Yorkshire Water
Draft Water Resources Management Plan 2024

October 2022

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 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 includes a twin track approach including demand reduction and increasing available supply. Demand reduction activity includes leakage reduction, smart metering and water efficiency.

In respect of supply options, in the early part of our plan (2025-2030) we will make use of new supplies including four new borehole sources and associated water treatment works. We have also included plans for two river abstractions and associated treatment. In the medium term our plans include a treated water transfer within our operational area to offset the loss of imported water from outside our region. In the long term, to mitigate the future resource reductions associated with the need to protect sensitive river environments our plans include a transfer from Northumbrian Water and new storage and treatment capacity at existing or new water treatment works.

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 will also reflect on the experiences of the ongoing drought in 2022 and expect to include any necessary adjustments to our WRMP in the final version to be published next year.

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 and significant risks have been identified in our WRMP24 and have reshaped our future water resource position. These risks include a need for 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.

Further risks include future licence reductions 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 extreme weather events in 2018 and 2022 with the drought of 2022 still ongoing whilst we were creating this draft plan. 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.

Once all the emerging risks 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 the risks 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. Our aim is to reduce the volume we abstract from the environment and put into supply each day. This will reduce average demand in our supply area and reduce our daily average energy consumption used for treating water and pumping to customers. 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 shall 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. To meet the longer-term environmental needs, we are developing an option for a potential import from Northumbrian Water. Additionally, we will identify and explore further options to consider as an alternative to the import and to increase the portfolio of options available to us in future iterations of our 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.

We intend to develop our WRMP24 further before publishing as final. Many of the needs and complexities considered in our WRMP24 did not emerge until 2022. These needs include the environmental destination licence reductions that were originally agreed with regulators to be zero in the most likely scenario. Further, we are experiencing a drought in 2022 and this is ongoing at the time of writing our draft WRMP24. We will need to reflect on the learning from this latest dry period when finalising our WRMP24. We therefore consider it likely our plan will change between draft and final, but at this stage we require further information to clarify the extent of these potential changes.

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 take action. 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 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* and supporting documents (Environment Agency, Ofwat and Natural Resources Wales, 2021), the *Water Resources Management Plan (England) Direction 2022* (Defra, 2022) and *Government Expectations for Water Resource Planning* (Defra 2022). These guidelines and directions define the methods we use for estimating the components of supply and demand to inform our plan and 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 energy costs. 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 these have created significant stress on our network and in the future, without further interventions, they could result in 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 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 WRMP (WRMP19) 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 Guidance, 2022. 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 20th September 2022, has allowed the Board to agree the following assurance statement, which meets the requirements of the Water Resources Planning Guidelines.

Our Board assurance statement is provided below. The required supporting statement is included as Appendix D to our dWRMP24. The Yorkshire Water Board makes the following statement:

a) The Board is satisfied that the Yorkshire Water dWRMP 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, the Water Framework Directive and Habitats Regulation Assessment). 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.

Government's 25-year Environment Plan[4] - 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 (WReN0 has included the 25-year Environment Plan ambition as a key objective, which our WRMP will help to achieve. 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 shall aim to support nature recovery and deliver net gain for the environment.

The Yorkshire Water Drought Plan – our Drought Plan 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 e.g. 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.

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 next business plan will be prepared for the Price Review 2024 (PR24). 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.

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

The Yorkshire Water Drainage and Wastewater Management Plan

Our Drainage and Wastewater Management Plan (DWMP) 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 (WwTW), the interconnecting drainage systems from other Risk Management Authorities (RMAs), 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.

River Basin Management Plans

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.

The Water Resources Planning Guidelines 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 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) and Environmental Destination.

The RBMP Cycle 3 plans are not yet finalised. Should this change before our final WRMP is published, we will review any changes and discuss possible impacts of those changes with the EA before finalising our WRMP.

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 (NWL), Hartlepool Water (HW) 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-national-framework-for-water-resources.

1.4.1 National Framework

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,[5]
- 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's needed through more transfers of different scales and lengths,

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

- 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.

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[6] 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.

The reconciliation process was carried out between the autumn of 2021 and spring 2022 and included three phases. 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 (NWL). 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 that the existing transfer between WReN and WRW would cease. This is a key strategic import to the YW supply area. It is discussed further in Section 3.11.3 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 Water Resources West (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. Although Anglian Water has a deficit in its WRMP24, the area of need is not geographically close the YW supply area but is 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 Yorkshire Water's supply–demand balance risks meant that any trades with Anglian Water were limited by the future water availability.

[6] Regulators' Alliance for Progressing Infrastructure Development

1.4.4 Environmental Destination

The National Framework 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 *Water Resource Planning Guideline* (Environment Agency, Ofwat and Natural Resources Wales, 2021, abbreviated in this document to WRPG) require water companies to reflect both the short and long-term changes in abstraction (as set out in the regional plans) in their WRMPs.

1.4.5 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 (STW) in WRW to Yorkshire Water. 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. WRW's feasible options include an option to cease or reduce the existing transfer and the option has been selected in the majority of WRW Regional Plan scenario solutions (which are aligned with STW's WRMP scenario solutions).

Yorkshire Water and STW are developing a Strategic Resource Option (SRO) that would increase the reservoir capacity in the STW supply area with potential to meet STW's needs and allow the transfer to Yorkshire to be maintained. However, during the third round of the reconciliation process, WRW's options appraisal concluded STW would be required to both stop the transfer *and* increase its reservoir capacity to meet its own supply–demand balance deficit. This means that the most likely scenario is that the transfer will cease in 2035 and we have included this loss of resource in our WRMP24 baseline supply–demand balance. The transfer is currently a critical source of supply to the South Yorkshire area and our plan must include a new source of supply to this area to offset the loss of the transfer.

STW's supply–demand balance is showing a significant deficit driven by the impacts of climate change on its future supplies and reduced resource availability to meet Environmental Destination objectives. There is further work to be carried out to conclude the Environmental Destination impact on STW's available supplies and complete the SRO. Due to the uncertainty this creates and the potential for the transfer to continue, our plan includes an adaptive pathway in which the transfer is maintained.

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 NAVs 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 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, 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. We will continue to engage with this group as we move into consultation on our WRMP and towards our final WRMP24 and our PR24 business plan submission. 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 and which is continuing as we write our draft WRMP24 – 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 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 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 Water Resources North 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 model outputs 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 Water Resources North Regional Plan, and in partnership with Northumbrian Water and Hartlepool Water. The Water Resources North 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 (e.g., 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 (e.g., drought resilience) they would only support meeting minimum levels or regulatory standards.
- Little research was completed at PR19 specifically around water trading or drought permits / orders (related to environmental destination). This helped to inform additional research carried out for the Water Resources North Regional Plan.

Building on the existing knowledge from previous research, Yorkshire Water, 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 comprised 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 (e.g., 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.

Although the research was carried out at a Water Resources North 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 Water Resources North 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 didn't 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 Water Resources North region.
- Water Resources North WRMP objectives gained support, although a focus on education was something that was felt to be potentially missing.
- 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 don't 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 ensuring an improved 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 the last resort.

Since the Water Resources North customer engagement work was completed, we have carried out further research with Yorkshire Water'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 Water Resources North 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 HH and NHH customers.
- Previously, these are some of the priorities that customers are most likely to say they'd 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's very clear that both HH and NHH 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 Water Resources North's Regional Plan and, by extension, WRMP24 are provided in Water Resources North Regional Plan Appendix 7.

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 Water Resources North, one of five new regional groups.
- The formation of the Regulators Alliance for Progressing Infrastructure Development (RAPID), created at PR19 to bring together water regulators across England and Wales to help drive investment in key Strategic Resource Options (SROs). Yorkshire Water was not a part of any SRO scheme at PR19, but has subsequently proposed a new SRO -the

Upper Derwent Valley Reservoir Expansion scheme – in partnership with Severn Trent Water, and which is described in more detail elsewhere within WRMP24.

- The publication of the 25 Year Environment Plan and subsequent passing of the Environment Act 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. Consultation on the Environment Act targets took place through spring 2022. A key target for water resources planning is likely to relate to demand reduction, although the final target was not available at the time of writing our WRMP24.

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, 2022) 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, etc.).

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, 2022) 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, 2020) 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 strategic regional schemes (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 3rd October 2022 and has now been published for consultation. The consultation period runs for 14 weeks from 18 November 2022 to 24 February 2023. There are some key areas of our draft WRMP24 on which we wish to seek the views of our customers and stakeholders, and these are listed below.

- **Plan objectives**
  Determine 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**
  Seek 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 anticipate the need to make changes to our final plan because of the on-going 2022 drought and seek 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 – seek 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**
  Explore 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**
  Seek views on range and appropriateness of demand options. Explore support for some specific policy areas including the government's proposed scheme for water efficiency labelling and potential Yorkshire Water policy to install a meter on 'change in occupancy', i.e. when a new customer moves into a house that was previously unmetered. Seek views on the range of supply options and identify any other options that could be considered.
- **Metrics for assessing the best value plan**
  Seek views on the levels of support for the proposed metrics. Are there any other metrics that should be included?
- **Preferred plan**
  Seek views on the levels of support for the preferred plan. Will seek opinions of preferred approach to specific requirements such as replacement of the Severn Trent Water import. Seek views on the levels of support of the longer-term investment for the transfer of water from Northumbrian Water.

During the consultation period and in confirmation of our final plan, we will continue to work with stakeholders, in particular ensuring that we engage on the changes that may be required as we develop our understanding of the ongoing drought and the implications on long term security of supply. We will produce a statement of response to representations we receive on the plan in May 2023. Should we identify the need for changes to our draft plan, we will publish a revised draft WRMP24.

Our final WRMP24 and Statement of Response will be made available on our website once we receive notification from Defra that the plan can be published as final. We shall write to stakeholders to notify them at each stage of the plan's development.

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.

Critical period

Since publishing our WRMP19 we have experienced exceptionally dry weather in 2018 and again in 2022 (whilst our 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.

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 that we would reduce PCC to 119.3 litres/head/day (l/h/d) by 2025. Following the increase in PCC as a result of the lockdowns and the prolonged impact of increased home working, it is no longer realistic to assume we could reduce PCC to 119.3 l/h/d (an 8.9% reduction compared to 2015/16) by the end of AMP7 and instead our aim is to return to pre-COVID levels of 127.8 l/h/d (an 11.5% reduction compared to 2020/21). In reaction to this 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.

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. This is explained further in Section 4.4.5.

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.

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 is that we will lose 11Ml/d in ground water supplies by 2035 and a further 130Ml/d from a single surface water abstraction (River Derwent) by 2050. 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.

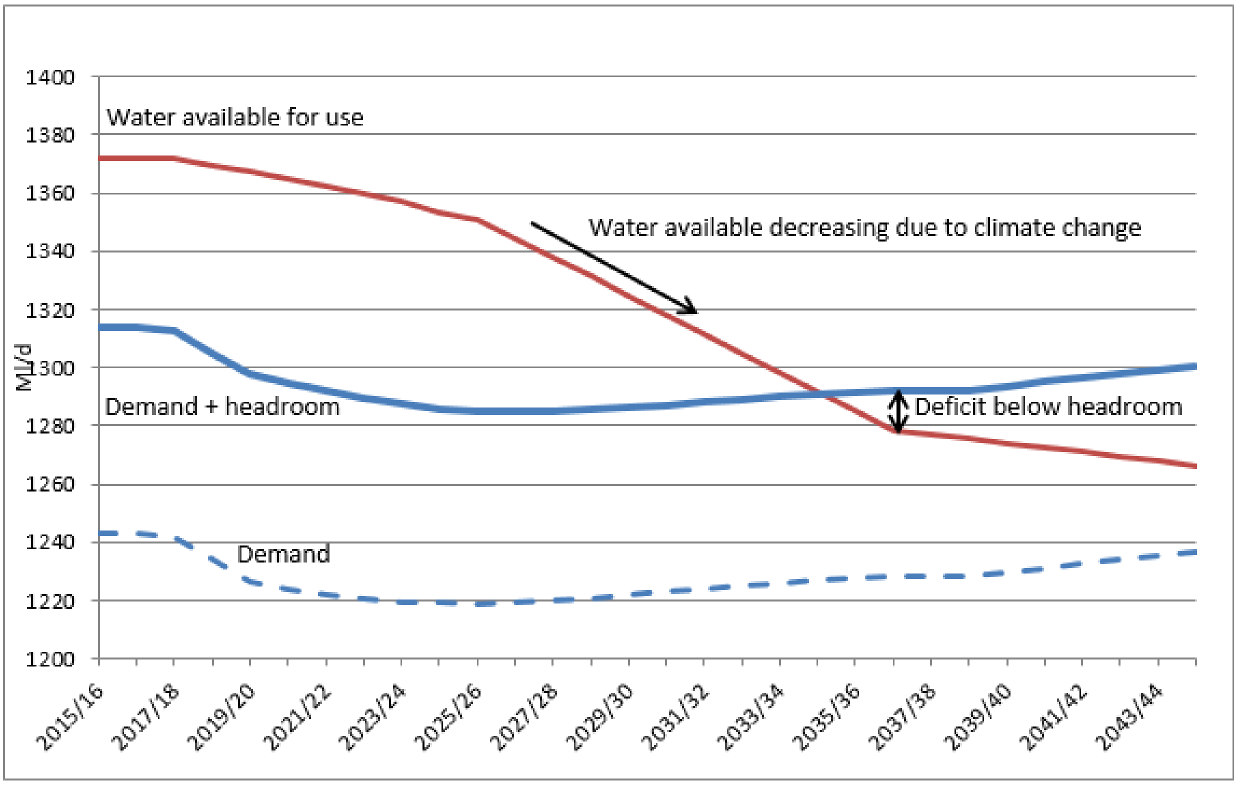
1.7.1 Review of our WRMP19 solution

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 Borehole, 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 2 option was added to the final WRMP19 post draft to meet a localised demand increase. A river licence variation 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. The R9 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 will be submitted to the Environment Agency during the 2022/23 financial year and the 2Ml/d benefit of the option is included in the WRP table YWSGRD line for "Total other changes to DO". This is a year later than originally scheduled in our WRMP19.

The R13 East Yorkshire Borehole 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 East Yorkshire option 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 AMP7.

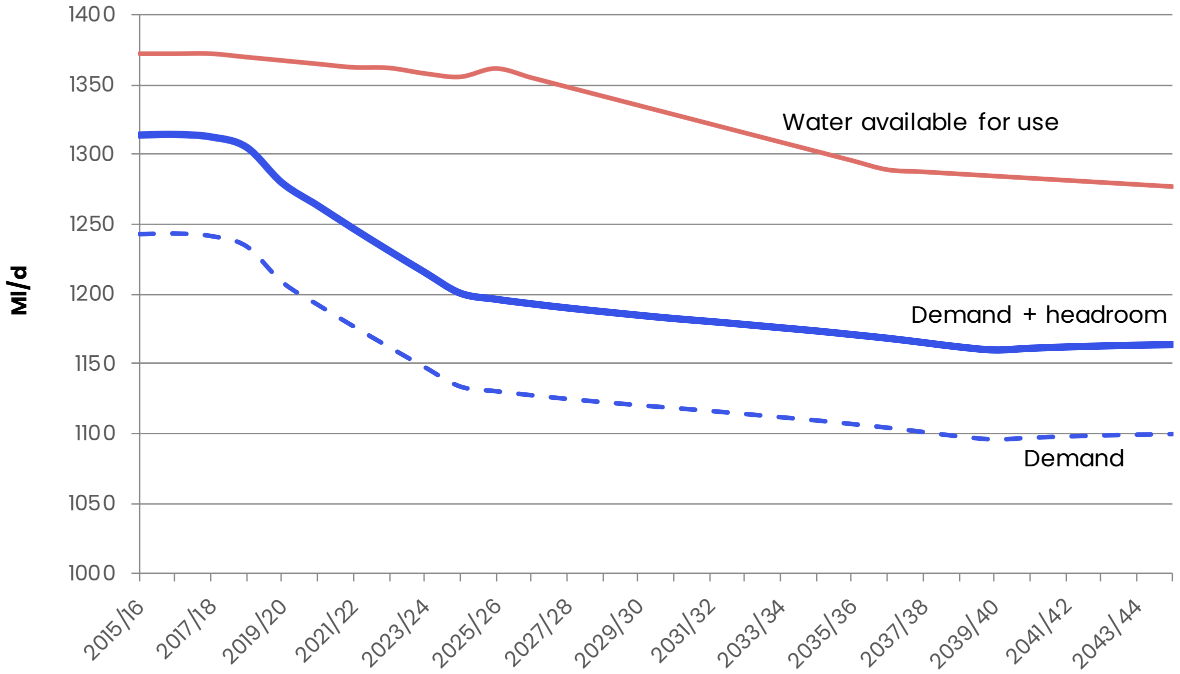
Our WRMP19 includes a variation to an existing licence to increase permitted abstraction from a second borehole in the North Yorkshire area. The variation has since been granted by the EA. The licence increase provides support to the local area and, together with investment in additional treatment facilities, 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 in AMP7 and are awaiting determination. 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 increase option requires a licence variation to be granted by the Environment Agency to allow 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 now 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 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 1.1 summarises how these components have changed since our last plan.

Table 1.1: 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 1278.22 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 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 33.36Ml/d due to climate due to the new approach to calculating base year deployable output compared to previous plan	Assumed no loss of deployable output due to climate change in the base year of the plan.
Climate change impact on supply	Loss of 43.95Ml/d compared to base year by 2049/50 (note, base year already includes 33.36Ml/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 additional losses	Loss of 1.5Ml/d yield by 2024.
Environmental Destination (long term changes to protect the environment)	Loss of 11 Ml/d compared to base year by 2035/36 (due to groundwater abstraction reductions) Loss of 142 Ml/d compared to base year by 2049/50 (groundwater abstraction	This is new and was not a component of WRMP19

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 earlier in Section 1.4.5. Our modelled deployable output includes an existing import from STW. The import transfers a raw water source (approximately 50Ml/d) from the Derwent Valley reservoirs in the STW 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, Water Resources West (WRW), which includes STW, informed us that the transfer termination option would be part of the WRW solution and therefore is part of STW's WRMP24 solution. We have committed to work together to investigate options for a solution that could enable the transfer to continue. This includes an SRO that is currently being developed jointly by YW and STW.

