario of 1 in 200 years for level 4 drought restrictions until 2038/39. Level 2 and 3 drought option benefits are included until 2028/29. However, the DYAA deficit is not met in the first two years of the planning period (2025/26 and 2026/27) and the CP deficit is not met in the first year (2025/26).

Our long-term drought resilience objective is to meet the National Framework for Water Resources requirement to be resilient to a 1 in 500 year drought return period for emergency drought orders (Level 4) by 2039.

In the shorter-term, we aim to achieve a 1 in 200-year drought resilience level as soon as possible. However, at the start of the planning period (from 2025/26 to 2026/27), it is not possible to adopt this resilience level. The immediate deficit in our WRMP24 is a significant change from our WRMP19, which previously did not show a deficit until the mid-2030s in the 1 in 500-year drought scenario.

The early deficit is a result of the new deployable output approaches and latest climate change datasets which we have incorporated into our WRMP24 supply forecast, in line with regulatory guidance and the latest planning methods. This creates a step change in deployable output reduction when compared to the WRMP19 supply but does not represent actual loss of supply. Until the benefits of further demand management and leakage reductions are realised the WRMP24 deficit cannot be closed, and our level of service is reduced.

As such, in the Grid SWZ DYAA scenario we will be resilient to a 1 in 100-year drought from 2025/26 to 2026/27. From 2027/28 to 2038/39 we will be resilient to a 1 in 200-year drought for Level 4 restrictions, and from 2039/40 onwards a 1 in 500-year drought severity. The East SWZ is resilient to a 1 in 500 drought throughout the planning period.

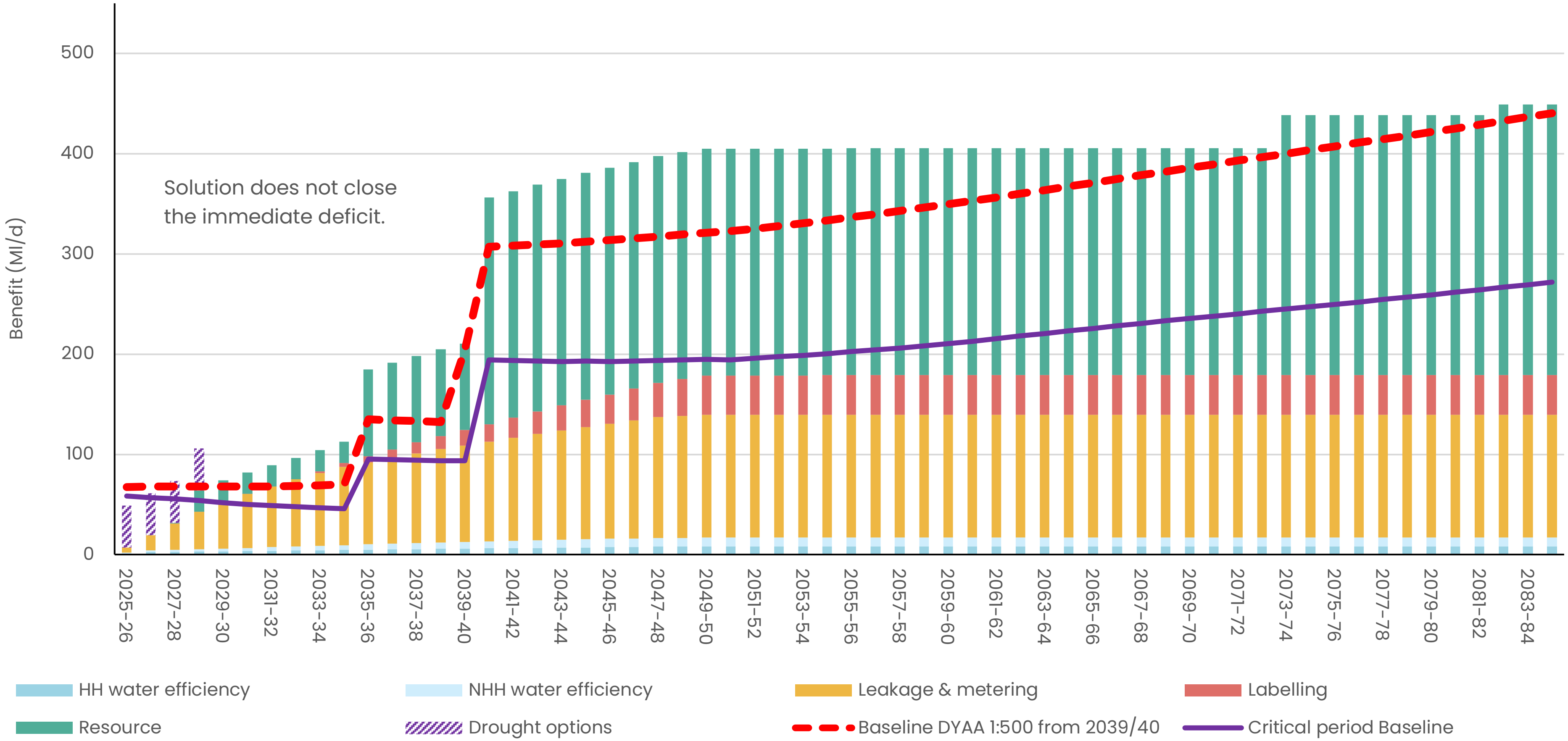
The critical period scenario is met by the DYAA solution as shown on Figure 9.8. There would also be an additional benefit from the R3a River Ouse licence variation 1 option, which has a 15Ml/d utilisation benefit in the critical period and 0.3Ml/d in the DYAA scenario. In the critical period scenario, due to the lower deficit, it is only in the first year of the plan the deficit is not met.

The critical period scenario relies on the benefit of drought measures until 2028/29, but it is not linked to levels of service and so, unlike the DYAA scenario, the deficit cannot be reduced by planning to a lower drought return period in the short term. As this scenario is not linked to a level of service, we only meet the deficit if we apply a reduced target headroom in year one of the plan. We have applied a target headroom adjustment to 2025/26 in the Grid SWZ critical period final plan WRP tables (Table 3f). The lower target headroom for 2025/26 in the critical period scenario is another consequence of changes to the supply forecast to align with the latest methodologies.

By updating our plan to incorporate new supply methodologies we have identified an immediate deficit that was not apparent in our WRMP19. In the medium term the deficit increases further due to the cessation of the STW transfer and the licence reductions under the environmental destination. These risks have also emerged since production of our previous plan.

We could not have predicted this scale of deficit in our WRMP19, and we require time to address the risks created by the methodology changes in the near term. Under the new methodology our customers are subjected to a lower level of service than our previous plan, however, had we continued with the WRMP19 supply forecast methodology the deficit risk would have been later in the planning period. This is shown in Figure 9.8 which compares the Grid SWZ WRMP19 WAFU to the WRMP24 WAFU and demand (distribution input plus target headroom) for the baseline DYAA scenario.

Figure 9.8: Preferred plan supply-demand balance with 1 in 200-year level of service until 2038/39 then 1 in 500



Demand reduction: From 2025/26 leakage, metering, household (HH) and non-household (NHH) options start to reduce demand and benefits build up until 2049/50

Levels of service: Level 4 restrictions - 1 in 100 years to 2026/27, then 1 in 200 from 2027/28 to 2038/39 and from 2039/40 onwards 1 in 500 years.
2025/26 to 2027/28 - drought options needed to meet the deficit. From 28/29 onwards deficit met without level 1 to 3 drought options.

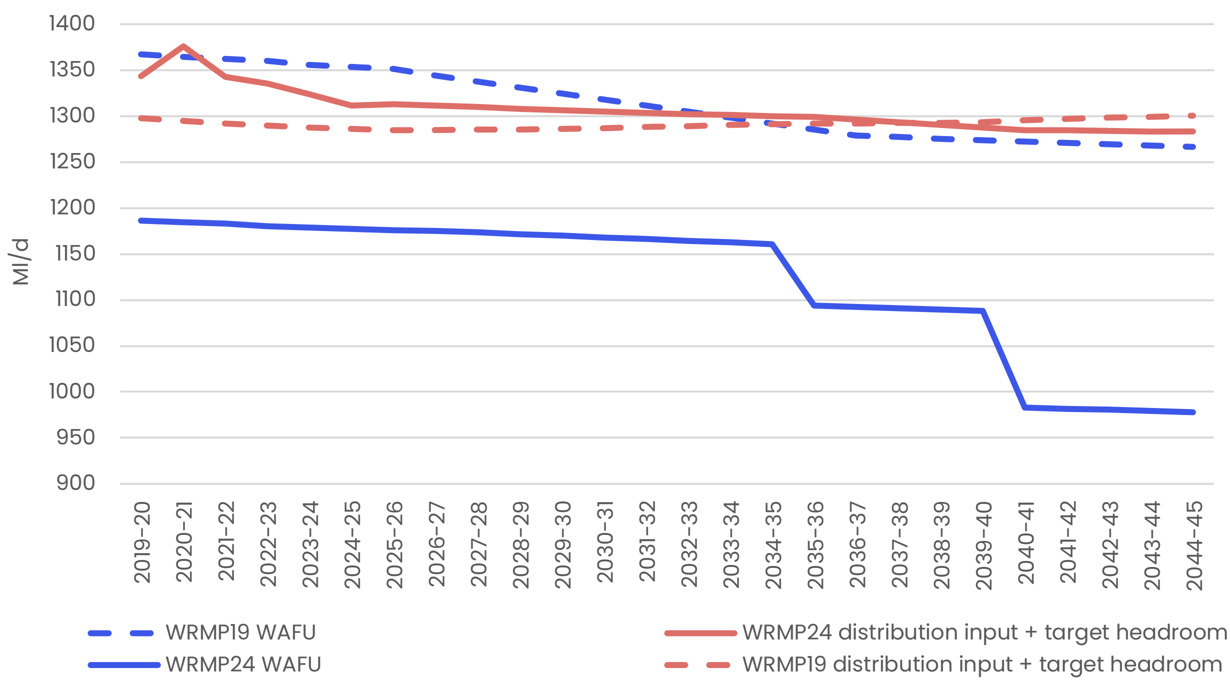
New supplies: Benefit of 0.3Ml/d from Ouse abstraction variation in 2027/28 in DYAA and 15Ml/d in critical period scenario. In 2028/29 benefit from two groundwater schemes and new infrastructure to increase abstraction from the Ouse at higher flows.

The STW backfill option and a new borehole and WTW abstracting from the Sherwood Sandstone aquifer provide benefits in 2035/36.
The Tees transfer benefits starts in 2040/41 and the River Aire abstraction and York WTW bankside storage are not needed until 2073/74 and 2082/83 respectively.

Comparing the WRMP19 to WRMP24 demand our Grid SWZ was vulnerable in 2020 during the high COVID-19 pandemic as most of the population were at home during the day instead of in their place or work. However, after this year there is no supply-demand deficit until the 2030s as forecast in our WRMP19 (Figure 9.9). The WRMP24 WAFU is 180Ml/d lower in the 2019/20 base year once the new deployable output methodology is applied. Further significant reductions in supply occur in 2035/36 and 2040/41 due to the loss of the STW transfer and the potential River Derwent licence reduction respectively, and by the end of the WRMP19 planning period (2044/45) the WAFU difference is nearly 290Ml/d.

This change does not mean our system is any less vulnerable than in the previous plan, but it does show that the risks are greater than previously predicted. To address this, we require time to implement the solution and under this methodology we are planning to a 1 in 100 level of service for the first two years of the plan, whereas under the previous methodology by incorporating the benefits of leakage reduction we achieved a 1 in 500 level of service for the full planning period.

Figure 9.9: Grid SWZ WRMP24 and WRMP19 baseline supply and demand forecast comparisons



Customer preferences

Before we published our draft WRMP24 (June 2021) a group of YW customers were consulted on their priorities as part of research carried out on behalf of WReN. The strongest level of support (70%) was for 'creating a plan that is affordable and sustainable over the long term', closely followed (63%) by 'meeting the future PWS needs in our region'. This creates a conflict, and a trade-off was needed between the cost to deliver schemes and the benefit of increasing the level of service.

Due to the timescales for delivering WRMP schemes it is not feasible to close the immediate deficit any sooner than 2027/28 in our Grid SWZ preferred plan, without reducing the level 4 level of service to 1 in 100 years. From 2027/28 we achieve a 1 in 200-year level of service and we increase to 1 in 500-years by 2039/40. Our preferred plan avoids relying solely on demand options in AMP8 by investing in both supply and demand options. However, by planning to a lower level of service in the short to medium term we reduce the overall expenditure on supply schemes, while the benefit of demand options accumulates.

We also carried out customer research on our WRMP24 in early 2023, after our draft plan was produced. Customer views of levels of service and drought resilience were mixed with some (44%) wanting YW to aim for resilience to the most serious drought events sooner, whereas the majority were either happy with 2039 or did not think it was a priority. Overall, in comparison to other plan objectives, drought resilience was seen as a low priority.

9.5.2 PyWR modelling of preferred plan

Some resource options have non-linear impacts, wherein the option benefit is dependent on the deficit scenario and the potential implementation of other resource options. Options selected in the best value cost solution (candidate solution 04.01) were assessed using our PyWR simulation model to confirm the yield benefits.

To cost the schemes for the Grid SWZ, each feasible supply side option is assigned a yield that could be available from implementing the individual scheme. However, the final yield of each scheme is influenced by the supply-demand balance scenario and the other options selected. PyWR modelling has been used to determine the option yield for the preferred solution, taking into account the hydrological conditions and infrastructure constraints of the Grid SWZ at the given deficit.

We cannot confirm the option yield in PyWR until after the supply-demand deficit is known. PyWR also considers the cumulative impact of the options selected. The yield of the scheme may be dependent on the other schemes selected, particularly if the yields are to be treated at the same treatment works. The schemes are considered in PyWR in correlation with each other to account for any interdependencies.

We have modelled how our options fulfil our supply demand deficit using our PyWR water resources simulation model. For key time slices related to supply interventions (2027, 2028, 2035, 2040 and 2073), the options in our preferred solution have been modelled for the 1990s (in terms of hydrology, without climate change) and with our selected climate change scenario for the 2070s to ensure that the options are robust to climate change. We have calculated deployable output and interpolated between years using the scaling equations as we have for other scenarios. We have also calculated the levels of service at each stage. Our modelling shows that our supply demand deficit is met, and that from 2027 our levels of service remain at or better than our targets for TUBs (4% annual risk), Drought Permits (1.25% annual risk), and level 4 restrictions (with a change from 1 in 200, 0.5% annual risk to 1 in 500, 0.2% annual risk). Before 2027 we only meet the supply demand deficit by operating at a reduced level of service, as described above. This is fully described in the Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request.

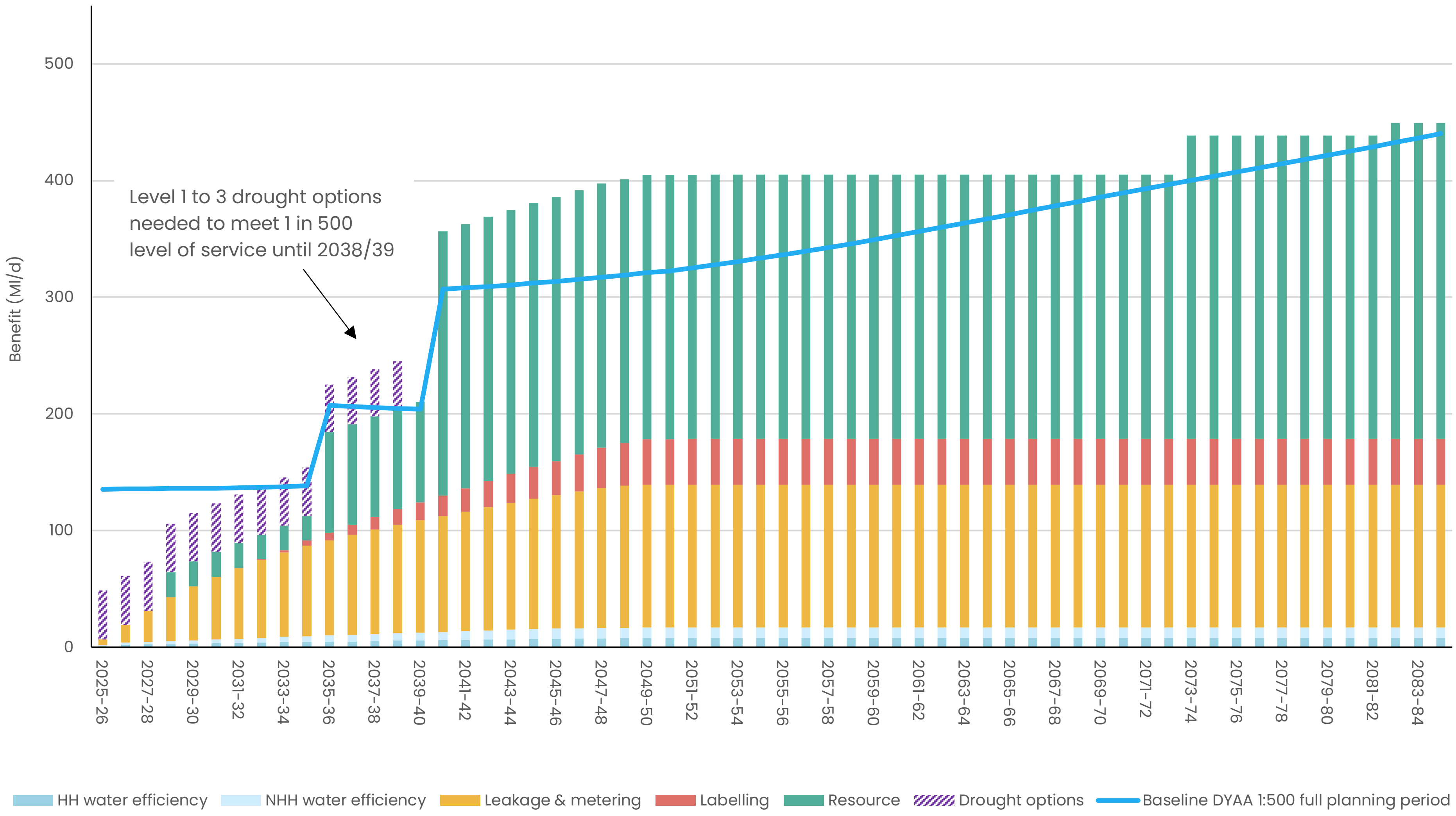
We estimate deployable output of our system with the solutions in place as described in the deployable output assessment Section 3.

9.5.3 Modelled Levels of Service

Our WRMP24 level of service objectives are to be resilient to level 4 restrictions at a 1 in 500-year return period by 2038/39 and to reduce reliance on level 1 to 3 drought actions over the planning period. Our preferred plan achieves level 4 drought resilience by 2039/40 and closes the deficit without inclusion of level 1 to 3 drought actions from 2028/29 onwards. Prior to this date there is no target level of service for level 4 restrictions in the WRPG and there is no target for level 1 to 3 drought actions.

Figure 9.10 shows the solution against the 1 in 500-year supply-demand balance for the full planning period. This suggests we could meet a 1 in 500-year level of service earlier than 2038/39 (i.e., in year 2034/35) with the benefit of drought actions incorporated until 2038/39. However, the supply-demand calculation does not capture the spatial complexities of our system that are tested by our simulation model and we have used the PyWR model to review our levels of service.

Figure 9.10: Grid SWZ preferred plan benefits against the 1 in 500 year level of service supply-demand balance with level 1 to 3 drought option use extended



Once our best value plan had been selected, we ran our PyWR model for each stage of supply solution changes. This was in order to ensure that the options do actually meet the deficit, and to model the levels of service throughout the plan. Table 9-11 shows how modelled levels of service vary during our planning period, as new supply options are brought into use. This gives us confidence that the supply solutions can meet our supply demand deficit and meet the 1 in 500-year level of resilience by 2039.

Table 9-11: Changes in modelled LoS over planning period-Preferred Plan

	Level 4 restrictions-Return period	TUBs LOS	Drought permits LOS
Base year	1 in 106 years (10.94% annual risk)	1 in 26 years (3.85% annual risk)	1 in 50 years (2.00% annual risk)
2027	1 in 227 years (0.44% annual risk)	1 in 49 years (2.06% annual risk)	1 in 82 years (1.22% annual risk)
2028	1 in 207 years (0.48% annual risk)	1 in 45 years (2.22% annual risk)	1 in 80 years (1.24% annual risk)
2035	1 in 259 years (0.39% annual risk)	1 in 52 years (1.90% annual risk)	1 in 90 years (1.11% annual risk)
2040	1 in 537 years (0.19% annual risk)	1 in 86 years (1.16% annual risk)	1 in 185 years (0.54% annual risk)
2073	1 in 507 years (0.20% annual risk)	1 in 82 years (1.22% annual risk)	1 in 164 years (0.61% annual risk)
2082	1 in 500 years (0.20% annual risk)	1 in 86 years (1.17% annual risk)	1 in 181 years (0.55% annual risk)

In order to close the deficit in the supply demand balance at the start of the plan, we have had to reduce our levels of service in the first years of the planning period, before we are able to see the benefit of any of our supply options. In our preferred plan, we are planning to a 1 in 100-year level of resilience to level 4 restrictions until 2026/27, and to a 1 in 200-year level of resilience from 2027/28 until 2038/39. The modelled outputs in Table 9-11 also show initially our level of service for drought permits is 1 in 50, below our target of 1 in 80 years. Once we start to benefit from our preferred solution programme, we increase to 1 in 80 years by 2027/28.

9.5.4 Options utilisation

We have used our PyWR model to show how much the options in our preferred plan are used in different scenarios. We have used the stochastic model runs, and analysed results for the median stochastic variate. Table 9-12 shows the utilisation for the options in our preferred plan. It shows that most of the options are utilised all of the time. The two options on the River Ouse are grouped, as once they are both implemented, it isn't possible to separate their impact. Similarly, the DV8(v)A New WTW (York) supplied by the River Ouse and DV8(iv)A(i) Dual Main South Yorkshire Pipeline are grouped, as the WTW supplies the transfer. Modelling different scenarios gives slightly different utilisation rates, but Table 9-12 gives an indication of the relative utilisation rates of the supply options, with the maximum utilisations generally reflecting use at peak times.

Table 9-12: Options utilisation

Preferred plan solutions	First year of benefit	% of time utilised	Maximum utilisation Ml/d	Average utilisation Ml/d
R3a River Ouse licence transfer	2027/28	100%	10.00	10.00
R3 River Ouse abstraction capacity	2028/29	100%		
R91 New internal transfer to North Yorkshire WTW2	2028/29	100%	5.00	4.56
R13 East Yorkshire Groundwater Option 2	2028/29	100%	6.00	6.00
DV8(v)A New WTW (York) supplied by the River Ouse	2035/36	100%	50.00	49.95
DV8(iv)A(i) New north to south internal transfer connection -dual main	2035/36			
R8g Sherwood Sandstone Boreholes support to North Yorkshire	2035/36	45%	15.00	5.64
DV7a(vi) Tees to York pipeline - NWL import 140 Ml/d	2040/41	100%	140.00	101.45
R37b(ii) River Aire Abstraction option 4	2073/74	57%	34.00	16.33
R31a Additional bankside storage at York WTW	2082/83	100%	10.00	10.00

9.6 Early start schemes

Our optimisation and decision-making highlighted a near-term risk that in the Grid SWZ. In our final plan scenario this zone will be resilient to a 1 in 100-year level of service for level 4 restrictions until 2027/28 when we increase to 1 in 200-years. Achieving the 1 in 200 level of service is dependent on the successful delivery of supply and demand options in AMP8.

The planning period is 2025 to 2085 and the solution start dates in the optimiser model are aligned with this period, that is, they cannot start earlier than 2025. Any supply interventions that start in 2025 will take several years to implement and provide a benefit. We have reviewed the potential to start schemes earlier than 2025 and achieve the benefits sooner. Our demand options require procurement of services, and we are already gearing up ahead of 2025 in preparation for delivering our AMP8 demand reduction strategy. This will ensure we have the necessary contractors and delivery strategies in place but does not bring the benefits forward.

The end-to-end delivery of supply schemes takes several years and requires approvals and consents, detailed design and environmental impact studies before construction can start. We refer to this as the option 'lead in'. Depending on the individual option requirements the construction phase can also take a number of years. It is therefore not feasible to deliver the supply options by 2025. However, to help us achieve the 1 in 200-year level of service as soon as practicable, we shall start implementation of supply options before April 2025 (in AMP7).

Both the New WTW (York) and dual main south (DV8(v)A & DV8(iv)A(i)) and DV7a(vi) Tees to York transfer option are being progressed as part of existing or proposed strategic resource options for AMP8 which would accelerate the development of the strategically important WRMP options.

Given the importance of early delivery schemes to the supply-demand balance and moving to a 1 in 200-year level of service, we commit to provide quarterly update reports on progress through our Environment Agency Account Manager meetings. We will report on any risks that manifest at the delivery stage, and the implementation of mitigation measures.

The early start options are listed in Table 9-13. Options R3, R3a, R13 and R91 are scheduled to be complete in AMP8. We shall also start early investigation work for R8g Sherwood Sandstone Boreholes support to North Yorkshire and R37b(ii) River Aire Abstraction option 4. Option R37(ii) is linked to option R86 Aire and Calder WTW and the early start for this option is to enable an adaptive pathway and not to deliver the R37b(ii) option. The decision point for implementation for these schemes is 2030, therefore the investigation work is required prior to this. The adaptive pathways are discussed in Section 10.1.

Changes to the supply options since the draft WRMP24 was published are described in Appendix I.

Table 9-13: WRMP24 supply options with an early start date (October 2024)

Option	Build start	Benefit start
R3 Increase River Ouse pumping capacity	2024/25	2028/29
R3a River Ouse licence variation 1	2024/25	2027/28
R13 East Yorkshire Groundwater Option 2	2024/25	2028/29
R91 New internal transfer to North Yorkshire WTW 2	2024/25	2028/29
R8g Sherwood Sandstone Boreholes support to North Yorkshire	2024/25	2035/36
R37b(ii) River Aire Abstraction option 4 and R86 Aire and Calder WTW	2025/26*	2073/74

* AMP8 will be investigations into the water availability in the rivers Aire and Calder in case required earlier than the preferred plan under an adverse adaptive pathway scenario (see Section 10.1).

9.7 Stress testing

The preferred plan has been selected as the best value plan for closing the DYAA and critical period baseline deficits. Before we finalise our plan, we must consider alternative scenarios and the adaptability of our plans. The deficit presented in our baseline scenarios is driven by three key risks:

- Climate change impact on future supply
- The loss of the STW transfer
- Environmental destination.

Each of these risks is based on the most up to date information we have at the time of producing our plan and baseline scenarios represent the most likely supply-demand balance for the DYAA and critical period over the planning period. However, forecasts are inherently subject to uncertainty and factors that we cannot control; therefore, we must plan for alternative futures. To do this we stress test our plan to the known risks that could trigger a material change to our plan. For WRMP24 our stress tests are based on Ofwat's common reference scenarios discussed in Section 7.3. In addition, we consider the risks linked to the delivery of our preferred plan.

We have tested our preferred plan against the alternative futures represented by the common reference scenarios and two bespoke scenarios we used in creating the best value option portfolio. This is presented in Table 9-5. Each pathway represents the reduced level of service until 2039/40.

The three adverse pathways, high climate change, hydrogen and high ED, have potential to drive additional need for investment in the future. Each pathway represents the reduced level of service until 2039/40.

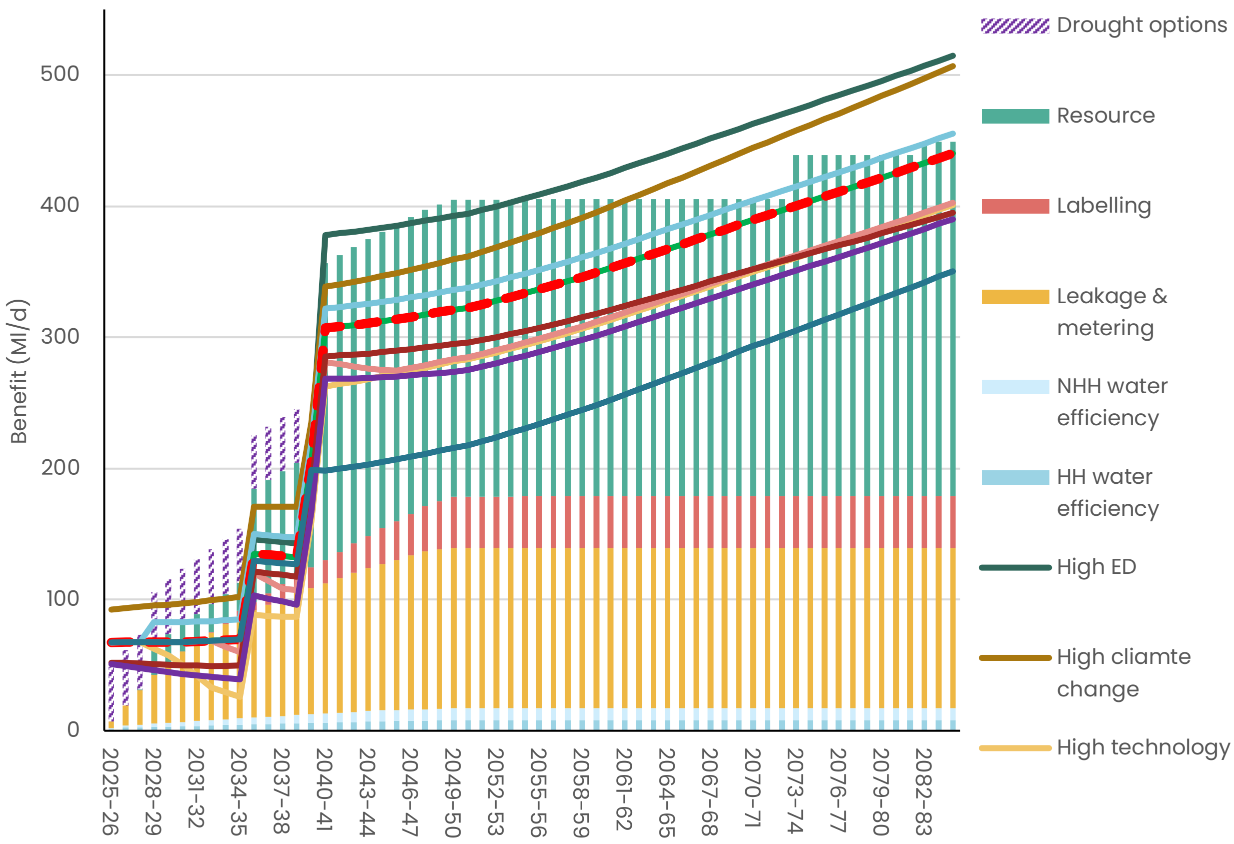
Both the high climate change and hydrogen scenarios show a risk of a near term deficit that is worse than the most likely scenario. We have built supply-side options into our preferred plan for delivering in AMP8 to provide resilience to this risk and as shown in we would be required to rely on level 1 to 3 drought orders until 2031/32 in the hydrogen scenario and until 2033/34 in the high climate change scenario.

The stress testing also further exposes the near-term risk while WRMP options are being implemented. In our preferred plan we are operating to a level of service of 1 in 100-years for level 4 drought measures in 2025/26 and 2026/27. From 2027/28 to 2038/39 we increase our level of service for level 4 to 1 in 200-years, then from 2039/40 onwards it is 1 in 500-years. As shown in Figure 9.11 under the high climate change scenario the 1 in 200-year level of service is met a year later in 2028/29. Under all other scenarios the near-term risks are no worse in the first three years of the planning period and the level of service for level 4 restrictions is not impacted. Under the low scenarios the 1 in 200-year level of service would be met a year earlier in 2026/27.

With the assumed benefits of drought options our preferred plan can meet all the adverse scenarios, however by 2040/41 assuming that the enhanced abstraction reduction is applied to the River Derwent in the high ED scenario there is a deficit. We also fall into deficit again under the high climate change scenario in 2060/61 and under the hydrogen scenario in 2066/67. As these risks are further into the future there is sufficient time to monitor the potential triggers and react through investment in further options. To do this we must investigate options in addition to our preferred plan scenario options to enable them to be implemented if triggered.

Conversely it is possible in the future the deficit is lower than our most likely scenario and we follow a benign pathway. This includes the low climate change, low demand and low ED scenarios and could mean options we plan to deliver to meet the most likely deficit can be delayed or may not be required.

Figure 9.11: Grid SWZ best value plan stress testing to alternative DYAA scenarios



9.7.1 Solution programme uncertainty

The delivery of any water resource plan solution can also create uncertainty and impact on the success of our preferred plan. In previous WRMPs we have reassessed target headroom for our final plan scenario and added additional headroom distributions to represent the risk of not achieving the full benefit of individual solutions. This leads to an increase in the final plan target headroom compared to the baseline and can drive additional investment if it creates a deficit in the final plan supply-demand balance. For our WRMP24 we are taking a scenario-based approach to solution uncertainty and have not reassessed target headroom.

Demand reduction solution uncertainty

Our preferred plan includes leakage reduction, smart metering / networks and customer (household and non-household) water efficiency initiatives to reduce demand. The options will be implemented from 2025/26 and require continued investment throughout the planning period. We are also assuming a PCC reduction benefit from water labelling. These options present best value as they reduce the volume we are required to abstract, treat and transfer to customers, which leaves more water for the environment.

The total benefit from demand reduction in the Grid SWZ is 179Ml/d. With the combined benefits of water labelling, smart metering, and household water efficiency activity DYAA average PCC is projected to be 105.4 l/h/d by 2050.

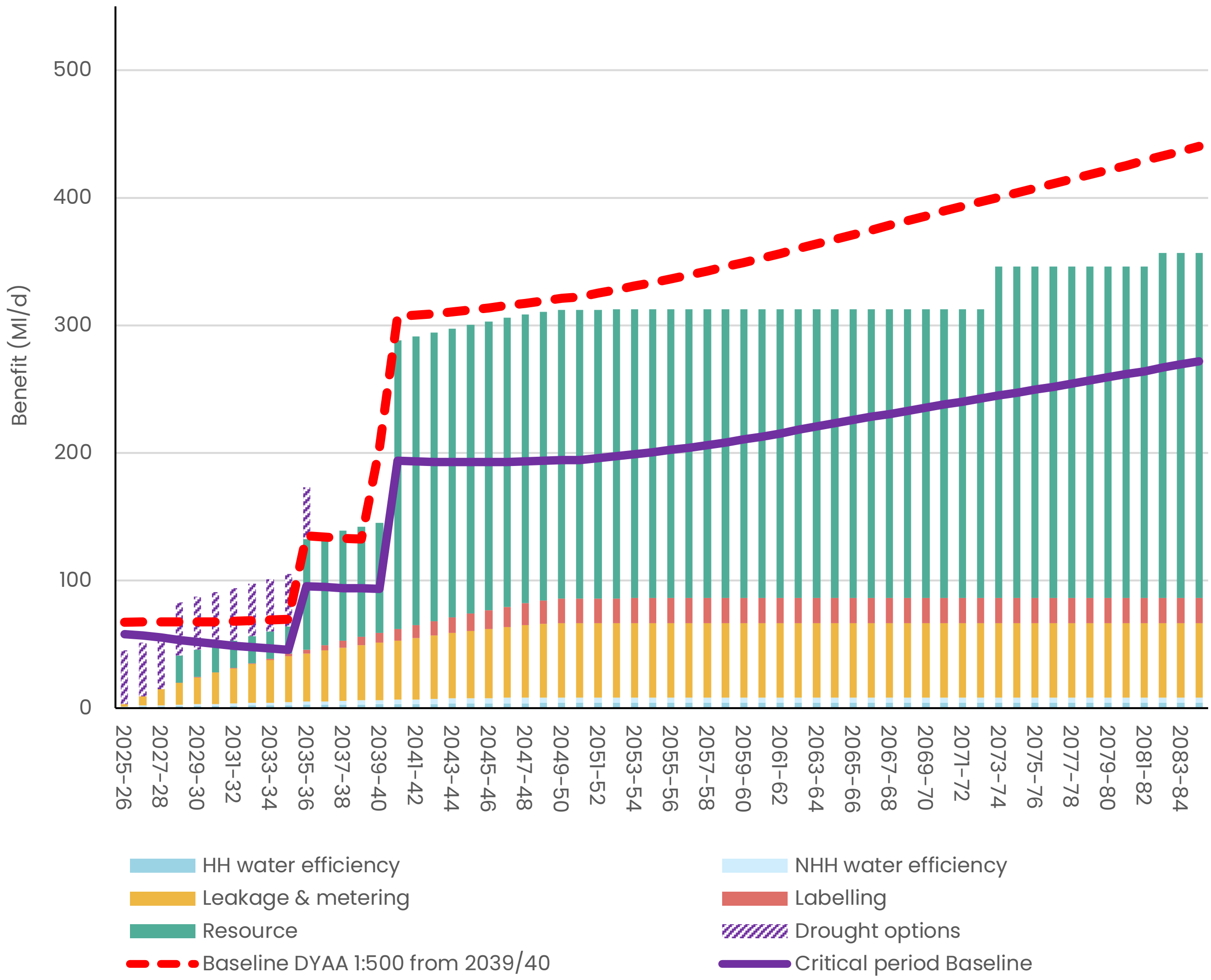
Although our preference is to meet the deficit through demand reduction activity to achieve regulatory policy targets, there is a risk that the assumed benefits from the initiatives will not be fully achieved. The certainty of achieving the demand reduction objectives' benefit reduces over time as the costs increase. However, it is likely techniques will improve and new initiatives will be identified, and we will continually monitor progress and review the initiatives.