Due to the needs identified by STW in its own WRMP24 it is currently considered unlikely that the transfer would continue. 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 8Mld and it reduces the resilience of our network, as the transfer from STW is a key resource in the South Yorkshire area. Our modelling shows in a dry year the loss is 39Md on average but during peak demand could be up to 60Mld.

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 288 Ml/d by 2050.

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 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 WRPGL 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 1.2.

Table 1.2: 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 106.4 l/h/d by 2049/50 in a dry year (assuming a water labelling benefit and 112 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've further refined our non-household forecasting model and taken account of known large developments. The forecast gradual decline remains comparable to WRMP19, with a 14 Ml/d reduction 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 2020, 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 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), abbreviated in this document to WRPG
- Water Resources Planning Guideline supplementary guidance on:
  - 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 water resources zones

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."

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 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 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 for the DYAA scenario 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 the 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	✓	✓
Critical period	✗	✓
Environmental destination (BAU+)	Baseline no impact	Baseline reductions
Enhanced environmental destination	✗	✓
Loss/reduction in STW transfer	n/a	✓
Sensitivity testing – Ofwat Common reference scenarios	✓	✓
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 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-week experienced as experienced in 2018.

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 2020 we experienced an increase in demand as a result of lockdowns during the Covid-19 pandemic and demand peaks were higher than 2018. At the time of producing this plan in 2022 we have experienced a summer drought that is continuing into autumn. For our final plan we will need to reassess the supply-demand balance risks and the impact of the 2022 drought and how this influences our final decision making for WRMP24.

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 shall 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 sensitivity 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 water resource simulation model. 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[7] such as rota cuts more than 1 year in 500. We also maintain a level of service of no more than a 1.25% risk of drought permits or orders[8] and 4% risk of a temporary use ban[9] 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 1:500 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 3.14.

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 loses are discussed in Section 3.15.

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.

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[7] Level 4 restrictions can only be imposed if a water company has been granted an emergency drought order by Defra.

[8] Drought permits or orders provide water companies with temporary permissions that may increase available supplies or restrict non-essential use. The EA can grant drought permits and Defra drought orders.

[9] Temporary use bans restrict certain water use activities, such as use of a hosepipe, and do not require any regulatory permissions but can only be imposed if there has been exceptional shortage of rainfall.

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 are also developing a strategy for achieving the Defra requirement to reduce non-household water use by 9% by 2037[10]. We have provided information on this in Section 5 but we have not assumed any benefit in our final plan scenarios. We shall consider this further for our final plan when our strategy is more developed. However, while the benefits are not evidenced, we are not building the 9% reduction into our plan as the risks are too high to use this as a means of securing supply to customers.

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, 2002). 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.

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

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.

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.

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 this 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 low.

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 lined 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 WRPGL 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 e.g. 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 score – Environmental net gain score – Bio-diversity net gain – Six capitals (natural, financial, manufactured, social, human and intellectual) – Drought resilience benefit – Non-drought resilience benefit 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 optimisation 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 utilisation we include option dependencies in the optimiser and use our system simulation model to assess the utilisation 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 recognised 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 optimisation 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 nearly 300Ml/d.

2.11 Our best value planning approach

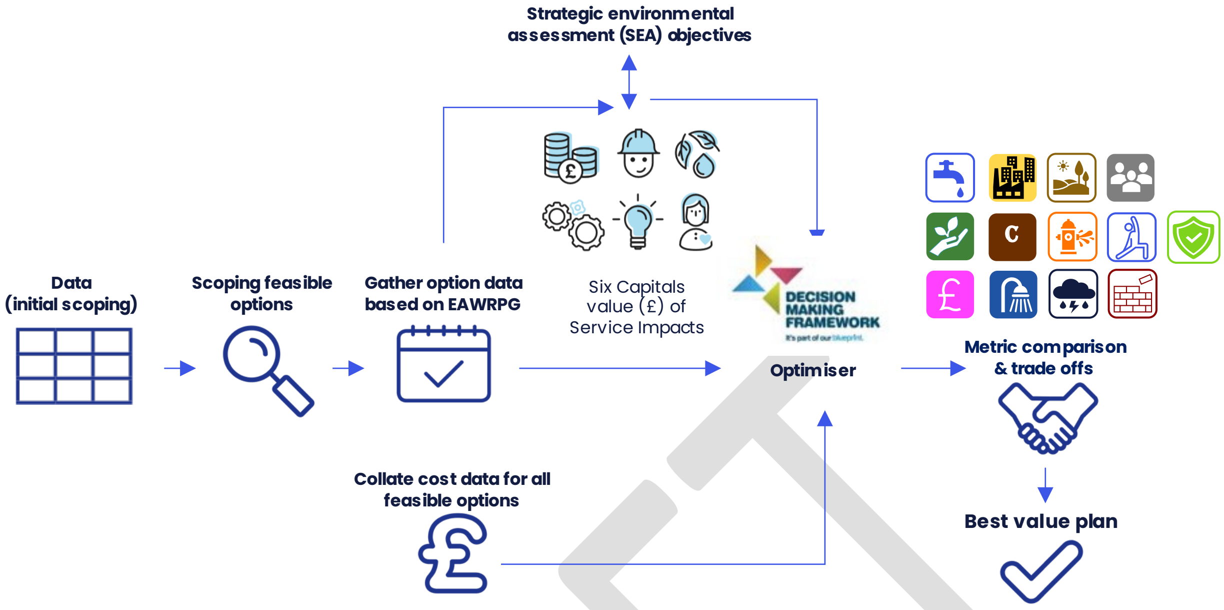
To ensure our plan meets our WRMP24 objectives, can be considered best value and is compliant with the latest EAWRPG we have developed a new decision-making methodology that expands on the approach used for WRMP19. To determine a solution to the Grid SWZ deficit in our WRMP19 we followed the approach 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 non-monetary 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.

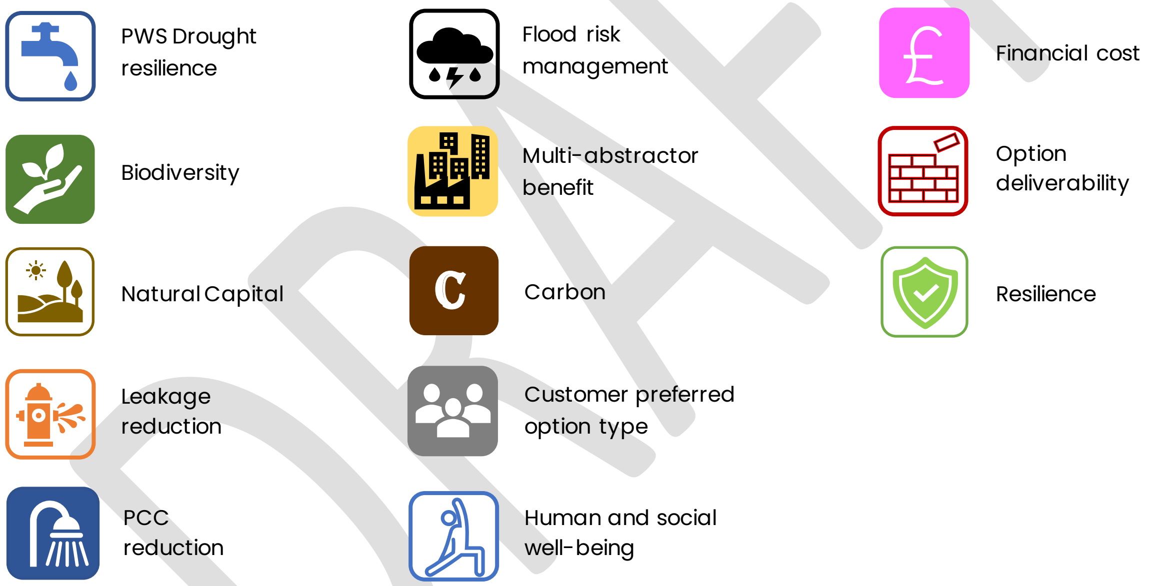
Figure 2.4: The six capitals

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 alterative 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, i.e. 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 is 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 ground water 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, 2002). 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 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 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 2025, 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 model, WRAPsim.

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 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 report on deployable output and climate change.

3. Supply forecast

This section describes how we have calculated how much 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).

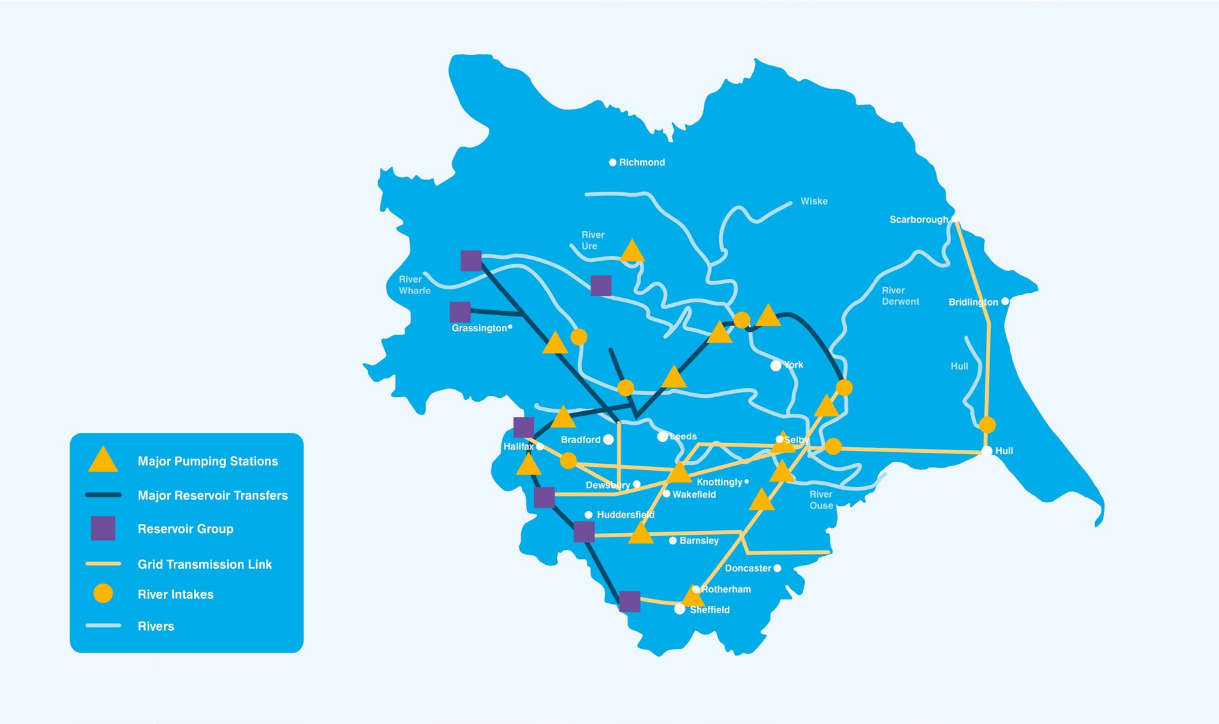
We have an agreement with Severn Trent Water to abstract up to 21,550Ml per year from the Derwent Valley reservoirs in neighbouring Derbyshire. This water is used to supply part of South Yorkshire.

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.

Figure 3.1: Overview of Grid system



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.

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 the trial 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.

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.

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 13 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 11 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 line with our WRMP19 solution we will be applying 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. The licences where we will be applying for increases include reservoirs in West and South Yorkshire and two boreholes in North Yorkshire.

Table 3.2: Time limited licences

TLL Expiry Year	AMP period	No. of Time Limited Licences due for renewal
2027	AMP8	2
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 have applied to increase the annual abstraction limit on the River Wharfe. This is to increase our resilience and are awaiting the outcome of that application from the Environment Agency.

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 2.5). We model our deployable output using our water resources simulation model.

The WRPG states that "baseline supplies should be available in a 0.2% 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).

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 *Water resources planning tools* (UKWIR, 2012), report describes a risk-based approach for assessing deployable output. This means that the degree of complexity required depends on the nature of the source or group of sources being assessed. The revised methodology realigns existing tools for calculating deployable output within a risk-based framework. Many of the previous reports and methods used for assessment of deployable output are discussed below, and are still relevant, representing the existing tools used by the *Water resources planning tools* (UKWIR, 2012) methodology. The methodology takes into account the vulnerability to climate change.

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 Ground Water 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 (SRO) 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.

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 WRAPsim model inflows by HR Wallingford (HR Wallingford, 2022a). We have used these to produce historic inflows from 1900-2020, and stochastic inflows for 19,200 years (400 x 48-year replicates).

3.4.3 Regional deployable output modelling

As stated above, we model our deployable output using our WRAPsim water resources simulation model. 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).

For WRMP24, we have updated our WRAPsim model 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 WRAPsim water resources modelling software is used to carry out the analysis required for the determination of deployable output. The model incorporates the following, which are required for the determination of deployable output:

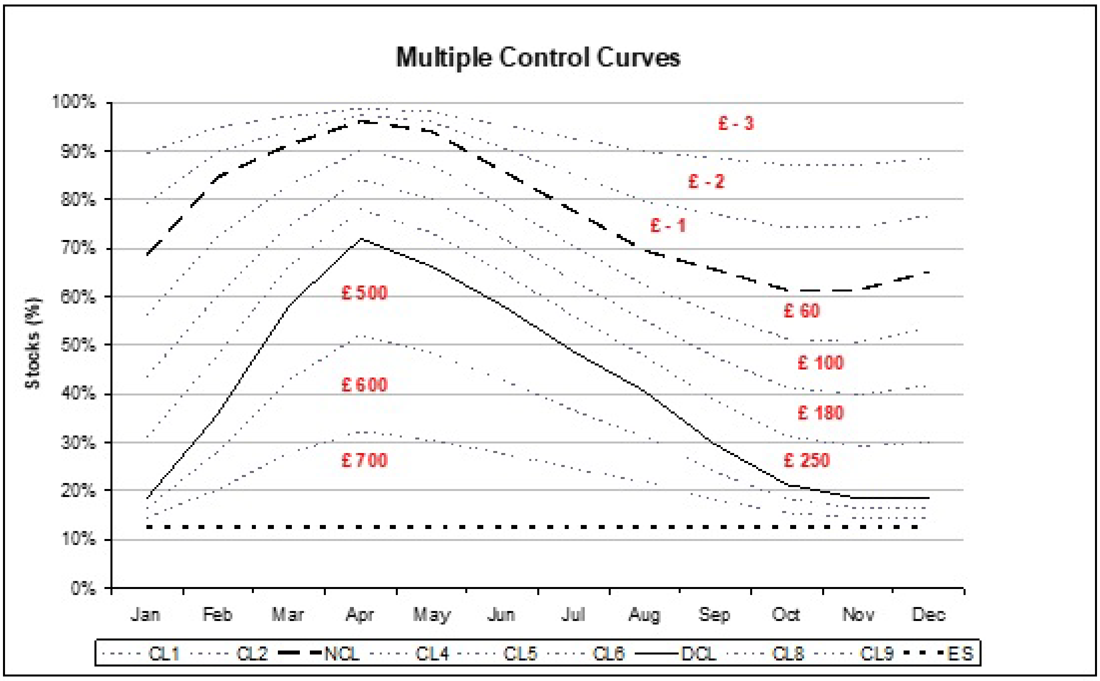
- the same demand profile should be used for every year of the simulation;
- the defined physical capacities of the existing system should be adopted for the simulation;
- each modelled system must incorporate emergency storage;
- inflows from 1900 to 2020 for our historic period (ensuring a long simulation 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;
- demands are maximised to the point of failure as required for the determination of deployable output, by re-running the model at increasing demands until the levels of service are just met.

The supply reservoirs and the Hull borehole group in the WRAPsim model 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 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 WRAPsim 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 WRAPsim 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.

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.

For the 1 in 500 resilience, we have therefore considered only the 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 differ greatly 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.

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 WMRP24.

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 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.

Table 3.3: Target level of service

Restriction	Frequency of Restriction	Annual risk of restrictions (%)	Risk of restrictions in 25-year planning period (%)
Rotacuts/ Standpipes	1 year in 200 (WRMP24) 1 in 500 (WRMP19 and WRMP24)	0.5 0.2	12 5
Drought Order Implementation*	1 year in 80	1.25	27
Temporary Use Ban Implementation*	1 year in 25	4	64

* for a period of at least 3 months

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.

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 is highlighting that the 'cost of living crisis' is affecting customer views. It is clear that both HH and NHH 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.

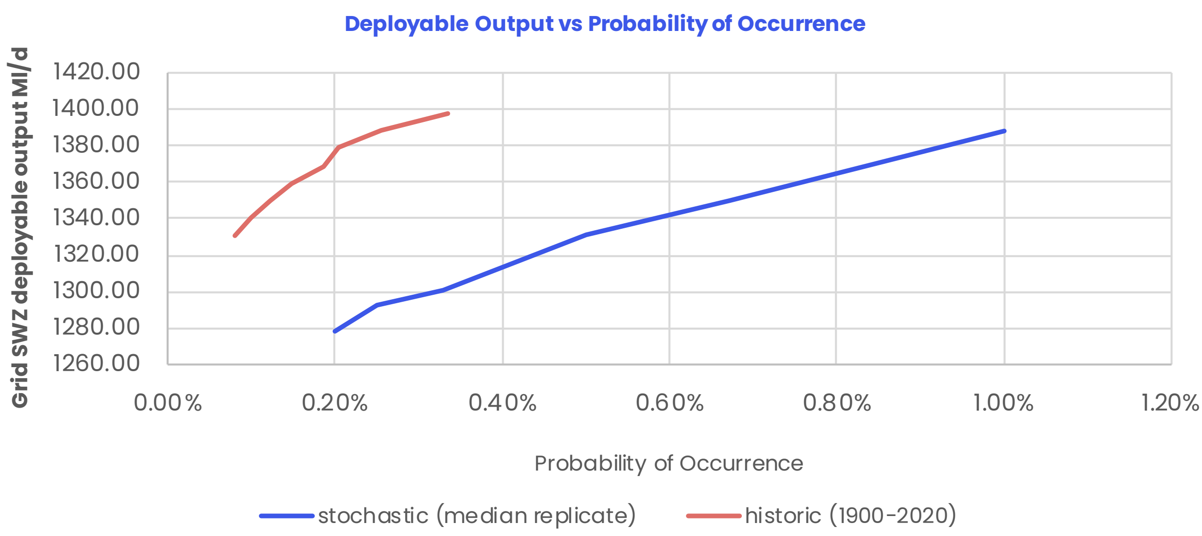
For each of the level of service deployable output calculations, the model was run at decreasing demands until the level of service was just met (using the Permitted Failures method as described in, *Handbook of Source Yield Methodologies* (UKWIR, 2014). The deployable output represents the highest demand 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. This relationship is shown both for the simulation runs using historical inflows, and those using the stochastic time series.