To test the sensitivity of our preferred plan to demand reduction uncertainty we created a scenario that halves the assumed benefits included in the preferred plan for demand reduction, see Figure 9.12. In this scenario the DYAA scenario would be in deficit in the early years of the planning period even with the benefit of the AMP8 supply options (R3a Moor Monkton licence increase- DYAA/ River Ouse licence variation 1, R3 Increased River Ouse pumping capacity and R13 East Yorkshire Groundwater Option 2). However, level 1 to 3 drought options could close this deficit until 2035/36 when the STW backfill and R8g Sherwood Sandstone options provide a benefit. There would still be a deficit in the first three years of the planning period, and we would have a reduced (1 in 100-year) level of service until 2027/28, a year longer than the preferred plan.

In the critical period scenario, there would be an additional benefit from the R3a Ouse licence transfer and level 1 to 3 drought options would not be needed beyond 2026/27. There is a deficit in the two years that is not closed by the solution programme. This is a headroom deficit, and the forecast demand would be met. Beyond 2026/27, the critical period deficit is met by the preferred plan and this scenario does not drive further investment.

In the DYAA scenario we become vulnerable again in 2039 when we move to a 1 in 500-year level of service and fall into deficit again. This deficit cannot be met through level 1 to 3 drought actions, and we would need to invest in additional options to close the gap.

Figure 9.12: Grid SWZ preferred plan sensitivity testing to demand reduction solutions



New supply solutions

The benefits from new supply solutions also carry some uncertainty that we must factor into our planning. In addition, any new supplies will need to consider the environmental and social impacts and how to mitigate the effects, such as achieving a 10% biodiversity net gain where planning permissions are required and reducing our operational carbon to align with carbon net zero targets. This creates a further risk that the time to implement could take longer than predicted, especially if the impacts and mitigation measures are complex.

Supply options have been assessed through desktop studies to collate the data needed to meet the WRPG for option development. Further work is needed to support licence applications and planning permissions. Furthermore, water quality data must be collated, and treatment practises scoped to satisfy regulatory requirements. We would also need to consider the impact of a change in water quality to customers. These factors are considered for the preferred plan in Appendix G. Assuming all preliminary permissions are granted, there is then a construction phase before the water would be available for supply.

Due to the complexities of delivering supply-side options there is a risk that schemes become infeasible, or the assumed benefits are not achieved. For example, planning permission and abstraction permits may not be granted. The preferred plan supply-side options and the delivery risk are summarised in Table 9-14 and further information is provided in Appendix G.

Table 9-14: Preferred (best value) plan delivery risks

Preferred plan solutions	First year of benefit	Delivery risk
R3a River Ouse licence transfer	2027/28	Dependent on the outcome of a WINEP investigation and EA permitting a licence variation. In addition, the River Ouse licence is held by the Canal and River Trust (CRT) and Yorkshire Water has a contract to abstract with the CRT who would need to approve the variation.
R3 Increase River Ouse abstraction capacity	2028/29	Pending the outcome of the WINEP investigation this is potentially a low-risk option as it utilises an existing abstraction permit and requires (new abstraction pump) additional assets.
R91 New internal transfer to North Yorkshire WTW 2.	2028/29	A drinking water quality scheme is already going ahead to refurbish a borehole. The WRMP scheme would require an additional pipeline connection to increase use of an existing abstraction. It therefore has low construction risks.
R13 East Yorkshire Groundwater Option 2	2028/29	This is a new borehole and water quality could be a risk, but the location assumed favourable. A variation in the abstraction licence is required and there is a risk the Environment Agency may not approve this. Further investigation is required into the impacts of the drawdown.
DV8(v)A New WTW (York) supplied by the River Ouse	2035/36	This option makes use of an existing licence, but water availability is dependent on the outcome of a WINEP investigation. Planning permissions would also need to be granted.

Preferred plan solutions	First year of benefit	Delivery risk
DV8(iv)A(i) New north to south internal transfer connection -dual main	2035/36	Planning permissions would need to be granted. This option enables water to be transferred from York to South Yorkshire and increases utilisation (WAFU) of the DV8(v)A option.
R8g Sherwood Sandstone support to grid	2035/36	The WFD assessment concluded that there is uncertainty over the compliance of this option with further investigation proposed. However, we have assumed a conservative benefit from the aquifer. Planning permissions would need to be approved.
DV7a(vi) Tees to York pipeline - NWL import 140 Ml/d	2040/41	Water is available but requires significant new infrastructure and assets and assumed delivery time up to 13 years. Planning permissions would need to be approved. The option is also dependent on a new import from NWL and there is potential the water could be needed by another sector or water company.
R37b(ii) River Aire Abstraction option 4	2073/74	Further modelling needed to confirm water availability and address potential system constraints. The Environment Agency would need to grant a new abstraction permit and planning permissions sought.
R31a Additional bankside storage at York WTW	2082/83	Low risk as utilises existing resources and stores water for dry periods.

In the DYAA scenario to achieve the 1 in 500-year drought resilience by 2039/40, the delivery risks are partially offset in the medium term as our plan includes sufficient supply and demand options to create a surplus that could withstand some under performance in the programme. The AMP8 investment includes two options (R3 and R91) that require low scale construction and utilise existing licence permissions. R3a would require the Environment Agency to grant an abstraction permit variation and include discussions with the CRT, however there is no construction required. The R13 groundwater scheme requires a variation to an existing licence, effectively meaning no change to the permitted abstraction from the aquifer. All these schemes require early start implementation in AMP7. In addition, the R8g Sherwood Sandstone Boreholes support to North Yorkshire scheme requires development of a new groundwater source and to reduce the risk on delivery would require early start investigation in AMP7 which will continue into AMP8.

Although the near-term options are considered low risk, there is still a risk the options will not be deliverable or underachieve the assumed benefits. We will therefore start investigations on alternative options in parallel to the preferred AMP8 options in case we need to change our plan in the near-term. This includes the R37b(ii) River Aire Abstraction option 4 option, which our preferred plan includes later in the 60-year period but is also linked to the R86 Aire and Calder WTW option which could be needed to enable an adaptive pathway. The AMP8 investigations would focus on water availability in the rivers Aire and Calder.

The medium-term options to offset the loss of the STW transfer and the abstraction reduction on the River Derwent require more complex new assets and infrastructure to be delivered. DV8(v)A New WTW (York) supplied by the River Ouse makes use of an existing abstraction permit that currently has 60Ml/d surplus available. A WINEP investigation on the River Ouse abstraction is due to complete in 2025. We consider this risk further in Section 10.1.

The DV7a(vi) - Tees to York pipeline - NWL– import - 140Mld option will take considerable time to implement and we have assumed up to 13 years. However, there is still a risk the transfer could not be available if the water was required by another water company or sector. WReN is taking this forward as an SRO in AMP8 and will consider these uncertainties. To allow time to consider these complications we have increased the lead in time of the option to 15 years. Before construction begins, the option would require increased design / scoping and planning applications for new WTWs and lengthy pipelines. The option would require support from Kielder Water, which can be made available but would require a new rising main and electricity supply at an existing pumping station. The electricity supply cannot be guaranteed and our WRMP level investigations have concluded this should not be assumed until the application for the new connection has been made and granted.

There are insufficient alternative options in our plan to offset the risk of the Tees transfer not being available and we will carry out further option identification and appraisal for WRMP29. This work will start in AMP7 and we will provide the Environment Agency with regular updates.

For the longer-term risks of options needed in 2073 and 2082, we will have sufficient time to monitor the progress of our plan and bring in more options in future WRMPs if the solutions are not achieving the benefits. The final decision on the future of the River Derwent licence in 2040 and which ED pathway we are following will be made in 2027, which could also influence the longer term options.

Through experiencing a severe dry year in 2022, we recognise the need to work with NWL to understand if this impacted on their modelling of availability of the supply. Although the water may be available for transfer from Kielder Water, the terms of the Kielder operating agreement include the need to maintain a minimum flow on the River Tees that is supported by a reservoir at the head of the river. This supply could potentially limit the transfer in drought events. Subject to approval by RAPID, we will explore this option in more detail with NWL and UU as part of a Kielder SRO. All options in respect of transfers from Northumbrian Water are considered technically feasible and have been scoped in accordance with WRPG, but further scoping investigations will be required before design and construction commence.

9.8 Incorporating carbon into the best value plan

Addressing carbon emissions across the whole life of new and upgraded assets is a key element of our best value assessment and links to our net zero transition (see also section 11.7).

Our carbon management processes, and approach comply with the requirements of PAS2080:2023. This is a global standard for managing these emissions and ensures we are delivering high quality carbon reduction activities across our company.

Carbon is a key component of our decision-making framework and incorporated into our six capitals approach, which is designed to help us become more sustainable and resilient by considering value in the broadest sense.

Our decisions and investments impact many different types of capital (for example, natural, social, human, technological and financial). We consider the carbon across the whole life cycle and integrate.

Yorkshire Water's approach to achieving embedded carbon reduction is fundamentally aligned to the application of the TOTEX hierarchy philosophy developed to identify financial efficiency.

The approach is to remove carbon at source, not at the point of delivery.

The intention has been to prioritise the development of alternative low embedded carbon solutions, including nature-based solutions, to the areas of the programme where there is the greatest opportunity. If during the definition phase the notional / traditional solution is the only viable option, carbon reductions will be sought through the supply chain and smart delivery only.

We have embedded carbon reduction into our decision making at key points along our project life cycle through our Engineering Design Approach and TOTEX Hierarchy. The TOTEX Hierarchy ensures that during solution optioneering and development we look to eliminate the need to build, reduce what we build and if we must build (this includes WRMP solutions which are required to secure future water supply), we do it smarter and more efficiently with the least carbon impact possible.

To support this carbon volumes, as well as the impacts of service measures on other types of capital, are assigned a monetised value. In the case of carbon this is based upon UK Government carbon prices. We currently use a value of £354.67/tCO_2e, based on Department of BEIS' September 2021 update on carbon prices as explained in Section 9.1.

This is a significant uplift from the previous value used of £18.88/tCO_2e and by weighting whole life carbon in this way we have a greater emphasis on decarbonisation in our cost benefit analysis. The move to the higher monetised value more fairly reflects the impact and cost of abating future emissions.

Our WRMP24 includes carbon as a decision-making metric. In our PR24 business plan, alongside financial cost and monetised service impact, monetised carbon values are all components of a total net present value (NPV) calculation that is produced to inform evaluation and choices for different solutions to meet needs that have been identified.

These costs are used to evaluate potential solutions, help us to better understand the economic, environmental, and social impacts and benefits of different investment options, and to make best value decisions that align with our carbon goals.

As we decarbonise our operational emissions, embedded emissions in capital goods and wider purchased goods and services will represent the most significant contribution to our carbon footprint. Using the approach described above is therefore essential to avoid locked in carbon emissions across the life of new assets and deliver these in a sustainable manner.

10 Best value plan

Section 9 describes how we have created our preferred plan for the most likely pathway and tests our plan to more adverse and benign scenarios. However, our best value plan is not a single plan for closing one scenario deficit. It is a plan for meeting a range of plausible futures. This section of our WRMP describes our core and adaptive pathways that, together with the most likely pathway, provide a best value plan.

Our preferred (or most likely) plan for WRMP24 is a twin track approach, which invests in both supply and demand reduction options. The solution has been selected through our decision-making approach and stress tested against alternative futures including the Ofwat common reference scenarios. The stress tests are based on known risks that create significant future uncertainties. The final step in formulating our preferred plan is to identify the options needed if we deviate to an alternative pathway and the decision and trigger points that ensure we can adapt to the alternative pathways.

10.1 Adaptive planning

We used the WRMP optimiser to produce solutions for each of the Ofwat common reference scenarios and for two bespoke scenarios (section 9.4). The optimisation outputs provided options that could be classed as 'no- and low-regret options' and were included in the best value option portfolio for consideration in our preferred plan.

These outputs and the stress testing described in section 9.7 have been used to create the core and adaptive pathways.

10.1.1 Core pathway

Our best value plan 'core pathway', in line with the *Ofwat PR24 and beyond: Final guidance on long-term delivery strategies*[52] must include any activities that meet the following criteria:

- no and / or low regrets' investments, for example investments that are required:
  - in both benign and adverse scenarios;
  - across a wide range of plausible scenarios; or
  - need to be undertaken to meet short-term requirements; and
- investment required to keep future options open (such as enabling work or learning and monitoring), where possible, or is required to minimise the cost of future options.

We used no / low regrets options from a range of scenarios to create our preferred plan to the most likely scenario, therefore the preferred plan and core pathway are almost the same. However, our core pathway also includes near term investment that is required to keep future options open and allow us to deviate to a more adverse pathway if triggered. This is particularly important for our WRMP as there is a risk that options in our most likely scenario will need to be implemented sooner than planned or that additional options will need to be implemented. There is also a risk that the preferred plan options could be undeliverable, if for example planning permission is not approved or an abstraction permit not granted.

[52] PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf (ofwat.gov.uk)

The core pathway includes investment to deliver our preferred (most likely) plan. However, we have based the core pathway on investment needs for the next 25 years (2025 to 2050) and excluded the R37b(ii) River Aire and R31a Bankside storage options required for closing the 60-year supply-demand deficit post 2050. We have also considered options required under adaptive pathways and our core pathway includes enabling work to develop options required to keep more adverse pathways open.

Two significant changes to our core pathway since draft are the inclusion of:

- STW backfill options which includes DV8(v)A New York WTW 2 supplied by the River Ouse DV8(iv)A(i) New north to south internal transfer connection -dual main
- DV7a(vi) Tees to York pipeline - NWL import 140 Ml/d.

The backfill option was not included at draft as there was high potential for the transfer to continue through the SRO to raise the Upper Derwent Valley reservoirs. Since the draft submission STW has confirmed the transfer will cease and the Upper Derwent Valley dam raising is not a feasible solution. The backfill option is therefore part of our core pathway with enabling work already progressing.

The Tees transfer for NWL was not included in the draft plan core pathway as it was not required until 2049/50. We proposed to carry out further investigations on the River Derwent ED needs (through assessments) and if needed an option appraisal to assess if there were any alternative schemes to offset the potential licence reduction. This work was planned for AMP8 and confirmation of the need for the Tees transfer would have been determined in WRMP29.

Since publishing our draft plan, we have continued to liaise with the Environment Agency and Natural England on the CSMG target for the River Derwent and subject to future assessments the date for the potential licence reduction has been brought forward to 2040. The Tees transfer option was selected in 77% of the optimised solutions and in most plausible futures, which included five of the common reference scenarios and both the bespoke alternative futures. The construction of the scheme will not start until AMP9 at the earliest and we include more benign pathways where the Tees transfer is either delayed and the volume reduced or not required at all.

10.1.2 Adaptive pathways

Not all risk and uncertainty can be quantified accurately and, although our forecasts incorporate the most up to date information available to us, our plans are still based on estimates, and the future may deviate from our most likely pathway. The known risks in our plan allow us to incorporate an appropriate level of flexibility and divert to an alternative future if required.

Risks, such as the environmental destination licence reductions, can be linked to key dates that trigger an alternative pathway. To ensure we are prepared for diverting to an alternative plan, we identify decision points in advance of the pathway diverging. There are other significant uncertainties in our plan that are not determined by a point in time, such as the impact of climate change on supply and the outcome of demand reduction interventions. We must carefully monitor these risks as we progress forward and deliver our plan.

We have created alternative pathways by stress testing our preferred plan to the common reference scenarios (see Section 9.6). The stress tests show which of the adverse and benign pathways could cause our plan to divert from the most likely pathway and trigger additional options or remove the need for some options. We have not created adaptive pathways for all the alternative futures. Not all the common reference scenarios result in an adverse future that cannot be met by our preferred plan. And not all benign scenarios will result in options being removed from the programme. Our best value plan includes a core pathway and five potential alternatives.

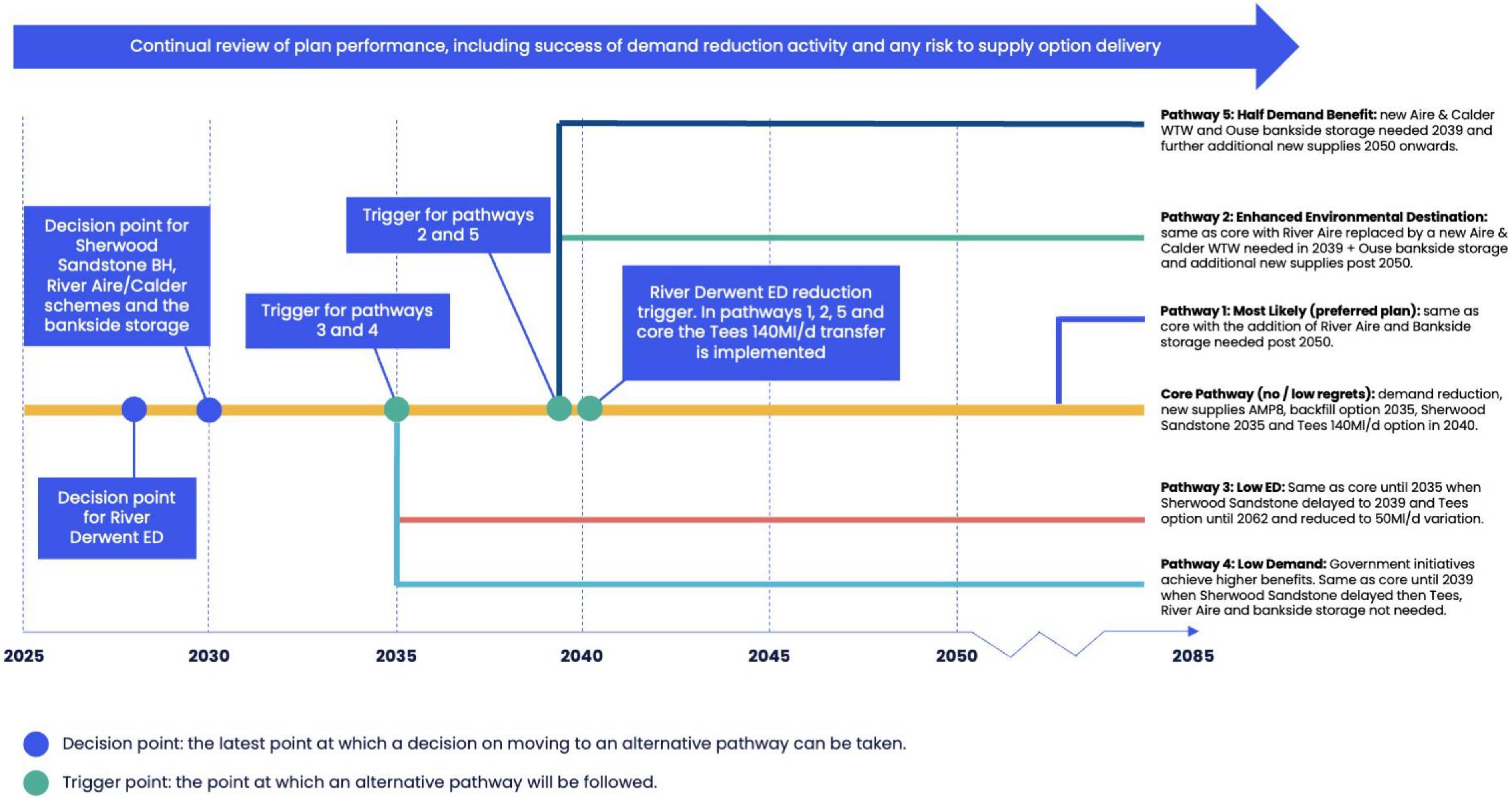
The options we include to meet the adverse scenarios are based on the best value portfolio and those selected by the optimiser to meet alternative futures. The solutions are not the same as the optimised outputs for the individual scenarios as we are now planning to adapt our preferred (most likely) plan to the alternatives.

The five pathways are described below and represented in Figure 10.1. Figure 10.1 shows decision points that represent when we must decide on which pathway we are following and trigger points for diverting to an alternative pathway. The decision points are to ensure a solution for mitigating a risk is implemented in advance of the risk occurring.

The adaptive pathways are based on the risks that are considered to be most material and do not represent all the uncertainties. To plan for all uncertainties would be complex and the outcome may become unmanageable. There is also a risk of over investing if we do not balance our actions with the time our plan can allow for the risks to develop. For example, we have created an alternative pathway to represent the high (enhanced) environmental destination scenario. This scenario shows a similar deficit to the high climate change scenario and the alternative solution programme is representative of action we could take if either pathway materialised.

The baseline climate change impact already represents a severe reduction in supply and to plan for a combined high climate change and enhanced environmental destination could lead to over investment. By monitoring our available supplies and the emerging risks in the short to medium term, we will identify a combined high climate change and enhanced environmental destination scenario if it becomes a likely risk in future WRMPs.

Figure 10.1: WRMP24 core and adaptive pathways



Pathway 1: Preferred (most likely): This is the most likely pathway represented by the baseline supply-demand balance in the YWSEST and YWSGRD WRP tables. The best for resilience plan has been selected to close the deficit in the Grid SWZ DYAA and critical period baseline scenarios. The solution benefits are represented in the WRP YWSGRD WRP Tables 3b and 3e and are described in section 10.4.

Pathway 2: High (enhanced) environmental destination: This pathway represents the enhanced environmental destination and the risk of additional deficit if the outcome of both the WINEP investigations on groundwater sources and the River Derwent investigations is more severe than assumed in our preferred pathway. Under this scenario we would follow the preferred pathway 5 until 2039. In this year, the R86 West Yorkshire new WTW option is triggered, and the decision point would be in 2030 to allow time to construct the WTW. This option is mutually exclusive with the R37b(ii) River Aire Abstraction option 4 option included in the preferred plan in 2073/74 and the R37b(ii) scheme would no longer be available. Due to the potential for the decision to be made in 2030 we will start enabling work for the Aire and Calder in AMP8.

In the longer term six further supply side options (see Table 10-1) are needed from 2066 onwards. This includes a new abstraction from the Humber Estuary that would be stored in a tidal abstraction reservoir (R78) or used at a desalination plant in East Yorkshire (R61). Use of the Humber Estuary would require environmental investigations in advance to ensure the water was available and further scoping to understand which of the two options would be implemented.

Subject to the WINEP investigations, the trigger for the pathway is 2040. The decision point is well in advance of this date in 2027. The time between the decision and the trigger allows for the complexities of this pathway to be resolved. Currently the scale of any loss is unknown but could potentially be high (130Ml/d or more). If this occurred, this reduction in our available supply would have a significant impact particularly if we were also following the half demand benefit pathway. We have allowed time for understanding the impact and ensuring we have sufficient options implemented that can reliably secure supply to our customers.

Pathway 3: Low ED: In the low ED pathway there would be no abstraction reductions on the groundwater sources or the River Derwent. This pathway is the same as the preferred plan until 2035 when the R8g Sherwood Sandstone support to grid option would be delayed until 2039. The decision would be made in 2025 when the groundwater WINEP investigations will reach conclusion.

Later in the programme the preferred plan could deviate again following the conclusion of the River Derwent investigations. If following further assessments there is no need for reduction to our abstraction the DV7a(vi) Tees transfer option will be delayed until 2062 and the capacity will be reduced from 140 to 50Ml/d. Other minor changes would occur post 2050, when the R37b(ii) River Aire option and R31a Bankside storage options are delayed by one year.

Pathway 4: Low demand: In the low demand pathway greater benefits are achieved from Government initiatives for water labelling and building regulations. This delays the R8g Sherwood Sandstone support to grid option to 2039 and the Tees transfer is not needed in 2040. Later in the period the R37b(ii) and R31a options are not required either.

The trigger for moving to this pathway is in 2035. As both the R8g and DV7a(vi) options are needed in the majority of pathways and the low pathway has high uncertainty we will make a decision on this pathway in 2030.

Pathway 5: Half Demand Benefit: This pathway recognises the success of our planned demand reduction activity cannot be guaranteed and assumes the year-on-year combined benefits of leakage reduction and PCC reduction (through smart metering/ networks and water labelling) will be half that assumed in our preferred plan pathway. It would trigger both R86 West Yorkshire new WTW and the R31a Bankside storage options in 2035(and exclude R37b(ii)). The decision point for both schemes would be 2030 and we discuss enabling work for these options in our core pathway description below.

In the longer term six more supply-side options are needed from 2066 onwards. This includes the R78 tidal abstraction reservoir and the R29 reservoir desilting option. Both options would require significant enabling work and environmental assessments. However, due to the timescales this work does not need to start in AMP8 as there is sufficient time to review the need in future WRMPs.

Core pathway: The core pathway includes options needed in both the benign and adverse scenarios and that are needed to be undertaken to meet short-term requirements. Option delivery is the same as the preferred plan except that the post 2050 options are excluded. However, enabling work for the development of the R86 option (also relevant to R37b(ii)) is also included in the core as there is potential for this option to be triggered earlier in the planning period and investigation are needed to confirm the scope.

The work we will deliver to meet the core pathway includes, but is not limited to:

- investigating source availability where licence applications will need to be made
- water quality sampling and analysis
- detailed scoping and design
- hydrological assessments
- environmental impact assessments
- stakeholder engagement
- customer engagement including demand related options such as tariffs included in AMP9 and change of occupancy which is not included in the preferred plan but will be consider in more detail for AMP9.

Enabling work linked to adaptive plan

As reference above to ensure we can deviate to the adaptive pathways if triggers are met, we must carry out enabling work in parallel to delivering solutions in AMP8. Development costs for these schemes are included in the WRP Table 8 but were added post optimisation.

The supply side schemes included in our preferred plan and requiring enabling work to keep adaptive pathways open include:

- R37b(ii) River Aire Abstraction option 4and R86 West Yorkshire new WTW - these options are mutually exclusive, and we shall investigate both the water availability and the potential for abstractions from the River Aire and River Calder
- R8g Sherwood Sandstone – this is one of a number of Sherwood Sandstone options and the investigations for this option will provide information on the feasibility of other Sherwood Sandstone options.

We shall continue to deliver the SRO for the backfill option, which has been proposed for delivery as direct procurement for customers. We will also work as part of WReN on the Tees transfer solutions whilst continuing to work with the Environment Agency and Natural England on the CSMG target outcome for 2027. These factors all have potential to impact on this option and we will formalise any changes in scope as this work is developed, ahead of WRMP29.

Our R31a Additional bankside storage at York WTW option is triggered in 2035 if we are following Pathway 5. We will review the scope of this option as uncertainties on the Ouse WINEP needs and River Derwent licence reduction are resolved and as we develop the backfill option further.

Table 10-1: WRMP24 Adaptive pathway options

Option ref.	Option Name	Benefit (Ml/d) on full implementation	Core pathway	Pathway 1: Preferred (Most Likely)	Pathway 2: High (enhanced) ED	Pathway 3: Low ED	Pathway 4: Low demand	Pathway 5: Half Demand Benefit
R48	Reduce level of service to 1 in 100 to 26/27 and then 1 in 200 (27/28 to 38/39)	118.92-73.74	2025	2025	2025	2025	2025	-
R48b	Reduce level of service to 1 in 100 to 26/27 and then 1 in 200 (27/28 to 38/39)	118.92-73.74	-	-	-	-	-	2025
C1d	Domestic customer audits and retrofit	3.3	2025	2025	2025	2025	2025	2025
C6a	Non-household customer audits and water efficiency retrofits (schools, leisure centres and hospitality)	0.2	2025	2025	2025	2025	2025	2025
LSM	50% Leakage Reduction + 0.66% 10yr Mains Renewal + Smart Metering (94.62ML/D)	115.9	2025	2025	2025	2025	2025	2025
C12a3	Rainwater harvesting - commercial customers	2.0	2025	2025	2025	2025	2025	2025
C27d	School Visits	1.0	2025	2025	2025	2025	2025	2025
C28e	Household Media Campaign	1.7	2025	2025	2025	2025	2025	2025
C34a	Non Household Media Campaign	0.8	2025	2025	2025	2025	2025	2025
C35c	Water Retailer Incentives	0.3	2025	2025	2025	2025	2025	2025
C6a(ii)	Non-household customer audits and water efficiency retrofits (general domestic use only)	4.5	2025	2025	2025	2025	2025	2025
C15d	Household flow regulator-internal	0.5	2025	2025	2025	2025	2025	2025
C30a	Water Labelling Conservative Baseline	39.6	2025	2028	2028	2028	-	2028
C30b	Water labelling – low demand	202.5	-	-	-	-	2025	-
DO03	Supply rivers drought permits- ends in 2038- DYAA	4.65	2025-28	2025-28	2025-38	2025-38	2025-38	2025-38
DO13	Demand Reduction	19.25	2025-28	2025-28	2025-38	2025-38	2025-38	2025-38
DO08	Drought Supply Reservoir Compensation Drought Permits	18.01	2025-28	2025-28	2025-38	2025-38	2025-38	2025-38

Option ref.	Option Name	Benefit (Ml/d) on full implementation	Core pathway	Pathway 1: Preferred (Most Likely)	Pathway 2: High (enhanced) ED	Pathway 3: Low ED	Pathway 4: Low demand	Pathway 5: Half Demand Benefit
C32c	Household Rainwater Harvesting- New Development	1.4	2025	2025	2030	2030	2030	2030
R3a	River Ouse licence transfer at low flows	0.3	2027	2027	2027	2027	2027	2027
R3	Increased River Ouse pumping capacity	10.0	2028	2028	2028	2028	2028	2028
R91	New internal transfer to North Yorkshire WTW 2.	5.0	2028	2028	2028	2028	2028	2028
R13	East Yorkshire Groundwater	6.0	2028	2028	2028	2028	2028	2028
C23b1	Rainwater Harvesting- agriculture	1.0	2030	2030	2030	2030	2030	2030
C13c	Household Tariffs	0.4	2030	2030	2030	2030	2030	2030
DV8B	New York WTW and Dual Main South Yorkshire Pipeline	50.0	2035	2035	2035	2035	2035	2035
R8g	R8g Sherwood Sandstone Boreholes support to North Yorkshire	15.0	2035	2035	2035	2039	2039	2035
DV7a(vi)	Tees to York pipeline - NWL import (140Mld)	140.0	2040	2040	2040	-	-	2040
R37b (ii)	River Aire Abstraction option 4	33.5	-	2073	-	2074	-	-
R31a	Bankside storage at York WTW	10.6	-	2082	2066	2083	-	2039
R8f	Sherwood Sandstone and Magnesian Limestone Boreholes option 6	20.0	-	-	2070	-	-	2066
R86	West Yorkshire new WTW	50.0	-	-	2039	-	-	2039
R85	Rebuild Kirklees WTW	8.0	-	-	2074	-	-	2072
R78	Tidal Abstraction Reservoir	20.0	-	-	2077	-	-	2074
R87	Rebuild Northallerton WTW	4.0	-	-	2083	-	-	2079
DV3	Magnesium Limestone	5.0	-	-	2084	-	-	2080
C4	Change of Occupancy metering	18.70	-	-	-	-	-	-
R29	Reservoir Desilting	11.0	-	-	-	-	-	2082
DV7a(iv)	Tees to York Pipeline - NWL import 50 Ml/d	50.0	-	-	-	2062	-	-
Total benefit (Ml/d) by 2084/85 (excludes drought option benefits)			**398.74**	**442.08**	**516.34**	**352.84**	**421.66**	**441.12**

10.2 Option delivery

Our preferred solution includes an ambitious demand management program starting in 2025 and continuing over the first 25 years of the planning period. Over the full 60-year planning period, we plan to deliver eight supply schemes, four of which are scheduled to be completed in AMP8. Our adaptive plan provides flexibility to uncertainties that could trigger additional supply options or decrease the number of supply schemes needed in the future.

An additional risk to our plan is the deliverability of schemes. The benefits realised could be lower than anticipated or a scheme classed as feasible under the WRMP criteria could become infeasible on further investigation. For demand uncertainty we have included a half demand reduction adaptive pathway to address this risk. For the supply schemes we have reviewed the risks at option level and considered the potential mitigation measures.

10.2.1 Supply scheme delivery

This section considers risks and mitigation associated with the supply schemes included in the preferred plan.

AMP7 supply schemes included in WRMP19

In our WRMP19 plan we included four supply side options, R9 North Yorkshire Groundwater Option 1, R13 East Yorkshire Groundwater Option 2, R63 North Yorkshire Groundwater Option 2 and R72 River Wharfe licence increase. These options were for resilience benefits in the Grid SWZ and were not driven by a WRMP19 supply-demand deficit.

The R63 North Yorkshire Groundwater Option 2 provides increased local supply to a rural area and the R72 River Wharfe licence increase provides additional resilience for meeting high winter demands following a dry summer. Both options required a variation to an existing abstraction permission we hold with the Environment Agency. The applications have been submitted and subsequently approved therefore these schemes are now delivered and available for use operationally, however, there is no benefit to WAFU in the WRMP scenarios.

The R9 North Yorkshire Groundwater Option 1 option is also a licence variation, and we originally planned to apply for an increase to both the daily and peak abstraction limits. Test pumping has been carried out and there is a risk that the increase to the peak abstraction could impact on a nearby abstractor. We will continue with the scheme; however, we have now only applied for a licence variation to increase the annual average by 2Ml/d, and have not requested to change the daily maximum volume. In our WRMP19 plan the benefit was scheduled to start from 2022/23, however, in our WRMP24 tables the benefit is now delayed to 2025/26. As the scheme will be completed in this year, we have assumed a 1Ml/d benefit, increasing to 2Ml/d from 2026/27 onwards.

The R13 East Yorkshire Groundwater Option 2 Borehole option was planned for delivery in AMP7 with 2025/26 as the first year of benefit. A decision was made not to deliver this scheme in AMP7 as the WRMP24 decision making process had potential to result in an alternative solution. It has however, been reselected in our WRMP24 preferred plan, and we shall start the implementation in 2024/25.

WRMP24 supply schemes

We have reviewed the potential for delivery risks for each of our preferred plan supply options and any adaptive pathway options that could be needed in the first 25 years of the plan. A high-level summary of the delivery requirements for each of the options is presented in Appendix G.

The risks include abstraction permissions not being granted or providing a lower benefit than expected, and planning applications being unsuccessful. We must also ensure we comply with drinking water quality regulations and mitigate environmental impacts. To fully understand the risks and mitigation, environmental impacts assessments, water quality sampling, hydraulic modelling, flood risk assessments, archaeological and ecological surveys are needed.

Consideration of mitigation measures is an integral part of the SEA process and further details on potential measures that could be implemented are available in Section 8 of the SEA Environmental Report. The SEA assumes the implementation of standard best practice mitigation measures and has highlighted any additional measures where these are known and identified. Following consideration of any reasonable mitigation measures, the SEA has reported residual adverse effects. These are generally minor and limited to construction impacts, particularly where schemes contain large pipeline components. The detail of any remaining mitigation will need to be considered during the planning phases for each individual measure if, and when, they are taken forward for implementation.

Three of our preferred plan options are linked to two abstraction licences we hold for taking water from the river Ouse. Although we have permission to abstract from the river currently, there is a risk the permitted abstraction volumes could change in 2025. This is discussed in the next section.

R91 New internal transfer to North Yorkshire WTW 2, R3 Increased River Ouse pumping capacity., R3a River Ouse licence variation 1, R13 East Yorkshire Groundwater Option 2 and R8g Sherwood Sandstone Boreholes support to North Yorkshire have already been passed to our Asset Planning team and are progressing through the Yorkshire Water 'Capital Process'. This is a gated end to end process that the Asset Planning team use to deliver capital projects from initiation through to completion. A summary of the process is provided in Appendix G.

R91 New internal transfer to North Yorkshire WTW 2 is linked to a PR24 scheme to refurbish an existing borehole and address water quality issues. Both the PR24 and the WRMP R91 schemes have been through gate 2 of the Capital Process and investigation funding has been allocated. Investigations to finalise the scope are now underway and a Strategic Planning partner has been appointed. A programme for delivery with key investigation milestones is provided below in Table 10-2 and Table 10-3. Delivery and construction are scheduled to start in 2025.

Table 10-2: North Yorkshire Borehole water quality scheme milestones

Site/Scheme	Yorkshire Water investigation Dates				DWI Notice Dates -Enhanced BH Capicity		
	Gate 2	KM2	KM3	Gate 3	Outline Design	Detailed Design	Compliance
North Yorkshire WTW	22/12/2023	21/03/2024	21/02/2025	19/03/2025	30/04/2025	30/11/2026	30/06/2028

Table 10-3: R91 New internal transfer to North Yorkshire WTW 2 milestones

Site/Scheme	Yorkshire Water investigation Dates				WRMP Target Completion Date
	Gate 2	KM2	KM3	Gate 3	Enhanced Distribution interconnectivity
Internal transfer to N. Yorkshire WTW 2	22/12/2023	21/03/2024	21/02/2025	19/03/2025	31/03/2028

R3 Increased River Ouse pumping capacity, R3a River Ouse licence transfer at low flows and R13 East Yorkshire Groundwater have been passed through gate 1 and we are progressing to gate 2. Investigation funding has been allocated and a project team set up. However, investigations are still to be confirmed (with defined milestones) and a contract partner appointed.

R8g Sherwood Sandstone Boreholes support to North Yorkshire is also progressing to gate 2. The delivery date is 2034/35 and the early start is to enable the scheme details to be verified ahead of construction.

The R37b(ii) River Aire Abstraction option 4 and R86 West Yorkshire new WTW schemes both depend on a new abstraction from the River Aire and R86 option is also dependent on a new abstraction from the River Calder. Under the preferred plan, is not required until 2073/74, however, under the more adverse adaptive pathways the R86 West Yorkshire new WTW option is required in 2039/40. To keep this pathway open we will start investigations on the rivers Aire and Calder in 2025.

The DV8B New York WTW and Dual Main South Yorkshire Pipeline is part of an ongoing strategic resource option (SRO) project, and we are discussing the progression with RAPID. The DV7a(vi) Tees to York pipeline – NWL import (140Mld) will, subject to confirmation by RAPID, form part of a new SRO for Kielder Reservoir. Since the submission of the revised draft WRMP24 in October 2023, we have been working with RAPID, Northumbrian Water and United Utilities to develop a new SRO for Kielder Reservoir that would explore the potential to optimise the use of this underutilised water source to provide value to both customers and the environment.