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.

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 EVA analyses 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



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 only 1 in 75 years. We expect to reach this level of resilience by 2039 by implementing our supply and demand solution, and by doing this the drought permits LoS would return to above 1 in 80 years.

Table 3.4: Relationship between level of service for emergency drought restrictions and deployable output for the Grid SWZ (Simulation model using stochastic inflows): baseline scenario 1990s

Frequency of Level 4 restrictions	Annual risk of restrictions (%)	Deployable output (Ml/d)	TUBs LOS	Drought permits LOS
1 in 100 years	1	1388.09		
1 in 200 years	0.5	1330.65	1 in 88 years (1.14% annual risk)	1 in 153 years (0.65% annual risk)
1 in 400 years	0.25	1292.36		
1 in 500 years	0.2	1278.22	1 in 44 years (2.27% annual risk)	1 in 75 years (1.33% annual risk)

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 (TUBS) 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.

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.

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. RCP8.5 represents a high carbon dioxide emissions scenario. 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 WRAPsim 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 (a medium emissions scenario) of the UKCP18 probabilistic projections. 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 our supplementary report on deployable output and climate change.

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. RCP6.0 represents 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.

3.5 Reported deployable output

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.

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	1244.86	1295.27	1383.53

3.5.1 What we have included in deployable output

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.

3.5.2 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 they are 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 caried out sensitivity analyses will carry out further analyses before publishing our final WRMP24. 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 Environment Agency Water Resource Planning Guideline 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[11]. 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

[11] https://www.gov.uk/government/publications/keeping-the-country-running-natural-hazards-and-infrastructure

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[12]. 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 plan to publish our resilience framework and our long-term strategy as part of our business plan submission to Ofwat in 2024.

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 approach 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[13], 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.

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.

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.

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[12] https://www.ofwat.gov.uk/publication/pr24-and-beyond-final-guidance-on-long-term-delivery-strategies/

[13] 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.

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 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 underyling 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 deliver multiple 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 land owners 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 Water Resources Management Plan 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 are writing our draft WRMP during an on-going drought, the worst drought since 1995, so it is likely there will be learning from this current drought that may lead to changes to our plan between the draft and final WRMP24.

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.

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 at the deployable output at 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*.

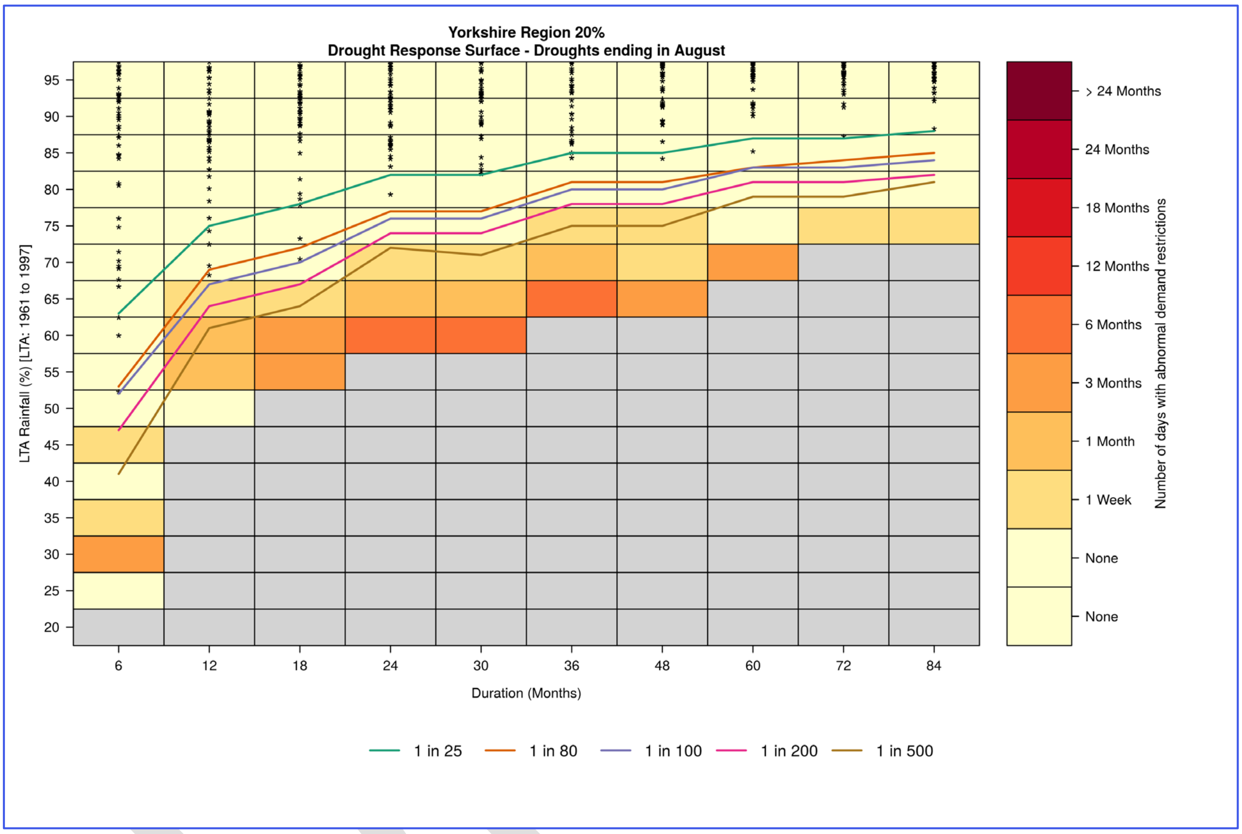
We have used the modelled reservoir stocks from each year of the stochastic simulations to calculate how often stocks fall below the trigger for level 4 restrictions.

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 LTA 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.

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



These analyses are markedly different from those we carried out for WRMP19, as we now have stochastic rainfall data. In line with the EAWPGL we are using these data sets 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 report on deployable output and climate change.

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.

3.6.5 Links between our WRMP and Drought Plan

Table 6 in the WRMP 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%.

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.

3.8 Sustainable Abstraction and Environmental destination

Our WRMP24 delivers the regulatory actions to ensure that our surface and groundwater abstractions continue not to cause environmental damage or deterioration. 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.

3.8.1 Water Industry National Environment Programme

The Water Industry National Environment Plan (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. 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.

3.8.2 Environment Agency Environmental Destination Scenarios

The Environmental Destination Scenarios that the Environment Agency has presented, in support of the National Framework for Water Resources, estimate the potential changes in abstraction that may be required to ensure the water environment is sufficiently protected in the long-term. Using this information, the national model estimates the reduction in abstraction required by each sector to ensure the long-term needs of the water environment are maintained. Through the regional planning process, we have reviewed the national model and validated the outputs with regional Environment Agency and Natural England representatives. This approach has been summarised in Water Resources North's draft plan.

To promote consistency between each region's interpretation of the WRNF 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 Table 3.7). These reference scenarios are aligned with and adapted from the national WRNF scenarios[14].

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

Table 3.7: Environmental Destination Reference Scenarios

Name	L/M/H	Description
Baseline	Low 1	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)	Low 2	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 national 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*)

We have taken BAU+ as the central scenario for environmental destination on which our adaptive plan is based.

3.8.3 Yorkshire Water WRMP Environmental Destination Scenarios

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 2024.

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. Under the BAU+ scenario, the reduction in deployable out 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. 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 due to the adoption of environmental flow targets to support the Lower Derwent SAC and SSSI complex (CSMG targets). The licences under consideration will be investigated in depth as part of an AMP8 Environmental Destination WINEP scheme and the outputs reflected in future iterations of our WRMP.

As the estimated abstraction reductions in the WRNF are not currently known legal requirements and are subject to uncertainty over whether the reductions are required, we have assumed zero long-term reductions in the Baseline and BAU scenarios respectively.

As the BAU+ scenario includes for CSMG targets and in lieu of an agreement of alternative targets with regulators, we have assumed compliance with default CSMG targets for this scenario. Under this scenario we have assumed a 131Ml/d reduction in abstraction (dry year annual average) from Yorkshire Water's River Derwent abstraction linked to achievement of CSMG targets for the River Derwent, effective from 2050, in line with regulator expectations.

Under the Enhanced scenario, the reduction in deployable output under BAU+ would increase to 272Ml/d which is caused by additional losses at Yorkshire Water's intakes coupled with impacts of climate change on natural river flows.

Summary

Table 3.8 summarises the timing and extent of the impacts of deployable output through the planning period in relation to Environmental Destination.

Table 3.8: 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	6	6	2035
BAU+	Groundwater River	11 131	142	2035 2050
Enhanced	Groundwater River	17 272	289	2035 2050

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 have 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 WRAPsim model, 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. 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 3.9 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 3.9: 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 (Atkins, 2021). To reduce the number of water resources simulation model runs required to calculate the deployable output, we sampled 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 have 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. The 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 samples.

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

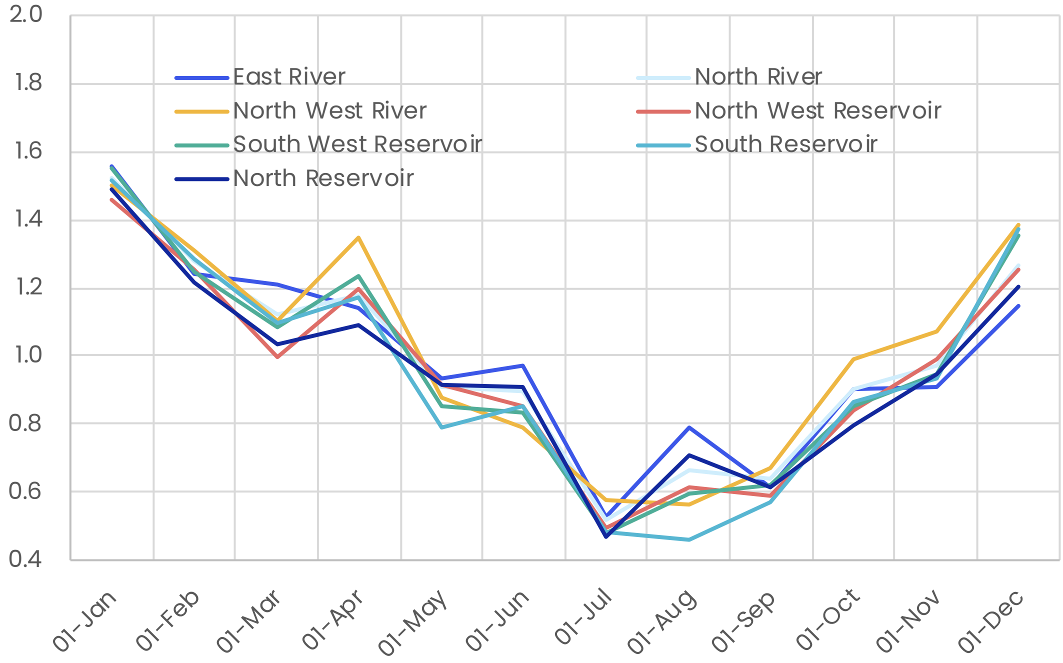
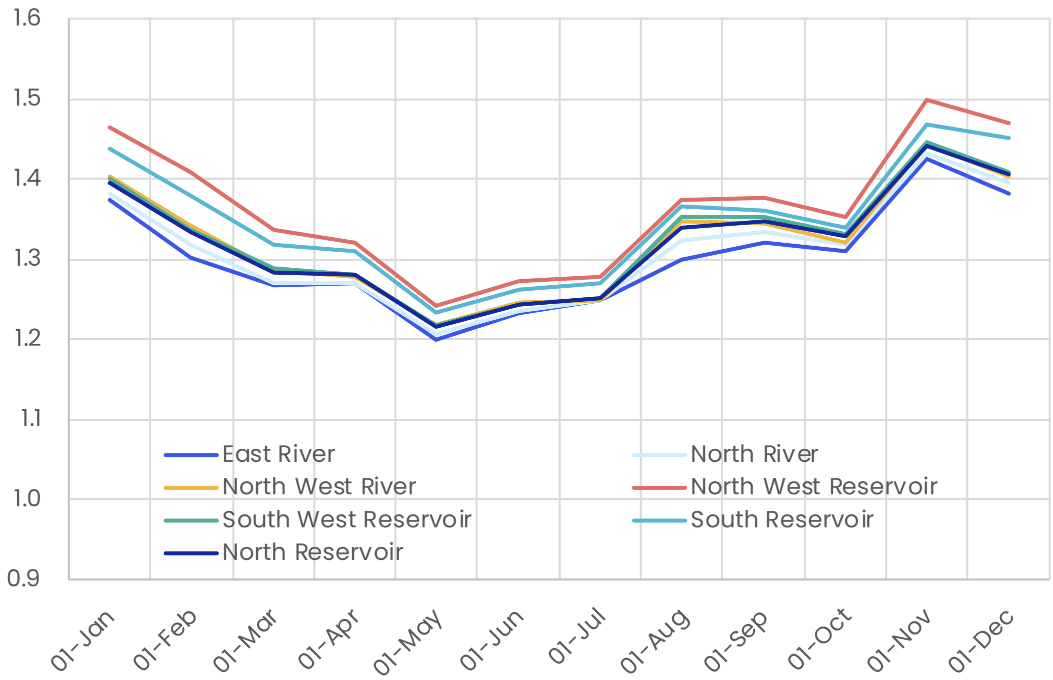


Figure 3.6: Monthly PET factors for RCM09 RCP8.5 scenario:2070s



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, and we have modelled a sample of 56 of the 400 stochastic 48-year replicates. The selection of the climate change samples is described in more detail in our supplementary report on Deployable output and climate change, and in full in HR Wallingford, 2022b.

We will further investigate the impacts of using stochastic time series for our Final WRMP24. We are currently experiencing an exceptionally dry period this year and will need to review the impacts in our final plan assessment also.

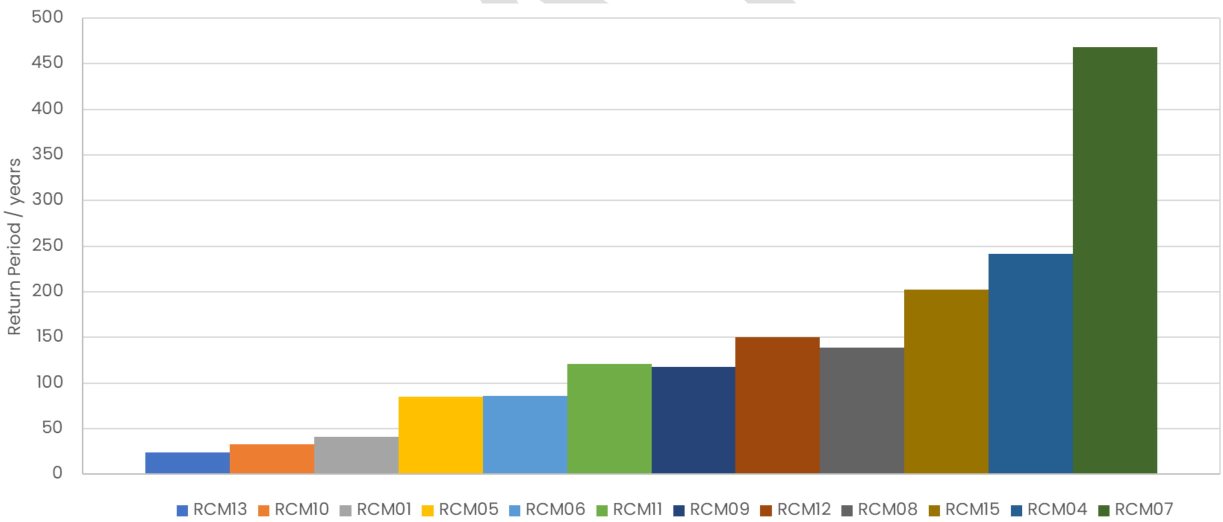
3.10.4 Interpolation of deployable output

The WRAPsim 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 56 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 1175Ml/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 1175Ml/d regional demand for all RCMs

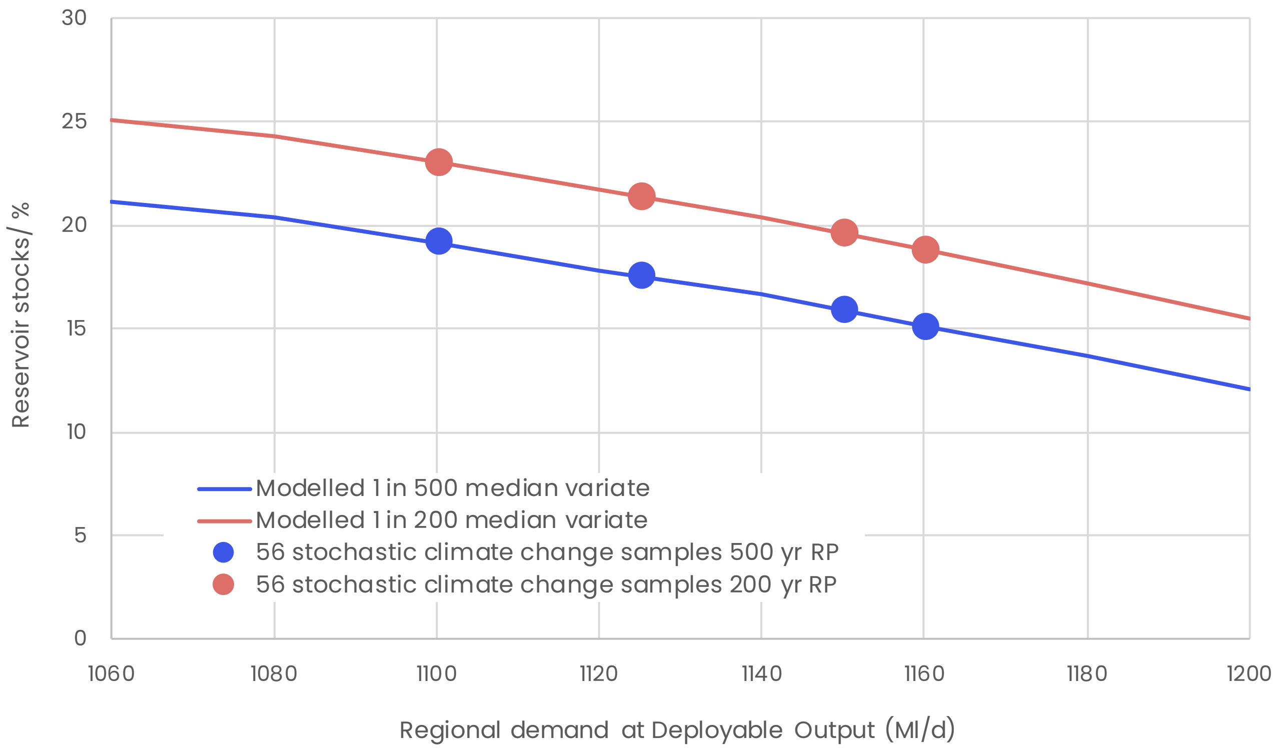


We calculated the deployable output for the climate change scenarios to determine the deployable output of the region in 2070. We used climate change perturbed inflow files in the model and ran the model at varying demands until the minimum modelled reservoir stocks had a 1 in 500 frequency of occurrence. 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. 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: Modelled minimum reservoir stocks versus system demand for RCM09:2070s