River Ouse WINEP investigation

A key source of supply to our preferred plan are our River Ouse abstractions. We have two abstraction points on the Ouse, Ouse abstraction and York abstraction, and the licences are independent of each other. York abstraction has a 60Ml/d surplus under current licence conditions as infrastructure limitations mean we cannot utilise the full licence. The Ouse abstraction volume varies depending on the flow in the river and the abstraction permissions are linked to four flow levels (bands). The volume we can take increases as the flow in the river increases. In the lowest flow band, we must cease abstraction altogether.

The River Ouse is currently under a WINEP investigation which focuses on the York abstraction point. We have three schemes in our plan that impact on the River Ouse:

- R3a River Ouse licence variation 1 - DYAA
- R3 Increase River Ouse pumping capacity to full licence capacity
- DV8(v) New WTW (York) supplied by the River Ouse

The R3 option is proposing to increase abstraction from our Ouse abstraction point when the river is

would not provide a benefit. Option R3a proposes to transfer 15Ml/d of the surplus at York abstraction to Ouse abstraction when the river is in the two lowest flow bands. This could be utilised by existing infrastructure, however, there is a WAFU benefit as the source is currently licence limited. We would apply to the Environment Agency for a licence variation to permit the abstraction at low flows. We would retain the same licence permission at the York abstraction site, but if we were utilising the increased abstraction at Ouse abstraction we would need to reduce the abstraction from York abstraction by the equivalent volume up to a maximum of 15Ml/d.

The third option (DV8(v)A) would abstract the 60Ml/d surplus and pump to a new WTW before onwards transfer to South Yorkshire to offset the loss of the STW import. On average we would use 50Ml/d to meet the South Yorkshire demand and 10Ml/d would be available to take from Ouse abstraction when in the lower flow band.

Our AMP7 WFD WINEP investigation into using the full licence at York abstraction is ongoing. Provisional conclusions indicate that increased abstraction itself is unlikely to lead to any adverse environmental impacts; however there remains uncertainty around the environmental impact of increased abstraction in combination with episodes of poor quality linked to combined storm overflows following heavy rainfall. Therefore, at this stage we cannot conclusively state that increased abstraction will not deteriorate WFD status in the future. Although the deadline for completing the investigation is April 2025, additional work is likely to be required beyond the scope of the existing WINEP investigation to understand these potential environmental risks. Therefore, there may be less water available for the York abstraction solution than anticipated.

This presents a risk to our preferred plan if the volume we can take is reduced during low flows. The R3a option benefit is only at certain times of the year during low flows and the DYAA benefit is 0.3Ml/d. During drought conditions this option could help avoid drought actions and provide resilience, but due to the limited benefit in the DYAA scenario and the critical period surplus provided by the preferred plan the risk does not drive an adaptive pathway. The R3 Increase Ouse abstraction to full licence capacity option is also considered low risk as it is only applicable when the river is in the higher flow bands.

The impact of the WINEP investigations on the feasibility of the DV8(v)A New York WTW 2 works does present a risk to our preferred plan. If the volume we can take from York abstraction is reduced, we will need to model if storage options could provide sufficient benefit to offset the reduction. This could include the R31a bankside storage option. We are also investigating how to make use of the WTW that currently treats the STW import. It is possible that the works could still be fed from local reservoirs sources, but will need to be adapted to treat a lower capacity. It is also possible that we would be able to continue to import from the Derwent Valley when the reservoirs are full.

The worst-case scenario would be that the average 50Ml/d needed to supply South Yorkshire was not available. This would require alternative options such as the R37b(ii) River Aire Abstraction option 4 or R86West Yorkshire new WTW to be brought forward. However, the interconnector from York to South Yorkshire would need to be replaced with alternative infrastructure, and further option design and scoping would be needed. This work will be carried out over the next two years in combination with other enabling studies needed for our adaptive pathway and is part of the SRO for delivering the backfill option.

10.2.2 Mitigation of supply scheme delivery risks

Our adaptive pathways provide alterative plans that could be triggered in the future if the supply-demand balance deviates from the most likely scenario. This provides mitigation to the forecast uncertainties and the risk that the deficit is greater or lower than forecast.

Successful supply scheme delivery also presents a risk to our plan. There is a risk that the supply option delivery takes longer than estimated or individual schemes do not provide the assumed benefits. Some options may prove to be unviable during the delivery phase, for example, if abstraction or planning permissions are not granted. Below we consider the mitigation and alternative strategy for managing these risks.

AMP8 supply schemes

To deliver our twin track solution of both demand reduction and new supplies we are starting implementation of the AMP8 supply schemes in 2024/25 (see section 10.2.1), with some preliminary preparations already underway. Progressing sooner than the plan start year of 2025/26 will help close the early deficit and move to the 1 in 200-year drought resilience objective by the third year of the plan.

In the near term there is a risk that one or more of the AMP8 supply-schemes under delivers on benefits. In total our supply schemes provide 21.3Ml/d by 2029/30. If the benefits from each of these was delayed until the start of AMP9 we would mitigate this risk through implementation of drought options for an additional year to 2029/30 in both the DYAA and DYCP as shown in Figure 10.2.

In a worst-case scenario, where none of the planned AMP8 supply-side solutions resulted in a benefit, as shown in Figure 10.3, the use of drought actions would continue until 2031/32 in the DYAA scenario. The Grid SWZ would then be at risk of deficit again in 2039/40 for a single year, from 2069/70 to 2072/73 and from 2078/79 until the end of the planning period in 2084/85 (see Figure 10.3). The deficit in 2039/40 (-14.85Ml/d) can be closed by delaying th move from a 1 in 200-year to the 1 in 500-year drought resilience by a single year.

The deficit from 2069/70 to 2072/73 could be met by bringing the R37b(ii) River Aire Abstraction option 4 scheme forward from 2073/74, whereas the increasing deficit from 2078/79 (-0.59Ml/d) to the end of plan (-12.28Ml/d) would trigger a need for additional intervention. However, the risk is sufficiently further into the planning period that we can consider in future WRMPs and once the outcome of the AMP8 options is known.

In the DYCP scenario if the AMP8 schemes are unsuccessful, drought options are needed until 2029/30, beyond which we would have sufficient surplus resources to close this deficit with the remaining planned interventions.

Although extending drought and reduced level of service options could mitigate unsuccessful AMP8 supply-schemes delivery, our objective is to reduce reliance on drought options as this creates a risk to the environment. In addition, the AMP8 supply schemes provide non-drought resilience and local benefits that are not identified by the WRMP planning process.

Figure 10.2: Supply-demand balance impact if AMP8 supply scheme benefits delayed until 2030/31

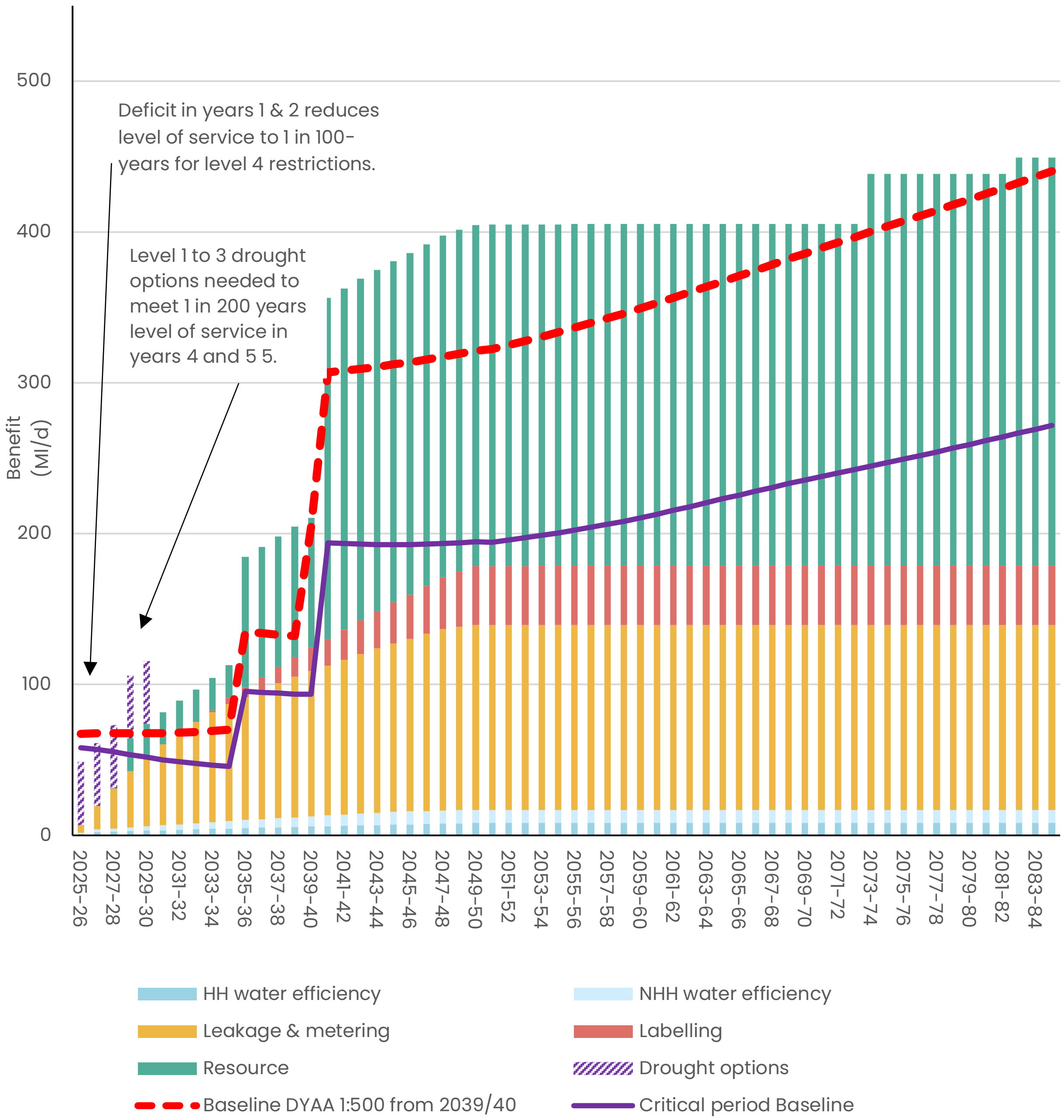
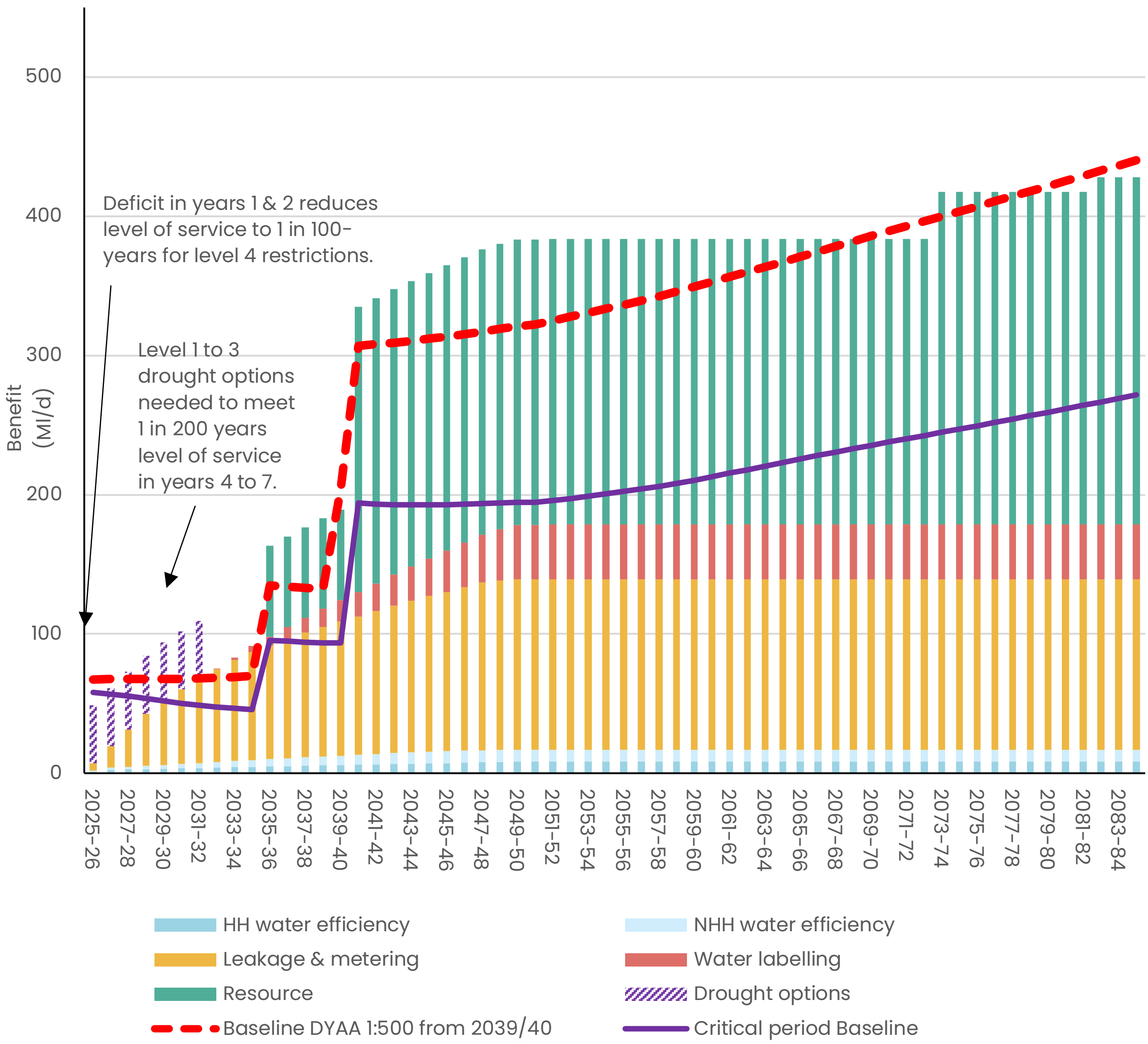


Figure 10.3: Supply-demand balance impact if AMP8 supply scheme benefits delayed until 2030/31



Mitigating unsuccessful delivery of the AMP8 supply-side schemes with drought actions is also only feasible if our demand reduction strategy is successful. It would not align with our preferred strategy, which is to provide a twin track supply / demand solution that safeguards against the risk of relying solely on demand reduction. As the demand strategy carries its own risk, it is represented by the half demand benefit adaptive pathway. Under this scenario the AMP8 supply-side success is more critical to ensuring our system is resilient to extreme droughts in the future.

We have not compounded the AMP8 supply-scheme sensitivity testing with the half demand benefit scenario, because although individually these scenarios present a plausible risk, the probability of demand benefits being halved and all AMP8 supply-schemes not being realised is low. If the risk does materialise as we progress through AMP8 we could need to implement alternative supply-side schemes in AMP9.

Between now and 2027, as we deliver our AMP8 schemes and enabling work for the pathways, we will be carrying out further option identification to develop new options ahead of our WRMP29 draft plan, which will be published in draft form in 2027 or early 2028. If any AMP8 schemes are determined to be undeliverable, we shall review our adaptive pathway options and any newly identified schemes and determine if any of these could be escalated.

Strategic Resource Options

Both the Severn Trent backfill option and Tees transfer are required to offset the impact of loss of supply in specific locations. It is critical that we provide an alternative source of supply to the areas that rely on these resources. Both the options are being developed either as existing or proposed SROs in parallel to the options identification programme for WRMP29 (see Section 12).

We are considering the Severn Trent backfill alternatives further due to the risk highlighted above on the River Ouse abstraction. This work has already started as a decision would need to be made ahead of the construction phase of the current solution.

The Kielder SRO is being proposed in collaboration with Northumbrian Water as part of the WReN Regional Plan development. The Regional Plan will consider the Tees resource and Kielder support in a broader context that includes potential for Northumbrian Water to provide transfers to United Utilities or to support the energy industry. Any alternatives we identify will be considered in the decision making for the next iterations of the Regional Plan and our WRMP.

10.3 Monitoring WRMP24 pathways

Decisions to divert from the preferred pathway to an alternative pathway will be based on evidence collated over time as we monitor both our own progress and the external factors that influence our plan. It is most likely our plan will change in the future. It is reviewed every five years and with each iteration we assess new data and integrate new approaches and objectives that alter our supply and demand scenarios. The critical period risks become apparent during drought events such as 2018 and 2022 and this provides more data on which we can assess water availability and demand increases due to hot, dry weather.

Figure 10.4 summarises our WRMP24 key dates and actions. Between each iteration of our plan, we shall carry out investigations on needs, such as the environmental destination requirements, and we shall be implementing our solutions. The monitoring plan for the WRMP24 solution is outlined in Table 10-4 and we shall report progress to Defra in annual reviews of our WRMP.

Figure 10.4: WRMP24 key dates and actions

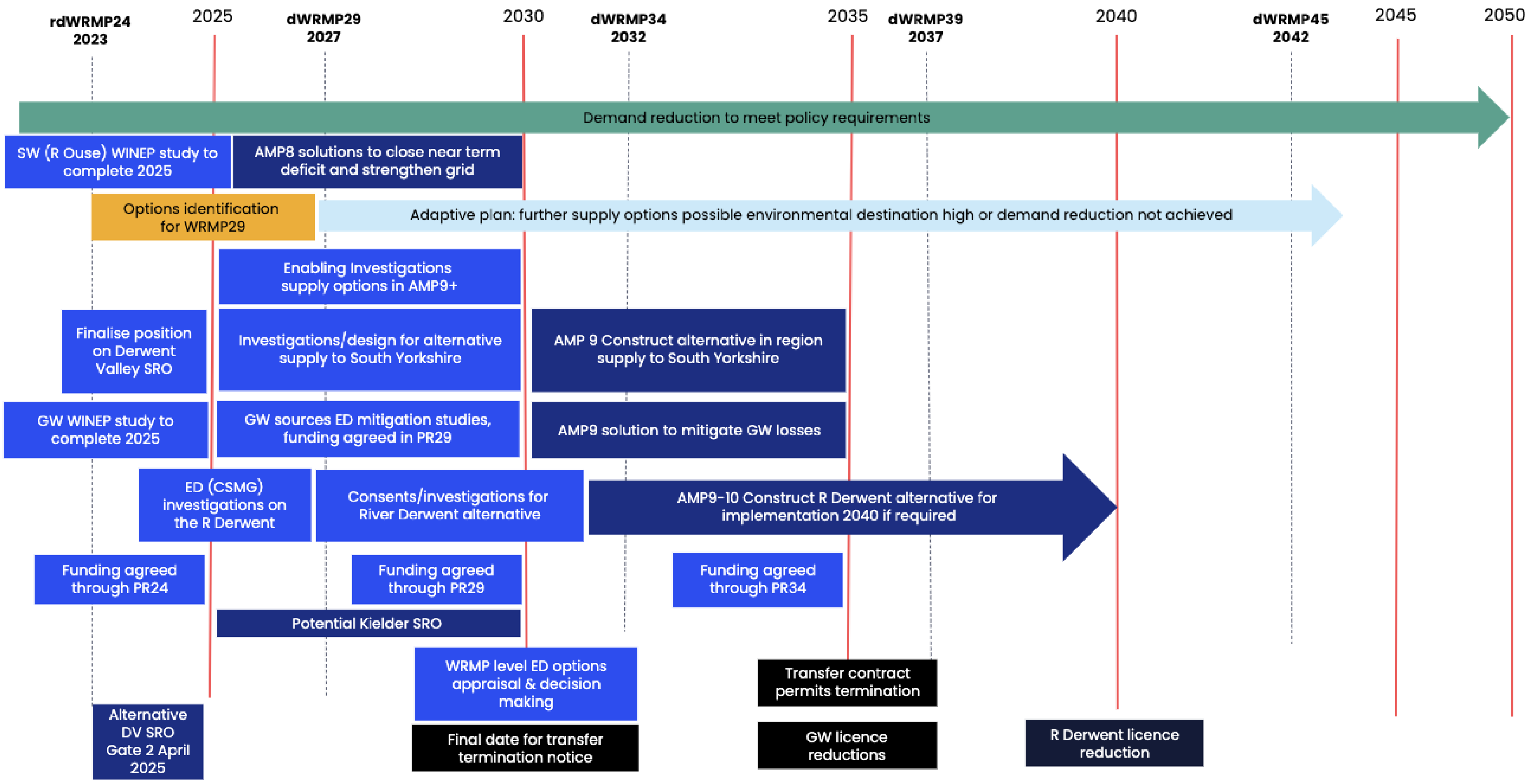


Table 10-4: WRMP24 adaptive plan monitoring

Option	Decision point	Trigger	Metric	Frequency	Monitoring
Plan to a 1 in 100 level of service to 2026/27, then 1 in 200 from 2027/28 until 2038/39	2027 (and each iteration of draft WRMP)	2030 (and the start of each AMP)	Supply demand balance (surplus/deficit)	Annual (WRMP)	• Our WRMP24 forecasts that we could achieve reaching the 1 in 500-year drought resilience objective by 2039/40.We intend on reaching the 1 in 200-year resilience by 2027/28, after operating to a 1 in 100-year resilience level for a short-period of two years at the start of the plan period. • Our levels of service are reviewed with each iteration of our WRMP and drought plan and following dry weather events. We would not increase to a higher level of service unless our monitoring supported this following the delivery of our solutions. • We will review the stochastic approach to calculating deployable output for WRMP29 and this could alter the supply-demand balance and level of service.
			Levels of service (see monitoring column)	5 yearly	
Drought measures	2027 (and each iteration of draft WRMP)	2030 (and the start of each AMP)	Levels of service (see monitoring column)	5 yearly	• Our plan shows we should be resilient to a 1 in 500-year level of service by 2039/40. Level 1 to 3 drought actions are not required from 2028/29 but this could be extended if supply options benefits are not realised. We shall review this with each iteration of our WRMP and drought plan. • Once the solution is implemented, we shall use our simulation model to confirm our levels of service. If our modelling shows that we are resilient to 1 in 500 drought we will review our drought plan and the triggers for actions.

Option	Decision point	Trigger	Metric	Frequency	Monitoring
L6 Leakage reduction (95Ml/d 50%)	2027 (and annually thereafter)	2030 (and the start of each AMP)	Leakage outturn values compared against the target	Annual	• A delivery assurance group meets monthly to track leakage against the annual target and weather conditions to adjust the approach if required. • Active monitoring of the overall outcome of the leakage investment plan, will track on a yearly basis the natural rate of rise and outcome performance. In the event that the natural rate of rise is less than a 25% deviation from the historic average, and leakage reductions are >30% short of the plan for 2 successive years, Yorkshire Water will review the overall leakage programme, and review the adaptive plan options for leakage reduction. This may result in higher cost, lower risk solutions being included in the plan. • Every six months we review the leakage benefits achieved operationally and through the introduction of new processes or technology. We then optimise the forward investment programme accordingly. The business case for attaining leakage is compared to more traditional leakage techniques to assess efficiency and the need to achieve the required frontier level of leakage. • Active monitoring of the individual leakage interventions will be put in place and monitored at Programme Control Boards. The benefits monitoring for each intervention will be tracked and escalated where benefits or costs have a 20% or greater deviation from plan. Or if the delivery of the intervention is not achievable within 12 months of the planned benefit date. The intervention level monitoring will trigger a review of the intervention delivery project and may result in adapting the scale or blend of solutions within the plan. • Our annual performance is reported to regulators each year. • With each iteration of the WRMP we will assess if we are on track to achieve the target or not and if we should switch to the low demand pathway (this will be in combination with revising all supply-demand component data). In our WRMP24 our low demand pathway decision point is 2032 and the trigger 2038. This could change if our monitoring suggests we need to act sooner.

Option	Decision point	Trigger	Metric	Frequency	Monitoring
Household Water Efficiency (PCC)	2027 (and annually thereafter)	2030 (and the start of each AMP)	PCC outturn values compared against the target	Annual	• A delivery assurance group meets monthly to track PCC against the annual target and weather conditions to adjust the approach if required. • Our annual water saving campaigns are aligned with weather conditions and will be enhanced during dry weather. • Active monitoring of the overall outcome of the PCC investment plan, will track on a yearly basis the climatic conditions of the year and outcome performance. In the event that the critical summer or winter periods are greater than a 25% deviation from the historic average, and PCC reductions are not within 30% of planned reductions for 2 successive years, Yorkshire Water will review the overall PCC programme, and review the adaptive plan options for leakage reduction. This may result in higher cost, lower risk solutions being included in the plan. • Active monitoring of the individual PCC interventions will be put in place and monitored at Programme Control Boards. The benefits monitoring for each intervention will be tracked and escalated where benefits or costs have a 20% or greater deviation from plan. Or if the delivery of the intervention is not achievable within 12 months of the planned benefit date. The intervention level monitoring will trigger a review of the intervention delivery project and may result in adapting the scale or blend of solutions within the plan. • Our annual performance is reported to regulators each year. • With each iteration of the WRMP we will assess if we are on track to achieve the target or not and if we should switch to the low demand pathway (this will be in combination with revising all supply-demand component data). In our WRMP24 our low demand pathway decision point is 2032 and the trigger 2038. This could change if our monitoring suggests we need to act sooner.

Non-Household Demand reduction	2027 (and annually thereafter)	2030 (and the start of each AMP)	PCC outturn values compared against the target	Annual	• A delivery assurance group meets monthly to track PCC against the annual target and weather conditions to adjust the approach if required. • Our annual water saving campaigns are aligned with weather conditions and will be enhanced during dry weather. • Active monitoring of the overall outcome of the NHH demand reduction investment plan, will track on a yearly basis the climatic conditions of the year and outcome performance. In the event that the critical summer or winter periods are greater than a 25% deviation from the historic average, and NHH demand reductions are not within 30% of planned reductions for 2 successive years, Yorkshire Water will review the overall NHH demand reduction programme and review the adaptive plan options for leakage reduction. This may result in higher cost, lower risk solutions being included in the plan. • Active monitoring of the individual NHH demand reduction interventions will be put in place and monitored at Programme Control Boards. The benefits monitoring for each intervention will be tracked and escalated where benefits or costs have a 20% or greater deviation from plan. Or if the delivery of the intervention is not achievable within 12 months of the planned benefit date. The intervention level monitoring will trigger a review of the intervention delivery project and may result in adapting the scale or blend of solutions within the plan. • Yorkshire Water will monitor the applications for new connections for non-household customers. Where significant demands are required by individual customers, the associated demand will not be included within the reported demand reduction, with reconciliation of the significant new demands as part of the future WRMP and PR planning processes to rebaseline the demand reduction target. • Our annual performance is reported to regulators each year. • With each iteration of the WRMP we will assess if we are on track to achieve the target and if we should switch to the low demand pathway (this will be in combination with revising all supply-demand component data). In our WRMP24 our low demand pathway decision point is 2032 and the trigger 2038. This could change if our monitoring suggests we need to act sooner.

Option	Decision point	Trigger	Metric	Frequency	Monitoring
Labelling of water use appliances	2027 (and annually thereafter)	2030 (and the start of each AMP)	PCC outturn values compared against the target	Annual	• It is unlikely the benefit of labelling will be disaggregated from our other PCC reduction measures (C5). We shall monitor PCC reduction as described above.
AMP8 supply interventions	2025 (and annually thereafter non-SROs)	2030 (and the start of each AMP)	Progress of option (delivery against the delivery programme for each option and any constraints to achieving the DO)	Annual (small schemes e.g., non SROs)	• Decision and trigger points are not included as the decision is already reached for implementing these actions. • We shall start preliminary investigations of the smaller supply options this AMP (e.g., River Ouse licence transfer at low flows and East Yorkshire Groundwater) to facilitate with AMP8 monitoring of programme delivery. For the Sherwood Sandstone Boreholes support to North Yorkshire scheme due in 2035 we will also monitor against programme delivery. • Our preferred plan can be mitigated by extending use of level 1 to 3 drought actions if supply benefits not realised. In the DYCP, additional headroom allows for the solution under achieving provides resilience benefits during short duration (less than seven days) peak demands.
STW transfer	2030 (contractual date), although occurs under all pathways in STW plan	2035	Backfill option development (RAPID gated process); further option identification studies	Annual	• Tracking progression of Derwent Valley backfill option detailed option development towards required 2035 cessation date. To ensure that we can maintain supplies once the Upper Derwent Valley transfer ceases in 2035, we must progress with the development of option DV8B through the SRO process (as above) and will agree a programme for this with RAPID following publication of our final WRMP. The option will be monitored through the gated process. • In addition, we will carry out further option identification studies in AMPs 7 & 8 before the transfer termination decision date of 2030.

Option	Decision point	Trigger	Metric	Frequency	Monitoring
Groundwater ED	2025 (WINEP investigation); 2030 (dependent options)	2035	WINEP scheme outcomes and benefits (volumetric reductions in DO)	2025	• The WINEP investigations on our groundwater sources will be complete by 2025. This will determine if any licence reductions are required. We have assumed that any reductions in licence will be implemented by 2035. • We will monitor the evidence based volumetric reductions and incorporate these into our licences and update our models (and quantities of flow increases and benefits) to ensure that we incorporate the metric in our flow assessments. • Ongoing option development and identification activity
Surface water ED (River Derwent)	2027	2040	Outcome of CSMG target discussions with EA & NE	Annual progress updates	• Progression and conclusion of the River Derwent investigations, which influences the timing of need for the Tees transfer. • Tees transfer would not commence construction until AMP9, but if abstraction reductions are required then this would result in AMP8 option development work to work towards future implementation. • Low demand pathway could still remove the need for the Tees transfer following WRMP29 and with the trigger point of 2030 for potential scheme delay.

10.4 Benefits of the Grid SWZ preferred solution

Our preferred plan is a twin track approach to reduce demand and increase supply. It aims to achieve multiple benefits. Initially we will operate to a reduced level of service and be reliant on drought measures due to the much higher climate change impact our plan is now showing compared to the WRMP19 methodology. The benefits of the preferred plan have been summarised in Table 10-5 against the objectives set out in Section 9.

Table 10-5: Preferred plan benefits

Yorkshire Water WRMP24 Objectives	Preferred plan benefits
1. Close the supply-demand balance deficit	The preferred plan solution will close the most likely deficit in both the DYAA and critical period scenarios. It is a twin track approach that includes ambitious demand reduction targets and invests in strategy supply options that provide resilience to near term deviations in the supply-demand balance.
2. Reduce leakage by 50% compared to 2017/18 levels by 2050	A year-on year target from 2025 to 2050 has been built into our preferred plan. This will reduce demand by 32.47Ml/d in 2029/30 increasing to 94.96Ml/d in 2049/50. No further leakage reduction beyond 2050 is included in this plan however, we review potential for further leakage reduction with each iteration of the plan.
3. Achieve an average PCC of 110 l/h/d by 2050	Metering and household water efficiency initiatives will reduce PCC to below the policy target - 105.4l/h/d in DYAA and 102.9 l/h/d NYAA. This provides a year-on-year target between 2025 to 2050 to achieve 5.9 l/h/d by 2029/30 and 22.4 l/h/d reduction by 2049/50. The success of this objective is partly dependent on the government's water labelling initiative.
3. Achieve the non-household demand reduction targets of 9% reduction by 2037/38 and 15% reduction by 2050	Meeting the Defra non-household demand reduction targets have been built into our plan to achieve the interim target of 9% reduction by 2037/38 and we continue to work on our plan to achieve our 15% reduction by 2050. The total benefit from the non-household initiatives is 7.97Ml/d in 2029/30 and 15.20Ml/d by 2037/38.
5. Become resilient to 1 in 500 drought events without reliance on drought measures	Our plan aims to meet this objective by 2039/40. Our preferred plan provides sufficient benefit to reduce reliance on level 1 to 3 drought actions by 2028/29 however, under alternative more adverse pathways these measures may still be needed.
6. Increase resilience in the Grid SWZ and localised growth hot spots	Our preferred plan includes investment in the new supplies (R3a, R3 and R13, R91) in AMP8, which provide a combined benefit of 21.3Ml/d by 28/29. These supplies will also enhance our resilience in resilience in our supply systems. In the longer term we will invest in the R8g Sherwood Sandstone to a further provide 15Ml/d by 2035. (See points 8 and 9 also.)
7. Offset the ED BAU+ Groundwater loss	Assuming we achieve our demand and supply option benefits we should meet this objective through our AMP8 investment. We shall review in our WRMP29 if additional interconnections are needed to support the areas directly supplied to the groundwater supplies.
8. Offset the STW transfer termination	This will be met through investment in the back fill option which includes DV8(v)B York 2 WTW supplied by the River Ouse and DV8(iv)B –New north to south – dual main and provides supply to South Yorkshire. The combined benefit of the two solutions is 50Ml/d.
9. Offset the ED BAU+ Surface water loss on the River Derwent	We have included the DV7a(vi) Tees transfer option which will provide a 140Ml/d benefit and offset any required River Derwent licence reduction. However, there is significant further work to do to understand both the scale of the loss and the true cost of the option. We shall be developing our understanding of these during AMP8 as part of the proposed Kielder SRO. The loss of the supply is triggered in 2040/41 and we include adaptive pathways for both a higher and lower licence reduction.

The combined benefits of the preferred plan demand reduction and supply increase is 69.77 Ml/d in 2029, increasing to 398.22Ml/d in 2049/50 and 442.84 Ml/d in 2084/85. The benefits of the preferred plan are presented in Figure 10.5 by option category. A breakdown of the yield benefits of the preferred solution is presented in Table 10-6.

During the first five years of our planning period, from 2025 to 2030 (AMP8) we will implement four new supply options to achieve a combined DYAA benefit of 21.3Ml/d and critical period benefit of 36.3Ml/d. We shall also start enabling investigations in AMP7 into option R8g Sherwood Sandstone which is needed in 2035 and option R37b(ii) River Aire Abstraction / R86 Aire and Calder WTW required under Pathway 5 in 2035. For R31a Additional bankside storage at York WTW , during AMP8, we will gain a formal understanding of scope ahead of WRMP29. This will enable schemes to be brought forward if an alternative pathway is triggered.

In AMP8 we shall also be delivering the backfill option to meet the loss of the STW transfer in 2035. This includes the DV8(v)B York 2 WTW supplied by the River Ouse and DV8(iv)B New north to south – dual main which are being developed as direct procurement for customers.

In 2040 the DV7a(vi) Tees transfer is required when the River Derwent licence reduction will be applied to meet the CSMG target. This option will provide an additional 140Ml/d and we will remain in surplus until 2073. We have included further supply options to close the longer-term deficit. These include R37b(ii) River Aire Abstraction option 4 and R31a Additional bankside storage at York WTW.

Although not part of our WRMP, we are also proposing a licence variation to an abstraction we hold for a reservoir in North Yorkshire (R90 North Yorkshire Reservoir 1 licence variation). This solution requires a licence variation but does not have a supply-demand benefit. The licence variation will enable a greater volume to be transferred direct from the reservoir to treatment. We will offset this increase by reducing the volume we release to the watercourse downstream of the reservoir and abstract from the river. The benefits are operational and will reduce pumping requirements for transferring the water into supply.

As there is no WAFU benefit, in line with the WRPG we have not included it as a feasible option but are considering applying for the licence variation as part of our carbon reduction plans. On this basis we have carried out the same WRMP environmental assessments on the option as for our feasible options. The SEA assessment was favourable, with negligible adverse impacts, and small positive impacts identified. The WFD assessment indicated this option would be WFD compliant, whilst the HRA identified there would be no likely significant effect either alone or in-combination.

In addition to the supply options implemented, in AMP8, we will implement six leakage options, four household options and five non-household demand options to achieve a combined demand reduction benefit of 60.44Ml/d by 2030 (11.45Ml/d by 2030 for household and non-household demand options including water labelling and 48.99Ml/d by 2030 for Leakage and Metering).

These options include mains renewal, pressure management, above ground assets pressure management, smart metering, intensive active leakage control, and additional active leakage control, to reduce leakage by 32.47Ml/d by 2030. Additionally smart metering will provide additional benefits to household and non-household demand reduction, both directly through customer interaction and habit change and through improved ability to target the most beneficial customers for specific water efficiency interventions.

To deliver the household per capita consumption reduction, Yorkshire Water will deliver; water efficiency home audits, flow regulator installations, a household media campaign and school education for households. In support of non-household demand reduction Yorkshire Water will deliver; business water efficiency audits, rainwater harvesting support for large non-households, water retailer incentives and a non-household media campaign.

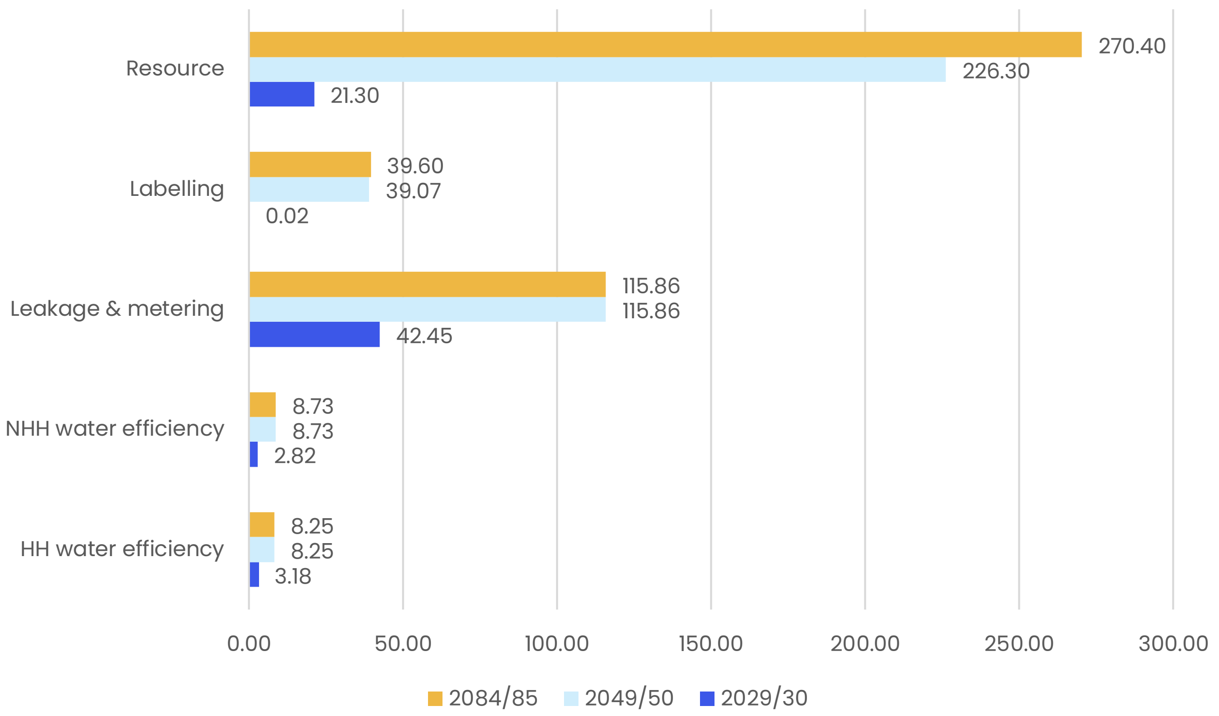
In addition to the benefit from the initiatives specific to household and non-household demand, there are additional benefits from the implementation of AMI smart meters (which are not listed in Table 10-5) and the improved consumption data which will be available to enable customers to identify and repair continuous flows.

Beyond AMP8 the demand options included in the preferred plan to 2050 equate to a demand reduction of 178.47Ml/d by 2050 (62.62Ml/d by 2050 for household and non-household demand options including water labelling and 115.86Ml/d by 2050 for leakage and metering).

The demand options implemented beyond AMP8 include household rainwater harvesting for new developments, household tariffs, rainwater harvesting for agricultural non-household and the implementation of water labelling.

A breakdown of the options category benefits over the planning period is provided in Figure 10.5. In the near-term benefits are provided by demand reduction whereas further into the future more new supplies are needed to meet long-term drivers.

Figure 10.5: Supply-demand benefits by option category



* Labels Ml/d

Table 10-6: Start date and yield of schemes to deliver the Grid SWZ preferred solution

Ref.	Option	First year of benefit	Benefit on completion (Ml/d)
C1d	Domestic customer audits and retrofit	2025/26	3.3
C6a	Commercial water user audits and retrofit (New)	2025/26	0.2
LSM	50% Leakage Reduction + 0.66% 10yr Mains Renewal + Smart Metering (94.62ML/D)	2027/28	115.9
C12a3	Rainwater harvesting - commercial customers	2025/26	2.0
C27d	School Visits	2025/26	1.0
C28e	Household Media Campaign	2027/28	1.7
C34a	Non-Household Media Campaign	2027/28	0.8
C35c	Water Retailer Incentives	2027/28	0.3
C6a(ii)	Commercial water user audits and retrofit (smaller sectors)	2029/30	4.5
C15d	Household flow regulator-internal	2028/29	0.5
C32c	Household Rainwater Harvesting- New Development	2030/31	1.4
R3a	Acomb Landing Moor Monkton Licence increase	2027/28	0.3*
C30a	Water Labelling Conservative Baseline	2028/29	39.6
R3	River Ouse pumping capacity to full licence capacity.	2028/29	10.0
R91	East Ness Full Site Throughput and Feed to Huby/ New internal transfer to North Yorkshire WTW 2.	2028/29	5.0
R13	East Yorkshire Groundwater Option 2	2028/29	6.0
C23b1	Rainwater Harvesting - agriculture	2030/31	1.0
C13c	Household Tariffs	2030/31	0.4
DV8B	New York WTW and Dual Main South Yorkshire Pipeline	2035/36	50.0
R8g	Sherwood Sandstone support to grid	2035/36	15.0
DV7a(vi)	Tees to York Pipeline - NWL import 140 Ml/d	2040/41	140.0
R37b (ii)	River Aire Abstraction option 4	2073/74	33.5
R31a	Additional bankside storage at York WTW	2082/83	10.6

* Critical period benefit 15Ml/d.

Links to our business plan (PR24) in relation to our best value WRMP

In this section we provide a summary of a number of WRMP related content that more information can be found in our PR24 submission.

New water treatment works
The PR24 business plan includes a new WTW to be constructed adjacent to an existing WTW in West Yorkshire. This is being constructed to allow supply to customers to continue while the existing works undergoes maintenance. It is not a WRMP scheme as the source of supply to the existing works is limited in dry weather and the additional works does not increase WAFU.

Nature based solutions (Nbs)
Whilst we do not include catchment and Nbs in our WRMP as options, because these options do not provide a direct deployable output benefit, we do however include these in our plans as part of the PR24 submission. However, we do recognise that catchment stewardship is crucial to improving catchment resilience and in combination with reducing unsustainable abstraction achieving holistic catchment management will bring wider benefits for abstractors (such as improved water quality, more catchment sustainable flows and better ecological status).

Our investment plans for catchment interventions can be found in our PR submission at WINEP

Demand management interventions

- Our metering enhancement case can be found at Metering Enhancement Case
- Our mains renewal case can be found at Cost Adjustment Claims (including Mains Renewal)

WRMP supply demand driver

- Our overall supply demand business case can be found Supply Demand Enhancement Case and will be updated between Ofwat's draft and final determination as part of the PR24 – WRMP24 reconciliation process.
- Our supply side options will each deliver a specified increase in deployable output and have no direct interaction with base funding. We have set out our full required costs through the business planning PR24 process and can confirm we have excluded base funding from our enhancement requests.

10.5 SEA of Preferred Plan

Table 10-7 below provides a summary of the SEA outputs for the preferred plan.

Table 10-7: SEA outputs of Grid SWZ preferred solution

Adverse

Scheme	1.1	1.2	1.3	1.4	2.1	2.2	3.1	4.1	4.2	4.3	4.4	5.1	6.1	6.2	6.3	7.1	8.1
C1d Household customer audits and water efficiency retrofits		None		None		None						None				None	None
C6a Non-household water use audit and retrofit				None								None				None	None
C6a(ii) Non-household domestic water use audit and retrofit				None								None				None	None
C12a3 Rainwater harvesting for commercial customers		None		None		None						None				None	None
C13c Household tariffs				None		None						None				None	None
C15d Installation of internal household flow regulators				None		None						None				None	None
C23b1 Rainwater harvesting for agriculture				None		None						None				None	None
C27d School Visits		None	None	None		None						None				None	None
C28e Household media campaign																	
C30a Water labelling			None	None								None				None	None
C32c Household Rainwater Harvesting- New Development				None		None						None				None	None
C34a Non-household media campaign	None			None		None						None	None	None		None	None
C35c Non-household water efficiency incentive scheme			None	None								None				None	None
LSM Leakage reduction and smart metering				None													
DO03 Supply rivers drought permits- ends in 2038- DYAA		None	None		None	None	None			None	None	None	None	None	None	None	
DO13 Drought demand reduction- ends in 2038- DYAA	None	None				None	None	None	None	None	None	None	None	None			
DO08 Supply reservoir compensation drought permits- ends in 2038- DYAA		None	None		None	None	None			None	None		None	None	None	None	
DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d				None							None						
DV8B New York WTW and Dual Main South Yorkshire Pipeline											None						
R3 Increased River Ouse pumping capacity				None							None						
R3a River Ouse licence variation 1				None		None											None
R8g Sherwood Sandstone Boreholes support to North Yorkshire				None							None						
R13 East Yorkshire Groundwater Option 2				None							None						
R31a Additional bankside storage at York WTW				None							None						
R37b(ii) River Aire Abstraction option 4											None						
R91 New internal transfer to North Yorkshire WTW 2											None						

Beneficial

Scheme	1.1	1.2	1.3	1.4	2.1	2.2	3.1	4.1	4.2	4.3	4.4	5.1	6.1	6.2	6.3	7.1	8.1
C1d Household customer audits and water efficiency retrofits				None		None						None				None	None
C6a Non-household water use audit and retrofit				None								None				None	None
C6a(ii) Non-household domestic water use audit and retrofit				None								None				None	None
C12a3 Rainwater harvesting for commercial customers				None		None						None				None	None
C13c Household tariffs				None		None						None				None	None
C15d Installation of internal household flow regulators				None		None						None				None	None
C23b1 Rainwater harvesting for agriculture				None		None						None				None	None
C27d School Visits			None	None		None						None				None	None
C28e Household media campaign																	
C30a Water labelling			None	None								None				None	None
C32c Household Rainwater Harvesting- New Development				None		None						None				None	None
C34a Non-household media campaign				None		None						None	None	None		None	None
C35c Non-household water efficiency incentive scheme			None	None								None				None	None
LSM Leakage reduction and smart metering				None													
DO03 Supply rivers drought permits- ends in 2038- DYAA	None	None		None			None	None	None		None	None	None	None		None	None
DO13 Drought demand reduction- ends in 2038- DYAA		None		None			None					None	None	None			
DO08 Supply reservoir compensation drought permits- ends in 2038- DYAA	None	None		None			None	None	None		None	None	None	None		None	None
DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d											None						
DV8B New York WTW and Dual Main South Yorkshire Pipeline																	
R3 Increased River Ouse pumping capacity											None						
R3a River Ouse licence variation 1				None		None											None
R8g Sherwood Sandstone Boreholes support to North Yorkshire											None						
R13 East Yorkshire Groundwater Option 2											None						
R31a Additional bankside storage at York WTW											None						
R37b(ii) River Aire Abstraction option 4											None						
R91 New internal transfer to North Yorkshire WTW 2											None						

Key

No effect	Negligible adverse	Minor adverse	Moderate adverse	Major adverse	Negligable beneficial	Minor beneficial	Moderate beneficial	Major beneficial

The preferred plan includes 14 demand management options: 13 customer management options and one glidepath option (LSM) that includes activities relating to leakage reduction and smart metering. The customer options are assessed within the SEA as resulting in largely minor beneficial effects across a range of SEA objectives including sustainable and efficient use of water resources, population and human health and climate resilience.

Option C30a (Water labelling) identified moderate beneficial effects for the same objectives as a result of the predicted water savings. Option LSM - Leakage reduction and smart metering glidepath (50%) is assessed as resulting in major beneficial effects across three SEA objectives in relation to human health and wellbeing, sustainable and efficient use of water resources and climate change resilience. Moderate adverse effects have been identified regarding use of material resources as a result of implementing Option LSM. For the majority of demand management options, minor adverse effects have been identified in relation to the air and climate SEA objectives regarding air pollutant and greenhouse gas emissions.

A total of nine supply side measures are also included within the preferred plan. Major adverse impacts for options DV7a (vi) - Tees to York Pipeline - NWL import 140 Ml/d and DV8B - New York WTW and Dual Main South Yorkshire Pipeline within the preferred plan are anticipated in relation to biodiversity, material assets and resource use, protection and enhancement of geology/soil quality, and minimisation of greenhouse gas emissions. Dv7a(vi) has also identified moderate adverse effects on surface water flows, population and human health, air quality, cultural heritage, and landscape. Meanwhile, Option DV8B identifies additional major adverse effects on air quality and landscape, and moderate adverse effects on human health, flood risk and cultural heritage. However, Options DV7a(vi) and DV8B are also anticipated to be associated with major to moderate beneficial effects on population and human health and climate change resilience due to the increase in available public water supply.

The construction phases of a further three resource options within the preferred plan are anticipated to result in moderate adverse effects on biodiversity during construction. Elsewhere, minor adverse effects have been identified across a number of SEA objectives, including for population and human health and cultural heritage. The remaining three supply side options (R3a, R8g and R91) in the preferred plan are assessed as resulting in negligible to minor adverse effects only across all SEA objectives. The majority of resource options provide opportunities to result in biodiversity enhancement (habitat creation/restoration), provide beneficial effects on population and human health and in relation to climate change resilience.

Although WINEP investigations are required during AMP8 no additional abstractions (to include no use of existing licensed headroom) from the River Derwent are planned to be required as part of the preferred plan options and there is no plan to service future growth in demand through increases in abstraction from or likely to affect the River Derwent SAC. The HRA of the WRMP preferred plan has concluded that, following inclusion of appropriate mitigation measures during the construction phase of relevant schemes, no adverse effects on the integrity of any European site are anticipated.

The WFD compliance assessment has informed SEA findings against the water topic objectives and has identified potential WFD non-compliance issues from activities associated with implementation of the preferred plan. Additional abstraction from the water body associated with options R3, R3a and DV8B could result in deterioration in fish status. A WINEP investigation undertaken during AMP7 concluded that additional abstraction from this water body could exacerbate existing water quality issues attributed to stormwater discharges. Yorkshire Water are committed to making improvements to these discharges through the WINEP and, in doing so, address the risks associated with this pressure. Yorkshire Water are still in consultation with the Environment Agency on the closure of the WINEP investigation and any further mitigation measures that would be required to prevent further WFD deterioration.

There are two options (R13 and R8g) in the plan where uncertain impacts associated with multiple WFD water bodies as the level of hydrogeological understanding is not sufficiently developed at this stage to be able to provide a WFD compliance assessment proportionate for a WRMP. One of these options (R13) is due to be operational during AMP8 and further evidence-based assessment will be required prior to development and licensing of these options.

10.6 SEA cumulative impact assessment of the preferred plan

A cumulative assessment of the preferred plan was undertaken to consider whether the preferred solution options, when constructed or operated together, led to additional effects on each of the SEA topics.

There are potential cumulative impacts between the following options which would require construction in the vicinity of York WTW 2 should these schemes have overlapping construction phases:

The first year of benefit for R31a within the preferred plan is identified as 2082 and this scheme is estimated to be associated with an approximately 4 year construction phase. Option DV8B is associated with a 10-year time-to-build period (of which a large proportion will be construction) and is identified as operational in 2035, and therefore the construction phases will not coincide with that of R31a. The DV7a(vi) scheme is identified as operational in 2040 within the preferred plan with an approximately 13 year construction phase where elements of the construction will overlap with DV8B.

The DV7a(vi) and DV8B schemes are likely to have overlapping construction phases and there is therefore potential for cumulative impacts between two schemes related to construction impacts on biodiversity, population and human health, material assets and resource use, air quality, archaeology and cultural heritage, and landscape and visual amenity. Construction measures that need to be incorporated into the scheme design and/or planning to avoid or mitigate potential effects will be agreed during the detailed design and planning stage should these schemes be progressed. The DV7a(vi) scheme will cover a large geographical area (pipeline construction from the River Tees to York WTW2) as will the DV8B scheme New York WTW and Dual Main South Yorkshire Pipeline) and therefore until detailed construction plans are available it is not possible to identify if works in proximity to sensitive receptors will coincide. However, any such cumulative impacts would be expected to be minor, as most of these activities would be localised and small in scale, and could be effectively mitigated through careful project management and best practice construction methods.

Options R3, R3a and DV8B all impact the River Ouse during their operation:

- R3a – implemented in 2027 – The operation of the scheme would see up to 15Ml/d of the York WTW 1 licence transferred to River Ouse WTW to allow additional abstraction at River Ouse WTW when flows are below the lowest flow bands (<650Ml/d). The scheme would provide a benefit as an annual average of 0.3Ml/d as it would only be a benefit when flows are in the lower bands.
- R3 – implemented in 2028 – would allow River Ouse WTW to abstract up to full licence capacity (150Ml/d). This scheme assumes the additional yield under normal operations will be constrained to 10Ml/d (134Ml/d total) with the ability to increase to provide the full 150Ml/d as a temporary measure if required in an emergency situation.
- DV8B – implemented in 2035 – would increase the abstraction at York WTW 1 by up to full licensed rates of 96Ml/d annual average.

The River Ouse is known to support the migratory qualifying features of the Humber Estuary SAC; sea lamprey and river lamprey. As such, the operation of numerous abstractions on the River Ouse could result in a deterioration of offsite functionally linked spawning habitat. Despite there being no risk to the physical habitats as a result of additional abstraction, the WINEP investigation could not rule out any impact on the aquatic ecology in the river Ouse, particularly fish, due to the potential for the reduction in flow resulting in the exacerbation of dissolved oxygen sags that were observed in the river.

Though the primary driver for these dissolved oxygen sags are water quality pressures (most can be timed as attributable to stormwater discharges), it was identified that any reduction in flow has the potential to reduce the dilution of any water quality pressure and potentially cause a greater impact to the fish community in the river Ouse. The investigation concluded that, with flow not being the driver for the potential dissolved oxygen pressure to the fish community, abstraction from the river Ouse should not be constrained. Subject to approval of the Business Plan by Ofwat, Yorkshire Water are committed to making improvements to storm overflow discharges through the WINEP to meet the obligations of the Environment Act. It is worth noting that, at the time of writing this final WRMP, Yorkshire Water are still in consultation with the Environment Agency over the closure of the investigation.

Prior to further assessment it appeared there was potential for cumulative adverse effects during the operation of Options R3, R3a, DV8B, R91, R13 and R37b(ii) as they all involve additional abstractions from waterbodies upstream of the Humber Estuary European Marine Site (EMS). However, hydrological modelling undertaken as part of our final plan has concluded that there would be an indiscernible change in freshwater flow input to the Upper Humber Estuary as a result of implementing options within the Preferred Plan. No cumulative adverse effects are therefore anticipated on the Humber Estuary EMS.

There would be benefits associated with implementation of each option in parallel, i.e., increasing the overall volume of water savings made or water provided for supply.

At a plan level, cumulative effects with other relevant plans, programmes and projects were also considered. These included our Drought Plan, WRMPs and drought plans from neighbouring water companies, EA Drought Plans, Canal and River Trust Management Plans, Local Development Frameworks, National Policy Statements and National/Regional Infrastructure Plans, and major projects. No significant cumulative impacts were identified between WRMP24 and any other relevant plans, programmes, and projects.

10.7 Biodiversity net gain

As part of the WRMP, water companies must demonstrate that they have considered a range of environmental legislation and guidance, including the Environment Act (2021) which requires any options within the plan that need planning permission to provide biodiversity net gain (BNG) of 10%. Biodiversity net gain seeks to provide a means of quantifying losses or gains in biodiversity value bought about by changes in land use. When designed and delivered well, BNG can secure benefits for nature, people, and places, and for the economy[53.]

Additionally, the EA have published supplementary guidance on Environment and Society in decision-making[54], which provides more detail about the expectation for biodiversity net gain assessment and how this can support decision-making.

In preparing our WRMP we have therefore prepared an assessment of the potential for biodiversity net gain for each feasible option. The results of this assessment have been included the SEA and demonstrate there are significant opportunities for biodiversity net gain within our preferred plan. (see SEA Objective in Table 8-7).

As our schemes are further developed it will be necessary to undertake a full biodiversity net gain assessment with identification of habitat restoration and creation and to agree detailed on-site and off-site enhancement measures to ensure our plan achieves significant net gain.

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[53] Natural England (2021), Biodiversity Net Gain – more than just a number. Accessible via: https://naturalengland.blog.gov.uk/2021/09/21/biodiversity-net-gain-more-than-just-a-number/

[54] EA (2021) WRPG 2024 supplementary guidance – Environment and society in decision-making. Published 24/03/2021

10.8 Mitigation and monitoring

Consideration of mitigation measures has been an integral part of the SEA process. The SEA appraisals have been based on residual impacts that are likely to remain after the implementation of reasonable mitigation.

Figure 10.4 in Section 10.2 gives a timeline of the implementation of the resource options included in the preferred solution. This includes a period of monitoring and assessment to show when the investigations of the environmental effects would be carried out.

Where appropriate, the SEA has identified additional mitigation measures that may be required, either during the construction phase or operational phase of the resource options in the preferred solution. These mitigation measures will be further defined during the more detailed design stages of the schemes as they come forward for implementation. Mitigation measures will also be discussed as appropriate with the environmental regulators, planning authorities and Historic England, as appropriate.

Appropriate monitoring has been identified in the SEA to track any potential environmental effects during implementation of the options, which will in turn trigger deployment of suitable and practicable mitigation measures. Prior to implementation, we will review the specific requirements for environmental monitoring in consultation with the EA, Natural England, and Historic England, as appropriate.

We will fully comply with the requirements of The Water Supply (Water Quality) Regulations 2016 Regulation 15, when considering introducing any new sources to be used for drinking water. Specifically, we will meet the arrangements stated in Drinking Water Inspectorate (DWI) Information Letter 06/2012, around providing adequate information to the DWI; appropriate sampling and monitoring; reporting requirements; following our Drinking Water Safety Planning risk assessment methodology; and submission of Regulation 28 documentation as necessary.

11 Final planning scenario supply-demand balance

This section presents the final planning scenario for our WRMP24 – the surplus available with our preferred solution implemented. It describes the impact our preferred solution will have on our future leakage, non-household demand and PCC targets. It also discusses the carbon footprint and bill impact of our plan.

Once we have implemented our preferred plan the Grid SWZ shows a surplus supply-demand balance. There will also be an increased surplus in the East SWZ from water efficiency options that benefit both zones. A surplus is the volume available above demand plus target headroom.

Our WRMP24 has been built to comply with regional and national water resource planning objectives and with government strategies. It directly aligns with the WReN Regional Plan. It also aligns with YW plans and strategies for future interventions to ensuring a safe and reliable supply of water to customers. Our draft PR24 Business Plan was submitted to Defra in October 2023. As part of this process, we received guidance from Ofwat to use our 'best available data' in our PR24 submission ahead of revised draft WRMP submission at the end of October 2023. We have updated our PR24 Business Plan, including enhancement cases where appropriate, to align and reconcile with this final WRMP24 and are awaiting Ofwat's final determination. Our WRMP24 is also aligned with other internal plans as we create or revise them, including Drinking Water Safety Plans, our Drought Plan, and the Water Industry National Environment Plan (WINEP).

11.1 Final supply-demand balance

The final plan supply-demand balance for our two zones is presented in WRP tables YWSEST and YWSGRD. The YWSEST final plan scenario shows a minor change due to the benefits of the demand reduction interventions to reduce PCC, including water labelling. The YWSGRD table shows a much more significant change once the best value (preferred) solution to close the DYAA and critical scenario deficits is incorporated into the final supply-demand balance calculations.

The final planning figures shown below have been adjusted post-optimisation to include the impact of new appointments and variations supplies (NAVs), this is described fully in section 3.13.3. NAV demand forecast information was provided after the revised draft submission in October 2023 and so could not be incorporated into the baseline scenario. The overall impact to distribution impact was a decrease of 4.95 Ml/d over the planning period, the impact to WAFU is a decrease of 5.97 Ml/d. This results in an overall average decrease to the supply demand balance of 1.02 Ml/d over the planning period.

Table 11-1 presents the WAFU, distribution input and surplus in each zone, with the impact of the preferred plan incorporated. The demand reduction included in our preferred plan will achieve the 20% reduction in water production per a head of population by 2038 as required under the Government's Environmental Improvement Plan.

Through implementation of our preferred plan, we achieve the National Framework for Water Resources requirement to be resilient to a 1 in 500-year drought return period without the need for level 4 drought actions by 2039/40. Prior to this our level of service for level 4 drought actions is 1 in 100-years until 2026/27 then 1 in 200 from 2027/28 onwards. Our level of service for level 2 drought restrictions (temporary use bans) is 1 in 25 or higher throughout the planning period. Our level of service for level 3 drought actions (permits) is 1 in 50 until 2026/27 then 1 in 80 or greater from 2027/28 (see Section 9.5).

Table 11-1 shows the Grid SWZ final plan scenario supply-demand balance with the preferred plan benefits. In 2025/26 and 2026/27 the supply (WAFU) has the benefit of planning to a 1 in 100-year level of service for level 4 drought measures. Figure 11.1 shows the difference this makes to the DYAA supply demand balance in the final plan scenario compared to planning to a 1 in 200-year level of service for level 4 drought actions.

In the DYCP scenario the deficit in 2025/26 is met through reducing target headroom. The supply demand balance using the modelled CP target headroom volume is shown in Table 11-2.

Table 11-1: Final plan supply-demand balance

Resource Zone Scenario	2025-26	2026-27	2027-28	2029-29	2029-30	2049-50	2084-85
Grid SWZ DYAA FP WAFU (Ml/d)	1336.52	1335.56	1286.13	1305.26	1261.67	1197.76	1194.38
Grid SWZ DYAA FP distribution input (Ml/d)	1236.14	1224.11	1212.50	1200.89	1191.29	1081.21	1133.15
Grid SWZ FP DYAA surplus (Ml/d)	29.69	42.90	5.10	37.75	5.69	93.21	35.22
Grid SWZ CP FP WAFU (Ml/d)	1422.49	1423.38	1438.28	1459.18	1417.38	1463.15	1507.25
Grid SWZ CP FP distribution input (Ml/d)	1357.63	1346.09	1334.91	1323.72	1314.52	1215.54	1290.24
Grid SWZ Final plan CP (Ml/d) surplus (Ml/d)	0.49	5.93	34.27	68.63	38.29	218.99	186.36
East SWZ FP DYAA WAFU (Ml/d)	13.30	13.28	13.26	13.24	13.22	12.79	11.97
East SWZ FP DYAA distribution input (Ml/d)	7.40	7.42	7.41	7.39	7.36	6.99	7.32
East SWZ FP DYAA surplus (Ml/d)	4.88	4.85	4.83	4.83	4.84	5.03	3.73

Figure 11.1: Grid SWZ final plan DYAA surplus

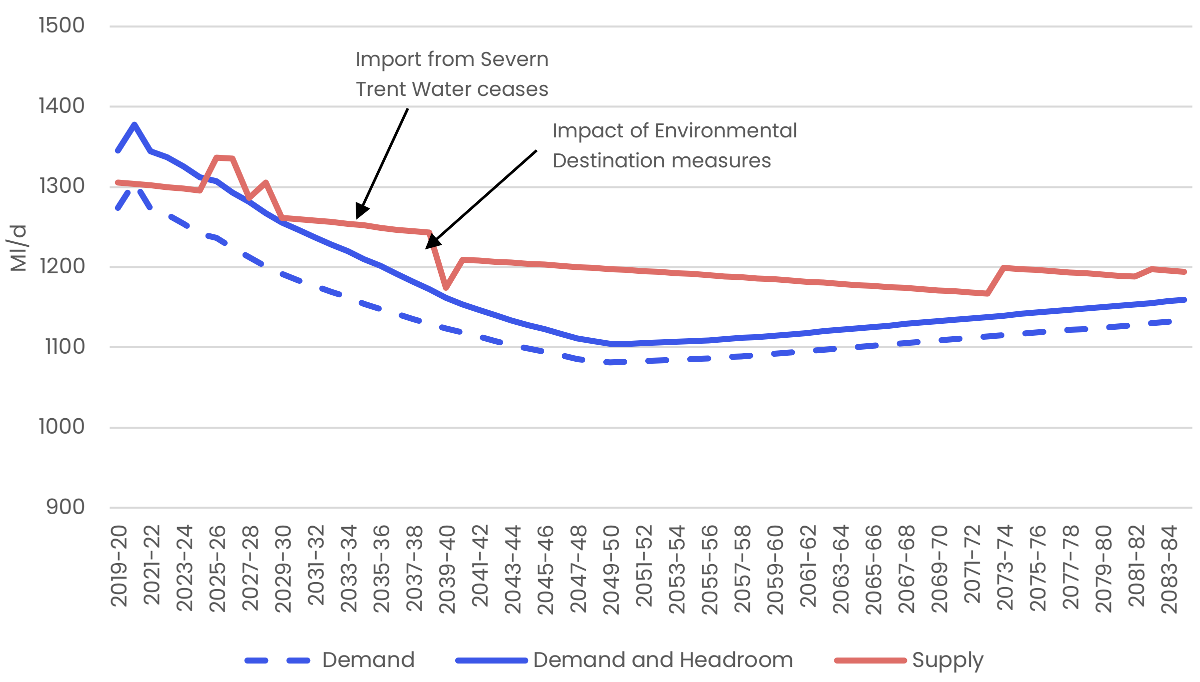


Table 11-2: Grid SWZ final plan supply-demand balance, showing 1 in 100-year for first 2 years

Resource Zone Scenario	2025-26	2026-27	2027-28	2028-29	2029-30	2049/50	2084/85
Grid SWZ FP DYAA surplus (Ml/d)	-40.98	-27.71	5.10	37.75	5.69	93.21	35.22
Grid SWZ FP DYAA surplus (Ml/d), with 1 in 100-year drought resilience in 2025-26 and 2026-27	29.69	42.90	5.10	37.75	5.69	93.21	35.22
Grid SWZ FP critical period surplus (Ml/d)	-8.76	5.93	34.27	68.63	38.29	218.99	186.36
Grid SWZ FP critical period surplus (Ml/d) with target headroom reduction	0.49	4.35	32.62	66.96	36.64	224.85	192.21

11.1.1 Final planning headroom

We have not carried out a final plan headroom assessment for WRMP24 and target headroom in the final plan is the same as the baseline headroom assessment described in Section 6. The East SWZ did not require a solution to a deficit and no further headroom analysis is needed. The Grid SWZ did require solutions but as a scenario approach to uncertainty has been applied though the adaptive pathways, we did not reassess target headroom for the final plan. We shall monitor the risks and adapt in the future if we are following an alternative pathway to the preferred (most likely) plan.

The final WRP tables for both zones show an increase in available headroom compared to the baseline due to the implementation of the solutions.

For our critical period scenario, we are operating at a reduced target headroom in 2025/26. In our DYAA the level of service in 2025/26 and 2026/27 is 1 in 100-years. The immediate deficit is due to the reductions in supply following the latest stochastic deployable output methodology and UKCP18 climate change emissions. This has a much more severe impact on our future supplies than the WRMP19 approach and we shall carry out further work to assess the approach and if it is representative of our system.

11.2 Final plan leakage forecast

Table 11-3 summarises the final plan leakage targets, incorporating additional leakage reduction in the Grid SWZ to achieve the 50% policy requirement by 2050. The leakage target is represented as an annual target in the WRMP. It reduces from 256Ml/d in 2024/25 to 162Ml/d by 2050 and will remain at this level until the end of the 60-year planning period.

The target presented in Table 11-3 is based on the annual forecast with the benefit of interventions. It has been derived from the same data as the performance commitment three year rolling average leakage target used for Ofwat reporting.

Table 11-3: Future leakage targets

Future Leakage Targets (Ml/d)		AMP8					2050
	2024/25	2025-26	2026-27	2027-28	2028-29	2029-30	2049/50
Cumulative leakage reduction (Ml/d)	-	4.48	12.98	20.66	27.42	32.74	94.96
YW Leakage Target (Ml/d)	256.30	251.82	243.32	235.64	228.88	223.56	161.34

11.3 Per capita consumption target

Table 11-4 shows PCC reduction over the planning period to achieve the 2050 policy requirement. The benefit from the smart metering / networks and water efficiency activity we will deliver has been assigned to measured household use, whereas water labelling has been assumed to benefit both measure and unmeasured households.

The PCC reductions built into our WRP24 preferred plan provides the annual PCC forecast for the next AMP. It has been derived from the same data as the performance commitment three year rolling average leakage target used for Ofwat reporting.

With the benefit of interventions. average PCC will reduce to 105.4 l/h/d by 2050 in the DYAA scenario and 103.6 l/h/d in the NYAA, over-achieving the policy requirement to archive a target of 110 l/h/d by 2050. The interventions include water labelling which is dependent on government action and appliance manufacturers. We shall review this in the next iteration of our plan and monitor alongside our in-house water efficiency activity benefits.

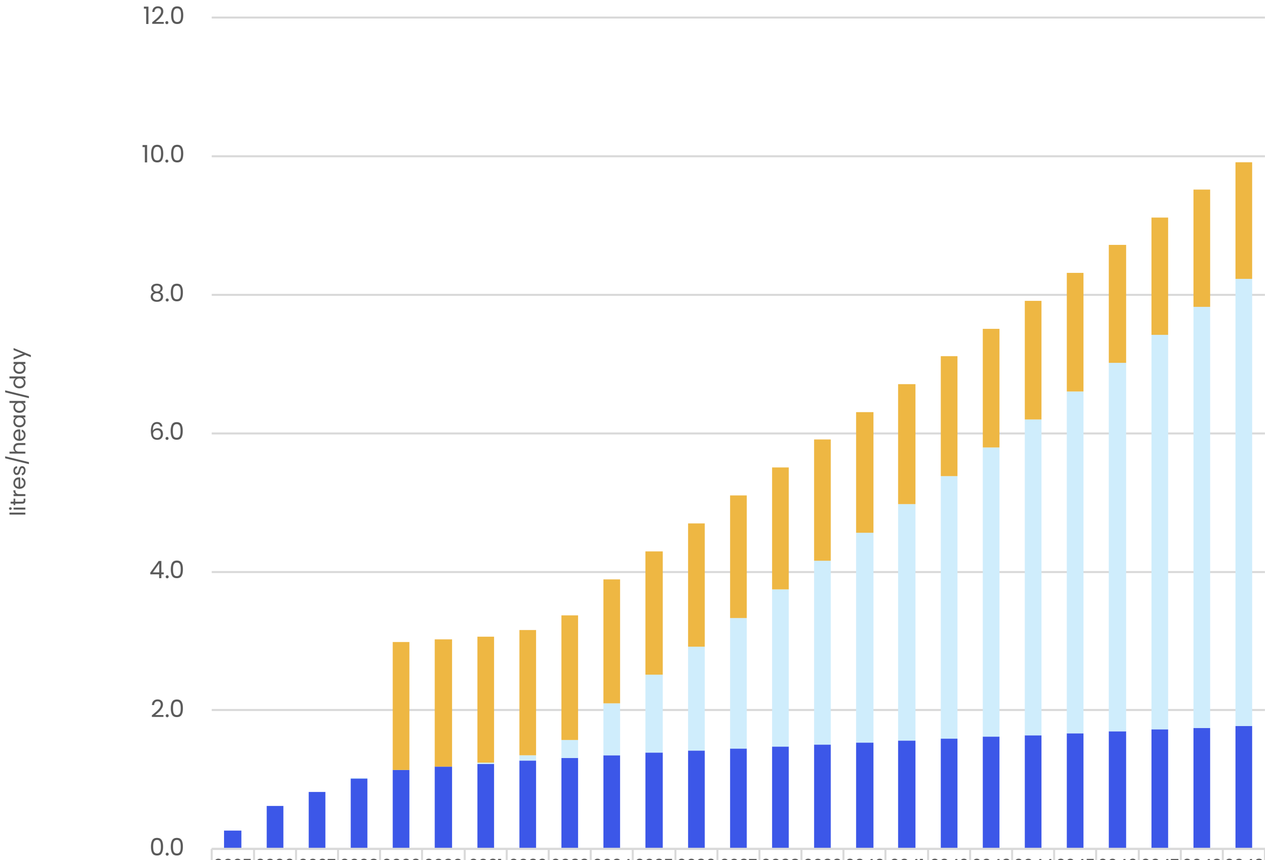
Table 11-4 includes the NYAA PCC projections with demand reduction initiative benefits. Table 2a of the WRP tables presents normal year demand forecast data, incorporating the preferred plan benefits, annually for the first five years of our plan, and then at five-year intervals until 2080. This data will form the basis of the performance trends we present in our PR24 Business Plan submitted to Ofwat.

Table 11-4: Future PCC projections

Future PCC projections (Ml/d)	AMP8					
	2025-26	2026-27	2027-28	2028-29	2029-30	2049-50
DYAA						
Cumulative household demand reduction (Ml/d)	2.1	6.3	11.1	16.4	21	85.7
Measured household PCC (l/h/d)	109.5	108.8	108	107.1	106.3	96.6
Unmeasured household PCC (l/h/d9)	156	155.7	155.5	155.4	155.2	147.7
Average household assuming water labelling benefits PCC (l/h/d)	126.7	125.5	124.3	123	121.8	105.4
YW PCC initiatives assuming no water labelling benefits (l/h/d)	127.1	126.7	126.3	126	125.6	113.1
NYAA						
Cumulative household demand reduction (Ml/d)	2.1	6.3	11.1	16.4	21	85.7
Measured household PCC (l/h/d)	107	106.2	105.4	104.5	103.7	94.1
Unmeasured household PCC (l/h/d)	152.4	152.1	151.9	151.8	151.6	144.2
Average household assuming water labelling benefits PCC (l/h/d)	124.1	122.9	121.7	120.4	119.2	103
YW PCC initiatives assuming no water labelling benefits (l/h/d)	124.1	122.9	121.7	120.4	119.2	109.5

The benefit of the PCC reduction to our supply-demand balance is shown in Figure 11.2. Initially Yorkshire Water initiatives have the largest impact but over time water labelling benefits increase and by the 2040s has the greater impact.

Figure 11.2: PCC reduction benefit



	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37	2037-38	2038-39	2039-40	2040-41	2041-42	2042-43	2043-44	2044-45	2045-46	2046-47	2047-48	2048-49	2049-50
Metering	0.0	0.0	0.0	0.0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Water labelling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.7	1.1	1.5	1.9	2.3	2.6	3.0	3.4	3.8	4.2	4.6	4.9	5.3	5.7	6.1	6.5
Household efficiency	0.3	0.6	0.8	1.0	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8

11.4 Non-household target

Table 11-5 shows the non-household demand reduction over the planning period. Our ambition is to achieve the 15% reduction in use compared to 2019/20 non-household use by 2050. However, as previously noted further options identification and appraisal is needed to determine a feasible strategy to achieve the Environment Plan long-term objective. We have constrained options to meet the interim target of a 9% reduction by 2038 (excluding growth). This forms our AMP8 non-household demand target.