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

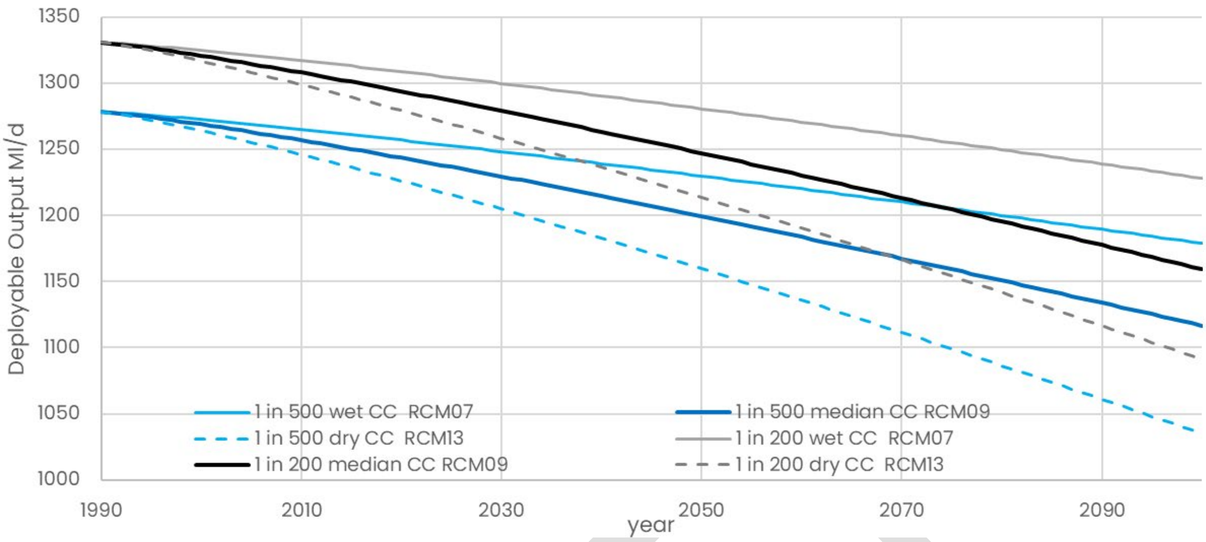
Table 3.10 shows the calculated deployable output in 2070 for the Grid SWZ, and the deployable output in 2070 factored to represent the impacts of the UKCP18 RCP6 probabilistic projections.

Table 3.10: 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	1278.22	1052.25	1167.37
1 in 200	1330.65	1090.96	1213.07

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



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 (HOF) 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 (DO) has been calculated for each RCM and scaled in the same was 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 3.11: 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 1:200	DO 1:500	DO 1:200	DO 1:500
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 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 Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request. 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 Technical Report on Deployable Output and Climate Change, which will be provided to the Environment Agency and is available on request, 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.

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.

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

3.11 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.

3.11.1 Failure of River Derwent weir

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.

3.11.2 River Derwent Common Standards Monitoring Guidance (CSMG) thresholds

Natural England and the Environment Agency have ongoing Habitats Directive investigations into the River Derwent. They have agreed to continue these investigations and committed to providing a hydrological target (either flow or level) by 2021. If they fail to agree a target, there will be no action. In the absence of such a target, we have modelled the standard CSMG targets for the two River Derwent abstractions. Imposing these targets (only 20% flow can be abstracted) results in a loss of deployable output of 130Ml/d in the base year. Again, this reduction is caused by a failure to meet demands in the driest years, rather than levels of service failures.

3.11.3 Severn Trent import uncertainty

We model the impact of the transfer ceasing on the grid supply forecast. We have created scenarios for both our DYAA and Critical Period and built these into our baseline forecast from 2035 onwards. The reduction is partially offset by our ability to deploy around 8Ml/d from alternative existing sources to the South Yorkshire demand area which relies on the import. Both the volume we lose and the value we can redeploy reduce over the duration of the planning period due to the impact of climate change on these sources.

3.11.4 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, but for our final WRMP24, we will use stochastic data series perturbed by a sample of the probabilistic projections.

3.12 Water Transfers

3.12.1 Raw water transfers

In our WRAPsim model, the STW import has an average of 51.87Ml/d. We have consulted with STW, and their modelling gives an average export from their system of 48.46 Ml/d. Although there is a small difference in our modelled values, we have modelled scenarios where the average of the import from STW is only 48Ml/d. In our model, this does not change our deployable output. We have also modelled a scenario with our assumed 51.87Ml/d export from their system. We are therefore confident that STW would be able to supply our import at a rate of 51.87Ml/d, and that if we could only import their modelled value of 48.46 Ml/d, our deployable output would not be compromised. Any uncertainty will be accounted for in our headroom component.

We have modelled the STW import for our climate change models. As with our other climate change modelling, we have used model ID 7910 for our WRP tables and used the others to calculate the headroom component for the STW import. This resulted in a year-on-year reduction in volume during the planning period.

STW has carried out its own climate change modelling which shows our import reducing to 47.95Ml/d by 2045.

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

- Yorkshire Water used factors for the Humber river basin/ Yorkshire region whereas Severn Trent Water used flow factors for the Severn river basin/ Midlands region;
- We both used a risk-based approach, which identifies UKCP09 model IDs based on drought indicator analysis and the risk of low reservoir stocks. The risk-based analysis allowed the selection of model ID's which best represent each companies' level of risk, but these model IDs are not the same; and
- STW has used 2030s climate change scenarios, and we have used 2080s.

In addition, we use a different water resource model to STW, 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 for WRMP19 but modelling differences in different models are inevitable. We both model our own system in detail and make assumptions about the use each other makes of the reservoirs. Our scenario modelling has shown our estimates are robust to this modelling uncertainty.

The STW import is transferred directly via a tunnel from an impounding reservoir to our water treatment works, where it is treated via appropriate treatment processes to required water quality standards. Due to the direct transfer of water to the treatment works there is no quality risk to a receiving waterbody.

This raw water import is the primary water supply to the treatment works and the treatment process has been designed to produce water to appropriate potable water standards.

The bulk transfer agreement for this import terminates in 2085, with an early 'break clause' which allows termination by either party from 2035 following a 5-year notice period. STW's WRMP24 includes an option for terminating the import and it is included in its most likely (baseline) scenario. We therefore must find an alternative source of supply and this is discussed in our options appraisal and best value plan sections.

3.12.2 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, this is not linked to 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.

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 three inset appointed water suppliers in our area. Two of these serve household customers with water and wastewater services via our clean and wastewater networks and the third provides wastewater services only. In our 2019/20 base year there were no inset appointees in our supply area. We have therefore not included a volume for supply to inset appointees.

The volume supplied in total in 2021/22 was 0.26 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. In the future there will be increased inset appointees across our area, but there is no data on which to base assumptions. If we did include in the forecast, the volume would need to be offset in the zone's distribution input forecast.

In the absence of any data on future inset appointee demands, this volume is accounted for in our household consumption forecast and we have not allocated an allowance for inset appointees in this WRMP. We have therefore not included inset appointee exports in the treated exports row of the WRP tables, as this would double count the volume. In future WRMPs, it is possible the volume will be more material and we should have data to separate this component from our own customers' demand.

3.13 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. The Environment Agency set out their expectations as to how water quality should be considered, in the Water Resource Planning Guideline. 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 for metaldehyde 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.

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 we are in the process of confirming 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 DOC residuals 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.

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 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.

3.13.1 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.

3.13.2 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.

3.13.3 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.

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.

3.14 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 3.15. 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. This section provides a summary of our outage assessment for the WRMP24. Further work will be carried out for the final plan and a technical document to describe the approach will be provided, which will be provided to the Environment Agency and made available on request. This further work is required as we have a new approach for recording planned and unplanned outages and only two years of data was available at the time of the assessment. An additional year's data will be available for the final plan, which will provide for a more robust analysis.

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 our outage planning allowance. Since producing our WRMP19 we have created a new database for recording outage events. The outage database records the output each of our water treatment works (WTW) can produce daily. Each works has a target output and if this cannot be met it is recorded as 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 data set 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.

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.

3.14.1 Unplanned outage

For this plan, we have based unplanned outage on data recorded in our new outage database for the report years 2019/20 and 2020/21. For the final WRMP we shall have an additional year's data which will improve confidence in our unplanned outage allowance. It is not possible to combine the previous outage database (known as KAM – Key Asset Management) events 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 WTW daily, which means there is a clear record of outages at each works.

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.

For previous WRMPs we modified this 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 cortical period outage to be based on the summer months.

For unplanned events, the distribution data is entered into a probabilistic software model 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.

For our Grid SWZ, as in previous plan submissions, we have chosen to plan for the median or 50% level of certainty. We have selected the median percentile as the zone has high connectivity and, in most years, we have sufficient flexibility in the system to reduce the impact of outages and reported unplanned outage is lower than this value. This flexibility is created via our conjunctive use system. 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. There is also further connectivity in other parts of the system that allow resources to be redistributed and outages are mostly offset.

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 50 percentile to represent the unplanned outage in the Grid SWZ. The critical period scenario is based on the summer months unplanned outage value as it is a summer critical period. Whereas the DYAA unplanned outage is based on the average of all 12 months, which is aligned with other supply-demand components that are annual average values.

The East SWZ unplanned outage reported in the WRP tables is zero. Historically there have been very few unplanned events recorded in the zone, which only has one WTW, and no events have been recorded in the period of data used in this assessment.

3.14.2 Reservoir safety outage

Statutory requirements of reservoir maintenance require reservoirs to be periodically drawn down 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.

For the WRMP24 we have included an outage allowance for reservoir safety schemes based on the average of reported values over five years from 2017/18 to 2021/22. 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.

For the final plan we shall assess the planned drawdowns for the next five-year period and if this provides evidence to alter the allowance. This information was not available for our draft plan as the data is still being collated for the PR24 business plan. 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.

3.14.3 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. These events 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. We therefore include an outage allowance for planned events.

We have not included any planned outage as a result of capital schemes to be delivered in AMP8. We shall review this for our final plan once we have identified the capital programme for our PR24 business plan. 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. Where possible the work will be phased, and storage managed to minimise the actual outage. The impact of the water quality schemes on outage was not available for our WRMP24.

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 two years data available from our new outage database. In the period of data, no planned events were recorded in our East SWZ and the allowance for WRMP24 is 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 previous 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.

3.14.4 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.

3.14.5 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. The East SWZ outage assessment results in an outage value of zero across the two relevant components (planned and unplanned).

Table 3.12 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. This will be reviewed for the final plan once the PR24 business plan is developed and we can align with the capital programme for improving assets and meeting outage objectives.

Table 3.12: 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	0	n/a	n/a	**0**
Grid SWZ DYAA	2.85	48.02	4.36	1.00	**56.24**
Grid SWZ critical period	2.85	38.42	6.37	1.00	**48.64**

The Grid SWZ outage is the total of unplanned outage, planned outage, reservoir safety outage and licence margins. The total DYAA outage is 56.24Ml/d, slightly higher than the WRMP19 value of 52.40Ml/d. The critical period value is lower than the DYAA and we did not create a critical period scenario in WRMP19. The lower critical period value is a result of basing unplanned outage on the summer months which tend to have lower outages. We have based it on the average of the 50 percentile values for June and July, as the four-week critical period has been during these months in recent years.

Figure 3.10 and Figure 3.11 show the percentage each outage category contributes to total outage value for the Grid SWZ DYAA and critical period scenarios respectively.

Figure 3.10: Grid SWZ DYAA outage percentages by category

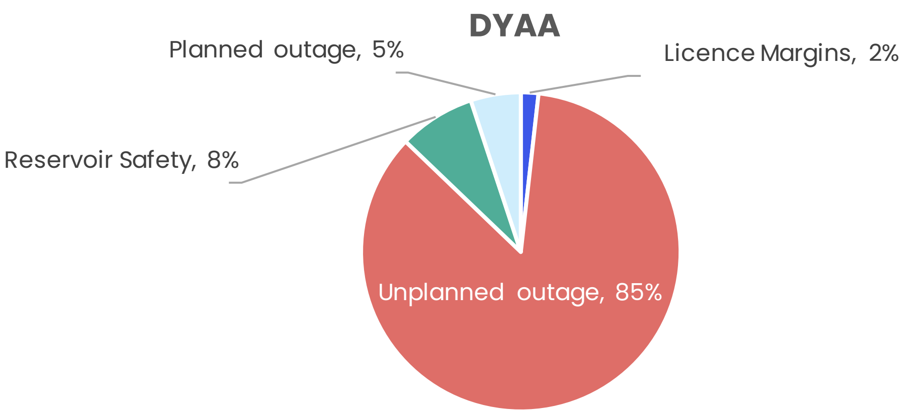
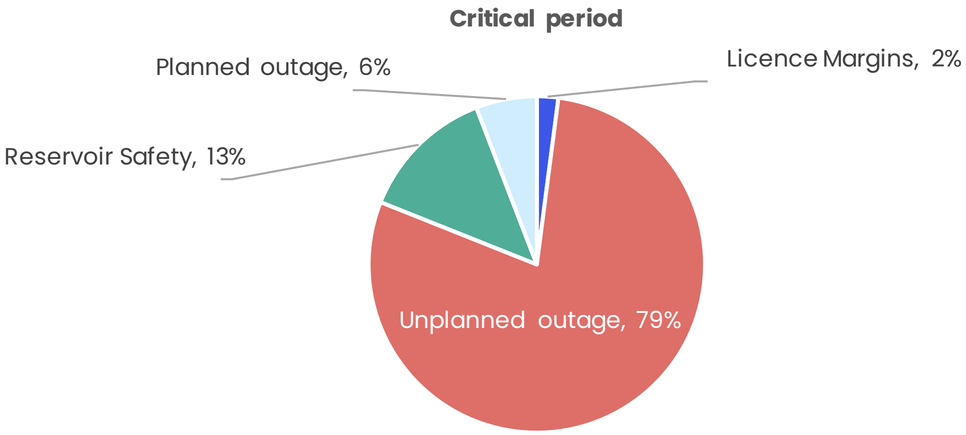


Figure 3.11: Grid SWZ critical period unplanned outage percentages by type of event



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.

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 (circa 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 conjunctively of the system. We have therefore not reduced the outage allowance based on reported data.

The recorded unplanned outage in the East SWZ is zero. No maintenance or capital schemes are planned that could lead to planned outage in this zone (this will be reviewed for the final plan). 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. However, this does not give absolute certainty there will be no events in the future and we have therefore assigned an outage volume of 0.65Ml/d. This is 5% of the WAFU volume for this zone and is based on the Grid SWZ DYAA outage as a percentage of the zone's WAFU.

3.14.6 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 (e.g. seasonal water quality variations) or require maintenance (e.g. water treatment filters blocking) or refurbishment (e.g. 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 out/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 that last longer than three months.

The WRP tables include a line for change in deployable output from prolonged outage reduction. At this 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. However, our business plan for the period 2025 to 2030 (AMP9) is in its early stages of development and we shall review the planned programme for the final version of our WRMP24. 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.

3.15 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 we have not included valve testing losses in WRMP24.

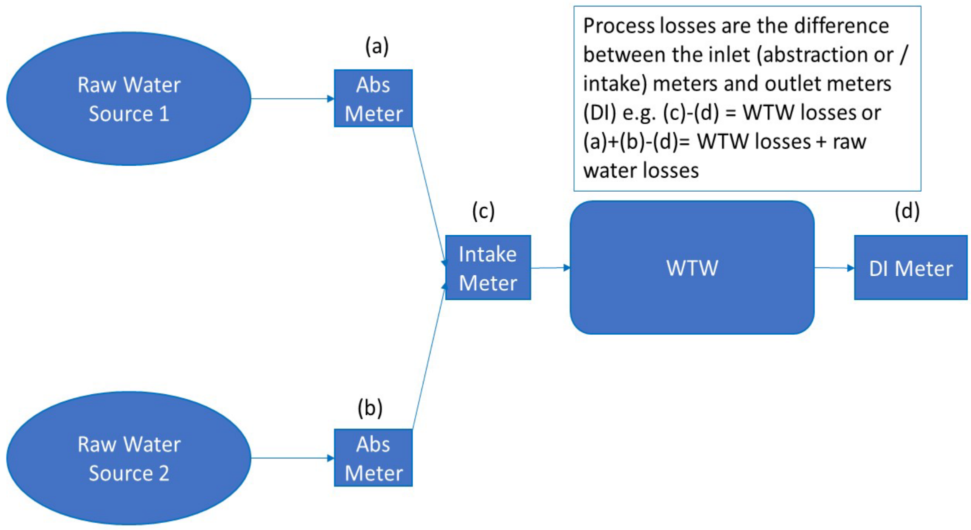
The WRMP represents an extreme drought scenario. During dry periods we would either delay valve testing until reservoirs levels recovered or carry out a dry flow test where we open the valves but do not release water. Where water is released, we would transfer it to a treatment works, a downstream reservoir or raw water storage therefore the losses would not be significant, particularly in a drought year. Furthermore, the valve tests generally last for one or two hours and the outage allowance methodology recommends losses below six hours are excluded. This principle can also be applied to valve tests.