Table 11-5: Future non-household demand projections

Future Non-household Targets (Ml/d)		AMP8					2050
	2024/25	2025-26	2026-27	2027-28	2028-29	2029-30	2049/50
Cumulative reduction in non-household consumption (Ml/d)	0	0.96	2.40	3.78	5.43	6.84	15.19
YW non-household demand target (Ml/d)	269.57	269.97	268.16	266.42	264.44	262.71	250.67

11.5 Greenhouse gas emissions

The Defra *Water Resources Management Plan Direction 2022* requires water companies to produce a description of "the emissions of greenhouse gases which are likely to arise as a result of each measure which it has identified in accordance with Section 37A(3)(b)" of the Water Industry Act 1991.

We have forecast the total regional greenhouse gas emissions (tonnes of CO_2 equivalent) for regional water production in each year of the planning period for the baseline scenario and the final planning scenario. This is presented in Figure 11.3 and includes emissions for both the East SWZ and Grid SWZ.

This chart represents the base and final plan greenhouse gas emissions assuming no change to the carbon impacts of our operations over time. It provides a comparison between carbon emissions before and after the implementation of schemes and is not accounting for carbon offsetting and our ambition to achieve net zero carbon.

Figure 11.3: Baseline and final planning scenario regional greenhouse gas emissions

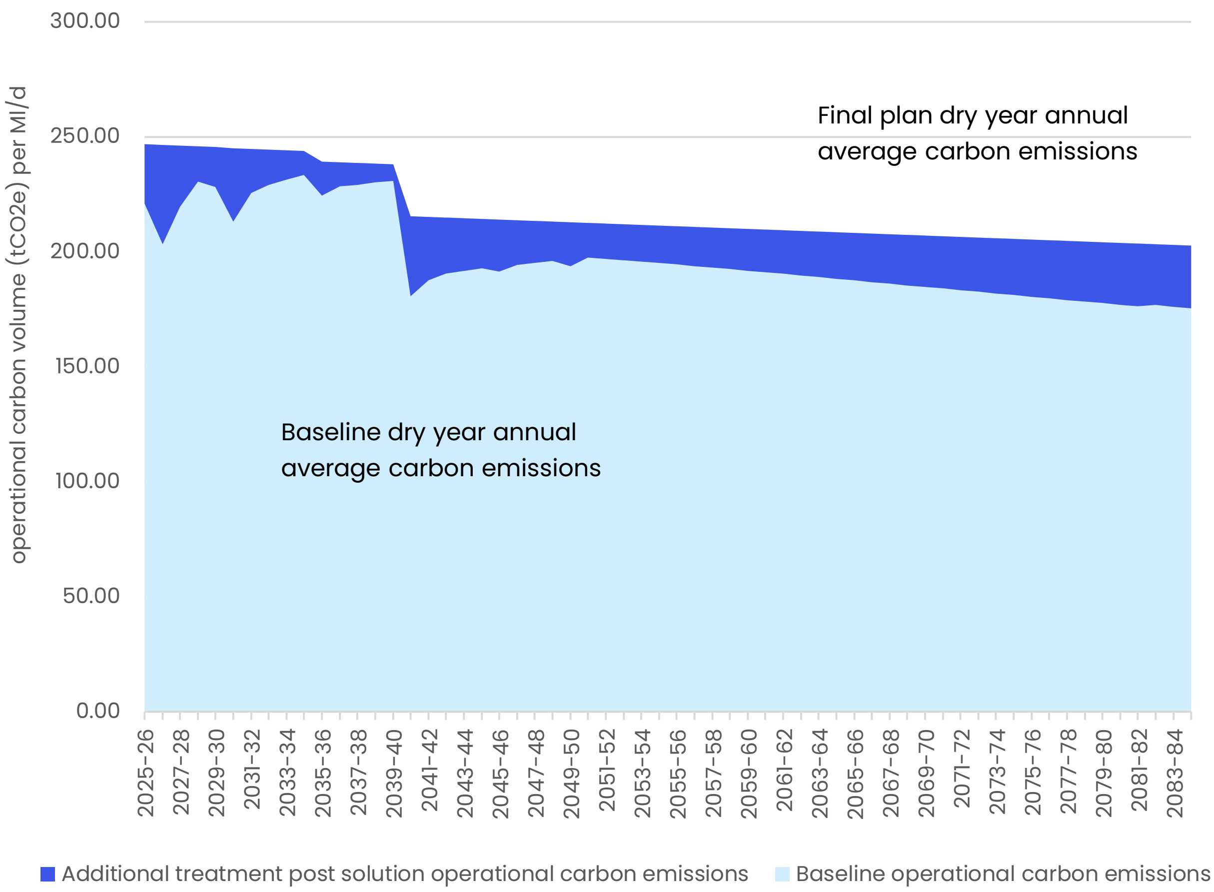


Figure 11.3 shows greenhouse gas emissions increase in the final planning scenario. In the baseline there is insufficient supply to meet demand and therefore we treat a lower volume than the final plan. Once the solution is implemented the volume of water we need to treat and distribute increases therefore greenhouse gas emissions increase.

The greenhouse gas emissions for operating each of the options we will implement as part of our preferred solution are provided in Table 11-6.

Table 11-6: Greenhouse gas emissions to deliver the Grid SWZ preferred solution after implementation

Option ref	Option name	Operational tCO_2e per Ml/d
C12a3	Rainwater harvesting for commercial customers	-0.40
C13c	Household tariffs	-0.37
C15d	Installation of internal household flow regulators	-0.20
C1d	Household customer audits and water efficiency retrofits	-0.35
C2	Metering domestic meter optants (growth)	-0.20
C23b1	Rainwater harvesting for agriculture	-0.37
C27d	School visits	-0.40
C28e	Household water efficiency media campaign	-2.30
C30a	Water labelling- baseline	N/A
C32c	Rainwater harvesting for households- new developments	-0.17
C34	Non-household water efficiency media campaign	-0.40
C37	Metering new developments (growth)	-0.14
C5	Metering on asset end of life	-0.18
C6a	Non-household water use audit and retrofit	-0.16
C6a(ii)	Non-household domestic water use audit and retrofit	-0.34
D15	Intensive active leakage control	-0.17
D7	Active leakage control	-0.18
D2	Pressure management	-0.19
D3	Mains renewal/ replacement	-0.18
D6a	Above ground pressure management	-0.20
D7	Permanent acoustic logging	-0.18
DO	Drought orders	0.00
DV7a(vi)	Tees to York Pipeline - NWL import 140 Ml/d	0.42
DV8(iv)A(i)	New north to south internal transfer connection A	0.36
DV8(v)A	New WTW (York) supplied by the river Ouse	0.69
R13	East Yorkshire Groundwater Option 2	0.48
R3	Increased River Ouse pumping capacity	1.32
R31a	Additional bankside storage at York WTW	0.01
R3a	River Ouse licence variation 1	0.20
R8g	New groundwater (Sherwood Sandstone) supply to existing North Yorkshire WTW	0.71
R91	New internal transfer to North Yorkshire WTW2.	0.00

11.5.1 Final plan cost of Carbon

The WRMP optimiser model provides a carbon (tCO2) cost for the embedded and operational carbon associated with the Grid SWZ solution programmes. As described in Section 9.1, we use a value of £354.67/tCO2e derived from the central carbon values per tCO2e as per Annex 1 in the BEIS approach[48].

The approach states that: "There is a significant range of uncertainty in the carbon values derived from any modelling. The differences in carbon price trajectories are often driven by either structural differences in modelling approaches or by differences in underlying scenario assumptions on future evolution of socioeconomic factors (for example, population or GDP forecasts). To capture the full range of uncertainty, a plus or minus 50% sensitivity range has been deemed appropriate around the central series."

To demonstrate this uncertainty, which is very relevant to the WRMP process, we applied the recommended plus or minus 50% sensitivity range to a central tCO2e cost estimate. In this calculation we converted the monetised carbon, that was based on the £354.67/tCO2e average unit cost, to a tCO2e volume for each option included in the preferred programme. Next, we summed the annual values then multiplied the total annual emissions volume by the central, low and high cost estimates for tCO2e provided in the BEIS approach.

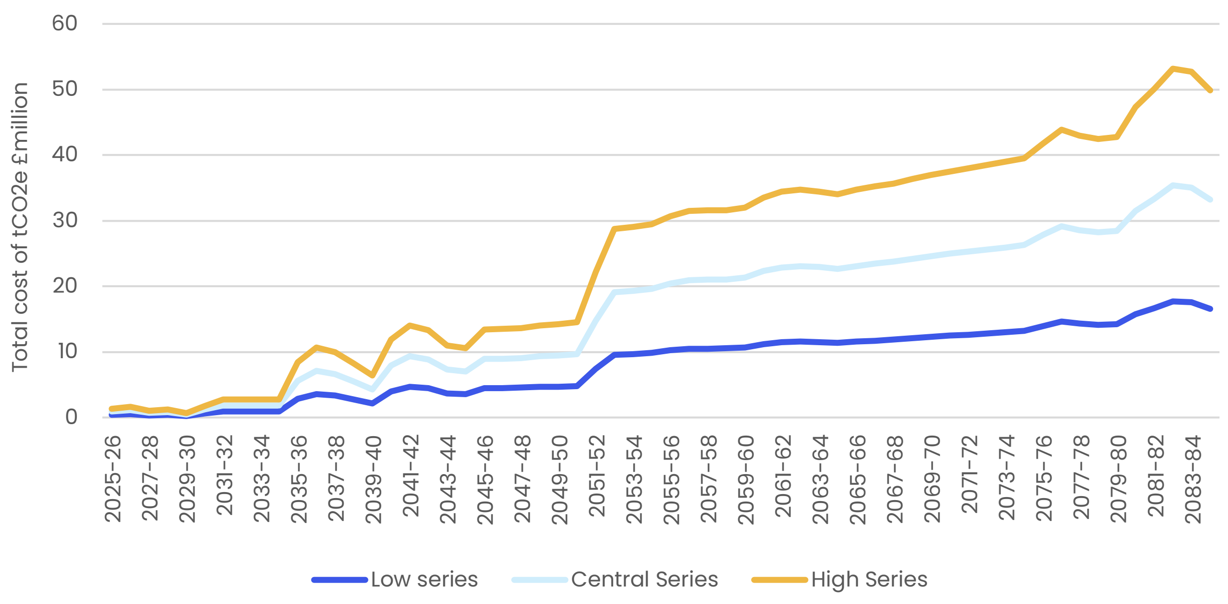
The BEIS approach carbon costs are only available up to 2050, whereas the WRMP planning period is to 2084/85. To extend the period in each of the three emission scenarios, we followed the advice in the BEIS approach and applied a real annual growth rate of 1.5% to derive the annual carbon cost from 2050/51 to 2084/85.

Figure 11.4 compares the low and high costs for the preferred plan solution programme to the central.

If no action is taken, the tCO2e costs will increase over time as the unit cost increases and as more schemes are implemented, and therefore daily operational carbon increases. The "spikes" in tCO2e costs represent the supply scheme delivery and the build carbon which is only applicable during the construction phase. The operation carbon accumulates over time as more schemes are delivered. The demand reduction schemes reduce the average total volume of water treated and put into supply each day, and this benefit is built into the forecast, however, the overall impact is a cost increase.

To offset carbon emissions, between now and 2050 we are working towards net zero carbon at a company level, and this is discussed in Section 11.7.

Figure 11.4: WRMP24 final plan scenario greenhouse gas emission estimates



11.6 Bill impact

The estimated bill impacts of our preferred plan have been calculated for each AMP period from 2025 to 2050 and presented in Table 11-7. The initial increase per annum will be around £6, this rises in AMP9, 10 and 11 with a minor reduction in AMP12 when the total bill impact is £23 per annum.

The largest increases are in AMP9 and AMP10. The AMP8 increase includes new supply sources in the early part of the plan. We shall also start to deliver the backfill scheme to prepare for the loss of the STW import. In AMP9 we will complete this scheme and start to deliver the Tees to York pipeline, which will continue into AMP10. As no further large supply schemes are needed until post 2050, bills start to stabilise in AMP11 and 12.

Table 11-7: Average bill increase per annum (costs shown in CPIH 20/21 price base)

Average bill increase per annum in each AMP for the preferred plan					
AMP 7	**AMP 8**	**AMP 9**	**AMP 10**	**AMP11**	**AMP12**
-	5.63	14.10	22.59	25.09	22.74

Where possible we try to spread the cost of the plan to achieve intergenerational equity for the benefit of future generations. This includes environmental and social impacts as well as financial. Our WRMP24 bill impact includes prices rises that are triggered by essential investment to offset key reductions in supply in 2035 when the STW transfer ceases and 2040 when there is a large sustainable reduction on the River Derwent. We stress tested the plan using a reduced discount rate and the total cost of the plan (NPV in £millions) was £1950m compared to £1620m in the preferred plan.

11.7 Carbon net zero

Transitioning to net zero carbon emissions is one of the six key outcomes of our forward business plan, and a key responsibility of our business in support of the national and international decarbonisation plans to mitigate the impact of greenhouse gas emissions by 2050.

In 2019/20 Yorkshire Water joined other companies in the UK water sector by making a public commitment to deliver net zero operational carbon emissions by 2030 covering our Scope 1 and 2 emissions and directly outsourced Scope 3 emissions. This was communicated in a Public Interest Commitment (PIC) made by water companies through Water UK, which states that "…we commit to work together [to]… Achieve net zero carbon operational emissions for the sector by 2030. In July 2021, in response to the PIC, we published some high-level information setting out our response to the commitment on our website[55]. Following the commitment there was also extensive work undertaken by Water UK and member companies leading to the development of a 2030 Routemap to net zero. These are captured online through the Water UK Net Zero 2030 Routemap Summary[56] and the Water UK Net Zero 2030 Full Routemap[57].

Understanding scopes 1, 2 and 3

Scope 1: greenhouse gas emissions from sources that we own or control directly, such as burning fossil fuels on our sites or emissions released during treatment processes.

Scope 2: greenhouse gas emissions indirectly released to the atmosphere through our purchase of electricity and heat.

Scope 3: other indirect greenhouse gas emissions associated with our activities in our value chain, such as emissions associated with purchased goods and services, capital goods, upstream and downstream transport etc.

[55] https://www.yorkshirewater.com/environment/climate-change-and-carbon/our-carbon-strategy/
[56] https://www.water.org.uk/sites/default/files/2023-08/Water-UK-Net-Zero-2030-Routemap-Summary-updated.pdf
[57] Water UK Net Zero 2030 Full Routemap

Our progress in reducing our carbon emissions to date includes:

- Purchasing 100% of our electricity from renewable sources.
- Transitioning approximately 18% of our light commercial fleet to electric vehicles, with plans to achieve 100% by 2030 (see below).
- Reducing our on-site use of fossil fuels and switching to lower carbon alternatives.
- Use of nature-based solutions for wastewater treatment to reduce process emissions.
- Peatland restoration and tree planting across our upland estate to store and sequester carbon.
- Installing renewable energy generation technologies, such as solar arrays, on our water and wastewater treatment sites.

In our business plans out to 2030 we have incorporated a further £51m to progress these reductions and address our process emissions.

To ensure we stay on track our emissions are independently verified each year against the ISO 14064-1 Carbon Footprint Verification standard. This helps to ensure we understand our emissions and where we need to focus our reduction efforts.

11.7.1 Our journey out to 2050

We have also set out in our long-term delivery strategy a commitment to further investment in:

- process emissions reduction particularly those related to nitrous oxide,
- reduction in our use of chemicals,
- decarbonisation of purchased goods and services and
- decarbonisation of capital goods.

The latter three investments are key scope 3 emissions which form a significant part of our wider indirect emissions. Addressing these is both linked to our procurement strategy, but also in our approach to assessing best value and avoiding locked in carbon.

Our commitment is to reduce emissions across all scopes by 90% by 2050 in line with the UK Government's net zero glide path and the baseline set out in the UK's sixth carbon budget.

In support of this, we aim to set science aligned targets, deliver a 90% absolute reduction and net off the residual 10% emissions. To deliver the final 10% will we use a combination of carbon insets from peatland restoration and woodland creation schemes on our own land and through the purchase of high-quality (verified carbon standard or gold standard) carbon offsets.

The scope 3 emission reduction pathway requires a range of strategies including investment in low carbon technologies, targeting low carbon goods and services and through addressing carbon reduction across the life of new or upgraded assets through our approach to best value solutions (See Section 9).

We aim to decouple carbon from growth and to continually reduce the intensity of carbon measured a tonnes of carbon dioxide equivalent per ml (tCO_2e/Ml).

More details of our AMP 8 plans and long-term delivery strategy can be found in our business plans: https://www.yorkshirewater.com/about-us/our-business-plan/

11.7.2 WRMP24 and net zero

Our net zero transition planning considers key factors set out in this draft WRMP and related plans including the expectations for demand, quality of water and growth and climate change scenarios etc.

Our carbon plans use these forecasts to evaluate for modelling purposes the likely impact in terms of operational emissions associated with changes in required energy for pumping and treatment, chemicals for treatment, vehicles to service and maintain operations, for example. These are mapped against decarbonisation plans and used to inform our net zero investment plans over the period out to 2050.

The final WRMP provides a view of growth projections and required changes in assets that will impact both our operational emissions and embedded emissions from our capital programme, and optioneering for low carbon solutions including nature-based solutions. These considerations are a key element of our 10-year corporate strategy that includes net zero as a core objective.

There will be various factors that impact our carbon emissions moving forward including those that create uncertainty in our emissions such as:

- Increased demand and pace of demand management.
- Growth both scale and nature.
- Quality requirement and scale of new asset development to meet these requirements.
- Rate of decarbonisation of scope 2 purchased electricity as the grid moves over to higher % mix of renewable derived energy.
- Consequential reduction in embedded scope 3 emissions associated with energy use.
- Efforts by our partners supply chain partners to reduce their scope 1 and 2 emissions (our scope 3 emissions).

Some of these factors present headwind and tailwinds to our emission reduction efforts and we continue to refine our models and use these to forecast emissions and the scale of investment required to address these emissions.

Parametric uncertainty is a key part of all carbon assessment – and is taken into account as part of our analysis and forecast of emissions. This is inherent to the use of standard emission factors, and inventories of carbon emissions for products, and we work to refine our analysis over time and use the most up to date factors and assessment methodologies in line with the principles set out in the Greenhouse Gas Protocol.

12 WRMP24 next steps

Our WRMP24 preferred 'best value' plan has been created to address the supply-demand balance risks and wider objectives identified during the process of collating the plan, in parallel to the WReN Regional Plan. Following approval by the Secretary of State to publish our plan as final, our focus will turn towards the development of the best-value supply and demand options required in the short to medium term. As an adaptive plan, future tracking and monitoring against our plan is key to effective delivery, along with further or ongoing work in a number of key areas. We will commence work towards WRMP29 shortly after the finalisation of WRMP24, allowing us to bolster key areas of our planning process to further develop our plans to meet the longer-term uncertainties and challenges we face.

12.1 WRMP24 plan development

WRMP24 has highlighted a much greater level of supply-demand need and risk than WRMP19 for Yorkshire Water. As such, our best-value adaptive plan has defined investment to ensure we can tackle pressing supply-demand needs in the earlier part of the planning horizon (along with improving supply resilience), whilst also over time allowing us to account for and address significant longer-term risks and needs such as environmental destination. The plan also includes stretching new targets for demand management and leakage reduction and are influenced by the benefits of future government policy interventions on water labelling and building regulations.

Many of the risks and needs only came to light relatively late in the production of the draft WRMP24. For example, as recently as January 2022 when the Emerging WReN Regional Plan was published, the most likely outcome was still that the existing Severn Trent Water (STW) transfer / import would be retained and the BAU+ environmental destination (baseline scenario) impact would be zero (i.e., no loss of permitted abstraction rights). At that stage, the retention of the STW transfer was subject to the conclusion of the Upper Derwent Valley SRO and we were preparing options for backfilling the loss if it was needed. The deficit driven by climate change was offset by the policy demand reduction benefits and therefore our options appraisal was focused on the loss of the STW import and where our system could benefit from small, localised options (that would meet resilience requirements whilst increasing our available supplies during peak demands).

By the time of submitting our draft WRMP24 for consultation, regulatory clarifications had resulted in a revised BAU+ environmental destination assessment with a significantly higher impact. The outcomes of the spring 2022 inter-regional reconciliation exercise also confirmed that the most likely plan for STW / Water Resources West (WRW) was to cease the existing STW import, although we retained an adaptive pathway at that stage should it be possible to retain it (subsequent to further work on the Upper Derwent Valley SRO). The production of the plan also took place against the backdrop of the (at that time) ongoing 2022 drought event, the most severe drought in the Yorkshire Water area since 1995/96.

Our final WRMP24 takes account of the valuable feedback provided through public consultation, includes targeted refresh of technical assessments, and reflects the latest inter-regional reconciliation position from Summer 2023 (which confirmed that STW would cease the existing STW import by 2035 in all scenarios). We have considered any relevant findings from our lessons learnt on the 2022 drought.

Whilst we are confident that we have developed a robust best-value plan, there remains further work to refine our plans in the longer-term, supported by more investigation work beyond WRMP24. In the longer-term, it may be necessary to move from one adaptive pathway to another, depending on how the future turns out compared to our most-likely forecasts. All these aspects bring about a strong need for tracking and monitoring against our future plan and require ongoing activity in a number of areas related to the plan.

Our key next steps for implementation, tracking, monitoring, and further development of our long-term plan are outlined in the following sections.

12.2 WRMP24 delivery to AMP8 (to 2030)

We have pressing short-term supply-demand challenges to address, and therefore the following activities are a priority:

- **Continued implementation of our WRMP19 plan towards enhanced AMP8 demand management and leakage reduction** - in particular for leakage reduction and demand management, whilst also moving towards implementation of our enhanced AMP8 programme of demand management and leakage reduction. We have already committed to provide further information on our planned activities as part of the most recent Annual Review.
- **Progressing delivery of AMP8 supply-side schemes** – Now that the preferred plan options have been identified, further detailed development work will take place when these become formal projects for implementation. These will include further consultation and involvement with stakeholders where appropriate with regards detailed design, environmental impact assessment, planning requirements, consents, and mitigation measures. We will provide quarterly updates to the Environment Agency on options delivery progress.
- **Progression of our Strategic Resources Options investigations** – To accelerate the development of key water supply infrastructure, we will complete a programme of SRO investigations. This will include solutions to offset the loss of the Upper Derwent Valley transfer from Severn Trent Water in 2035. In AMP8, we will also work collaboratively with Northumbrian Water and United Utilities as part of the Kielder SRO. This will review the potential strategic options to use the underutilised Kielder Reservoir (in Northumbrian Water's supply area) and will further consider variants the Tees-transfer import from Northumbrian Water required by 2040.
- **Further investigation of environmental destination needs and solutions** – The river Derwent in particular has a high long-term potential impact on our future water supply needs, and the final requirements (subject to further assessment) have the potential to alter our long-term plans. Further investigation of the best solutions to meet required environmental drivers is required. We have a plan for assessing the river Derwent risk, through our AMP8 WINEP investigation and also through the work that the Environment Agency and Natural England are undertaking, to understand the full impacts of naturalising the river, at a catchment level. Our preference is that the investigations will involve other sectors and water users and not be solely focused on public water supply needs. The river Derwent investigations will influence the decision on the changes to the river, and if the weir and barrage will be removed and by when. The first River Derwent WINEP investigation is due to conclude in December 2026 to inform WRMP29 plan development.

Further activities towards WRMP29 are also explained in Section 12.4.

12.3 Reviewing and monitoring our position

As we move towards implementation of our WRMP24, tracking and monitoring is key both in terms of delivery of the identified interventions in the preferred plan (Section 10) and in tracking the supply-demand position noting the key uncertainties identified (Section 6 and Section 10.1).

The key mechanisms for this are via the Annual WRMP review and reporting process to regulators, supported by regular liaison meetings between Yorkshire Water and the Environment Agency. Given the importance of early delivery schemes and options development to the supply-demand balance, particularly in the short-term, we commit to provide quarterly update reports on progress through our Environment Agency Account Manager meetings.

Key areas of activity include:

- Considering our position against the monitoring plan in the context of the adaptive plan as detailed further within Section 10.3, which defines key tipping points over time. We will track these major areas associated with our adaptive plan, which include:
  - Monitoring our progress against our stretching demand management and leakage outcomes, which are critical to ensuring a robust supply-demand position. We will regularly review the benefits being realised from our interventions.
  - Tracking the implementation of both small- and large-scale options development, both in terms of programme, feasibility and, ultimately, benefit realisation.
  - Reviewing the latest outcomes of environmental destination investigations, particularly on the River Derwent, which have a significant impact on our long-term plans.
  - Non-household energy sector growth, which is a specific area for ongoing engagement and monitoring associated with hydrogen production. This is reflected in our adaptive plan, given the potential for step changes in future demand needs.
- Beyond these major adaptive plan areas, we will routinely monitor our overall supply-demand position and trends in the underlying components against our WRMP24 forecasts, particularly related to the uncertainty areas documented in Section 6.6 (including customer PCC, population and property growth, non-household demand and process losses). This may identify further actions and / or investigations to understand any material changes or patterns observed.
- Reviewing our plan delivery position regularly with the WReN regional planning group, supported by engagement with stakeholders, regulators, and other regional groups.
- Tracking the implementation and roll-out of future government policy interventions

12.4 Towards WRMP29

With the step change in the future supply-demand challenge and therefore planning need for Yorkshire Water, the WRMP24 process has identified a number of areas for immediate progression towards WRMP29. We commit to progress this work, so that we can further refine our long-term best-value position in future. Key areas include, but are not limited to:

- **Further options identification work** – The scale of the long-term supply-demand challenge brings about the potential need for more feasible options. This will enable us greater choice in future preferred plan development in the longer-term. We commit to undertake an extensive review of feasible options, working with third parties and WReN as appropriate, in readiness for WRMP29.

- **Investigation of water transfers** - As documented in the *Inter-regional Reconciliation 3: Summary report*, there are currently no transfers in the preferred plans from Yorkshire Water (WReN) to Anglian Water (part of Water Resource East region), or adjacent companies in the Water Resources West region (Severn Trent Water and United Utilities). As we work on our wider feasible options portfolio, and as the outcome of relevant WINEP investigations are completed, we commit to explore further the potential for transfers in readiness for WRMP29 with neighbouring companies. This exercise will benefit from a consolidated plan position across all companies from WRMP24 to build upon.
- **Industry engagement and collaborative activity** – We will continue to engage fully with regulators and the industry (including NAVs) via the relevant forums, supported by pool UKWIR projects at a detailed technical level. This will ensure that we are ready to adopt the latest good practice methods and datasets. We envisage the need to track the potential for revised stochastic and climate change datasets, and to understand experiences from demand management delivery in other areas to inform our own future approach.
- **Working closely with WReN and other regional planning groups** – Our WRMP interfaces with the broader national and regional planning tier, and the next Water Resources National Framework will have a strong influence on our WRMP. We will work continue to work closely with WReN, and in particular this will support our activity to explore potential third party options, and / or those that may provide conjunctive benefit with future non-public water supply. We will also work closely with the non-public water supply sectors groups to explore short to longer term areas of demand growth.

- **Derwent Habitats Regulations Assessment** – As noted in section 3.8.4, we are committed to working with Natural England and the Environment Agency to progress the Derwent WINEP investigation which will include assessing any impacts of our Derwent abstraction on European sites. We acknowledge the uncertainties surrounding the potential impacts of existing water management activities and are committed to working collaboratively with Natural England to conduct an assessment to feed into WRMP29 to include consideration of existing abstractions and any changes that are relevant to relevant risks. This includes cumulative and in combination effects. We are committed to contributing to obtaining the required evidence to resolve the issues raised (for example via the WINEP programme) so that the information is available for WRMP29 plan development and for any annual reviews of our WRMP prior to WRMP29.

13 List of tables

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16 Glossary of terms

Abstraction Licences	An abstraction licence gives you a right to take a certain quantity of water from a source of supply (inland water such as rivers or streams or an underground source).
Adaptive pathways	Adaptive pathways indicate how the plan would change within an adaptive plan according to the decisions and steps that could be taken over time. Each pathway is a portfolio of options with a schedule of dates for when each option will be implemented.
Adaptive plan	An adaptive plan is a framework which allows you to consider multiple preferred programmes or options and sets out how you will make decisions within this framework. It responds to future uncertainties by setting out a sequence of manageable steps or decision-points when these are required and how it will be monitored.
AISC	Average Incremental Social Cost
Alternative plans	Several plans (as selection of options with an implementation schedule) may be developed through the water resources management planning process. Different or 'alternative' plans can be compared against a 'preferred plan.'
AMP	Asset Management Period (5-year price review period)
AMP6	Planning period 2015-16 to 2019-20
AMP7	Planning period 2020-21 to 2024-25
AMP8	Planning period 2025-26 to 2029-230
Baseline	A description of the present and future state, before any the adjustments due to changes or losses (e.g., due to development).
Best Value	An approach that considers other factors alongside costs when comparing different options e.g., other factors such as the environment, resilience, and customer preferences.
BL	Background Leakage.
BRE	Building Research Establishment.
CAMS	Environment Agency's Catchment Abstraction Management Strategies (local licensing strategies that set out how water resources will be managed within a catchment area).
Catchment Based Approach (CaBA)	The Catchment Based Approach (CaBA) is a community-led approach that engages people and groups from across society to help improve our precious water environments: https://catchmentbasedapproach.org/
Catchment Plan (CP)	A catchment plan identifies the key issues within a catchment and prioritises work which will improve the catchment holistically. This puts the catchment in a better position to achieve Water Framework Directive (WFD) targets, as well as other environmental and social goals: Catchment Planning | The RRC (https://www.therrc.co.uk/catchment-planning)
CCP	Constraint Challenge Process

COPI	Construction Output Prices Index
CROW Act	Countryside and Rights of Way Act 2000
DCL	Drought Control Line
DCM	Domestic Consumption Monitor
Decision-making metrics	Decision-making metrics are associated with developing an optimised best value plan. They sit beneath the overarching objectives to be achieved in the plan and might include measures of cost, environmental, social, and supply-demand benefits. Each metric is a criterion used to appraise option programmes or portfolios, towards identifying an overall best-value plan. They describe wider aspects of interest to regional water resources planning, beyond simply meeting supply-demand at least-cost as in traditional water resources planning.
Defra	Defra is the Department for Environment, Food and Rural Affairs and is the UK government department responsible for water resources in the UK.
Deployable Output (DO)	Deployable output is a building block in determining water supplies available for use and is defined as the output for specified conditions for a water resources system as constrained by; hydrological (source) yield; licensed quantities; abstraction assets; raw water transfer assets; treatment; water quality; and levels of service.
DMA	Distribution Management Area - Yorkshire Water leakage control zone (also known as District Metered Area).
Dry Year Annual Average (DYAA)	Represents a period of low rainfall and unrestricted demand and is used as the basis of a water company's resources management plans.
DWI	Drinking Water Inspectorate
ELL	Economic level of leakage
Environment Agency (EA)	The Environment Agency (EA) is an executive non-departmental public body, sponsored by the Department for Environment, Food & Rural Affairs. They are responsible for environmental regulation in England and includes producing and updating River Basin Management Plans.
Environmental Destination	Describes a long-term destination (to 2050 and beyond) for environmental improvement and sustainable abstraction considering factors such as climate change impacts and future demand.
EVA	Extreme Value Analysis – methods of assessing the severity and return periods of extreme events.
Feasible options	A set of options that are suitable to assess for inclusion in the preferred plan. Feasible options are identified from a longer list of options by a process of *screening* to remove options with constraints that make them unsuitable for further promotion.
GCM	Global Circulation Models
GWZ	Groundwater Zone (Environment Agency Water Resource Zone)

Habitats Regulations Assessment	A competent authority must decide if a plan or project proposal that affects a European site can go ahead. A European site is protected by the Conservation of Habitats and Species Regulations 2017 as amended (known as the Habitats Regulations). A habitats regulations assessment (HRA) under the Habitats Regulations, is applied to test if a plan or project proposal could significantly harm the designated features of a European site in England and Wales and their inshore waters (within 12 nautical miles of the coast).
Headroom	The difference between water available for use and demand at any given time.
HOF	Hands Off Flow licence conditions that require abstraction to cease (or reduce) when river flows fall below a specified level.
KAMS	Key Asset Management System – Yorkshire Water asset reporting system.
l/h/d	Litres per head per day
LoS	Level of–service - Frequency with which the different types of specified actions would need to be taken during dry weather periods to help maintain the water supply.
LwW	Living with Water – A partnership with the aim to build understanding across Hull and the East Riding about the threats and opportunities water brings to our region.
Ml/d	Mega litres per day
MLE	Maximum Likelihood Estimation
MSL	Marginal Storage Line
Multi-criteria analysis (MCA)	Multi-criteria analysis is a structured technique for assessing options against a number of distinct objectives whose performance can be measured against a number of distinct objectives. It can also be used to explicitly explore the trade-offs between different candidate plans to inform the selection of preferred or alternative plans.
National Environment Programme (NEP)	The NEP outlines the improvements which water companies are required to undertake in order to comply with new or amended environmental legislation over the next planning period and includes identifying investigations to be undertaken that will inform potential investment requirements in subsequent planning periods.
National Framework	The Environment Agency's National Framework explores England's long-term water needs and sets out the scale of action required for a resilient water supply that meets the needs of the future generation. It sets out a greater level of ambition for restoring, protecting and improving the environment that is the source of supply.
Natural Capital	The environment's stock of natural assets that support life including water, soil, air, minerals, and ecosystems.
NCL	Normal Control Line
Night flow	A night flow is a monitor of flow during the night, when water consumption is typically at its lowest. Monitoring the night flow allows leaks to be detected where increases or changes in consumption are picked up.

Non- Households	Properties receiving portable water supplies that are not occupied as domestic premises.
Non-Governmental Organisations (NGOs)	NGOs are typically voluntary groups of individuals or organizations that are not affiliated with any government and are formed to pursue purposes of public interest.
Non-public water supply (non-PWS)	Non-public water supply is any water supply that is not provided by a water company.
NPC	Net Present Cost
NPV	Net Present Value
Ofwat	Economic regulator for the water industry
Ofwat	The Water Services Regulation Authority, or Ofwat, is the body responsible for economic regulation of the privatised water and sewerage industry in England and Wales. The Environment Agency is responsible for environmental regulation, and the Drinking Water Inspectorate for regulating drinking water quality.
Per Capita consumption (PCC)	The amount of water typically used by one person per day.
Per Capita consumption (PCC)	The amount of water typically used by one person per day.
Per Household Consumption (PHC)	The average amount of water used in a household property each day, usually presented as litres per property per day.
PMZ	Production Management Zone – Yorkshire Water operational planning zone.
PR14	Price Review submission to Ofwat 2014
PR19	Price Review submission to Ofwat 2019
Preferred options	The set of water resources options included in the preferred plan.
Preferred Plan	A set of options that has been selected through the water resources planning process which are shown to perform better against the objectives of the plan.
Preferred Plan	A set of options that has been selected through the water resources planning process which are shown to perform better against the objectives of the plan.
Regional Climate Model (RCM)	A regional climate model is a numerical climate prediction model forced by specified lateral and ocean conditions from a general circulation model (GCM) or observation-based data set that simulates atmospheric and land surface processes, while accounting for high-resolution topographical data, land-sea contrasts, surface characteristics, and other components of the Earth-system. https://glossary.ametsoc.org/wiki/Regional_climate_model
Regional plan	A long-term multi-sector adaptive water resource plan.
Regulators' Alliance for Progressing Infrastructure Development (RAPID)	RAPID was formed to help accelerate the development of new water infrastructure and design future regulatory frameworks and is a joint team is made up of the three water regulators Ofwat, Environment Agency and Drinking Water Inspectorate.