3.15.1 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. We consider the new approach to provide a more accurate value of raw and treated losses than the previous calculation. However, we will continue to review the approach for the final WRMP24 to increase confidence in the 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, wash outs 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 3.12.

Figure 3.12: Process loss calculation



The WRMP24 process loss allowance is based on three years data from 2019/20 to 2021/22. No additional allowance is made for water lost due to raw water operational use for cleaning mains in the Grid SWZ as this should be incorporated into the calculation. We have only included processes 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 double counting as deployable output is constrained by the works output, which has already accounted for losses. The losses from these works are included in the raw water abstracted line of the WRP tables (1BL and 1FP) and the total losses are 68.02Ml/d. This is 5% of the base year distribution input and considered to be representative of the industry average.

The total allowances for raw water losses, treatment works losses and operational use in the Grid SWZ is 33.20M/d in the DYAA scenario and 31.77Mld in the critical period scenario. This is based on three years data. In our WRMP19 using the previous approach the allowance was 19.73Ml/d. The latest data shows a higher volume, but this is more likely to be due to an improved approach than actually increases. We shall consider further for the final WRMP24.

There are no raw water losses or operational use recorded for the East SWZ using the new approach. The deployable output of the zine 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 1.86Ml/d in 1BL. This is comparative to the 1.71Ml/d process loss allowance in WRMP19.

We have assumed process losses will remain consistent throughout the planning period in both zones as there are no planned schemes to reduce losses. We shall review this for our final plan.

3.16 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 3.13 and Table 3.14 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, also as shown in Table 3.13 and Table 3.14. 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.

Table 3.13: 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)	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Process losses [15] (Ml/d)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WAFU (Ml/d)	12.75	12.65	12.54	12.44	12.35	12.24	11.42
Imports [16] (Ml/d)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports [17] (Ml/d)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total WAFU (Ml/d)	12.75	12.65	12.54	12.44	12.35	12.24	11.42

Table 3.14: 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)	1238.55	1231.41	1220.88	1213.38	1207.29	1069.63	1016.48
Outage (Ml/d)	56.24	56.24	56.24	56.24	56.24	56.24	56.24
Process losses (Ml/d)	33.20	33.20	33.20	33.20	33.20	33.20	33.20
WAFU (Ml/d)	1149.11	1141.97	1131.44	1123.94	1117.85	980.19	927.04
Imports (Ml/d)	47.81	47.57	0.00	0.00	0.00	0.00	0.00
Exports (Ml/d)	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
Total WAFU (Ml/d)	1196.61	1189.23	1131.13	1123.63	1117.54	979.88	926.73

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

[16] Accounts for both raw and potable imports

[17] 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 of 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.

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 EA WRPGL and supporting UKWIR methodologies, including Household Consumption Forecasting (UKWIR, 2016) and Population, household property and occupancy forecasting (UKWIR, 2016)[18]. 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.

[18] The EAWRPGL 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. 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 4.1Table 4.1. 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 4.1: Regional maximum likelihood estimation table (2019/20 outturn)

	Pre-MLE	Confidence interval	Range	% of total	Adjustment	Post MLE	Change
Water Balance 2019/2020	**Ml/d**	**± %**	**Ml/d**	**%**	**Ml/d**	**Ml/d**	**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	

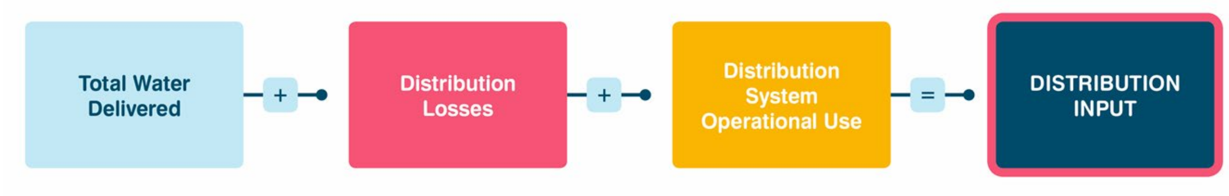
Water Balance 2019/2020 (cont.)	Pre-MLE	Confidence interval	Range	% of total	Adjustment	Post MLE	Change
	Ml/d	± %	Ml/d	%	Ml/d	Ml/d	Ml/d
Total Leakage (Ml/d)	**294.29**					**298.67**	**4.37**
– DMA Leakage (excl. SPL)	162.60	5%	16.26	5.88%	1.18	163.78	
– Trunk Main Leakage	56.71	30%	34.03	12.30%	2.47	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	5108140					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	2690720					2690720	
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	2417420					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, e.g. 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 are updated annually by CACI and have found that there is little variation in average occupancy for measured and unmeasured households between one year and the next. The occupancy rates used in the base year are provided in the table below:

Table 4.2: 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* (2020). 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 non-household in North Yorkshire, which has a population of 3,392 and is included in the data provided by Edge Analytics. This non-household 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[19] - 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 4.3.

Table 4.3: 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

[19] 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 4.4

Table 4.4: 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 (i.e. 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, 2020). 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, i.e. 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 EA WRPGL, 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:

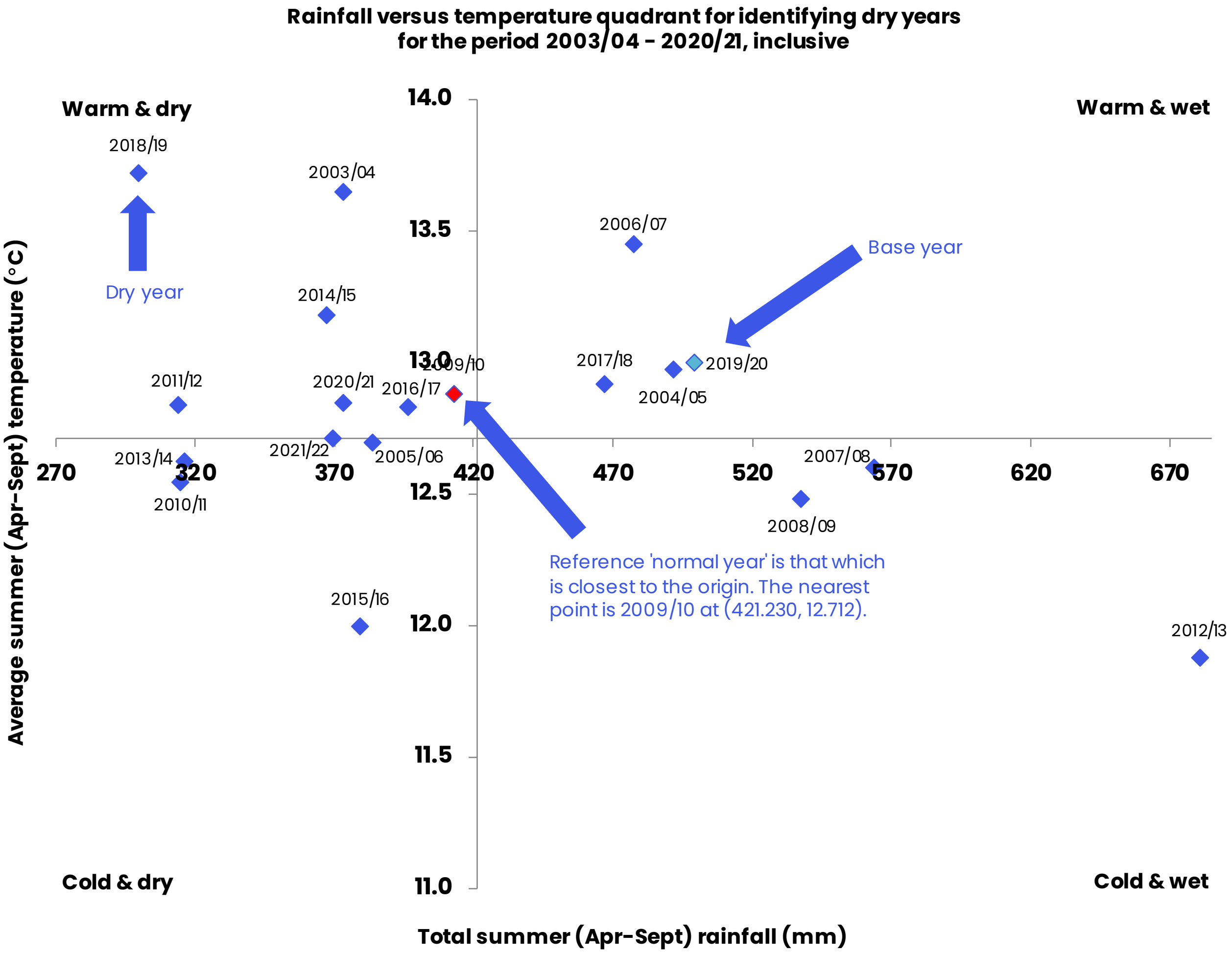
- **Quadrant analysis**, which uses long-term total summer rainfall and average summer temperature to identify potential reference 'normal' and 'dry' years; and,
- **Regression modelling**, to describe the relationship between demand and weather parameters.

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 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 (i.e. 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, i.e. 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 was selected.

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



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

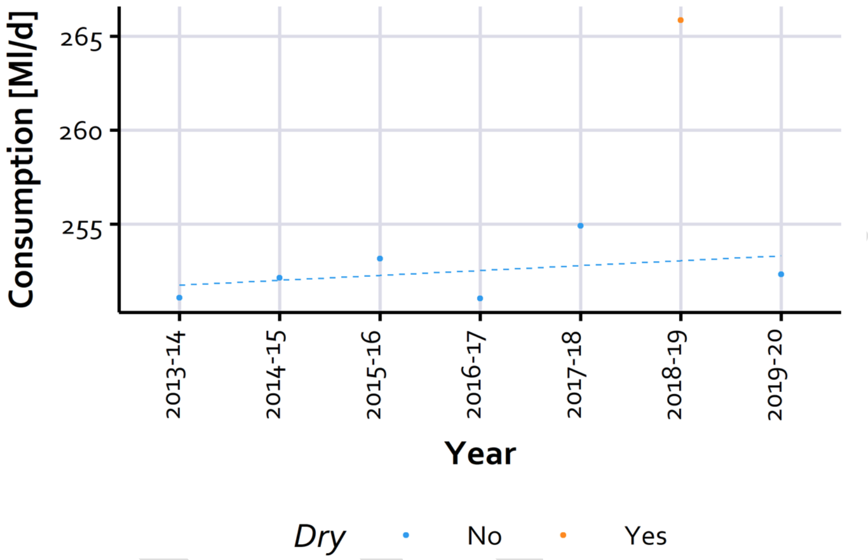
- In this case, 2018/19 is used as it is known to be a dry year
- It is one of the most distant from the origin point
- 2011/12 and 2012/13 are excluded as they are relatively old, and some reporting might have changed; 2018/19 by contrast is more recent data

The household consumption forecast was produced by Artesia 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 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 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 who compared the 28-day peak period data to the annual average of the seven-day rolling average data. The Artesia analysis assigned probability of peak demand by applying cumulative distribution functions (CDFs) to the peak volumes. This resulted in an 18% (1.1803 factor[20]) increase compared to the normal year demand and 16% compared to the DYAA for a 1 in 500 event. 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.

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

We have also 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 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 consultancy assessed our company datasets using the same approach as used in the national research project *The impact of COVID-19 on water consumption* (Artesia, 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, 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. In the years customers were subject to lockdowns the increase in household demand was 11.50% in 2020/21 and 4.41% in 2021/22. From 2022/23 onwards an uplift of 1.68% is applied to represent the 'new normal' with more people working from home than pre-Covid-19.

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.

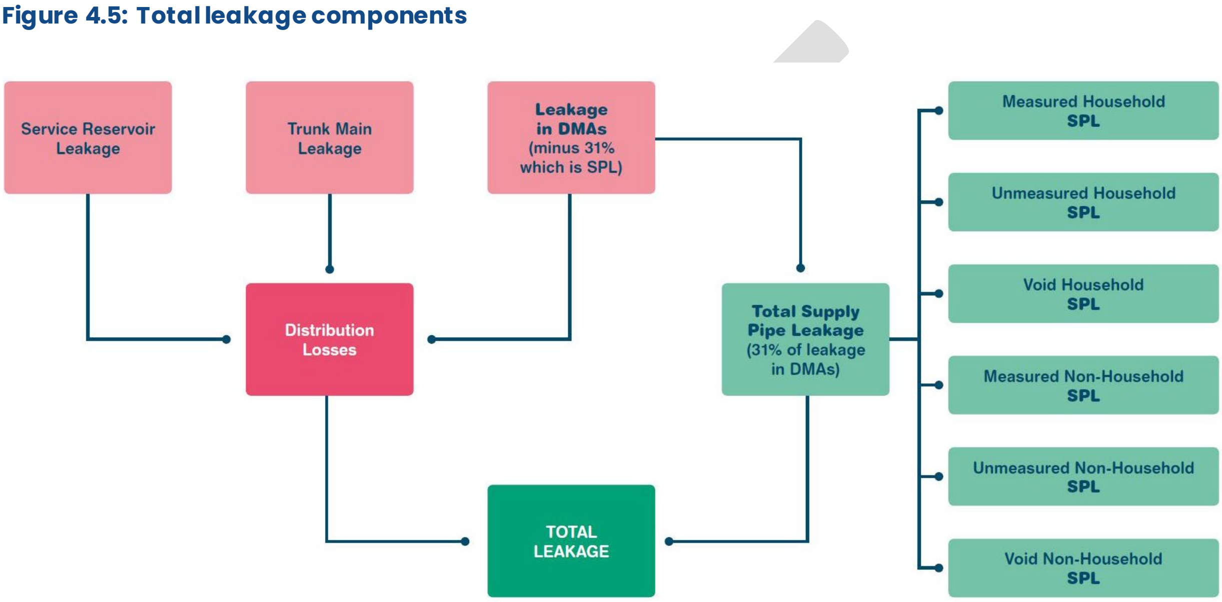
The water delivered to each property category is based on the number of properties or population in each zone. For the other components, such as water taken unbilled, distribution losses and distribution system operational use, zone ratios were used to split the volume of water between the two water 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 29.9% of leakage within DMAs. 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.

We provide a free repair service for all domestic supply pipes which are not under fixed structures. Domestic customers can claim one free repair in a two-year period.

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)[21]. 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.

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 EA 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 4.5 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.

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

Table 4.5: 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	-	-	-

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 (e.g. forecast population, economic growth etc.) 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 (i.e. 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: It explains the long-term baseline forecasts reflecting these current activities.

– Baseline metering strategy and DMO uptake

Household properties which opt to switch to a metered supply are known as domestic meter optants (DMOs)[22]. 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:

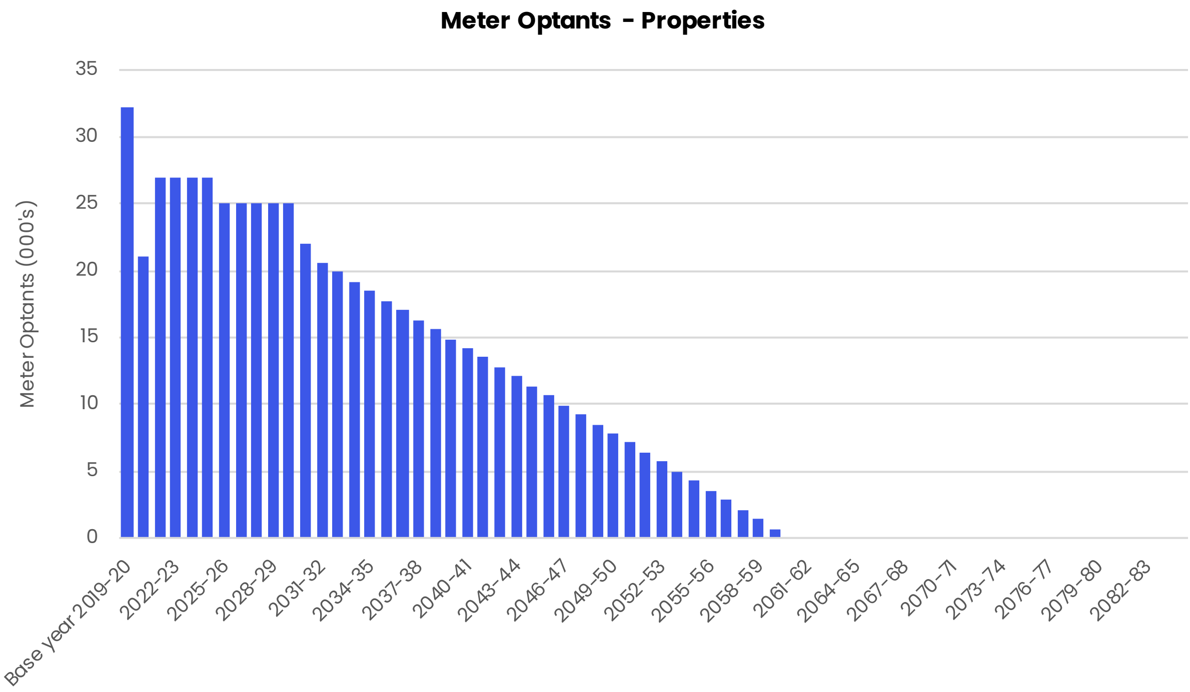
- Over time, the number of new DMOs is expected to fall. This decline reflects the decreasing number of unmeasured households both available to opt for a meter, and with a financial benefit of opting as an incentive. In general, low occupancy households and low rateable value properties that would usually 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.
- 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).

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

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 forecasts 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* (2020). 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[23] 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 WRPGL 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[24]. 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 EA WRPGL 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 from Edge Analytics 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.

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.