Representative Concentration Pathway (RCP)	A greenhouse gas concentration trajectory adopted by the Intergovernmental Panel on Climate Change (IPCC). Different pathways were used for climate modelling representing different climate futures which could arise depending on the volume of greenhouse gases emitted over time.
River Basin Management Plan (RBMP)	River basin management plans (RBMPs) describe the challenges that threaten the water environment and how these challenges can be managed and funded. The plans are based upon a detailed analysis of the pressures on the water bodies within the river basin district and an assessment of their impacts. They set out the environmental objectives for the water bodies and a summary of the programme of measures that will be taken to achieve them.
SAC	Special Area of Conservation
Screening	The process where options are filtered using a set of screening criteria that determines whether they have constraints that make them unsuitable for further promotion. Defined screening criteria are used to ensure options are screened consistently. There may be several iterations of screening before a feasible list of options is determined.
SDS	Strategic Direction Statement
SEA	Strategic Environmental Assessment
SELL	Sustainable economic level of leakage
SPA	Special Protection Area
SRO	Source Reliable Output or Strategic Resource Option
SSSI	Site of Special Scientific Interest
Strategic choices	Strategic choices are the key decisions to be taken in developing the plan and maybe regional or company or zone specific.
Strategic Environmental Assessment (SEA) European Directive 2001/42/EC	'An assessment of the effects of certain plans and programmes on the environment.' Transposed into UK law via The Environmental Assessment of Plans and Programmes Regulations 2004.
Strategic Resource Options (SROs)	Large-scale, inter-region strategic transfers of raw water being considered by companies and regional groups and supported by *RAPID* (see above).
Stress Testing	A process to test the resilience of a plan against future uncertainties.
Supply-demand balance (SDB)	Supply minus demand and target headroom. An annual average presented for each year of the planning horizon (2025-2085).
Sustainability reduction	A sustainability reduction is the reduction in water company deployable output due to a sustainability change to a licence, driven by environmental legislation or need. A sustainability reduction is calculated by the water company and included in its WRMP and would be linked to expected or possible interventions to be included in the WINEP.
SWZ	Surface Water Zone (Environment Agency Water Resource Zone)

Target headroom	This is a quantified *headroom* based on statistical analysis of uncertainties which is factored into the supply and demand balance estimates.
TLL	Time Limited Licence
UKCP09	United Kingdom Climate Projections 2009
UKCP18	United Kingdom Climate Projections 2018
Unconstrained list of options	A list of possible water resource options that could reasonably be used in the plan before they are filtered (screened) using a set of defined screening criteria which will determine those that are unsuitable for further promotion.
WAFU	Water Available For Use
Water Framework Directive (WFD) 2000/60/EC	A piece of EU legislation that requires all member states to make certain steps to protect and improve the quality and quantity of water within water bodies such as lakes and rivers.
Water Industry National Environment Programme (WINEP)	WINEP represents a set of actions that the Environment Agency have requested all 20 water companies operating in England, to complete between 2020 and 2025, in order to contribute towards meeting their environmental obligations. https://data.gov.uk/
Water Resource Zone	The WRZ is the principal building block used by companies to develop forecasts of supply and demand and produce a supply-demand balance (SDB). UKWIR/Environment Agency defines the WRZ as: "The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers will experience the same risk of supply failure from a resource shortfall."
Water Resources Investment Optimiser	Water Resources Investment Optimiser
Water Resources Management Plan (WRMP)	WRMPs are developed and published by water companies. They set out how water companies intend to achieve a secure supply of water for their customers and a protected and enhanced environment. The plan forecasts supply and demand over at least the statutory minimum period of 25 years. If a deficit is forecast, then the plan should consider supply-side options to increase the amount of water available and demand-side options to reduce the amount of water required. These plans are prepared every 5 years and reviewed annually and the two numbers following 'WRMP' indicate the year the plan is published.
What-if scenarios	This approach is applied to test proposed plans and explores what would happen if the future was different to that assumed in the forecast. For example, what if the impacts of climate change were more than assumed for the forecast or population growth was lower than forecast.
WRAP	Water Resources Allocation Plan (water supply network model)
WRAPsim	Water Resources Allocation Plan simulation (water network simulation model).
WRZ	Water Resource Zone
WTP	Willingness to Pay Survey
YWS	Yorkshire Water Services Limited

17 Appendices

17.1 Appendix A.1: Yorkshire Water unconstrained list of options

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
C10	Greywater supply to industrial customers	Household water recycling	Customer Options	YWSGRD	Benefits are uncertain as it is not known if industrial uses would participate and accumulate a sizeable benefit.
C14	Customer platform	Water efficiency customer education / awareness	Customer Options	YWSGRD	Potential to develop as part of our water efficiency strategy but this would be an enabler to other initiatives and not a standalone option
C16	Household flow regulator-external	Other water efficiency	Customer Options	YWSGRD	This is an alternative to C15 however, there is uncertainty over the savings and longevity of the scheme. This alternative would be high cost and intrusive to customers and the C15 scheme is considered more feasible.
C17	Household self-fit packs	Other water efficiency	Customer Options	YWSGRD	Already offer free packs and evidence shows low savings
C3	Compulsory metering	Metering compulsory	Customer Options	YWSGRD, YWSEST	Yorkshire Water not classified as a water stressed area
C7	Commercial water user audits and retrofit - customer pays	Non-household water audit	Customer Options	YWSGRD	Variation on C6 option, constrained out as there is no evidence customers would pay for the service making the benefits too uncertain
C8	Business customer supply pipe leakage/plumbing loss reduction	Other water efficiency	Customer Options	YWSGRD	Business customer service is under the control of commercial retailers. This option requires agreement with retailers and no agreements are currently in place.

C9	Greywater supply to domestic customers	Household water recycling	Customer Options	YWSGRD	Option is technically feasible but success of delivery uncertain as would require housing developers to deliver or homeowners to retrofit homes. This type of activity is considered as an innovation project and may become a scheme in the future.
D16a	Trunk main active leakage control A	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D16b	Trunk main active leakage control B	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D16c	Trunk main active leakage control C	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D16d	Trunk main active leakage control D	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D16e	Trunk main active leakage control E	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5a	Trunk main metering and logging A	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5b	Trunk main metering and logging B	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation

D5c	Trunk main metering and logging C	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5d	Trunk main metering and logging D	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5e	Trunk main metering and logging E	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5f	Trunk main metering and logging F	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5g	Trunk main metering and logging G	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5h	Trunk main metering and logging H	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5i	Trunk main metering and logging I	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D5j	Trunk main metering and logging J	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation

D9a	High tech active leakage control A	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9b	High tech active leakage control B	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9c	High tech active leakage control C	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9d	High tech active leakage control D	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9e	High tech active leakage control E	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9f	High tech active leakage control F	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9g	High tech active leakage control G	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9h	High tech active leakage control H	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation

D9i	High tech active leakage control I	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
D9j	High tech active leakage control J	Active leakage management	Distribution Options	YWSGRD	Modelling confirmed that the unit cost of MLD reduction or resource efficiency for this option is not preferential to other solutions for the duration of the optimisation
DV11b	Increase grid supplies to South Yorkshire - raw	Conjunctive use	Resource Options	YWSGRD	Option is technically feasible but would require new connections and INNS risk of transferring raw water constrains it out
DV12c	River Don abstraction to South Yorkshire	New surface water	Resource Options	YWSGRD	EA licensing data showed water availability was 10%, which would not provide a reliable source of water
DV9a	New groundwater treated supply to South Yorkshire - link to existing connections	Conjunctive use	Resource Options	YWSGRD	This is a variation of option D6. As the resource is under WINEP investigation the scheme was not taken forward for scoping
DV9b	New groundwater raw water supply to South Yorkshire	Conjunctive use	Resource Options	YWSGRD	This is a variation of option D6. As the resource is under WINEP investigation the scheme was not taken forward for scoping
DV9c	New groundwater raw water export	External raw water bulk supply/transfer	Resource Options	Export	Resource under WINEP investigation
E01	West Yorkshire reservoir export	External raw water bulk supply/transfer	Resource Options	Export	Water would not be available in dry years
E03	South Yorkshire WTW export	External raw water bulk supply/transfer	Resource Options	Export	This scheme was considered as a potential outage resilience scheme for STW but not as WRMP scheme.
R10	West Yorkshire boreholes	New groundwater	Resource Options	YWSGRD	Borehole locations have not been identified within a feasible distance to existing WTW.

R11	South Yorkshire borehole	Conjunctive use	Resource Options	YWSGRD	R6 was considered to be the preferred and more reliable option for this resource
R12	East Yorkshire Groundwater Option 1	New groundwater	Resource Options	YWSGRD	Further investigation needed. May need risk assessment as increase in volume and frequency of operation but likely low risk as existing transfer straight to WTW
R14a	Minewater use - Option 1	New groundwater	Resource Options	YWSGRD	Water treatability concerns - heavy metals in water quality sampling data
R14b	Minewater use - Option 2	New groundwater	Resource Options	YWSGRD	Water treatability concerns - heavy metals in water quality sampling data
R16	Sherwood Sandstone boreholes	New groundwater	Resource Options	YWSGRD	No water is available for new abstraction licences in this area.
R17	Reuse abandoned third party GW source option 2	New groundwater	Resource Options	YWSGRD	Further investigation needed. May need consultation with EA around boreholes and INNS risk
R18	Reuse abandoned third party GW source option 3	New groundwater	Resource Options	YWSGRD	Further investigation needed. May need consultation with EA around boreholes and INNS risk
R19	Reuse abandoned third party GW source option 4	New groundwater	Resource Options	YWSGRD	Further investigation needed. May need consultation with EA around boreholes and INNS risk
R1a	River Ouse water treatment works extension- Option 1	Surface water enhancement	Resource Options	YWSGRD	Site location creates a flood risk and associated network upgrades are in a built-up area that makes the option infeasible. An alternative R1c option has been create in a new location that avoids the risks.
R1b	River Ouse water treatment works extension- Option 2	Surface water enhancement	Resource Options	YWSGRD	This option is the same as R1a but would make use of a greater volume (the daily maximum licenced limit) however it is infeasible due to the above reasons and uncertainty over whether the maximum volumes will be available in the future.

R2	River Ouse to York WTW	Surface water enhancement	Resource Options	YWSGRD	Further investigation needed. Will need risk assessment as new pipeline created with new washout points and also increase volume/duration into River Ouse main but likely low risk as pipeline from River Ouse to York and transfer is straight to WTW
R20	Dam Raising North Yorkshire Reservoir	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns.
R21	Dam Raising West Yorkshire Reservoir-1	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns.
R22	Dam Raising West Yorkshire Reservoir-2	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns.
R23	Dam Raising West Yorkshire Reservoir-3	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns.
R24	Dam Raising West Yorkshire Reservoir-4	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns.
R25a	Embankment raising: North Yorkshire reservoirs 1	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns
R25b	Embankment raising: North Yorkshire reservoirs 2	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns
R26	West Yorkshire catchment increase	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns
R27	Bankside storage (West Yorkshire)	Reservoir enlargement	Resource Options	YWSGRD	No significant additional benefits and environmental impacts high
R28	Extend reservoirs sideways (catchment)	Reservoir enlargement	Resource Options	YWSGRD	Safety risk of extending an existing reservoir and environmental impact concerns

R30	Use compensation reservoir as supply- North Yorkshire	Surface water enhancement	Resource Options	YWSGRD	It is unlikely there would be additional water in the compensation reservoir for use in supply. Also, likely to be significant objections from public and local groups
R32	New pumped storage reservoir- North Yorkshire	New reservoir	Resource Options	YWSGRD	High environmental impacts and likely to be significant objections from public and local groups
R33	New pumped storage reservoir- East Yorkshire	New surface water	Resource Options	YWSGRD	No onsite location to build storage
R35	River Aire Abstraction option 1	New surface water	Resource Options	YWSGRD	Further investigation needed. Issues with storage and would need consultation with EA and either mitigation at source or risk assessment
R36	River Aire Abstraction option 2	New surface water	Resource Options	YWSGRD	Constrained out as requires installing a pipeline through a built-up area of Leeds for treatment, which is unlikely to be feasible. Other River Aire options have been created.
R37	River Aire Abstraction option 2	New surface water	Resource Options	YWSGRD	Alternative abstraction location closer to WTW identified - R37b(ii)
R38	River Trent abstraction	New surface water	Resource Options	YWSGRD	No new supplies identified from the River Trent
R39	River Don abstraction	New surface water	Resource Options	YWSGRD	This scheme will take flow from downstream and release upstream to compensate the river, allowing greater reservoir releases to go into supply. The downstream water quality would not be acceptable to the upstream environment. Water may not be available at low flows.
R40	North Yorkshire reservoir enhancement	New surface water	Resource Options	YWSGRD	This scheme would pump water from the River Wharfe to an existing reservoir. The reservoir is currently used to support the river so the scheme would not be viable.

R43	Scarborough to Middleton main	Internal potable transfer	Distribution Options	YWSGRD	Potential resilience scheme but no water resource benefit
R44	Malton to Middleton main	Internal potable transfer	Distribution Options	YWSGRD	Potential resilience scheme but no water resource benefit
R45	North Yorkshire main	Internal potable transfer	Distribution Options	YWSGRD	There is no potential to increase abstraction from Grimwith without creating a risk of not meeting the compensation requirements. A licence variation (R90) to transfer more water to North Yorkshire via an existing connection is being considered to reduce pumping from the river but this would mean a corresponding reduction in the river abstraction.
R5	Aquifer Storage and Recovery Scheme 1	Aquifer recharge/Aquifer storage recovery	Resource Options	YWSGRD	May need further investigation
R50	Raw water license variation	External raw water bulk supply/transfer	Resource Options	YWSGRD	Constrained out as need can be met by NWL existing licence.
R52	Tees-Wiske transfer Scheme	External raw water bulk supply/transfer	Resource Options	YWSGRD	Constrained out as the environmental impact would not be acceptable - INNS risk and volume too high for receiving watercourse
R53	NWL transfer- Option 1	External raw water bulk supply/transfer	Resource Options	YWSGRD	Constrained out as the environmental impact would not be acceptable - INNS risk
R55	North Yorkshire abstraction license variation	External raw water bulk supply/transfer	Resource Options	YWSGRD	Constrained out as the environmental impact would not be acceptable - INNS risk
R56	North Yorkshire to York pipeline license variation	External raw water bulk supply/transfer	Resource Options	YWSGRD	Constrained out as the environmental impact would not be acceptable - INNS risk

R57	Transfer from UU Option 1	External raw water bulk supply/transfer	Resource Options	YWSGRD	Constrained out as it is not clear if the water would be available in dry years when needed
R57(i)	Transfer from UU Option 2	External raw water bulk supply/transfer	Resource Options	YWSGRD	Constrained out as it is not clear if the water would be available in dry years when needed
R58	Transfer from UU Option 3	External potable bulk supply/transfer	Distribution Options	YWSGRD	Although the option is technically feasible the benefit is disproportionally low relative to the need.
R59	Transfer from UU Option 4	External potable bulk supply/transfer	Distribution Options	YWSGRD	Although the option is technically feasible the benefit is disproportionally low relative to the need.
R6	South Yorkshire Groundwater Option 1	Groundwater enhancement	Resource Options	YWSGRD	May need further investigation. May need risk assessment as increase in volume and frequency of operation but likely low risk as existing transfer straight to WTW
R62	North to East Yorkshire interconnector	Conjunctive use	Resource Options	YWSGRD	This option would provide resilience to a localised area but no new resource
R64	Tidal barrage at Hull	New technology	Resource Options	YWSGRD	Environmental concerns over impacts on the Humber Estuary
R65	River Ure abstraction	New technology	Resource Options	YWSGRD	This option would make use of sites that are owned and used by third parties e.g., aggregates and gravel suppliers near the River Ure. The benefits would be low, and the water quality is a potential risk.
R66	Use of canal water	Licence trading	Resource Options	YWSGRD	No locations identified and there is concern the water will not be available in dry years.

R67	Effluent reuse	Water reuse	Resource Options	YWSGRD	Innovation trials have delivered schemes with small benefits <0.5Ml/d. A third party large water user has been approached but not accepted due to water quality concerns.
R68	Dewatering of national rail tunnels	New groundwater	Resource Options	YWSGRD	Risks of poor water quality for public supply and uncertainty over yields
R69	Infiltration galleries	New groundwater	Resource Options	YWSGRD	This option is similar to the gravel pits and Doncaster recharge options. Yield likely to be low and availability is uncertain.
R6b	South Yorkshire Groundwater Option 2	Conjunctive use	Resource Options	YWSGRD	Resource under WINEP investigation
R6c	South Yorkshire Groundwater Option 3	Conjunctive use	Resource Options	YWSGRD	Resource under WINEP investigation
R6d	South Yorkshire Groundwater Option 4	Conjunctive use	Resource Options	YWSGRD	Resource under WINEP investigation
R7	Doncaster - river water recharge	Aquifer recharge/Aquifer storage recovery	Resource Options	YWSGRD	No guarantee recharging aquifer could provide water to go into supply. Also, water quality risks would need to be reviewed.
R71	Work with Internal Drainage Board to increase abstractions	New groundwater	Resource Options	YWSGRD	No certainty of yield availability
R73	Lower valves at West Yorkshire reservoirs	Surface water enhancement	Resource Options	YWSGRD	Option has been used during dry weather. In most circumstances and taking into account the impact on climate change on supply, the benefit would be limited by the need to maintain compensation flows unless accompanied by a drought permit to reduce the compensation, therefore not considered a long term option.

R74	Reservoir enhancement- West Yorkshire	Internal raw water transfer	Resource Options	YWSGRD	Benefit would conflict compensation requirements particularly if water supply reduced by climate change
R75	Catchment management	Catchment management	Resource Options	YWSGRD	Yorkshire Water has an ongoing catchment management programme
R77	Catchwater maintenance	Catchment management	Resource Options	YWSGRD	Yorkshire Water has an ongoing catchment management programme
R80	West Yorkshire to North Yorkshire pipeline	Internal raw water transfer	Resource Options	YWSGRD	Constrained out due to INNS risk
R81	East coast pipeline extension	New water treatment works	Resource Options	YWSGRD	Constrained out as high cost for low benefit
R82	Dales groundwater - reinstate sites	New water treatment works	Resource Options	YWSGRD	Groundwater sources closed in the past due to poor water quality could be reinstated with new licences and treatment processes. For WRMP24 focus has been on the Sherwood Sandstone aquifer as considered to provide a greater yield in a nearby location.
R8a	Sherwood Sandstone and Magnesian Limestone Boreholes option 1	New groundwater	Resource Options	YWSGRD	The location of this option was in a flood risk area and an alternative location was found - R8b
R8d	Sherwood Sandstone and Magnesian Limestone Boreholes option 4	New groundwater	Resource Options	YWSGRD	Constrained out as boreholes were located in flood zones and the raw water pipeline routes were travelling through flood zones. Also, the full proposed benefit of 30Ml/d may not be available.
R8e	Sherwood Sandstone and Magnesian Limestone Boreholes option 5	New groundwater	Resource Options	YWSGRD	This option was found to be located in flood zones and options R8f, g, and h were created to avoid the risk

R90	North Yorkshire Reservoir 1 licence variation	Surface water enhancement	Resource Options	YWSGRD	This option is a licence variation to increase an internal transfer from a reservoir to a WTW via an aqueduct. Flow released from the reservoir is also abstracted from the downstream river. There would be an equivalent reduction in abstraction at the downstream site, which would mean no increase to WAFU overall.
R92	Use compensation reservoir as supply- West Yorkshire	New surface water	Resource Options	YWSGRD	Will be reviewed for WRMP29. The reservoir status was uncertain at the time of options appraisal but if it will be available for supply in the future this could become a feasible option.
WReNB1	Bi-directional supply to Anglian Water	External raw water bulk supply/transfer	Resource Options	Export	Resource under WINEP investigation
WReNE4	Transfer to UU from North Yorkshire	External raw water bulk supply/transfer	Resource Options	Export	Constrained out - not technically viable and source required for Yorkshire Water plan

17.2 Appendix A.2: Yorkshire Water feasible list of options

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Gains in WAFU / Savings in Demand on full implementation (Ml/d)	Description
C11c	Retrofits of rainwater harvesting for households	Rainwater harvesting	Customer Options	YWSGRD	0.86	Household retrofits of rainwater harvesting and greywater recycling systems
C12a3	Rainwater harvesting for commercial customers	Rainwater harvesting	Customer Options	YWSGRD	2.01	Retrofits of rainwater harvesting systems are subsidised by YOW for large NHH users (3% NHH)
C13c	Household tariffs	Tariff	Customer Options	YWSGRD	0.39	Tariffs for smart metered HH. New meter installs/replacement customers only.
C15d	Installation of internal household flow regulators	Retrofitting indoor water efficiency devices	Customer Options	YWSGRD	0.48	Household flow regulator-internal
C18c	Leaky loo fixes	Other water efficiency	Customer Options	YWSGRD	0.14	Leaky loo detection and fixes as part of in person or virtual home audit efficiency visit scheme. For the number of visits undertaken this is given in VHEV summary
C1d	Household customer audits and water efficiency retrofits	Household water audit	Customer Options	YWSGRD	3.26	Home efficiency visits (HEV) - Targeted water efficiency audit with free water efficient device installation - In person or virtual. Excludes leaky loo fixes savings.
C2	Metering domestic meter optants (growth)	Other water efficiency	Customer Options	YWSGRD	18.14	Domestic Meter Optants due to growth

C21c	Community Incentives	Other water efficiency	Customer Options	YWSGRD	0.56	Community Incentives - targeted programme
C23b1	Rainwater harvesting for agriculture	Rainwater harvesting	Customer Options	YWSGRD	1	Retrofits of rainwater harvesting s ystems are costed by YOW for agriculture (9% NHH)
C27d	School visits	Other water efficiency	Customer Options	YWSGRD	1	School visits water efficiency lessons aimed at impacting behaviour at home
C28e	Household water efficiency media campaign	Other water efficiency	Customer Options	YWSGRD	1.71	Media campaigns to influence water use.
C29c	Household incentives	Other water efficiency	Customer Options	YWSGRD	0.13	Targeted incentives scheme - Individual customer/community reward (e.g., Greenredeem) - New meter installs/replacement customers only.
C30a	Water labelling-baseline	Other water efficiency	Customer Options	YWSGRD, YWSEST	39.6	Water Labelling Conservative (half Artesia) - Conservative Baseline
C30b	Water labelling-low demand	Other water efficiency	Customer Options	YWSGRD, YWSEST	191.28	Water Labelling Conservative (half Artesia) - Low CRS
C32c	Rainwater harvesting for households- new developments	Rainwater harvesting	Customer Options	YWSGRD	1.41	Working with developers so that rainwater harvesting is included in new HH developments.
C34a	Non-household water efficiency media campaign	Other water efficiency	Customer Options	YWSGRD	0.77	Online Communications - Media campaign and water online/app tools and resources.
C35c	Non-household water efficiency incentive scheme	Other water efficiency	Customer Options	YWSGRD	0.27	Rewards to water retailers for business water use savings

C36	Metering domestic meter optants (enhanced programme)	Other water efficiency	Customer Options	YWSGRD	4.5	Domestic Meter Optants enhanced policy
C37	Metering new developments (growth)	Other water efficiency	Customer Options	YWSGRD, YWSEST	4.31	New Developments due to growth
C4	Metering on change of occupancy	Metering change of occupancy	Customer Options	YWSGRD	18.7	A meter would be installed in unmeasured households on change of occupancy during house moves. The option has been calculated for change of occupancy over 25 years. This scheme would be a policy decision.
C5	Metering on asset end of life	Other water efficiency	Customer Options	YWSGRD, YWSEST	21.87	Yorkshire Water domestic customers paying for a metered supply currently have automatic meter reading (AMR) meters installed. This option is a 15-year programme to convert all domestic meters to smart meters in conjunction with an enhanced water saving campaign offering flow regulators.
C6a	Non-household customer audits and water efficiency retrofits (schools, leisure centres and hospitality)	Non-household water audit	Customer Options	YWSGRD	0.2	This scheme will deliver water efficiency to business customer premises across Yorkshire through auditing and retrofitting businesses over five years. We have assumed a five-year half-life of savings. The scheme can be delivered in phases.
C6a(ii)	Non-household customer audits and water efficiency retrofits (general domestic use only)	Non-household water audit	Customer Options	YWSGRD	4.49	Commercial Water Use Audits and Retrofits (Smaller Sectors)

D15a	Intensive active leakage control A	Active leakage management	Distribution Options	YWSGRD	0.77	Intensive ALC is undertaking high levels of Find and Fix activity usually in the form of a full thorough investigation utilising multiple approaches (zero pressure tests, step tests, lift & shift acoustic technology, stop tap bashing) rather than find & fix which is targeted in response to a specific trigger (like an acoustic logger alarm). From 2025
D15b	Intensive active leakage control B	Active leakage management	Distribution Options	YWSGRD	0.27	Intensive ALC. Intensive ALC is undertaking high levels of Find and Fix activity usually in the form of a full thorough investigation utilising multiple approaches (zero pressure tests, step tests, lift & shift acoustic technology, stop tap bashing) rather than find & fix which is targeted in response to a specific trigger (like an acoustic logger alarm). From 2030
D15c	Intensive active leakage control C	Active leakage management	Distribution Options	YWSGRD	0.25	Intensive ALC. Intensive ALC is undertaking high levels of Find and Fix activity usually in the form of a full thorough investigation utilising multiple approaches (zero pressure tests, step tests, lift & shift acoustic technology, stop tap bashing) rather than find & fix which is targeted in response to a specific trigger (like an acoustic logger alarm). From 2035

D15d	Intensive active leakage control D	Active leakage management	Distribution Options	YWSGRD	0.16	Intensive ALC. Intensive ALC is undertaking high levels of Find and Fix activity usually in the form of a full thorough investigation utilising multiple approaches (zero pressure tests, step tests, lift & shift acoustic technology, stop tap bashing) rather than find & fix which is targeted in response to a specific trigger (like an acoustic logger alarm). From 2040
D15e	Intensive active leakage control E	Active leakage management	Distribution Options	YWSGRD	0.03	Intensive ALC. Intensive ALC is undertaking high levels of Find and Fix activity usually in the form of a full thorough investigation utilising multiple approaches (zero pressure tests, step tests, lift & shift acoustic technology, stop tap bashing) rather than find & fix which is targeted in response to a specific trigger (like an acoustic logger alarm). From 2045
D17a	Transient Pressure Management	Pressure management	Distribution Options	YWSGRD	0.03	Transients- transients are short duration high impact pressure changes which can cause damage to the water network. By installing sensors to the network, we can identify the sources of transients and mitigate the damage done from transients, reducing the likelihood of bursts.

D1a	Active leakage control A	Active leakage management	Distribution Options	YWSGRD	5.57	Leakage analysts through to Leakage operations analysing nightlines & operational technology data, targeting areas of the network to undertake leakage find investigation and pinpoint leak location. Subsequent repair of leak. ALC in this model is additional ALC activity to reduce leakage through additional repairs. From 2025
D1b	Active leakage control B	Active leakage management	Distribution Options	YWSGRD	6.18	Leakage analysts through to Leakage operations analysing nightlines & operational technology data, targeting areas of the network to undertake leakage find investigation and pinpoint leak location. Subsequent repair of leak. ALC in this model is additional ALC activity to reduce leakage through additional repairs. From 2030
D1c	Active leakage control C	Active leakage management	Distribution Options	YWSGRD	6.18	Leakage analysts through to Leakage operations analysing nightlines & operational technology data, targeting areas of the network to undertake leakage find investigation and pinpoint leak location. Subsequent repair of leak. ALC in this model is additional ALC activity to reduce leakage through additional repairs. From 2035
D1d	Active leakage control D	Active leakage management	Distribution Options	YWSGRD	6.18	Leakage analysts through to Leakage operations analysing nightlines & operational technology data, targeting areas of the network to undertake leakage find investigation and pinpoint leak location. Subsequent repair of leak. ALC in this model is additional ALC activity to reduce leakage through additional repairs. From 2040

D1e	Active leakage control E	Active leakage management	Distribution Options	YWSGRD	4.33	Leakage analysts through to Leakage operations analysing nightlines & operational technology data, targeting areas of the network to undertake leakage find investigation and pinpoint leak location. Subsequent repair of leak. ALC in this model is additional ALC activity to reduce leakage through additional repairs. From 2045
D2a	Pressure management A	Pressure management	Distribution Options	YWSGRD	7.27	PM- Pressure Management- this is management of network pressures using PRVs (pressure reducing valves). Which reduce fluctuations in pressure and the overall pressure in a system. Reducing leakage and bursts.
D2b	Pressure management B	Pressure management	Distribution Options	YWSGRD	3.07	PM- Pressure Management- this is management of network pressures using PRVs (pressure reducing valves). Which reduce fluctuations in pressure and the overall pressure in a system. Reducing leakage and bursts.
D2c	Pressure management C	Pressure management	Distribution Options	YWSGRD	1.8	PM- Pressure Management- this is management of network pressures using PRVs (pressure reducing valves). Which reduce fluctuations in pressure and the overall pressure in a system. Reducing leakage and bursts.
D3a	Mains renewal/ replacement A	Mains replacement (not trunk mains)	Distribution Options	YWSGRD	10.52	Asset Renewal is the term being used for interventions which re-life the pipe assets. Asset renewal will provide structural integrity to the pipe, reducing burst rates and removing background leakage. This will cover open cut, direction drilling, slip lining and structural lining techniques. From 2025

D3b	Mains renewal/ replacement B	Mains replacement (not trunk mains)	Distribution Options	YWSGRD	9.97	Asset Renewal is the term being used for interventions which re-life the pipe assets. Asset renewal will provide structural integrity to the pipe, reducing burst rates and removing background leakage. This will cover open cut, direction drilling, slip lining and structural lining techniques. From 2030
D3c	Mains renewal/ replacement C	Mains replacement (not trunk mains)	Distribution Options	YWSGRD	5.28	Asset Renewal is the term being used for interventions which re-life the pipe assets. Asset renewal will provide structural integrity to the pipe, reducing burst rates and removing background leakage. This will cover open cut, direction drilling, slip lining and structural lining techniques. From 2035
D3d	Mains renewal/ replacement D	Mains replacement (not trunk mains)	Distribution Options	YWSGRD	4.44	Asset Renewal is the term being used for interventions which re-life the pipe assets. Asset renewal will provide structural integrity to the pipe, reducing burst rates and removing background leakage. This will cover open cut, direction drilling, slip lining and structural lining techniques. From 2040
D3e	Mains renewal/ replacement E	Mains replacement (not trunk mains)	Distribution Options	YWSGRD	3.05	Asset Renewal is the term being used for interventions which re-life the pipe assets. Asset renewal will provide structural integrity to the pipe, reducing burst rates and removing background leakage. This will cover open cut, direction drilling, slip lining and structural lining techniques. From 2045

D6a	Above ground pressure management	Pressure management	Distribution Options	YWSGRD	0.37	Above Ground Pressure Management- This is pressure control utilising pumping stations and pressure sensors in the network to more finely control pressure fluctuations and reduce overall pressure in the Network. Usually this will mean installing a soft start pump or variable speed driver to a pump
D7a	Permanent acoustic logging A	Pressure management	Distribution Options	YWSGRD	0.23	Acoustic loggers listen for leaks on the water network and inform leakage find teams of where to pinpoint a leak. They help improve leakage find efficiency and response to leakage outbreak, From 2025
D7b	Permanent acoustic logging B	Pressure management	Distribution Options	YWSGRD	0.71	Acoustic loggers listen for leaks on the water network and inform leakage find teams of where to pinpoint a leak. They help improve leakage find efficiency and response to leakage outbreak. From 2030
D7c	Permanent acoustic logging C	Pressure management	Distribution Options	YWSGRD	0.64	Acoustic loggers listen for leaks on the water network and inform leakage find teams of where to pinpoint a leak. They help improve leakage find efficiency and response to leakage outbreak. From 2035
D7d	Permanent acoustic logging D	Pressure management	Distribution Options	YWSGRD	0.59	Acoustic loggers listen for leaks on the water network and inform leakage find teams of where to pinpoint a leak. They help improve leakage find efficiency and response to leakage outbreak. From 2040
D7e	Permanent acoustic logging E	Pressure management	Distribution Options	YWSGRD	0.14	Acoustic loggers listen for leaks on the water network and inform leakage find teams of where to pinpoint a leak. They help improve leakage find efficiency and response to leakage outbreak. From 2045

DO01	Supply rivers drought permits- DYAA	Drought permits/orders	Resource Options	YWSGRD	4.65	In drought conditions in a dry year annual average drought permits for rivers will have to applied for to maintain supply to customers.
DO06	Supply reservoir compensation drought permits- DYAA	Drought permits/orders	Resource Options	YWSGRD	18.01	To resolve the short fall in raw water resource during dry weather periods then Reservoir Compensation Drought Permits must be applied for and temporary infrastructure installed to maintain service to customers.
DO11	Drought demand reduction- DYAA	Drought permits/orders	Resource Options	YWSGRD	19.25	Drought demand reduction- DYAA
DO05	Supply rivers drought permits- critical period	Drought permits/ orders	Resource Options	YWSGRD	5.14	In drought conditions in a dry year annual average drought permits for rivers will have to applied for to maintain supply to customers.
DO10	Supply reservoir compensation drought permits- critical period	Drought permits/ orders	Resource Options	YWSGRD	19.9	To resolve the short fall in raw water resource during dry weather periods then Reservoir Compensation Drought Permits must be applied for and temporary infrastructure installed to maintain service to customers.
DO15	Drought demand reduction- critical period	Drought permits/ orders	Resource Options	YWSGRD	21.28	Drought demand reduction- critical period
DO03	Supply rivers drought permits- ends in 2038- DYAA	Drought permits/ orders	Resource Options	YWSGRD	4.65	In drought conditions in a dry year annual average drought permits for rivers will have to applied for to maintain supply to customers.

DO08	Supply reservoir compensation drought permits- ends in 2038- DYAA	Drought permits/ orders	Resource Options	YWSGRD	18.01	To resolve the short fall in raw water resource during dry weather periods then Reservoir Compensation Drought Permits must be applied for and temporary infrastructure installed to maintain service to customers.
DO13	Drought demand reduction- ends in 2038- DYAA	Drought permits/ orders	Resource Options	YWSGRD	19.25	Drought demand reduction- critical period
DO02	Supply rivers drought permits- ends in 2034- DYAA	Drought permits/ orders	Resource Options	YWSGRD	4.65	In drought conditions in a dry year annual average drought permits for rivers will have to applied for to maintain supply to customers.
DO12	Drought demand reduction- ends in 2034- DYAA	Drought permits/ orders	Resource Options	YWSGRD	19.25	Drought demand reduction- ends in 2034- DYAA
DO14	Drought demand reduction- ends in 2044- DYAA	Drought permits/ orders	Resource Options	YWSGRD	19.25	Drought demand reduction- ends in 2044- DYAA
DO04	Supply rivers drought permits- ends in 2044- DYAA	Drought permits/ orders	Resource Options	YWSGRD	4.65	In drought conditions in a dry year annual average drought permits for rivers will have to applied for to maintain supply to customers.
DO07	Supply reservoir compensation drought permits- ends in 2034- DYAA	Drought permits/ orders	Resource Options	YWSGRD	18.01	To resolve the short fall in raw water resource during dry weather periods then Reservoir Compensation Drought Permits must be applied for and temporary infrastructure installed to maintain service to customers.

DO09	Supply reservoir compensation drought permits- ends in 2044- DYAA	Drought permits/ orders	Resource Options	YWSGRD	18.01	To resolve the short fall in raw water resource during dry weather periods then Reservoir Compensation Drought Permits must be applied for and temporary infrastructure installed to maintain service to customers.
DO16	Supply rivers drought permits- ends in 2028- DYAA	Drought permits/ orders	Resource Options	YWSGRD	4.65	In drought conditions in a dry year annual average drought permits for rivers will have to applied for to maintain supply to customers.
DO17	Drought demand reduction- ends in 2028- DYAA	Drought permits/ orders	Resource Options	YWSGRD	19.25	Drought demand reduction- ends in 2028- DYAA
DO18	Supply reservoir compensation drought permits- ends in 2028- DYAA	Drought permits/ orders	Resource Options	YWSGRD	18.01	To resolve the short fall in raw water resource during dry weather periods then Reservoir Compensation Drought Permits must be applied for and temporary infrastructure installed to maintain service to customers.
DV3	Magnesium Limestone new GW supply	New groundwater	Resource Options	YWSGRD	5	A new groundwater abstraction and WTW in South Yorkshire.
DV6(iv)	Tees to South Yorkshire - NWL import 50Ml/d	External raw water bulk supply/transfer	Resource Options	YWSGRD	50	This is a new bulk transfer from NWL
DV6(v)	Tees to South Yorkshire - NWL import 80Ml/d	External raw water bulk supply/transfer	Resource Options	YWSGRD	80	Tees to South Yorkshire WTW via a new partially treated-water pipeline (80Ml/d abstraction; 50Ml/d –South Yorkshire WTW, 30Ml/d onward transfer - not in scope)
DV6(vi)	Tees to South Yorkshire - NWL import 140Ml/d	External raw water bulk supply/transfer	Resource Options	YWSGRD	140	variations with different benefits.

DV7a(iv)	Tees to York Pipeline - NWL import 50 Ml/d	External raw water bulk supply/transfer	Resource Options	YWSGRD	50	Tees to York WTW via a new partially treated-water pipeline (50Ml/d abstraction; 50Ml/d –York WTW, 0Ml/d onward transfer)
DV7a(v)	Tees to York Pipeline - NWL import 80 Ml/d	External raw water bulk supply/transfer	Resource Options	YWSGRD	80	Tees to York WTW via a new partially treated-water pipeline (80Ml/d abstraction; 50Ml/d –York WTW, 30Ml/d onward transfer- not in scope)
DV7a(vi)	Tees to York Pipeline - NWL import 140 Ml/d	External raw water bulk supply/transfer	Resource Options	YWSGRD	140	Tees to York WTW via a new partially treated-water pipeline (140Ml/d abstraction; 50Ml/d –York WTW, 90Ml/d onward transfer- not in scope)
DV8(iv)	New north to south internal transfer connection	Conjunctive use	Resource Options	YWSGRD	0	This option is a new interconnection between York and South Yorkshire and requires a supporting option(s) to achieve a benefit.
DV8(iv)A(i)	New north to south internal transfer connection A	Internal potable transfer	Distribution Options	YWSGRD	0	Dual main transfer from York WTW to South Yorkshire
DV8(iv)A(ii)	New north to south internal transfer connection B	Internal potable transfer	Distribution Options	YWSGRD	0	Single main transfer from York WTW to South Yorkshire
DV8(v)	New WTW (York) supplied by the River Ouse	Conjunctive use	Resource Options	YWSGRD	10.28	Scheme to increase York WTW capacity
DV8(v)A	New York WTW 2	New water treatment works	Resource Options	YWSGRD	50	Scheme to York WTW capacity
DV8B	New York WTW and Dual Main South Yorkshire Pipeline	New water treatment works	Resource Options	YWSGRD	50	Scheme to include new treatment works and dual main

E2	East Yorkshire export to STW	External raw water bulk supply/transfer	Resource Options	YWSGRD	20	Pipeline route East Yorkshire export to STW
LSM	Leakage reduction and smart metering	Other leakage control	Distribution Options	YWSGRD	115.86	Leakage pathway composed of a combination of the demand reduction options
R13	East Yorkshire Groundwater Option 2	New groundwater	Resource Options	YWSGRD	6	This scheme proposes to relocate an existing borehole in the East Yorkshire area to replace the yield lost from an asset that is no longer in use due to water quality issues. A licence variation on the existing abstraction would be required. This source could provide the grid system with up to 6Ml/d annual average (8/9Ml/d peak).
R1c	New North Yorkshire WTW- 1	Surface water enhancement	Resource Options	YWSGRD	0	This is a new WTW that would be a pre-requisite to options R1d to R1g. It abstracts water from the River Ouse and requires additional infrastructure to transfer to demand areas. Without the onward transfer there is no benefit.
R1c(i)	New North Yorkshire WTW- 2	Surface water enhancement	Resource Options	YWSGRD	0	This scheme is an alternative to R1c and builds the works to a larger capacity.
R1d	Grid network enhancement: New River Ouse WTW to North Yorkshire 1	Surface water enhancement	Resource Options	YWSGRD	15	This scheme provides onwards transfer to R1c or R1c(ii).
R1d(i)	Grid network enhancement: New River Ouse WTW to North Yorkshire 2	Surface water enhancement	Resource Options	YWSGRD	0	This scheme provides onwards transfer to R1c or R1c(ii).