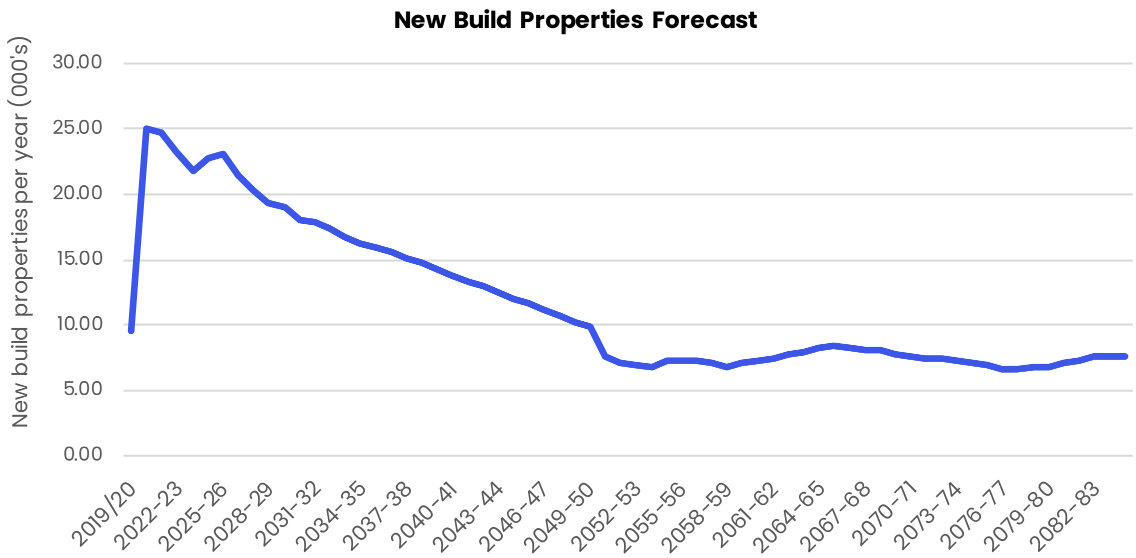
Under the trend-based forecast, which is based on historic trends in births, deaths and migration, the number of household properties and population forecasted are significantly fewer than the plan-based forecast. The impact of this potentially lower number of households and population on future demand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

[23] 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.

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

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:

Figure 4.7: New build household property forecast

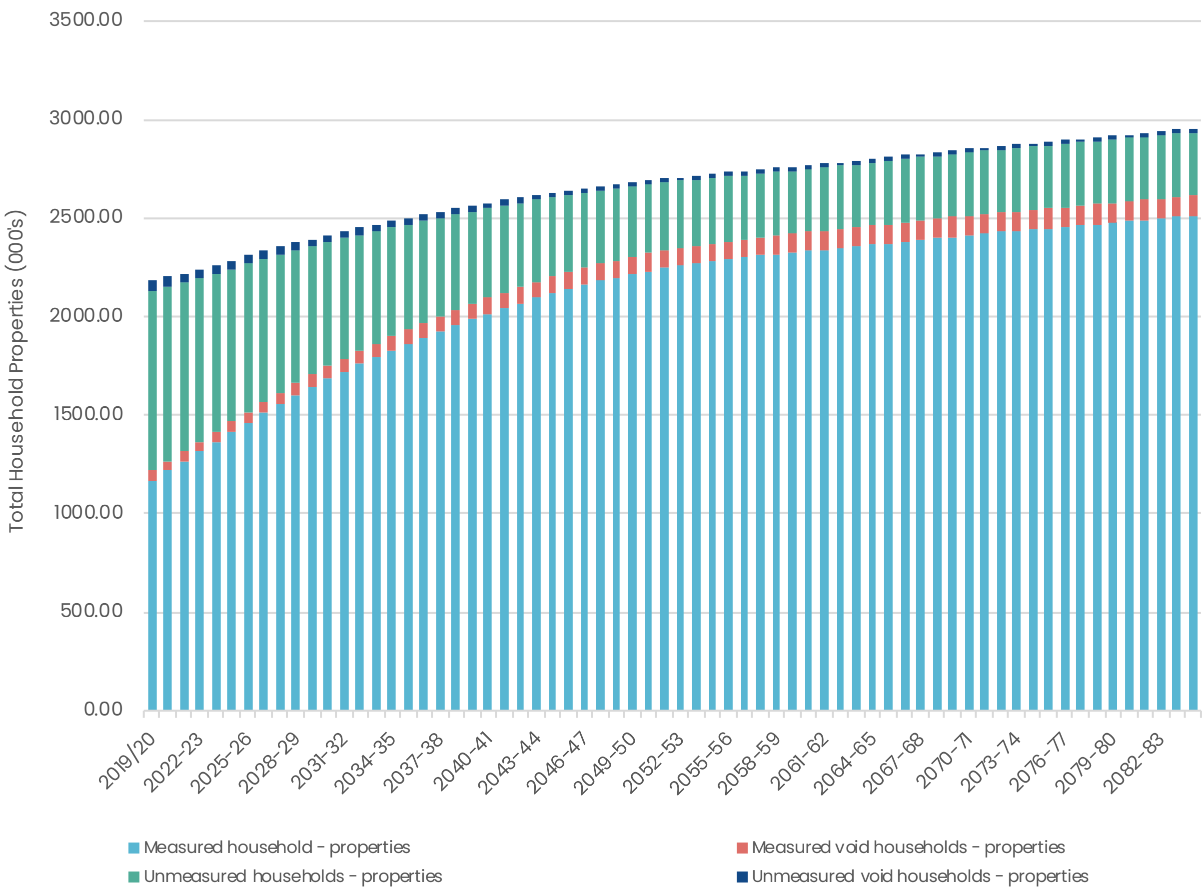


We rebased Edge Analytics' plan-based forecast of household properties to align with the base year numbers, which were taken from our billing file. The total forecast household properties were then divided between the measured and unmeasured household categories using our DMO forecast, and the Edge Analytics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



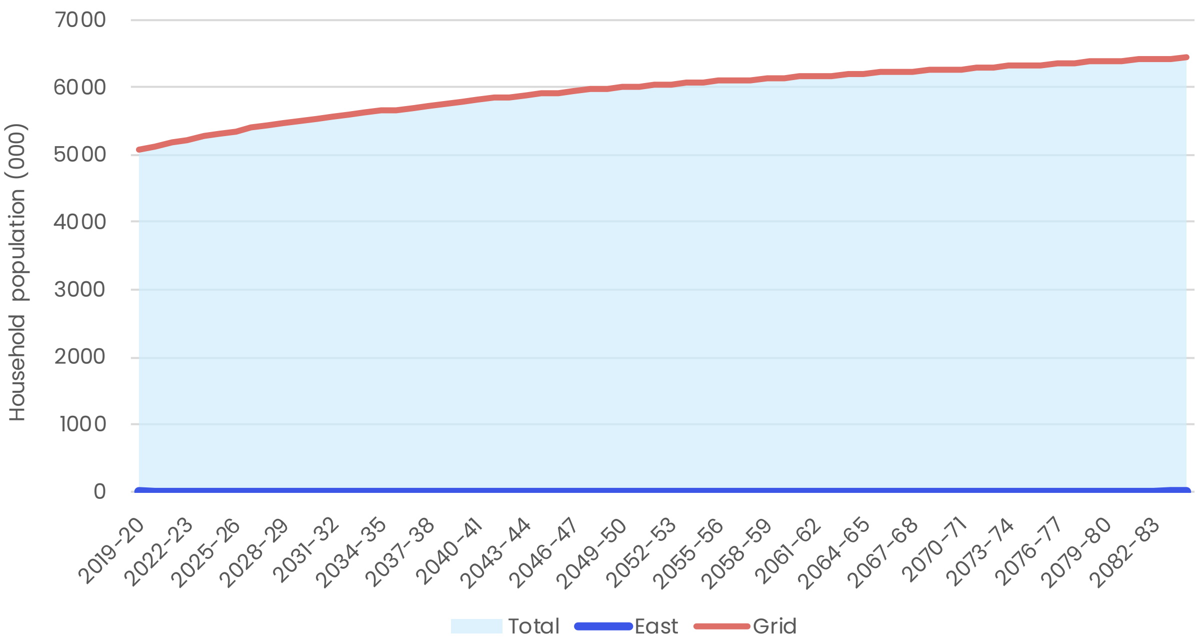
– Household population

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, 2020) and is split between the measured and unmeasured households as described earlier.

Figure 4.9: Household population split between East and Grid SWZ

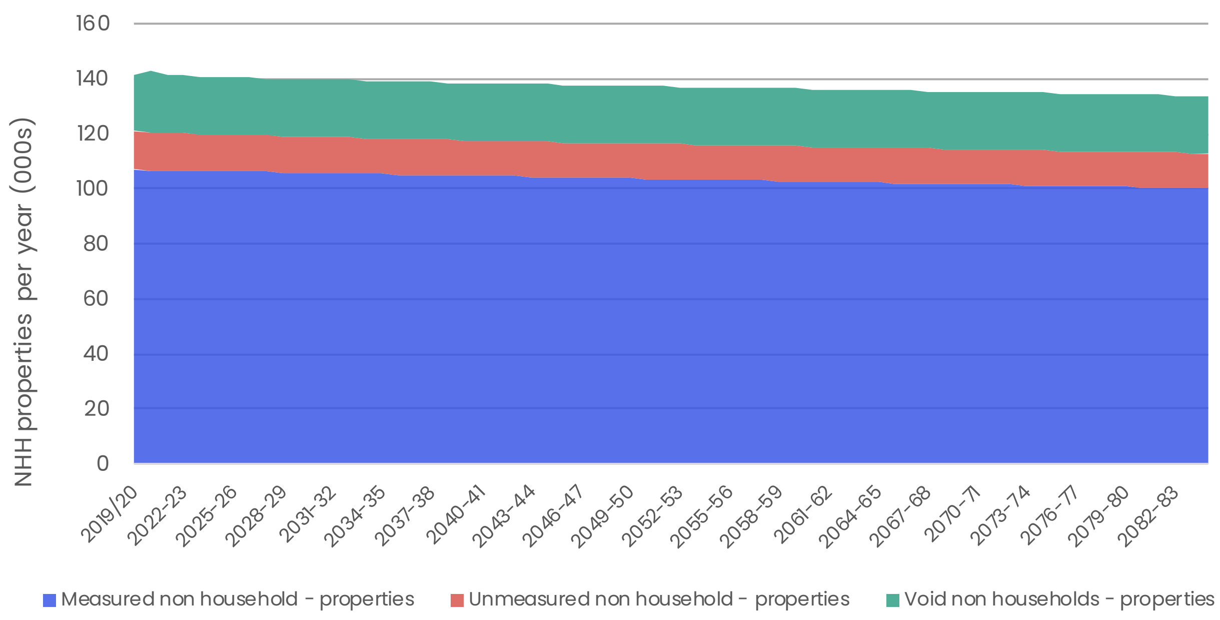


Non-households

– 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 i.e. 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* (2020) 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 NHH retailer team and asked for their advice on how best to profile the long-term forecast. The NHH team provided a profile of de-registrations, (i.e. those properties that are no longer classified as non-household) reflecting a slowing rate over time, i.e. 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 NHH 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 4.6: Unmeasured NHH 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 is 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.

– 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 4.7: 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 4.8. 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

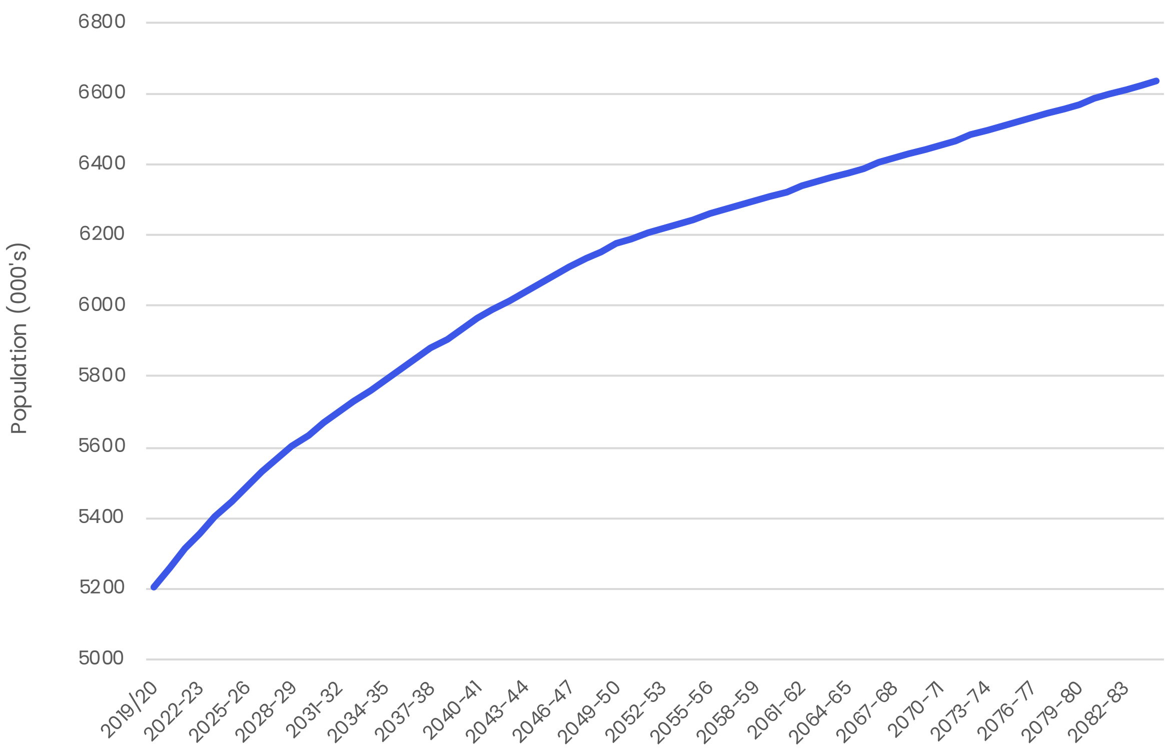


Table 4.8: Summary of total population forecast by AMP period

Population Forecast	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)
Grid SWZ	5,173.360	5,413.657	5,599.347	5,755.895	5,898.288	6,025.984	6,134.369
East SWZ	31.040	33.143	35.853	36.851	37.705	38.450	39.160
Total	**5,204.400**	**5,446.800**	**5,635.200**	**5,792.746**	**5,935.994**	**6,064.434**	**6,173.529**

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 2021[25]).

– 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, 2021)). 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.

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, 2012) 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.

[25] https://www.artesia-consulting.co.uk/blog/Collaborative%20study%20report%20on%20the%20impact%20of%20COVID-19%20on%20water%20use%20published

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 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

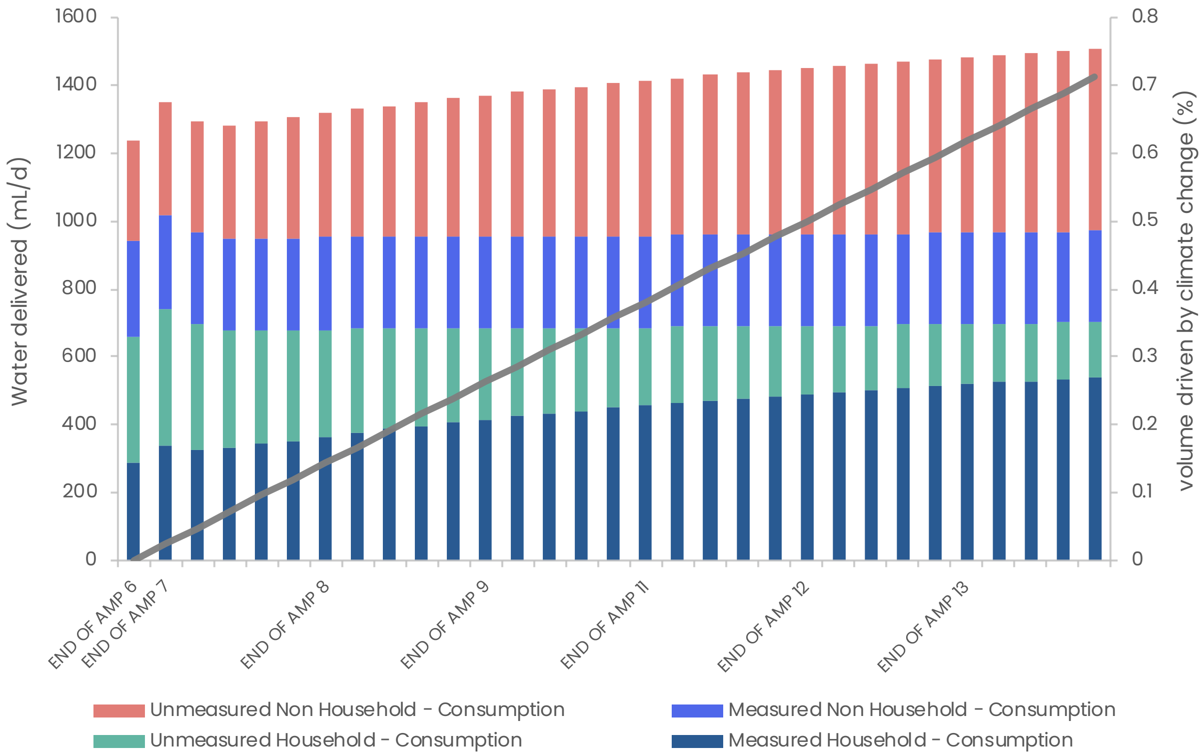
Following guidance from the EA, we have used the climate change scenarios[26] presented in the *Impact of Climate Change on Demand* (UKWIR, 2012) to determine the potential impact of climate change on customer demand.

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* (CCDeW, 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



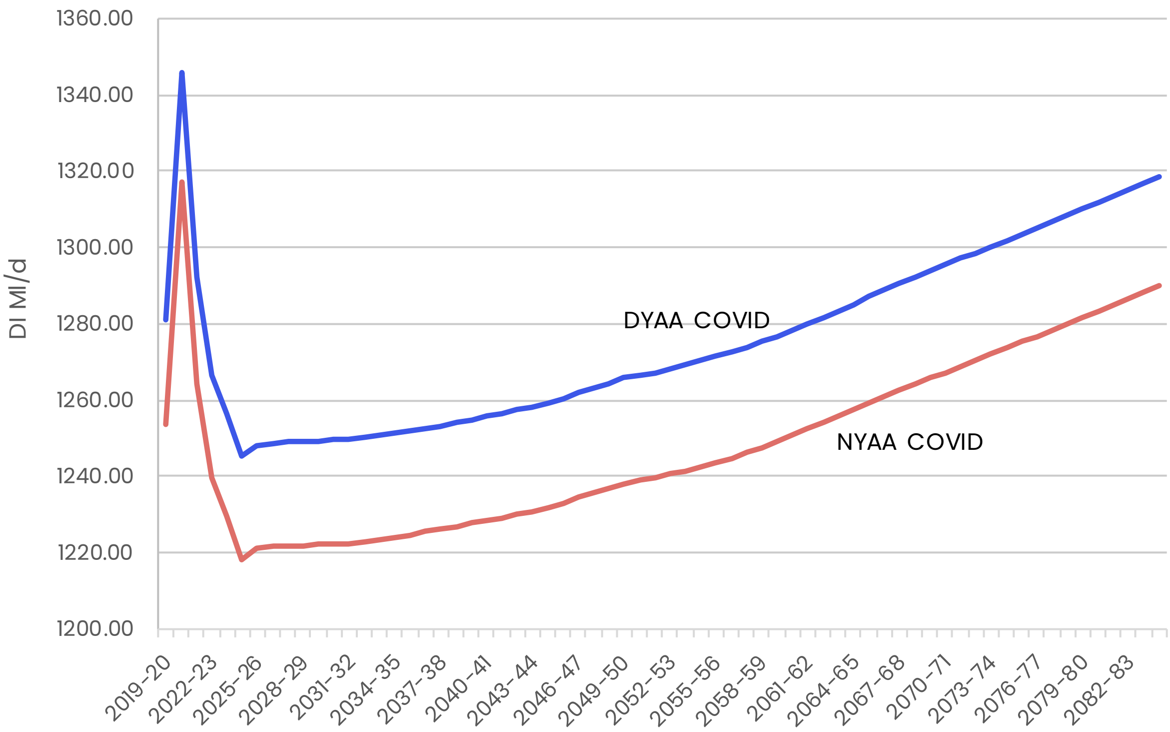
We have not added any climate change uplift to the non-household consumption. This is because there is no evidence of an impact on industrial demand. Equally, there is little potable water supplied for irrigation purposes in Yorkshire, and therefore, we are assuming no impact on agricultural demand in our region.

[26] 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 WRPGI 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 (we have provided at these internals to the end of the Statutory planning period only). Comparative tables of NYAA and DYAA based PCC are shown below.

Table 4.9: 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	127.0	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 WRPGL, 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 4.10 and Table 4.11 summarise the breakdown of PCC at the end of each AMP period.

Table 4.10: Breakdown of Grid SWZ PCC by microcomponent

Component	2019-20	2024-25	2029-30	2034-35	2039-40	2044-45	2049-50
Measured Household – PCC	**108.71**	**109.63**	**109.38**	**109.20**	**109.00**	**108.88**	**109.03**
Measured toilet flushing	26.00	25.75	25.67	25.59	25.51	25.46	25.46
Measured personal washing	41.93	41.53	41.39	41.27	41.15	41.06	41.06
Measured clothes washing	13.51	13.38	13.33	13.30	13.25	13.23	13.23
Measured dish washing	11.17	11.07	11.03	11.00	10.96	10.94	10.94
Measured miscellaneous internal use	14.58	14.44	14.39	14.35	14.31	14.27	14.28
Measured external use	1.53	1.64	1.76	1.89	2.01	2.13	2.26
Unmeasured Household – PCC	**154.47**	**155.80**	**155.16**	**154.46**	**153.85**	**153.29**	**153.13**
Unmeasured toilet flushing	35.75	35.42	35.23	35.03	34.85	34.68	34.60
Unmeasured personal washing	58.83	58.29	57.98	57.65	57.35	57.08	56.95
Unmeasured clothes washing	19.13	18.95	18.85	18.74	18.65	18.56	18.51
Unmeasured dish washing	14.89	14.76	14.68	14.59	14.52	14.45	14.42
Unmeasured miscellaneous internal use	20.89	20.70	20.59	20.47	20.36	20.27	20.22
Unmeasured external use	9.36	9.46	9.60	9.73	9.87	10.00	10.16
Average Household - PCC	**130.35**	**127.76**	**124.20**	**121.49**	**119.35**	**117.77**	**116.87**

Table 4.11: Breakdown of East SWZ PCC by microcomponent

Component	2019-20	2024-25	2029-30	2034-35	2039-40	2044-45	2049-50
Measured Household - PCC	**108.31**	**108.84**	**108.12**	**107.59**	**106.99**	**106.45**	**106.15**
Measured toilet flushing	25.90	25.57	25.37	25.21	25.04	24.89	24.79
Measured personal washing	41.78	41.24	40.92	40.66	40.39	40.14	39.98
Measured clothes washing	13.46	13.28	13.18	13.10	13.01	12.93	12.88
Measured dish washing	11.13	10.99	10.90	10.84	10.76	10.70	10.65
Measured miscellaneous internal use	14.52	14.34	14.22	14.14	14.04	13.96	13.90
Measured external use	1.52	1.63	1.74	1.86	1.97	2.08	2.20
Unmeasured Household - PCC	**162.41**	**165.34**	**164.83**	**164.44**	**164.12**	**163.95**	**164.22**
Unmeasured toilet flushing	37.61	37.61	37.45	37.32	37.20	37.12	37.14
Unmeasured personal washing	61.91	61.91	61.64	61.42	61.23	61.10	61.12
Unmeasured clothes washing	20.12	20.13	20.04	19.97	19.91	19.86	19.87
Unmeasured dish washing	15.67	15.67	15.60	15.55	15.50	15.47	15.47
Unmeasured miscellaneous internal use	21.98	21.98	21.89	21.81	21.74	21.69	21.70
Unmeasured external use	9.85	10.05	10.21	10.37	10.53	10.71	10.91
Average Household - PCC	**135.62**	**132.42**	**127.15**	**123.91**	**121.27**	**119.21**	**117.83**

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

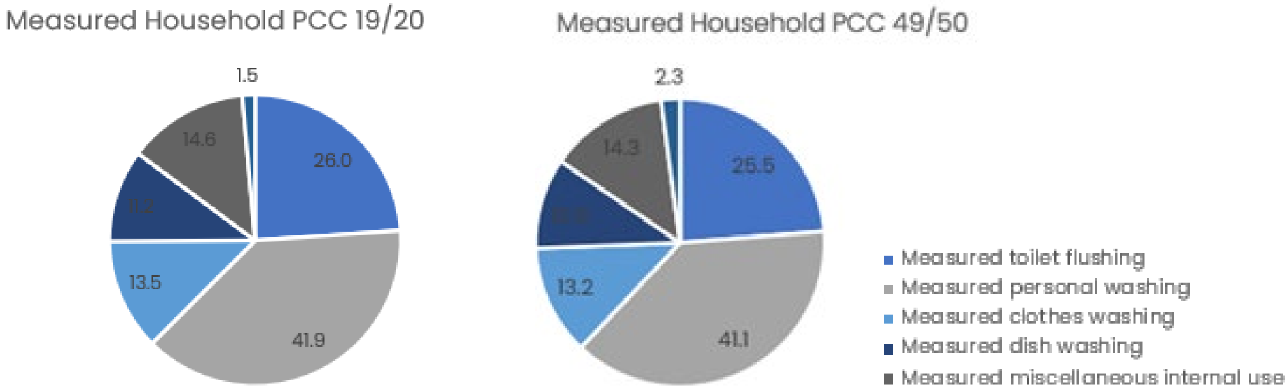
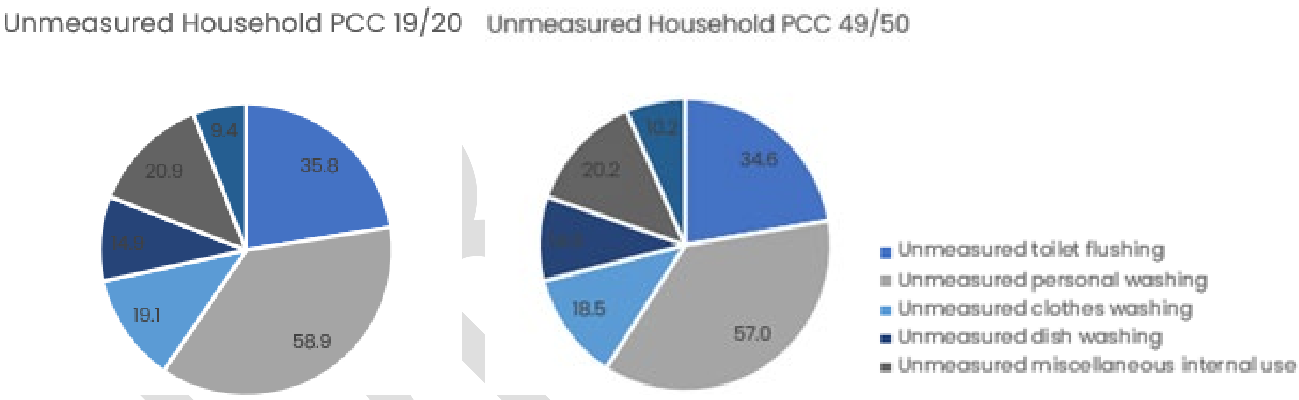


Figure 4.15: Percentage breakdown of unmeasured household PCC - Base year Vs 2049/50



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. dates to the model include more recent billing file data and insight to forecast NHH demand prior to completion of the model for the WRMP24.). This also incorporates the forecast impact of Covid-19 on non-household demand, including the forecast % of people working from home, changes in industrial ownership, as well as closures within certain business sectors.

We requested Artesia to review the non-household forecasting process and ensure that the NHH demand forecasts for the WRMP24 follows guidance correctly, with the process followed by other water companies, and by ourselves in the WRMP19. Artesia 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 NHH 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, are used 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:

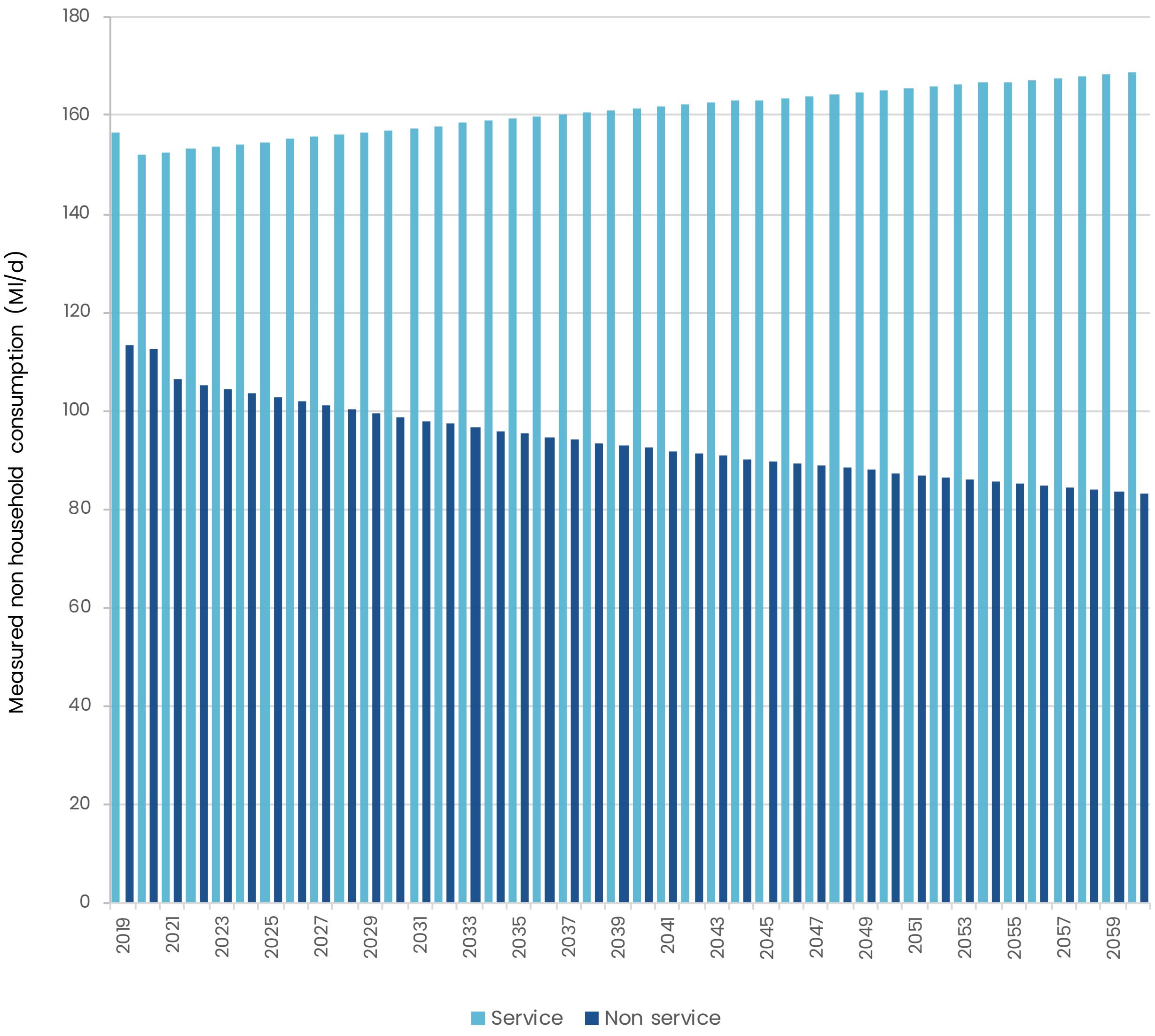
Table 4.12: Measured non-household forecast models

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 Uncertainty 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. For large water users, we have considered that the model outputs do not acknowledge any possible large users which we will need to provide water to in the future, increasing demand. Consumption for specific new large users is applied to the NHH demand forecast. Information on any new NHH 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.

Following the opening of the non-household water market in April 2017, there are now 20 retailers operating within our supply region. As part of our price review process, we will be consulting with all retailers to understand their priorities for the next five years and longer term.

Part of these discussions will be to understand planned water efficiency activity and known growth that may impact on water demand in the future. Any information provided by retailers during this consultation will be included in our non-household demand forecast presented in our final WRMP24.

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.

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 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).

For WRMP24, the forecast will remain at the 1.95 Ml/d reported figure in the base year. Actual consumption since 2017/18 have been relatively stable at or around 1.95Ml/d. In 2020/21, the decrease observed was due to covid, but our most recent figure for 2021/22 increased again to 1.95 Ml/d, and as such is considered an appropriate forecast assumption.

Table 4.13: Unmeasured non-household demand

Consumption	2017/18	2018/19	2019/20	2020/21	2021/22
UMNHH	2.09	1.96	1.95	1.88	1.95

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.

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 4.14. The measured household water delivered is forecast to increase from 318.70 Ml/d in the base year to 180.39 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 465.12Ml/d in the base year to 216.80Ml/d in 2044/45. This is due to a continuing trend of households switching to a metered supply.

Figure 4.17: Water delivered to households

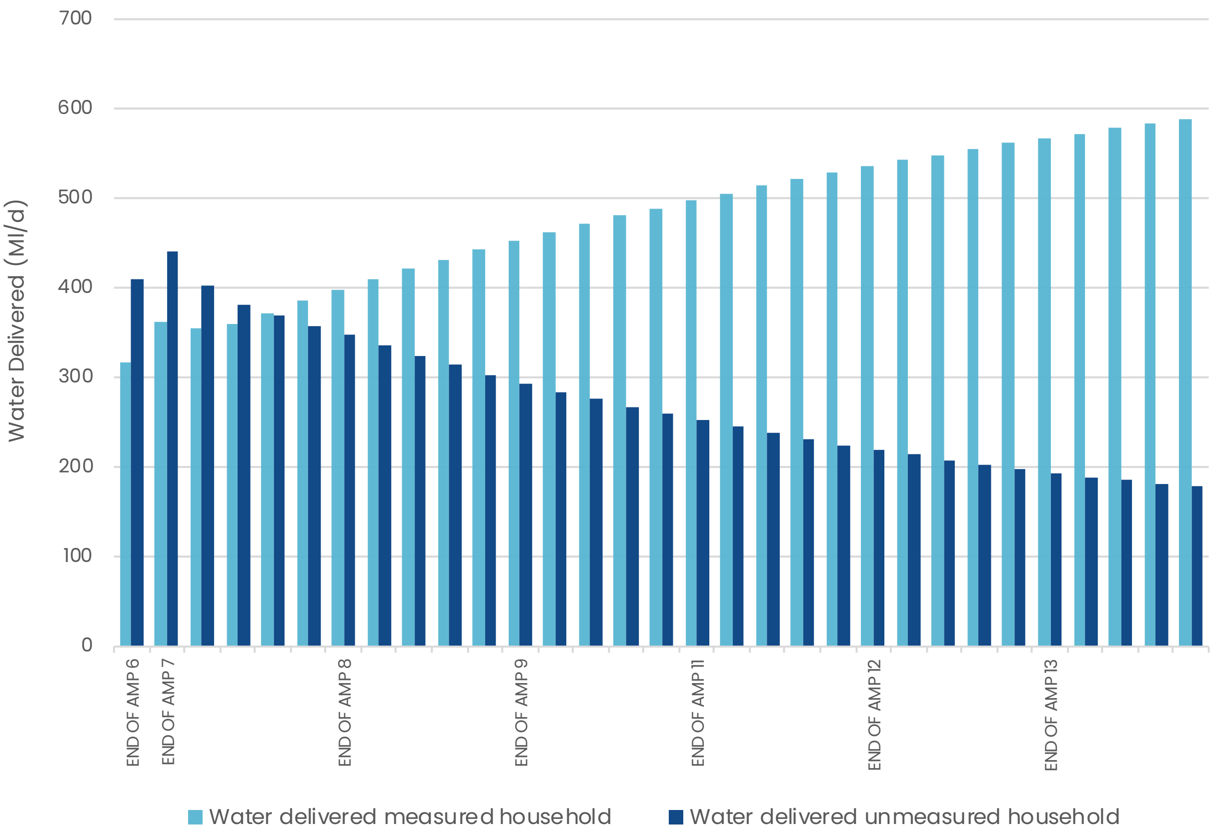


Table 4.14: Water delivered to households

Dry Year Forecast Water Delivered with covid impact (Ml/d)	Measured Households		Unmeasured Households	
	2019/20	2049/50	2019/20	2049/50
Grid SWZ	316.93	587.58	409.64	179.01
East SWZ	1.77	3.55	2.74	1.38
Total	**318.70**	**591.12**	**412.38**	**180.39**

Measured non-household water delivered

Table 4.15 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 4.15: Water delivered to measured non-households

Water delivered measured non- household in a dry year with covid	2019/20	2049/50
Grid	285.15	270.97
East	1.45	1.37
Total	**286.60**	**272.34**

Unmeasured non-household water delivered

The unmeasured non-household water delivered forecast has been projected in response to stable previous historical trends for unmeasured NHH consumption. The actual outturn for the consumption in base year was 1.95 Ml/day, this figure has been assumed unchanged for the rest of the planning period. Unmeasured NHH water delivered also takes into account customer supply pipe losses of this demand component, resulting in a small variation through the planning horizon, as shown in Figure 4.18.