R1e	Grid network enhancement: New River Ouse WTW to North Yorkshire 2	Surface water enhancement	Resource Options	YWSGRD	5	This scheme provides onwards transfer to R1c or R1c(ii).
R1f	Grid network enhancement: New River Ouse WTW to North Yorkshire 3	Surface water enhancement	Resource Options	YWSGRD	10	This scheme provides onwards transfer to R1c or R1c(ii).
R1g	Grid Network enhancement: New River Ouse WTW to York	Surface water enhancement	Resource Options	YWSGRD	25	This scheme provides onwards transfer to R1c or R1c(ii).
R29	Reservoir de-silting	Reservoir enlargement	Resource Options	YWSGRD	11	This scheme aims to increase the capacity of 26 reservoirs through dredging and desilting. The silt would be taken to a landfill site.
R3	Increased River Ouse pumping capacity	Surface water enhancement	Resource Options	YWSGRD	10	The scheme involves construction of a new transfer main and pumping station between the River Ouse and a nearby water treatment. The scheme could be used to maximize an existing abstraction licence on the Ouse. This is not the same Ouse licence as DV8(v) and R2 and this scheme could be delivered independently.
R31a	Additional bankside storage at York WTW	Surface water enhancement	Resource Options	YWSGRD	10.6	This scheme would construct new bankside storage at an existing WTW in the York area. Water could be abstracted during higher flows/low demand for use during low flows.

R34	River Calder Abstraction option 1	New surface water	Resource Options	YWSGRD	9.29	This option was constrained out on 2nd screening. This scheme is a new abstraction from the River Calder. It requires construction of a pumping station and water main, and transport of water to an existing water treatment works. This scheme would be subject to the EA granting a licence and specifying constraints at lower flows.
R37b(ii)	River Aire Abstraction option 4	New surface water	Resource Options	YWSGRD	#N/A	This is a third potential new abstraction site on the River Aire. It involves construction of a pumping station, new water main and bankside storage reservoir. This scheme would be subject to the EA granting a licence and specifying constraints at lower flows.
R3a	River Ouse licence variation 1	Surface water enhancement	Resource Options	YWSGRD	0.3	This scheme would transfer a proportion of the surplus licence capacity we do not use upstream to be used with existing infrastructure at low flows.
R48	Levels of service variation	Change in levels of service	Customer Options	YWSGRD	#N/A	This option presents a benefit of planning to a less severe drought than the 1 in 500 return period included in our baseline scenario. The benefit is based on modelling, and it is assuming the drought is less severe therefore more water is available.
R49	Import at the River Tees	External raw water bulk supply/transfer	Resource Options	YWSGRD	15	This scheme is a raw water import from NWL to feed the North Yorkshire area of our network. It would require a new WTW within the Tees catchment.
R51	Supply Dales from the Tees - treated	External raw water bulk supply/transfer	Resource Options	YWSGRD	15	This scheme is a treated water import from NWL to feed the North Yorkshire area of our network. It utilises a NWL WTW.

R61	East Yorkshire coast desalination	Desalination	Resource Options	YWSGRD	20	This would require an abstraction on the Humber Estuary, construction of a desalination plant and transfer to an existing WTW in East Yorkshire.
R78	Tidal Abstraction Reservoir	New reservoir	Resource Options	YWSGRD	20	This scheme is an alternative to the desalination plant. It requires an abstraction from the Humber Estuary to be transferred inland to new lagoons and treatment works within proximity to the existing East Yorkshire WTW.
R85	Rebuild Kirklees WTW	New water treatment works	Resource Options	YWSGRD	8	This scheme would build a new WTW in a location of a previously decommissioned works. The supply would be from existing reservoir sources, and it would enable more water to be treated and put into supply.
R86	West Yorkshire new WTW	New water treatment works	Resource Options	YWSGRD	50	This scheme would construct a new WTW that could abstract water from the rivers Aire and Calder to feed the Bradford area.
R87	Rebuild Northallerton WTW	New water treatment works	Resource Options	YWSGRD	4	This scheme would rebuild a previously decommissioned WTW in North Yorkshire. The supply would be from existing reservoirs but a licence application to increase the abstraction would need to be granted by the EA.
R88	Increase storage at an existing WTW 2 in North Yorkshire	Surface water enhancement	Resource Options	YWSGRD	0.32	This option would provide storage to offset outages at an existing WTW in North Yorkshire.
R89	Convert Wensleydale springs to boreholes	Groundwater enhancement	Resource Options	YWSGRD	0.77	This option would install boreholes at an existing spring sources in the Dales area. A licence variation would be required to abstract from the borehole.

R8b	Sherwood Sandstone and Magnesian Limestone Boreholes option 2	New groundwater	Resource Options	YWSGRD	5	This option is a new borehole and WTW that would require an abstraction licence in the Sherwood Sandstone in North Yorkshire.
R8c	Sherwood Sandstone and Magnesian Limestone Boreholes option 3	New groundwater	Resource Options	YWSGRD	5	This option is a new borehole and WTW that would require an abstraction licence in the Sherwood Sandstone in North Yorkshire to supply the Dales area.
R8f	Sherwood Sandstone and Magnesian Limestone Boreholes option 6	New groundwater	Resource Options	YWSGRD	20	This option is a new borehole and WTW that would require an abstraction licence in the Sherwood Sandstone in North Yorkshire to supply the Harrogate area.
R8g	Sherwood Sandstone Boreholes support to North Yorkshire	New groundwater	Resource Options	YWSGRD	15	This option is a new borehole and WTW that would require an abstraction licence in the Sherwood Sandstone in North Yorkshire to supply the Dales area.
R8h	New groundwater (Sherwood Sandstone) supply to existing North Yorkshire WTW 2	New groundwater	Resource Options	YWSGRD	5.5	This option is a new borehole and WTW that would require an abstraction licence in the Sherwood Sandstone in North Yorkshire to supply the Howardian Hills area.
R91	New internal transfer to North Yorkshire WTW2	Groundwater enhancement	Resource Options	YWSGRD	5	Reconfiguration of the wellfield at North Yorkshire 1 to maximise existing licence of 17Ml/d and provide increased resilience to North Yorkshire WTW 2 during low flow band at River Ouse abstraction (5Ml/d net benefit). Additional two new boreholes + relining existing borehole to reduce bact-risk + dedicated transfer to North Yorkshire WTW 2 to provide benefit of 5Ml/d

17.3 Appendix B: Option screening

Screening criteria	
1. Benefit	**Does the scheme provide a regional benefit? For example, does it:** • Provide a direct or indirect means of transferring resources from WReN to another region, or meet identified public water supply (PWS) or non-PWS need? • Does it provide a non-drought resilience benefit, e.g., water quality improvement, flood mitigation, mitigate a sustainability reduction / environmental risk or other? • Does the option meet any constraints agreed by the WReN option identification workstream e.g., de-minimus value for PWS? • Will the option have a moderate to high likelihood of providing the stated benefit to offer to other regions? • Will the option have a high likelihood of being able to mitigate against future resource loss due to climate change impacts or licence changes to existing sources?
2. Environmental acceptability	**Does the option avoid breaching any unalterable constraints that makes it unsuitable for promotion e.g., unacceptable environmental impacts that cannot be overcome or options which have a failure?** • Is the option likely to be acceptable in terms of planning and statutory environmental constraints relevant to the scheme (e.g., internationally, or nationally designated sites) subject to any reasonable mitigation measures? • Does the scheme avoid causing CAMS units to become over-abstracted (and/or avoid WFD status deterioration, where known)?
3. Regulatory acceptability	**Is the option promotable / does it meet regulatory and stakeholder expectations?** • Is the scheme likely to be acceptable to customers fed off this supply? • Is the scheme compatible with other parts of the WReN regional plan, other sectors, other regions, or national ambition? • Does the scheme provide any non-PWS benefits or additional regional benefits? • Is the scheme likely to be acceptable to (non-statutory) stakeholder groups, subject to reasonable mitigation? • Does the scheme avoid major carbon impacts, e.g., operational carbon effects and asset construction/replacement costs? • Is the option a favourable development for this source of water (e.g., a specific river)? • Are the option costs acceptable (based on available cost data)?
4. Risk of failure	**Is the risk of the option failing acceptable?** • Is the scale of the option proportionate? Can the option be scaled up or down? • Is there a high level of confidence that the scheme will be technically feasible? • Does the option have sufficient flexibility to still deliver a benefit under a range of external future scenarios different to the baseline? • Does the option avoid a disproportionately high level of up-front feasibility costs relative to the benefit it could deliver? • Are the necessary permissions likely to be granted? i.e., if a new abstraction permit (licence) is needed, is it likely EA will approve the application?

17.4 Appendix C.1: Optimisation outputs for 1 in 500 scenarios

Option name	1 in 500 unconstrained with drought options available	1 in 500 unconstrained without drought options available	1 in 500 constrained with drought options available
Drought options for demand, rivers and reservoirs	2025	-	2025
C30a Water labelling	2036	2028	2025
25 year leakage with smart metering trajectory	-	-	2025
C5 Metering on asset end of life	2025	2025	-
C37 Metering new developments (growth)	-	2025	-
C2 Metering domestic meter optants (growth)	2025	2025	-
C6a Non-household customer audits and water efficiency retrofits (schools, leisure centres and hospitality)	-	-	2025
C4 Metering on change of occupancy	2025	2025	2025
D1 Active leakage control A and E	2025	2025	-
D15 Intensive active leakage control A and B	-	2026	-
D2 Pressure management A to C	-	2025	-
D3 Mains renewal/ replacement A to D	-	2025	-
D6a Above ground pressure management	-	2025	-
D7 Permanent acoustic logging A and B	-	2026	-
D17a Transient Pressure Management	2025	2026	-
D2 Pressure management A	2025	-	-

D3 Mains renewal/ replacement A to E	2025	-	-
D15 Intensive active leakage control A and E	2068	-	-
C28e Household water efficiency media campaign	2025	2025	-
C1d Household customer audits and water efficiency retrofits	2025	2025	2026
C27d School visits	2025	2025	2025
C29c Household incentives	2049	-	-
C13c Household tariffs	2074	-	2025
C11c Retrofits of rainwater harvesting for households	2046	-	-
C15d Installation of internal household flow regulators	-	2025	2030
C32c Rainwater harvesting for households- new developments	-	2025	2026
C6a(ii) Non-household customer audits and water efficiency retrofits (general domestic use only)	2026	2026	2026
C23b1 Rainwater harvesting for agriculture	2029	-	2025
C12a3 Rainwater harvesting for commercial customers	-	2025	2025
C34a Non-household water efficiency media campaign	-	2025	2025
C35c Non-household water efficiency incentive scheme	-	-	2025
R3a River Ouse licence variation 1	2027	2027	-
R3 Increased River Ouse pumping capacity	2028	2028	2028
R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2	2028	2028	-
R8c Sherwood Sandstone and Magnesian Limestone Boreholes option 3	2028	2028	2028

R91 New internal transfer to North Yorkshire WTW 2	2028	2028	-
R8f Sherwood Sandstone and Magnesian Limestone Boreholes option 6	2029	2029	-
DV8B New York WTW and Dual Main South Yorkshire Pipeline	2035	-	2035
DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d	2040	2040	2040
R8g Sherwood Sandstone Boreholes support to North Yorkshire	2081	2060	-
DV3 Magnesium Limestone new GW supply	-	2028	2028
R13 East Yorkshire Groundwater Option 2	-	-	2028
R31a Additional bankside storage at York WTW	-	2035	-
R34 River Calder Abstraction option 1	-	-	2028
R37b(ii) River Aire Abstraction option 4	-	2029	-
R85 Rebuild Kirklees WTW	-	2081	-
R87 Rebuild Northallerton WTW	-	2033	-
R89 Convert Wensleydale springs to boreholes	-	2086	-

17.5 Appendix C.2: Grid SWZ baseline (1 in 500 by 2039/40) optimised solutions alternative objectives

Option selected	Least cost	Best for natural capital	Best for social and natural capitals	Best for carbon	Best for 6 capitals	Reduced long term discount
C23b1 Rainwater harvesting for agriculture	2025	2025	2025	2025	2025	2025
C34a Non-household water efficiency media campaign	2025	2025	2025	2025	2025	2025
C12a3 Rainwater harvesting for commercial customers	2025	2025	2025	2025	2025	2025
C27d School visits	2025	2025	2026	2025	2077	2025
C30a Water labelling	2025	2025	2025	2025	2025	2025
LSM Leakage reduction and smart metering	2025	2025	2025	2025	2025	2025
C6a Non-household customer audits and water efficiency retrofits (schools, leisure centres and hospitality)	2025	2025	2025	2025	2025	2025
C35c Non-household water efficiency incentive scheme	2025	2025	2025	2025	2025	2025
C4 Metering on change of occupancy	2025	2025	-	2025	2025	2025
C32c Rainwater harvesting for households- new developments	2025	2025	2055	-	-	-
C13c Household tariffs	2025	2025	-	2026	2027	-
C15d Installation of internal household flow regulators	2025	2026	-	2026	-	2031
C1d Household customer audits and water efficiency retrofits	2025	2025	-	2025	-	2025
Drought options demand	2025	2025	2026	2025	2025	2025
Drought options rivers	2025	2025	2026	2025	2025	2025

Drought options reservoirs	2025	2025	2026	2025	2025	2025
C6a(ii) Non-household customer audits and water efficiency retrofits (general domestic use only)	2026	2026	2026	2026	2026	2026
DV8B New York WTW and Dual Main South Yorkshire Pipeline	2035	2035	2035	2035	2035	2035
DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d	2039	2039	2037	2039	2039	2039
DV3 Magnesium Limestone new GW supply	2073	-	2061	-	2075	2063
R37b(ii) River Aire Abstraction option 4	2075	2067	-	2068	-	2072
C28e Household water efficiency media campaign	-	2025	-	2025	2025	2026
R8f Sherwood Sandstone and Magnesian Limestone Boreholes option 6	-	2078	2045	-	-	-
R31a Additional bankside storage at York WTW	-	-	-	2077	2071	-
R8g Sherwood Sandstone Boreholes support to North Yorkshire	-	-	-	2082	2076	-
R13 East Yorkshire Groundwater Option 2	-	-	2071	2080		2064
R3 Increased River Ouse pumping capacity	-	-	-	-	2078	
R91 New internal transfer to North Yorkshire WTW 2	-	2079	-	-	2047	2040
R85 Rebuild Kirklees WTW	-	-	2081	-		2077
R3a River Ouse licence variation 1	-	-	-	-	-	-
C18c Leaky loo fixes	-	-	-	-	-	2055
D17a Transient Pressure Management	-	-	2038	-	2035	2025
R87 Rebuild Northallerton WTW	-	-	-	-	-	2082

R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2	-	-	-	-	-	-
R89 Convert Wensleydale springs to boreholes	-	2083	2078	-	-	-
R86 West Yorkshire new WTW	-	-	2062	-	-	-
C29c Household incentives	-	-	-	2026	2076	-
R8c Sherwood Sandstone and Magnesian Limestone Boreholes option 3	-	-	-	-	-	-
C21c Housing Associations	-	-	-	2027	-	-

17.6 Appendix C.3: Candidate solution programmes – option selection

Option type	Ref.	Solution Name	Least cost		Best for environment (high ED)		Best for resilience		Social and natural capital	
			First year of benefit	Benefit (Ml/d)	First year of benefit	Benefit (Ml/d)	First year of benefit	Benefit (Ml/d)	First year of benefit	Benefit (Ml/d)
HH WE	C1d	Household customer audits and water efficiency retrofits	2025	3.26	2025	3.26	2025	3.26	2025	3.26
NHH WE	C6a	Non-household customer audits and water efficiency retrofits (schools, leisure centres and hospitality)	2025	0.20	2025	0.20	2025	0.20	2025	0.20
Leakage & metering	LSM	Leakage reduction and smart metering	2025	115.86	2025	115.86	2025	115.86	2025	115.86
NHH WE	C12a3	Rainwater harvesting for commercial customers	2025	2.01	2025	2.01	2025	2.01		
HH WE	C27d	School visits	2025	1.00	2025	1.00	2025	1.00	2025	1.00
HH WE	C28e	Household water efficiency media campaign	2025	1.71	2025	1.71	2025	1.71	2025	1.71
NHH WE	C34a	Non-household water efficiency media campaign	2025	0.76	2025	0.76	2025	0.76	2025	0.76
NHH WE	C35c	Non-household water efficiency incentive scheme	2025	0.27	2025	0.27	2025	0.27	2025	0.27
HH WE	C15d	Installation of internal household flow regulators	2025	0.48	2025	0.48	2025	0.48	2026	0.48
Leakage & metering	C4	Metering on change of occupancy	2025	18.70	2025	18.70	-	-	2025	18.70
Govt	C30a	Water labelling	2025	39.60	2025	39.60	2028	39.60	2025	39.60

NHH WE	C6a(ii)	Non-household customer audits and water efficiency retrofits (general domestic use only)	2026	4.49	2026	4.49	2025	4.49	2026	4.49
HH WE	C32c	Rainwater harvesting for households- new developments	2030	1.41	2027	1.41	2025	1.41		1.41
NHH WE	C23b1	Rainwater harvesting for agriculture	2030	1.00	2025	1.00	2030	1.00	2025	1.00
HH WE	C13c	Household tariffs	2030	0.39	2028	0.39	2030	0.39	2026	0.39
HH WE	C29c	Household Incentives	-	-	-	-	-	-	2026	0.13
HH WE	C21c	Housing Associations	-	-	-	-	-	-	2027	0.56
Resource	DV8B	New York WTW and Dual Main South Yorkshire Pipeline	2035	50.00	2035	50.00	2035	50.00	2035	50.00
Resource	DV7a(vi)	Tees to York Pipeline - NWL import 140 Ml/d	2039	140.00	2040	140.00	2040	140.00	2039	140.00
Resource	DV3	Magnesium Limestone new GW supply	2073	5.00	2075	5.00	-	-	-	-
Resource	R37b (ii)	River Aire Abstraction option 4	2075	33.50	-	-	2073	33.50	2068	33.50
Resource	R3a	River Ouse licence variation 1	-	-	-	-	2027	0.30		-
Resource	R3	Increased River Ouse pumping capacity	-	-	2040	10.00	2028	10.00		-
Resource	R91	New internal transfer to North Yorkshire WTW 2	-	-	-	-	2028	5.00		-

Resource	R13	East Yorkshire Groundwater Option 2	-	-	-	-	2028	6.00	2080	6.00
Resource	R8g	Sherwood Sandstone Boreholes support to North Yorkshire	-	-	2077	15.00	2035	15.00	2082	15.00
Resource	R31a	Additional bankside storage at York WTW	-	-	2039	10.60	2082	10.60	2077	10.60
Resource	R8f	Sherwood Sandstone and Magnesian Limestone Boreholes option 6	-	-	2039	20.00	-	-		-
Resource	R86	West Yorkshire new WTW	-	-	2062	50.00	-	-		-
Resource	R85	Rebuild Kirklees WTW	-	-	2040	8.00	-	-		-
Resource	R78	Tidal Abstraction Reservoir	-	-	-	-	-	-		-
Resource	R87	Rebuild Northallerton WTW	-	-	-	-	-	-		-
Resource	C61	Desalination Hull	-	-	2080	20.00	-	-		-
Drought option	DO03	Supply rivers drought permits- ends in 2038- DYAA	2025 (to 2039)	4.63	2025 (to 2039)	4.63	2025 (to 2028)	4.63	2025	4.63
Drought option	DO08	Supply reservoir compensation drought permits- ends in 2038- DYAA	2025 (to 2039)	17.94	2025 (to 2039)	17.94	2025 (to 2028)	17.94	2025	17.94
Drought option	DO13	Drought demand reduction- ends in 2038- DYAA	2025 (to 2039)	19.18	2025 (to 2039)	19.18	2025 (to 2028)	19.18	2025	19.18
		TOTAL Benefit 2084/85 (excludes drought options)	-	**419.64**		**519.74**	-	**449.30**		**444.92**

17.7 Appendix D: Board Assurance Supporting Statement

The Board engaged with the water resource management planning process through the Board Public Value Committee, and the PR24 Sub-Committee which received regular updates on the developing draft (dWRMP), revised draft (rdWRMP), and final Water Resource Management Plan.

Draft Water Resource Management Plan

The main engagement on the draft plan began in January 2022 with an overview of the strategic planning framework. In May 2022, the Committee received an update on the development of the strategic planning work and discussed WRMP19, key drivers and changes for WRMP24 as well as reviewing the anticipated shape of the WRMP24 plan, including supply-demand balance and the adoption of a twin track1 approach to ensuring future water resources resilience. The Committee were taken through the next steps, in line with planning guidance, to continue development of the plan.

In July 2022, the Committee reviewed and discussed the identified risks impacting the supply-demand balance resulting in potential investment. This included consideration of climate change impacts (including the impact of changes in methodology in line with revised guidance), government guidance in respect of drought resilience by 2039, increases in modelled demand (including changes in per capital consumption informed by the impact of Covid and a greater prevalence of home working), consideration of the loss of imports from a neighbouring company over the medium term, Water Framework Directive investigations into groundwater sources, environmental destination requirement implications on the River Derwent and peak period assessments. At the same meeting, the Committee reviewed the options appraisal approach of using multi-criteria analysis to meet government required policy objectives by 2050. The Committee considered the evidence for new supplies to close near-term deficits, AMP8 investigations and the potential investment in new supplies for AMP9 onwards to offset supply losses from environmental destination. Management was challenged over the approach to customer and stakeholder engagement and the approach to assurance was debated and endorsed.

At the September 2022 meetings the Committee was taken through the final WRMP non-technical document and a detailed accompanying presentation setting out the final preferred draft plan. The Committee considered the Board assurance requirements, the dWRMP planning requirements, discussed alignment between the dWRMP and the developing PR24 business plan and reviewed the approach and outputs of the assurance process. The Committee and management discussed the approach to customer and stakeholder engagement between draft and final plans, tolerance for risk in the early part of the plan and then again in the mid-2030s, the implications of the drought we have experienced in Yorkshire in 2022, and the approach to assurance was debated and endorsed.

The Committee has had several opportunities to review and challenge the draft plan's development, consider the supporting evidence and analysis, and consider the information presented to it. As a result, the Yorkshire Water Board endorsed the dWRMP and an assurance statement was drafted to accompany the dWRMP.

Revised Draft Water Resource Management Plan

Since publication of the dWRMP, in November 2022, a 14 week Regulatory and stakeholder consultation period followed, closing in February 2023. Our response to the feedback has resulted in proposed changes to the rdWRMP as outlined in our Statement of Response, which was published on 31 July 2023. In September 2023, the Committee received a full update on the consultation feedback and proposed changes to the revised draft WRMP. They were presented with a view of the updated supply/demand balance, the strategy for both demand and supply options and the preferred plan and how it would meet the obligations required under the Water Resources National Framework and how these would support customers and the environment. This was supported by an assurance plan which took the committee through how the changes to the plan would be assured in stages to include methodology and approach, governance associated with the management of changes and data assurance. This gave the Committee an opportunity to give feedback on the overall approach and this was signed off through the PR24 governance framework.

In October 2023, the Board was given a full update on key areas of change from the draft WRMP. Members were able to review and discuss how changes have been incorporated into the preferred revised 'Best Value Plan,' how this reconciled and aligned with the PR24 business plan submission, consideration of adaptive pathways, alignment with obligations and Regional Plans and the impacts for customers and environment including key risks and mitigations. This was supported by a final letter from the 3rd party assurers outlining the outcome of the findings.

Final Water Resource Management Plan

Following Defra's review of our rdWRMP and our Statement of Response, we received a letter from Defra on 6 February 2024 in which they raised eight issues requesting further information in support of a decision to finalise our plan. Our WRMP has been updated to reflect our response to the issues raised in the Defra letter but there are no material changes to our plan. We responded to Defra in April 2024 and our Board was informed in May 2024 regarding these updates.

The Board has had opportunity to review and challenge the supporting evidence and taking all information into account, including the alignment with the PR24 business plan submission, the Yorkshire Water Board makes the following statement:

a) The board is satisfied that the Yorkshire Water WRMP has met all obligations in its development.

b) The Board is satisfied the plan reflects the Water Resources North Regional Plan and has been developed in accordance with the national framework and relevant guidance and policy.

c) The Board is satisfied that the plan is an adaptive best value plan for managing and developing water resources, so obligations to supply water and protect the environment can be met.

d) The Board is satisfied that the adaptive best value plan is based on sound and robust evidence including those relating to relating to costs.

In providing this statement, the Board has taken account of the findings of an independent third-party audit and assurance process designed to provide assurance that:

a) Data is ready to be published and can be trusted and relied upon by external stakeholders

b) The team producing the plan understands the regulatory guidance and has met the requirements of this guidance

c) That data is competently sourced, processed, reported, and fit for purpose.

17.8 Appendix E: Supporting documentation

In addition to this main WRMP document, a number of supplementary technical documents have also been prepared, which we have listed below. Copies of these documents can be made available on request. Requests will be considered on a case by case basis, and it may be necessary to redact documents to meet security requirements.

Additional documents include:

- Strategic Environmental Assessment, including Non Technical Summary and Appendices
- Habitats Regulation Assessment
- Water Framework Directive Regulations Compliance Assessment
- Deployable Output and Climate Change Technical Document
- Demand Forecasting Technical Document
- Allowing for Uncertainty (Headroom) Technical Document
- Feasible Options Technical Document
- Best Value Plan Decision Making Technical Document

17.9 Appendix F: Lessons from 2022 Drought

Introduction

In 2022 the Yorkshire area experienced dry weather conditions that triggered the need for level 1 to 3 drought actions. Our increased communications campaign (level 1) started in May when reservoir levels fell below the EA trigger line. A temporary use ban (level 2) was in place from 26 August to 6 December and a number of drought permits/order applications (level 3) were granted by EA / Defra, although only a few of these were implemented. These actions had not been implemented in our region since the last severe drought in 1995/96. The lessons identified in this appendix will be included in our Drought Plan 2026.

Permits were granted to reduce compensation flows for reservoirs in the South and North West area, and to increase annual abstraction on the River Wharfe. We were also granted a drought order to increase abstraction in the lowest flow band on the River Ouse. In addition, the EA applied for drought orders for South West Area Reservoir 9 and another South West Area reservoir reservoirs to reduce compensation flows.

We only implemented drought permits to reduce compensation flow reductions for;

- North West Area Reservoir 2 and North West Area Reservoir 3 reservoir compensation releases
- North West Area Reservoir 11 reservoir compensation release

We are reviewing our assumptions on the timing of drought permit applications for our next drought plan, as our experience of 2022 has highlighted that the process can be protracted and therefore, benefits are delayed.

We reviewed the impacts of TUBs on demand, and analyses show a reduction in demand, of 42Ml/d from implementation during the period of hot weather (see section on drought action benefits).

WRMP and drought plan review of 2022 drought

Resilience

Following the drought of 1995/96, Yorkshire Water invested heavily in its strategic water supply Grid system increasing connectivity to enable us to transfer water around the region, significantly improving our resilience to drought and other extreme events. This resilience has been evidenced through our ability to maintain supplies during extreme cold weather events (e.g., Beast from the East); flooding and drought such as the 2018 and the recent 2022 drought, and the extremely hot period in spring / summer 2023.

Until 2018, this flexibility meant that we could meet the stresses arising during periods of peak hot-weather demand, lasting typically 2-3 days, with relative comfort. In 2018 however, we saw much higher and sustained peak demands than we had previously experienced (demand of 1450 Ml/d lasting up to 4 weeks). Such testing conditions are likely to become more common in the future and we will, consider over the long-term, how we can reinforce the Grid in ways which enhance drought (and operational) resilience. This will include ensuring that we consider opportunities for enhanced drought and operational resilience within the context of appraising new supply options within our WRMP.

As part of our long-term approach to operational resilience, we have conducted a series of Water Supply System Strategic (WSSS) reviews during AMP7 to identify opportunities to enhance the production and network resilience and flexibility to respond to extreme events. To date we have completed studies on 40% of our systems and will continue the process in AMP8 to create an even more resilient and flexible Grid, fit for the challenges of the 21st century (see below). We are currently developing a delivery plan, including a review of priorities, to complete the review. The outcome of these investigations will feed into draft Drought Plan 2025 (where applicable), WRMP29 and PR29.

The impacts of the drought in 2022 were most acute in the Worth Valley system and in addition to company-wide measures including a temporary use ban (26th August 2022 to 6th December 2022) and communications campaign, we implemented engineering and operational solutions to reduce the risk of interruption to customers supplies in the Worth Valley. These included: -

1. An overland raw water transfer pipeline from South West Area Reservoir 2 in Calderdale to another South West Area reservoir in the Worth Valley
2. Upgrading of emergency transfer pumping stations to enable increased transfer of treated water into the Worth Valley area.
3. Strategic re-zoning, to transfer areas onto other water supply systems, including installation of a new pressure reducing valve (PRV)
4. Targeted reduction in network pressures using existing PRVs to reduce both leakage and demand.

The engineering options were chosen in part based on speed of implementation and some options which might have brought greater benefits in overall terms were not pursued, because they would not have delivered in time. This combination of raw water transfer, treated water transfer, rezoning and demand management successfully avoided any service interruptions. With targeted active leakage control, these measures reduced demand on the system by around 50% and would be repeated in future dry weather events.

Of the above engineering measures the pumping station upgrades (2) have been or are in the process of being made into permanent solutions but we do not anticipate making (1) the South West Area Reservoir 2 to another South West Area reservoir raw water pipeline a permanent solution. In future drought scenarios, the additional treated water flexibility provided, and demand reduction measures identified, should enable us to act much earlier to transfer supplies and reduce demand which would potentially avert the need for the raw water transfer.

However, we wish to retain the options to use the transfer, as a future temporary drought measure. We recognise that this will require a variation to the existing abstraction licence, specifically with regard to the means of abstraction which should be varied by changing the words "*Valves and pipeline"* to *"Valves, pipelines and pumps*". We are in correspondence with the Environment Agency in this regard. This option will be included in our next drought plan.

A further measure which would reduce the risk to the Worth Valley in a future drought scenario, would be the optimisation of the compensation flow regime. This would give improved control of stocks whilst providing a flow regime which better mimics natural variation over the year. We have commenced a flow trial as agreed with the Environment Agency through a Temporary Local Enforcement Position (LEP) which commenced 10th July 2023 and will be reviewed prior to the flow trial advert expiring at midnight on 1st April 2027.

On the back of the 2022 drought, no specific new drought permits were identified.

Drought action benefits

We enhanced water savings communications in line with our drought plan and monitored the reach of these communications.

We estimated a potential benefit of up to 1000Ml in the period October-March, by implementation of the North West Area Reservoir 11 drought permit to reduce compensation flows, assuming it was granted in October, and that river flows were in a band that did not require a supporting release from North West Area Reservoir 11. The actual saving in release was about 230Ml from November to 10 January, as for part of that time a release was made to support abstractions on the River Wharfe.

We estimated we could save up to 600Ml by the implementation of the permit to reduce the compensation flows from North West Area Reservoir 2 and North West Area Reservoir 2 reservoirs during the period October 25th to the end of March. Our actual saving was 130Ml for the period October 25th until mid December, when reservoir stocks recovered.

Analyses of our demand data have shown that the implementation of TUBs resulted in a reduction in demand of about 42Ml/d from implementation during the period of hot weather, and about 26Ml/d from implementation until the end of October. These values are slightly higher than the savings assumed in WRP table 6- which indicate about 18Ml/d savings when appeals for restraint, leakage reduction, and TUBs are all implemented in our worst case historic scenario, but these values will be more similar if the benefits of the TUBs are averaged out over a DYAA scenario. We therefore believe that our assumed benefits are appropriate.

Deployable output and levels of service

We implemented TUBS for the first time since 1996. This aligns with our stated levels of service. We implemented a few drought permits and were preparing to implement others when our resources recovered. Although technically we implemented permits, this was because we were implementing permits in stages due to the time taken to apply for and implement permits. This means that some permits will be implemented before triggers are crossed, some at the time the trigger is crossed, and some after. We are reviewing our timelines for permit application and implementation based on experiences from 2018 and 2022, and will incorporate the learning into our next drought plan.

We have also reviewed groundwater deployable outputs, and the yield and control lines of reservoir sources based on our 2022 inflows, including our emergency storage assumptions. These result in a very slight change to our control lines, but no changes to our emergency storage assumptions. Our emergency storage is the larger of 20 day's supply at yield, or 12.5% of reservoir stocks, and in all cases the 12.5% is larger, so this has resulted in no change.

Figure F1 shows the normal and drought control lines used for the WRMP24 supply modelling, and the updated control lines using inflows including the 2022 drought. It shows that the drought control lines are almost identical, but that the updated normal control lines are a little higher than those used for the WRMP24 modelling. This would result in reservoirs use reducing sooner and river use increasing sooner than in the previous modelling. The modelled reservoir stocks are almost the same in both circumstances.

Figure F2 shows the relationship between regional demand and the return period of level 4 drought restrictions for the WRMP24 model, and the revised model with control lines updated to include the 2022 drought. It shows the results are very slightly different, but not to the extent that would require updating the WRMP supply forecasts. When we have selected the 1 in 500 to 1 in 200 scenario, we have used a return period within up to 30 years to represent that scenario, and the update of control lines has resulted in a change from 508 years to 512 years for the 1 in 500 scenario, which means there is no change to our supply forecast. The results for the 1 in 200 and 1 in 100 scenarios are even closer, with the lines almost indistinguishable for those return periods.

Figure F1: Normal and drought control lines and modelled Yorkshire Regional group stocks

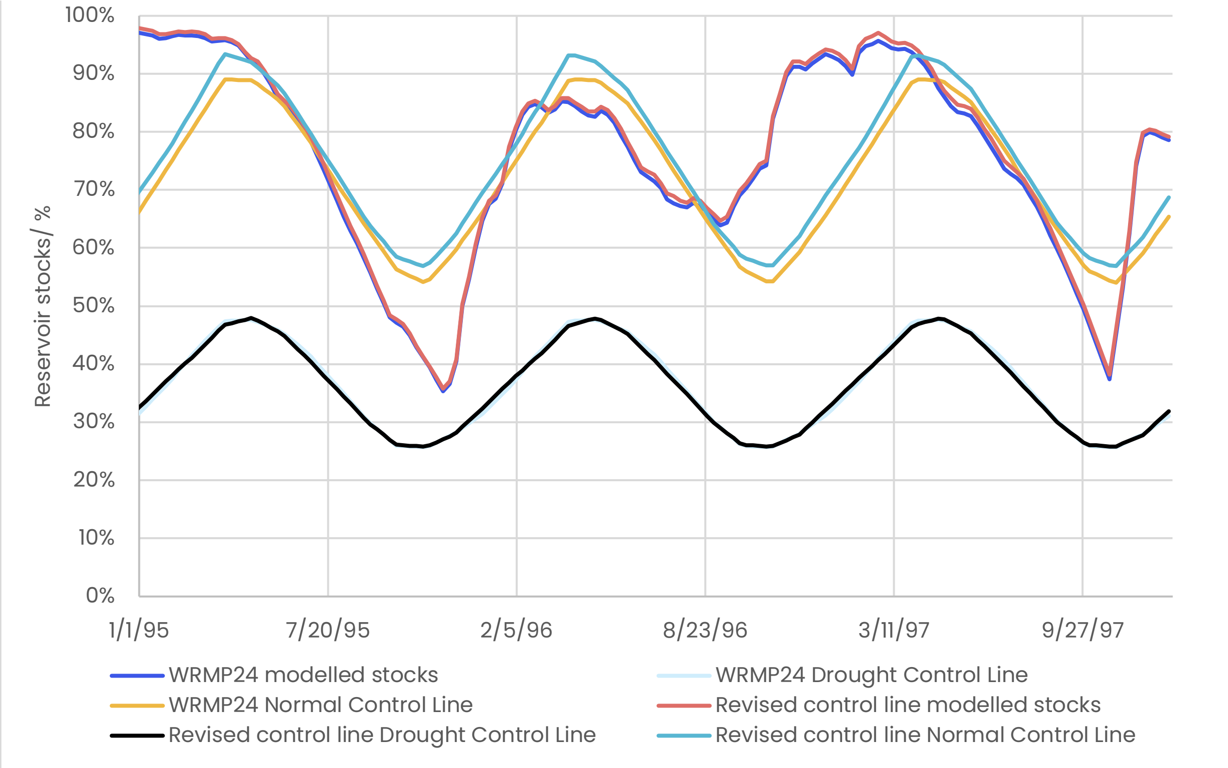
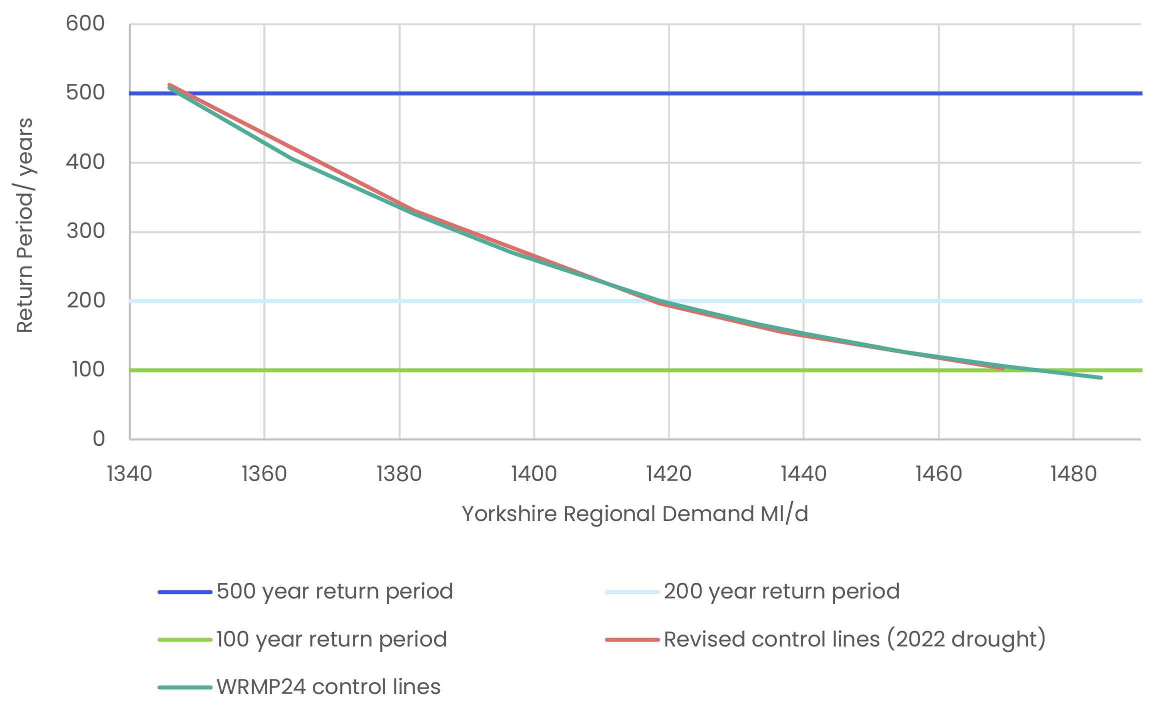


Figure F2: Comparison of deployable outputs for Base WRMP models- old and new control lines



These analyses show that although there are slight differences between the control lines when the 2022 drought is included in the period of record used to generate the control lines, there is no substantive change to the supply forecast, and we have not repeated all supply forecasts using the new control lines.

We have also reviewed groundwater source reliable outputs and again, have not made any changes to the source reliable outputs used in the supply forecast based on the 2022 drought.

Although 2022 was hot and dry, it did not alter the limits of supply for any of our groundwater sources. Groundwater sources are generally unaffected by summer drought. Although reduced winter recharge resulted in lower-than-normal groundwater levels, this did not affect the output of the sources. In most cases deployable output is restricted by licence and not yield of the groundwater sources.

Assessment of drought performance of our groundwater sources includes definition of the deepest advisable pumping water level, (DAPWL). This is the operational constraint on groundwater yield, based on drawdown of the water level in the pumping well. The DAPWL can be based on a variety of factors depending on the characteristics of individual wells. These may include major inflow horizons, saturated aquifer thickness or pump intake level. The DAPWL is considered a robust and objective threshold for assessment of resilience for groundwater abstractions, which can be applied across different aquifers and wellfields.

For each abstraction well the maximum drawdown has been compared to DAPWL for the period of seasonal groundwater minimum, (September to November) for 2022. This has been considered alongside the abstraction rate for each source, due to the significance of abstraction on drawdown in a pumping well.

Figure F3 shows the groundwater abstraction data for the period from January 2020 – March 2024. The overall abstraction from groundwater increased marginally over the drought period as surface water sources became increasingly stressed. This effect was seen to some extent across all of Yorkshire's principal aquifers and further demonstrates the natural resilience of groundwater resources to summer drought.

Figure F4 shows groundwater levels for a representative pumping well in each of Yorkshire's wellfields. The trend in each case is similar to that of a non-drought year, although in several cases the level is relatively low throughout all of 2022, compared to other years in the period 2020 – 2023. This is due to the relatively dry winter of 2021 -2022, which affected aquifer recharge prior to the dry summer of 2022.

The DAPWL is shown in each hydrograph, and these demonstrate how different groundwater sources behave in terms of their yield / drawdown relationship. This is because of the variability of hydrogeological conditions across different aquifers and indeed different sources within the same geological formation. All of Yorkshire's groundwater sources behaved sustainably during the summer of 2022, despite experiencing lower than normal winter recharge and seeing, in many cases increased abstraction rates compared to the recent average. This is consistent with the normal behaviour for our groundwater sources because Yorkshire's aquifers are recharged during the period from mid-Autumn to mid-Spring, after which no further recharge is expected. This, combined with the considerable storage capacity in our aquifers results in significant resilience to summer drought.

The source shown in Figure F4 for the Carboniferous Wellfield is the Bridge borehole source, which is the only consistently pumped Yorkshire Water source in that aquifer. The deflection seen during late summer 2022 is due to a pumping test at that source, where groundwater was abstracted above the maximum licence (under a Section 32 permit) for 4 weeks. The source recovered well after pumping rate returned to normal and groundwater level remained significantly above the DAPWL.

Figure F3: Combined groundwater abstraction

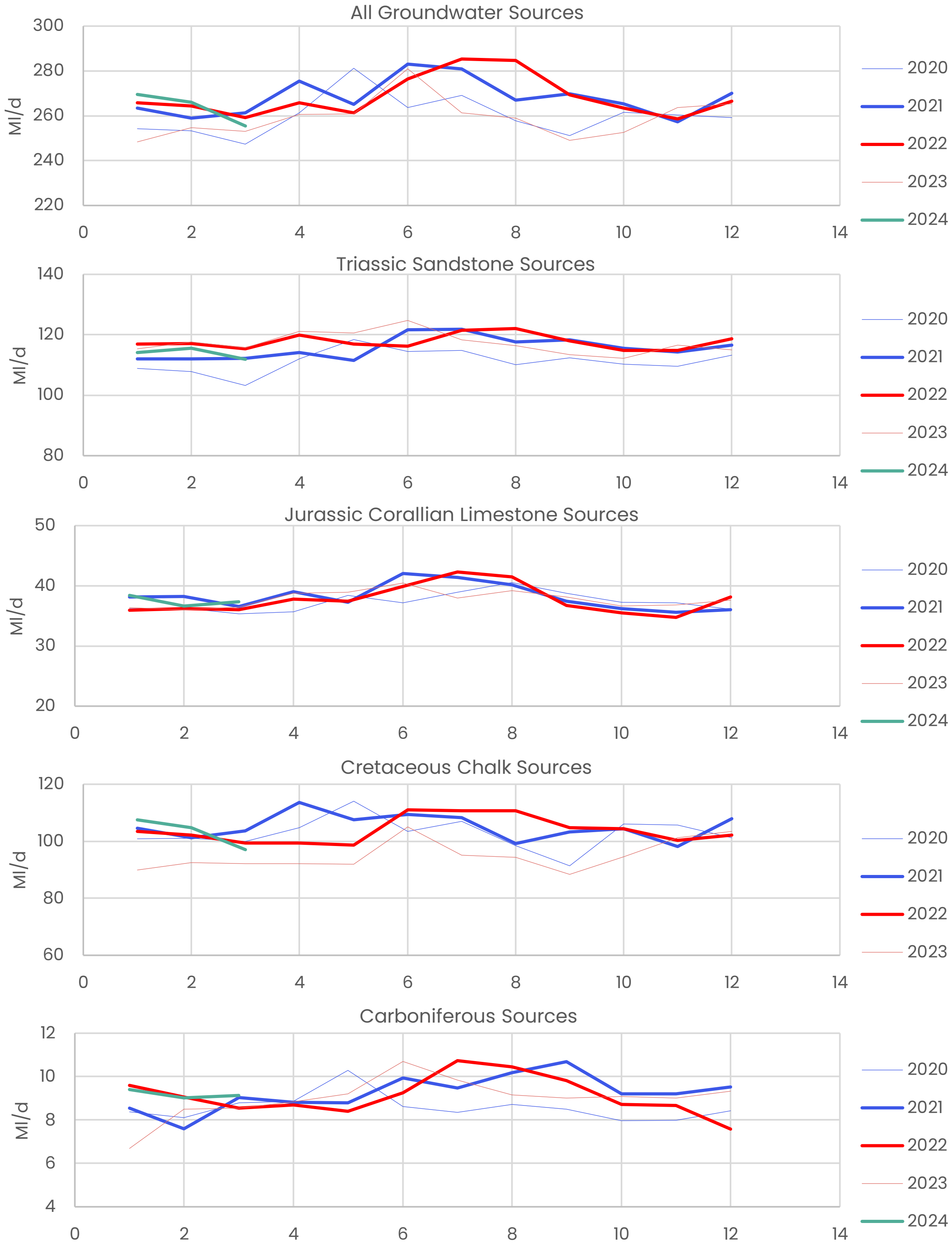
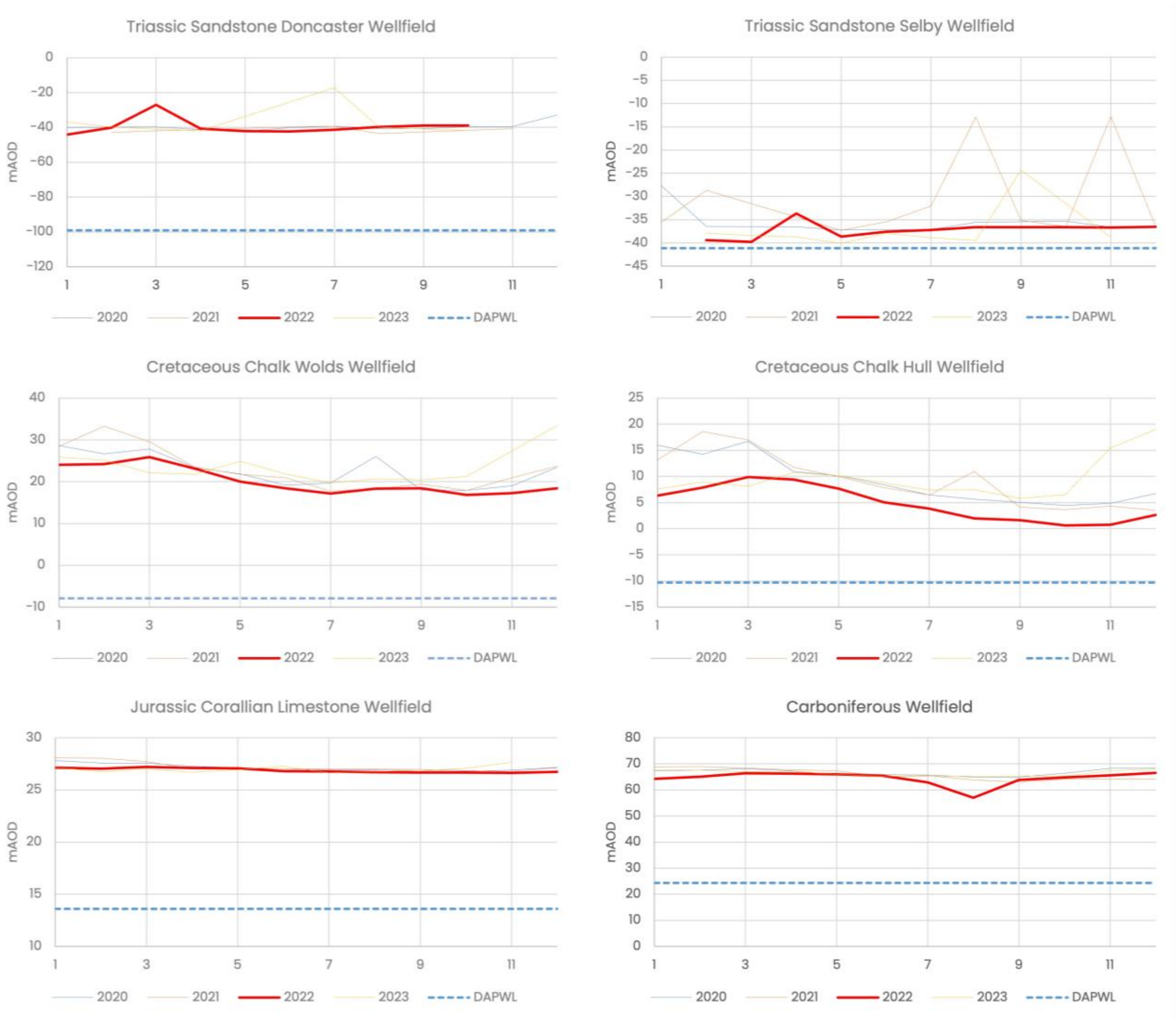


Figure F4: Examples of groundwater level response to 2022 summer drought



WRMP demand forecast

We have reviewed our dry weather and critical period demand assumptions against the 2022 demand data. During 2022 we experienced high summer demands which peaked in July and a temporary use ban was in place from late August until December. Our draft plan was based on a base year of 2019/20 and a critical period assessment based on the summer of 2018. During 2018 we did not require any restrictions on water use and, although we applied for and were granted drought permits, we did not need to implement them.

We have not altered our household dry year annual average uplift based on the 2022 drought data. Total daily average DI for 2022/23 out-turned at 1260.32Ml/d compared to a 2019/20 dry year demand forecast of 1281.19Ml/d. The 2018 summer demand profile shows a prolonged period of high demand over four weeks with a maximum 28 day rolling average demand of 1420Ml/d recorded. The 2022 data recorded a lower maximum 28 day rolling average demand of 1389Ml/d. However, during July of 2022 daily demand peaks were greater than 2018. The daily peak demand in 2022 was 1575Ml/d, whereas in 2018 it was 1488Ml/d.

We have carried out a regression analysis including per capita consumption (PCC) values from 2009/10 to 2022/23 and the 2022/23 PCC (123.9 l/h/d) was lower than 2018/19 (133.0 l/h/d). The demand we experienced in 2022 was influenced by our water efficiency campaign and a temporary use ban. These constraints reduce demand and although we can estimate the effects of demand drought actions, we cannot reliably adjust the drought demand to reflect either a normal or an unconstrained dry year demand. As the WRPG requires the baseline demand forecast to be unconstrained, we have maintained the 2019/20 base year and the draft WRMP24 household uplift calculated by Artesia Consulting using a household multi-linear regression model.

In our draft plan we applied a non-household uplift of 5% to our DYAA scenario which was based on an annual average consumption regression analysis carried out by Artesia Consulting (see section 4.3.6) prior to the 2022 drought. We have reviewed the 2022/23 non-household data, and this did not show a significant uplift. This is possibly due to non-household consumption still 'bouncing back' from the reduction experienced during the Covid-19 pandemic. We have therefore retained the 5% uplift based on the 2018 data.

Critical period

Our draft WRMP24 included a critical period scenario for our Grid SWZ. The East SWZ has sufficient headroom not to require a critical period scenario. The Grid SWZ critical period household uplift in the draft plan was based on a prolonged period of high demand during the summer of 2018, which lasted for four weeks. Artesia Consulting carried out a critical period demand assessment on Grid SWZ distribution data for the last 10 years by applying cumulative distribution functions (CDFs) to the peak volumes (see Section 4.3.6). This resulted in an 18% (1.1803 factor) increase compared to the normal year demand and 16% compared to the DYAA for a 1 in 500 event.

We have extended this analysis to include the 2022 data and the revised CDFs result in the same factor as those used for the draft plan. We have therefore not made any changes to the critical period uplift.

The draft plan included a 10% critical period uplift to non-household consumption, based on the 2018 dry year. We assumed the uplift would have been during the summer months and therefore doubled the annual average allowance. As discussed above we have extended the analysis however, due to Covid potentially demand skewing the 2022 non-household demand we have not altered the non-household uplift assumptions.

Our draft plan did not apply a leakage uplift to the DYAA scenario, but we included an 8% uplift to the annual average leakage targets to represent summer leakage breakouts. Leakage breakouts can increase in hot dry weather due to ground movement. Whereas in cold weather, breakouts result due to freeze-thaw events. Extreme weather events present a risk to achieving our leakage targets. We have reviewed the leakage data incorporating data for 2022/23.

Soil moisture deficit data from 2011/12 to 2022/23 shows 2018/19 and 2022/23 to have the highest soil moisture deficit. In these years we experienced drought conditions and higher leakage break outs due to the dry ground conditions. In normal years we control leakage to avoid any summer increase. During extreme conditions it is more difficult to control leakage at target levels and we can see a temporary increase in leakage, although we would also increase our efforts to reduce leakage. Analysis done on leakage during these periods has shown that there is no leakage uplift during our critical period, this is explained further in Section 4.3.6 Critical period.

Business plan

We have finalised our business plan submission for PR24 and we aim to continue the long-term process of enhancing our production and network resilience, taking a risk-based approach to the outputs of our Water Supply System Strategy programme to strengthen resilience in our systems. Potential resilience enhancement options will be assessed alongside other risks in the business planning process and may form resilience enhancement schemes or be considered as options in the WRMP if they have a deployable output benefit.

We are re-assessing the integrity of our water resource zones, and considering whether the drought in 2022 will impact our zones for future WRMPs, but will not make any changes to zones for WRMP24. Depending on the results of the analysis, we may change our resource zones, leave them as they are, or improve connectivity within zones.

Bulk supply agreements

In 2022, Severn Trent Water were granted a drought permit for our shared resource in the Derwent Valley. Their permit was to allow an additional abstraction point from which the Yorkshire supply could be made, and to reduce compensation flows to the Derbyshire Derwent river. The permit had conditions on the maximum allowed abstractions from the Derwent Valley reservoirs, which greatly reduced our allowed abstractions compared to what would have been allowed by the reservoir operational rules in the Derwent Valley Agreement. This caused considerable stress on our southern Pennine sources and our licence on the (Yorkshire) River Derwent. Severn Trent Water have since applied for a licence variation to allow the abstraction point, which will enable the supply to Yorkshire Water to be maintained from Ladybower reservoir, in addition to the usual abstraction from Howden and Derwent reservoirs. This has informed our assumed availability of the Severn Trent import in our WRMP for our critical period analysis.

Outage

During the 2022 drought period we recorded unplanned outages at WTWs and key assets daily, as we do throughout the year. This data is used in reporting of our unplanned outage performance commitment and our WRMP outage allowance.

Since publishing our draft WRMP24 we have remodelled the outage allowance for both water resource zones (see section 3.1.5) and included outage data for the 2022/23 report year. By including the 2022 outage data in the DYAA and critical period (Grid SWZ only) assessments we ensure our outage allowance includes the events recorded during the 2022 drought period. In line with the UKWIR risk-based planning suggested range for outage, we have used the 85th percentile risk value from the model outputs to represent our outage allowance. In most years our zonal outage values will be lower than the modelled values, however this is an appropriate approach as it plans for the risk that in a dry year outage could be worse than historically experienced.

By including an outage allowance we compensate for a risk that deployable output may not always be fully available. However, this is an average value and the WRMP process does not prevent an individual outage event creating a risk during a drought event. We limit and mitigate this risk through our operational response to drought and our production planning teams will optimise resources and redistribute supplies to meet demand. This includes rescheduling planned outage events that are not necessary at that point in time and escalating repairs to address critical unplanned outages.

As part of our drought learning we review outages once the situation recovers and consider any improvements needed to increase future resilience. During April to June 2022 there was an outage on the River Ouse due to a river abstraction pump being out of service. This reduced the volume we could abstract from the river and was a risk to a local area North Yorkshire WTW 2 that is fed by a WTW that has limited alternative supplies when the river is low. The pumps were returned to service in June 2022. The North Yorkshire WTW 2 area at risk during the outage has also been identified as at risk as part of our water system supply strategy resilience and options for removing the risk have been considered.

One of the options considered is an existing licenced groundwater abstraction. The borehole is to be refurbished as part of our drinking water quality plan, which will increase the reliable yield from the borehole within the licenced permissions. We have created a WRMP scheme that would link the North Yorkshire WTW 2 supply area to the borehole, thereby providing an alternative source of supply when the River Ouse has an outage or is in the lowest flow band. This provides an average supply benefit of 5Ml/d as it allows ‘locked in’ yield to be put into supply.

17.10 Appendix G: Supply option delivery

Supply option delivery risk

Supply option	Delivery uncertainty
R3 Increased River Ouse pumping capacity	• Licensing – permitted under current abstraction authorisations. The licence is subject to the outcome of a WINEP investigation on the River Ouse abstractions – see below. • Environment - During the construction of this option there are likely to be moderate residual impacts cultural heritage (details of which can be found in the SEA). The detail of mitigation will need to be considered during the planning phases when the option is taken forward for implementation, but this could include communication with property owners and Historic England prior to construction as well as the implementation of an archaeological watching brief during construction. However, once operational there will be no significant adverse impacts. • Drinking water quality – currently abstracting and treating from this source and a drinking water safety plan is in place. • Scope / delivery – requires a hydraulic study to confirm whether a river crossing on the Wharfe would need to be twinned. • Planning permissions – applicable if the river crossing is needed. This would be located in a rural area and require planning permission and access authorisation. • Benefit - there is a WAFU benefit of the scheme to provide additional support to a Leeds WTW. However, the water is only available when the river is at a specific flow level and supporting the Leeds WTW reduces support to a York WTW. The WAFU benefits have been adjusted to account for the limitations on use. Modelling has shown in the WRMP24 1 in 500-year drought scenario the WAFU increase is potentially 10 Ml/d.
R3a River Ouse licence transfer at low flows	• Licensing – requires the EA to grant a variation on two existing abstractions on the River Ouse. Variations also require agreement with the Canal and Rivers Trust. We would apply for a proportion of the downstream abstraction to be taken at the upstream point when the river was in certain flow bands. However, we would offset the take at the downstream abstraction by the volume we were abstracting. The licences are subject to the outcome of a WINEP investigation on the River Ouse abstractions – see below. • Water quality – currently abstracting and treating from this source and a drinking water safety plan is in place. • Scope / delivery – no additional infrastructure required. • Planning permissions – not applicable. • Benefit – the benefit is only available when flows are in the low flow bands as we are permitted to take more water in the higher flow bands. The WAFU accounts for the limitations. Modelling has shown in the WRMP24 1 in 500-year drought scenario the WAFU increase is potentially 0.3Ml/d. The additional abstraction will be greater at times, but the average WAFU benefit is small. From 2035/36 the STW backfill option will also make use of the spare licence capacity and we would need to manage the conjunctive use.

R91 New internal transfer to North Yorkshire WTW 2	• Licensing – permitted under current abstraction authorisations. • Water quality – currently abstracting and treating from this source and a drinking water safety plan is in place. • Scope / delivery – the existing borehole is being relocated within the permitted radius as a water quality scheme that is included in our PR24 Drinking Water Quality plan. The WRMP R91 scheme delivers additional infrastructure to provide a connection from the borehole to an existing WTW that provides a WAFU benefit within the existing abstraction permissions. • Planning permissions – permission will be sought to lay the pipeline for the new connection from the borehole to the WTW (any additional permissions linked to the borehole relocation will be requested as part of the PR24 scheme). • Benefit – the WTW is currently fed from the River Ouse and this will continue to provide the main source of supply to the area. The scheme would provide an additional source to the WTW when the River Ouse was in the low flow bands, and 'freeing up' the River Ouse during lower flows to support other demand areas.
R13 East Yorkshire Groundwater	• Licensing – the existing borehole is unusable due to water quality risks as a result of the poor condition of the borehole asset. A licence variation application will be submitted to relocate the borehole. • Environment – further WFD investigation is required to assess the impacts of the relocation of the abstraction. This will examine the status elements of the groundwater water body (particularly saline up-coning and chemical status) and possible surface water links • During the construction of this option there are likely to be moderate residual impacts on biodiversity, flora and fauna, water quantity (details of which can be found in the SEA). The detail of mitigation will need to be considered during the planning phases of each of the individual measures as and when the option is taken forward for implementation However, once operational there will be no significant adverse impacts. • Drinking water quality – there are microbiological, turbidity and nitrate risks. A drinking water safety plan exists for the previous abstraction. We will fully review the water quality risks and comply with the drinking water quality regulations and seek all necessary approvals before introducing the new borehole source to supply. • Scope / delivery – The relocation has been identified as a mitigation measure for the water quality risks. The new location is expected to give better quality due to the installation of a new asset, greater unsaturated zone and some protection from clays on the top of Brayton Barff. The scope includes installation of ultraviolet treatment to address the microbiological risk. Test pumping and water quality sampling will be needed to confirm the yield and that risks have been resolved. • Planning permissions – the relocation is within 300 metres of the existing borehole and on existing YW operational land. It is assumed the development will be permitted under a general permitted development order. • Benefit – the source would be used as part of our grid conjunctive use system and results in an increase in WAFU. The licence will allow for a daily maximum of 9Ml/d. However, in most scenarios it is likely the source would provide the daily average 6Ml/d.

DV8B New York WTW and Dual Main South Yorkshire Pipeline	• Licensing – permitted under current abstraction authorisations. The licence is subject to the outcome of a WINEP investigation on the River Ouse abstractions – see below. • Environment – The WFD compliance assessment has identified potential non-compliance issues associated with Option DV8B as additional abstraction may result in a risk to the deterioration in fish status in one water body as a result of existing issues with dissolved oxygen sags largely attributed to stormwater discharges. The WINEP investigation to date has concluded that through investment to improve storm overflow discharges, this impact and the risk to fish status would be significantly reduced. However, we are still in consultation with the Environment Agency on the outcome of a WINEP investigation on the River Ouse abstractions. • During the construction of this option there are likely to be major/moderate residual impacts on biodiversity, flora and fauna; population and human health; material assets and resource use; water quantity, soil, geology and land use; air and climate; archaeology and cultural heritage; and, landscape and visual amenity (the details of which can be found in the accompanying SEA). The detail of mitigation will need to be considered during the planning phases of each of the individual measures as and when the options is taken forward for implementation However, once operational there will be no significant adverse impacts. • Water quality – we are currently abstracting and treating from this source and a drinking water safety plan is in place. The river water would be transferred to South Yorkshire, an area currently fed by reservoir supplies. Customers and stakeholders would need to be consulted on the change in water supply. • Scope / delivery – the scheme requires a new raw water main, new WTW and a 100km twinned main to transfer treated water to customers. It is being developed under the RAPID SRO process and Gate 2 is scheduled to be completed by April 2025. We will develop and agree an overall delivery model with RAPID as part of the development of the Gate 2 submission. YW's PR24 draft business plan assumes that the solution is taken forward under the Ofwat 'direct procurement for customers' (DPC) process, which means a third party would be appointed to construct and potentially operate the solution. Although the WTW site will be partially on YW owned land, we will be required to purchase adjacent land to provide for the full footprint. • Planning permissions – permission will be sought for a new WTW, a new raw water pipeline from the River Ouse to the works and new treated water main from the works to South Yorkshire. We anticipate this will require a development consent order (DCO). • Benefit – modelling shows the scheme would be utilised to provide supply to South Yorkshire once the STW transfer terminates. If the scheme is unsuccessful this is a high risk to security of supply, and we are continuing to review alternative supply-side schemes.

R8g Sherwood Sandstone Boreholes support to North Yorkshire	• Licensing – a new abstraction permit would be required to take water from the Sherwood Sandstone in North Yorkshire. • Environment – The WFD compliance assessment concluded that further investigation may be required into the impacts of the drawdown caused by the increased abstraction on the status elements of the groundwater water body (particularly chemical status). • Water quality – risks include manganese, radioactivity, nitrate, pesticides and microbiological. A drinking water safety plan would be created to comply with drinking water quality regulations, and we would seek all necessary approvals before introducing a new source, including an appropriate source protection zone. • Scope / delivery – the scheme requires six new boreholes, a raw water transfer main, new WTW and treated water transfer mains to existing service reservoirs. Test pumping and water quality sampling would be needed to confirm the yield benefit, environmental impact and water quality treatment elements. • Planning permissions – permission will be sought for the boreholes, WTW and connecting pipelines. A DCO could be required. • Benefit – the 15Ml/d benefit would support an area which is undergoing population growth due to local development. Modelling shows high utilisation of this source if constructed, but subject to test pumping results.
DV7a(vi) Tees to York pipeline - NWL import (140Mld) **This scheme will be developed as a strategic resource option and data will be collated in line with the RAPID gated process.**	• Licensing – NWL currently has underutilised abstraction capacity on the Tees but not sufficient to meet the preferred plan 140Ml/d requirement. An additional abstraction permission would need to be approved by the EA and any future abstraction would need to comply with the Kielder operating agreement, which will be considered as part of an AMP8 Environmental Destination WINEP investigation. • Environment - During the construction of this option there are likely to be major/moderate residual impacts on biodiversity, flora and fauna; population and human health; material assets and resource use; water quantity, soil, geology and land use; air and climate; archaeology and cultural heritage; and landscape and visual amenity (the details of which can be found in the accompanying SEA). The detail of mitigation will need to be considered during the planning phases of each of the individual measures as and when the options is taken forward for implementation However, once operational there will be no significant adverse impacts • Water quality – risks include Cryptosporidium, microbiological, pesticides, nitrate, turbidity and poly- and perfluoroalkyl substances (PFAS). The scheme includes pre-treatment to sub-potable at a new WTW near the source before transfer to an existing WTW in the York area to meet INNS requirements. For both the new and existing WTWs, a drinking water safety plan would need to be developed and all water regulations DWI approvals in place. • Scope – the scheme requires an additional pump and electricity supply at a NWL pumping station to provide the support from Kielder Water. Additional infrastructure would be needed at the source and a new sub-potable WTW before transfer via a new main to the existing YW WTW. The existing works would also require modifications.

	• Planning permission – permission would be sought for the new WTW and connecting main. A development consent order is expected to be a requirement. Archaeology and ecology surveys and flood risk assessments would be carried out to support planning applications. • Benefit – the benefit is dependent on an import from NWL and would replace the reduction in the River Derwent abstraction (subject to an AMP8 WINEP investigation) that currently supplies the York WTW. The transfer would have high operational financial and carbon costs.
R37b(ii) River Aire Abstraction option 4 and West Yorkshire new WTW **In the preferred plan R37b(ii) is not needed until 2073 however, the source is included in the R86 Investigations and this option is needed in 2039 under the more adverse pathways. We will therefore start investigations that are relevant to both schemes in AMP8.**	• Licensing – new abstraction permits would be required to take water from the rivers Aire and Calder. The abstractions would be subject to hands off flow conditions and protecting downstream fish passes. The volumes proposed are based on EA Catchment Abstraction Management data and a desk top study on the fish passes and investigations will be required to confirm the benefit. • Environment - During the construction of this option there are likely to be moderate residual impacts on biodiversity, flora and fauna (details of which can be found in the SEA). The detail of mitigation will need to be considered during the planning phases of each of the individual measures as and when the option is taken forward for implementation. However, once operational there will be no significant adverse impacts. • Water quality – risks include Cryptosporidium, microbiological, pesticides, nitrate, turbidity and poly- and perfluoroalkyl substances (PFAS). The R37b(ii) scheme would treat the flow at an existing WTW, which would introduce the risk of trihalomethanes formation above permitted limits. To address this concern, granular activated carbon would be added as an additional treatment process. The R86 scheme would construct a new works to the required standard. • Planning permission – The new works under R86 and extension under R37b(ii) and the associated raw water mains to feed the WTW would be subject to planning approvals. Archaeology and ecology surveys, flood risk assessments, for example, would be required to support planning application. • Benefit – the benefit would vary depending on river flows. Based on the WRMP desk top study we have assumed an average benefit of 33.5 Ml/d from the River Aire and 50Ml/d if combined with the River Calder. The daily maximums are assumed to be 50 Ml/d and 110 Ml/d respectively. The benefits will be reviewed following AMP8 investigations into the water availability.

R31 Bankside storage at York WTW	• Licensing – permitted under current abstraction authorisations on the River Derwent. As the storage would take water when available at higher flows to store and use during lower flows, it is assumed this water is available following changes to the abstraction permissions to meet the CSMG target. • Environment - During the construction of this option there are likely to be moderate residual impacts on biodiversity, flora and fauna (details of which can be found in the SEA). The detail of mitigation will need to be considered during the planning phases of each of the individual measures as and when the options it taken forward for implementation However, once operational there will be no significant adverse impacts. • Drinking water quality – Risks to the source include, Cryptosporidium, microbiological, pesticides, nitrate, turbidity and poly- and perfluoroalkyl substances (PFAS). As the scheme utilises River Derwent water that is treated at an existing WTW, a site-specific drinking water safety plan is already in place. • Scope / delivery – The scheme facilitates expansion of the existing WTW site, utilising existing infrastructure. Further investigations will be required, including site topographic survey, geo-environmental desk study, ground investigations, and hydraulic calculations to confirm the design before construction. • Planning permission – The additional storage would be subject to planning approvals. Archaeology and ecology surveys, flood risk assessments etc. would be required to support the planning application. • Benefit – The benefit assumptions are based on the additional WAFU provided by the storage under the most likely scenario. The scheme would provide some mitigation to the impacts of climate change and the CSMG target that will reduce water availability on the river. This only offsets a small proportion of the loss of supply but would be in addition to other option benefits.

Yorkshire Water Capital Process

- Gate 1: Project initiation and approval – based on business case, available scope details, benefits, and whole life cost.
- Gate 2: Investigation funding approved – a project team will be set up and scope further defined to determine funding for investigations.
- Gate 3: Delivery solution approval – investigations completed and used to confirm viability for delivery.
- Gate 4: Delivery phase funding approval – Scheme design and costs updated, and tender process carried out.
- Gate 5: Design acceptance – Delivery contract(s) awarded, and design packages agreed.
- Gate 6: Construction testing acceptance - Construction phase and construction accepted to ensure assets meet all safety and design requirements.
- Gate 7: Commissioning testing acceptance - Commissioning and testing to confirm asset is performing as required, scope fulfilled and where relevant regulatory compliance achieved.
- Gate 8: Takeover and completion - Final documentation, approval of asset data capture and YW takeover asset on completion.
- Gate 9: Defects completion - Following remediation of all major defects the client issues a defects certificate.

17.11 Appendix H: Customer engagement reports

We have published the customer engagement report online. Please see:

https://www.yorkshirewater.com/media/2ipehzq2/yorkshire-water-wrmp-report-fv.pdf

17.12 Appendix I: Supply option changes since draft WRMP

Changes since the draft WRMP

The supply-side options included in our final WRMP24 have changed since our draft WRMP24 was published in November 2022. Table I-1 lists the early start options proposed in the October 2023 revised draft plan. The R37b(ii) River Aire Abstraction option 4 is now scheduled for 2073/74, however a new abstraction on the River Aire could be needed as part of our adaptive plan. DV3 Magnesium Limestone new GW supply and R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2 are no longer required in the AMP8 period and the DV8(v) New WTW (York) supplied by the River Ouse scheme has been replaced with a scheme to build a new WTW and the benefit will not be realised until 2035/36.

Our final plan includes the R13 East Yorkshire Groundwater Option 2 and R8g Sherwood Sandstone Boreholes support to North Yorkshire schemes, although the benefits will be later in the planning programme. In addition, we will implement schemes R3 Increased River Ouse pumping capacity and R91 New internal transfer to North Yorkshire WTW 2. R3a River Ouse licence variation 1 was included in the draft WRMP24 with a benefit in 2027/28, the same as the final plan. This was not included as an early start scheme, but we have reviewed and are proposing to start some of the preliminary investigations linked to the River Ouse licence (see Section 10.2).

Table I-17-1: Draft WRMP24 supply options with an early start date (October 2023)

Option	Build start	Benefit start
R13 East Yorkshire Groundwater Option 2	2022/23	2025/26
R37b(ii) River Aire Abstraction option 4	2022/23	2025/26
DV3 Magnesium Limestone new GW supply	2024/25	2027/28
R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2	2024/25	2027/28
R8g Sherwood Sandstone Boreholes support to North Yorkshire	2024/25	2028/29
DV8(v) New WTW (York) supplied by the River Ouse	2025/26	2029/30

The change to the AMP8 solution is a result of updates to the Grid SWZ supply forecast between draft and final plan, which impacted on the supply-demand balance for each of the scenarios. Subsequently we had to rerun the optimiser model to create solution programmes based on the revised scenario deficits. There were also some changes to the costs and benefits of individual options. The changes include:

- Remodelling of the deployable output and climate change impacts on supply using the PyWR model, which has replaced WRAPsim. For the baseline scenario, this has resulted in an increase to the 'deployable output post forecast changes' (line 6.1BL in Table 3a) ranging from 2.81Ml/d in 2019/20 to 19.09Ml/d in 2084/85.
- A change to the date for reducing the River Derwent licence to address the CSMG flow target for European protected areas in the Environmental Destination. It has been brought forward to 2040/41 from 2049/50. This results in a baseline reduction of approximately 118Ml/d in the 2040/41 to 2049/50 period compared to the draft plan. It also impacts the low and high ED scenarios which have been aligned to this date. The scale of the potential reduction in the River Derwent licence is subject to the outcome of the AMP8 investigations.
- A review of the leakage, household (including water labelling) and non-household options. This has led to changes to the number and type of feasible demand options, the benefits they achieve and the profile for delivering the options over the planning period. The total demand reduction benefits in the preferred solution by 2049/50 are 38.37Ml/d greater than included in our draft WRMP24.
- Addition of the R91 New internal transfer to North Yorkshire WTW 2 option, which was identified through our WSSS and water quality strategies after the draft plan had been submitted.
- A change to the option for backfilling the loss of the STW transfer. In the draft plan the scheme included an extension to an existing WTW that would provide a benefit in 2024/25, five years ahead of the transfer ceasing. In the final plan the option is a new WTW and the benefit is not realised until 2035/36.