Figure 4.18: Water delivered to unmeasured non-households

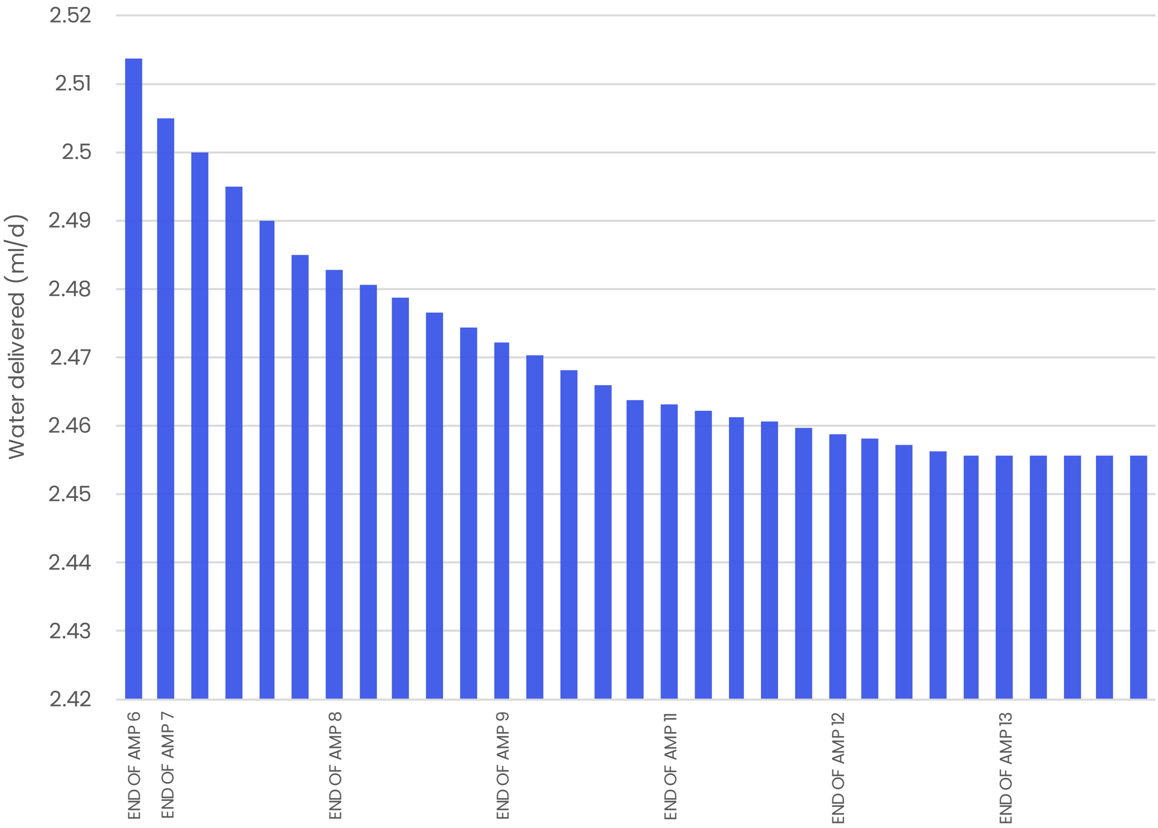


Table 4.16: Water delivered to unmeasured non-households

Water delivered unmeasured non- household in a dry year with covid	2019/20	2049/50
Grid	2.51	2.46
East	0.03	0.03
Total	**2.55**	**2.49**

Total water delivered

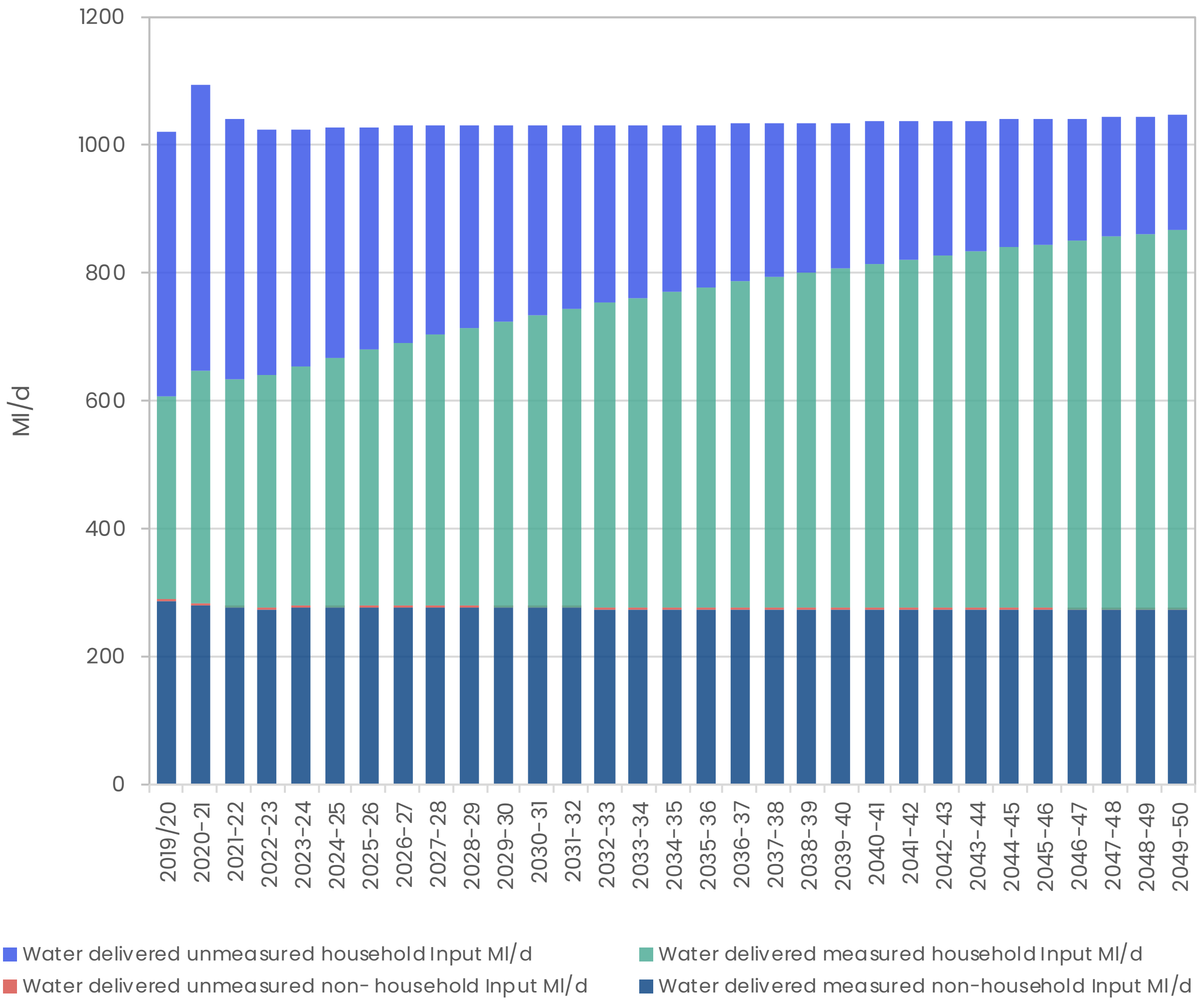
The total water delivered is the sum of water delivered to all properties (including voids) and unbilled water.

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 1,020.23Ml/d in the base year to 1,046.34Ml/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 EAWRPG 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 1,281.19Ml/d in the base year to 1265.701Ml/d in 2049/50 and through to 2084/85, down to 1318.52 Ml/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 4.17[27]

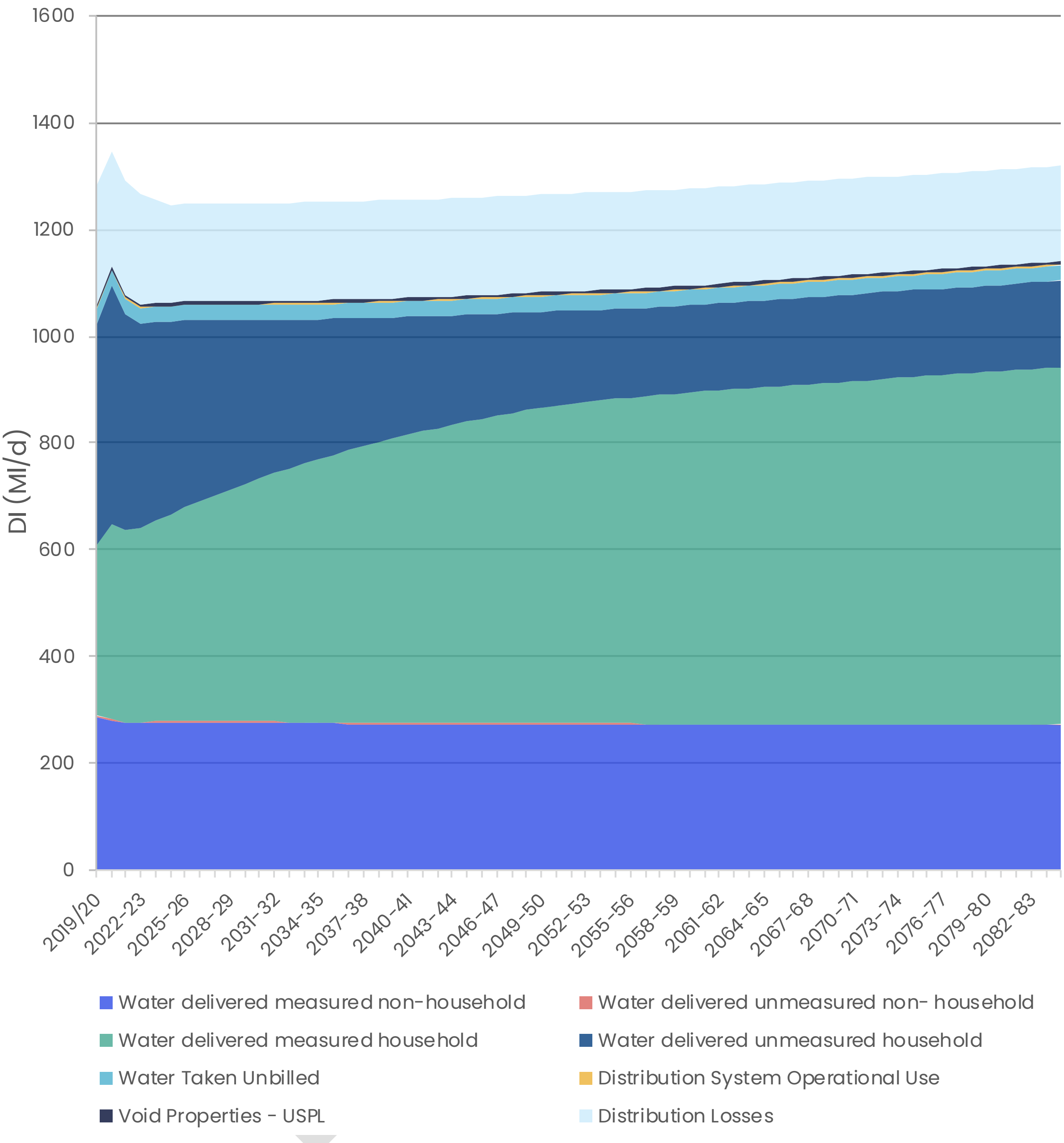
Table 4.17: Distribution Input for the Region (DYAA)

Distribution Input	2019/20	2024/25	2025/26	2030/31	2040/41	2044/45	2049/50	2084/85
East SWZ	7.18	7.30	7.36	7.46	7.46	7.46	7.49	7.84
Grid SWZ	1274.00	1238.07	1240.88	1242.03	1248.29	1252.03	1258.21	1310.68
Total	**1281.18**	**1245.37**	**1248.24**	**1249.49**	**1255.75**	**1259.49**	**1265.70**	**1318.52**

[27] 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.

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 WRPGI 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 (we have provided at these internals 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 relevant 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.

Table 4.18: 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	272.99	274.46	274.11	273.77	273.45	273.15	271.86	270.87	270.14	269.59
Unmeasured non-household consumption	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Measured household consumption	355.92	367.29	378.18	388.74	399.07	409.27	452.07	488.06	517.81	541.99
Unmeasured household consumption	327.42	317.46	307.51	297.59	287.72	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	1245.37	1248.24	1248.83	1249.14	1249.27	1249.33	1251.52	1254.97	1259.49	1265.70

Table 4.19: 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	259.86	261.26	260.92	260.60	260.30	260.01	258.79	257.84	257.15	256.63
Unmeasured non-household consumption	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Measured household consumption	348.61	359.75	370.42	380.76	390.88	400.86	442.79	478.03	507.18	530.86
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	1218.20	1220.98	1221.56	1221.87	1222.02	1222.08	1224.26	1227.67	1232.12	1238.21

5. Water efficiency and demand reduction strategy

This section describes how we intend to continue promoting water efficiency to our customers and investigate new, innovative measures for reducing demand in the future.

Demand reduction and water efficiency is 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 promoting water efficiency to our customers has increased as the risks to water availability and energy supplies increase.

The long-term strategy for water efficiency across all water companies nationally is to achieve a PCC target of 110 l/h/day by 2050. This reduction in consumption will provide sustainable benefits to water demand management, as evidenced in this WRMP. This will help to ease the pressure on the water environment and forecast future supply-demand deficits.

The key themes of our water efficiency strategy are:

- measuring and analysing consumption of household and non-household customers;
- reporting and monitoring PCC and NHH reduction;
- communicating the water efficiency message to our customers;
- collaborating with key stakeholders;
- educating customers on water efficiency; and
- a continued drive for innovation and best practice to reduce demand for water.

Details of our demand reduction and water efficiency strategy are outlined in the following sections.

5.1 Household customer water efficiency

Understanding household water consumption and promoting our water saving message to customers is evidenced in our current water efficiency initiatives summarised below:

- Water saving packs - household customers can request free water saving packs via our website. The water saving products available are a shower regulator, 4-minue 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.
- Home audit and retrofit service - customers will be offered a home water audit where 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.
- Behavioural change – we have several channels in place for promoting water efficiency behavioural changes through:
  - 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.
  - Water efficiency section on our website which includes information on water efficiency and includes a water use calculator.
  - Water saving tips for home and garden including a 4-minute shower playlist and self-audit leaflets.
  - The Green Classroom school pack and visits to our four education centres across Yorkshire.

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.

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.

Between 2018 and 2020 we delivered a pilot project where we offered customers a home water audit and installation of waver saving products applicable to their property. This pilot was stalled in 2020 due to Covid-19 and the inability to enter customers' properties; the pilot is to be restarted in 2022. If the pilot is successful, we will implement home audits and virtual audits as part of the wider water efficiency strategy to reduce demand for water.

We continue to offer visits to our four education centres across Yorkshire. During these visits, attendees are taught about the water cycle and opportunities to reduce water consumption. We provide a Green Classroom school pack 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. This face-to-face training would help to reinforce the understanding of the principles of water efficiency and the message to reduce water use.

Whilst these initiatives are useful, they are soft measures to reduce water use based on behavioural change or from installing water saving devices in their home. To meet our target for PCC reduction the introduction of SMART technologies and installation of more water efficient devices is imperative. We are currently in the project scope phase to trial the use of flow restrictors on household 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 and they continue to use water in the same way.

The potential saving of the flow restrictor has been estimated to be at least 11 l/p/d so the realised benefits from installing these could reduce water use significantly with no change on customer behaviour. If the trial is successful, we have plans to install these devices on new build homes and offer to a proportion of meter optants and existing metered properties.

5.2 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 we have continued promoting water efficiency to non-household customers and working in collaboration with retailers. Three examples of this are a dedicated web page for non-household customers which has business tailored water efficiency advice; free 'save a flush' cistern bags which are available to all businesses; and the Water Promise Campaign where we incentivise businesses to ensure they are efficient with their water use.

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 and that market participants require £22m of funding to achieve the 9% non-household demand reduction targeted by 2037 by Defra.

Our future approach for non-household demand reduction will be to build on our existing services as follows:

- We will develop and promote our website, providing enhanced functionality for non-household customers to engage and be better informed on water efficiency opportunities and how this can benefit their business.
- We will review our tariffs and charges, and how they apply, seeking opportunities to incentivise non-household customers to be more efficient with their water use.
- We will seek to ensure an appropriately phased roll out of smart meters to non-household customers and introduce new innovative data services to support customers in identifying opportunities for water efficiency.
- In conjunction with other wholesalers, retailers and MOSL we will seek to develop a non-household market water efficiency incentive scheme. This will provide a standardised market approach and support retailers and third parties develop business models aimed at delivering non-household demand reduction.
- We will develop new innovative data and field solutions to enhance our supply point data which will incentivise efficient water use through enhanced accuracy of customer billing.

We will continue to monitor developments and opportunities in the Retailer Wholesaler Group Water Efficiency Subgroup and seek to adapt our approach to non-household water efficiency accordingly.

5.3 New Developments

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 125l/h/d.

We want to develop this incentive further by reducing the target for l/h/d to 100 or less but increase the incentive received on their infrastructure charges to 50%. This is 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.

5.4 Communication campaign 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.

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.

5.5 Free supply-pipe repairs

We continue to offer free supply pipe investigation and repairs/renewals, to ensure that supply pipe leakage is kept to a minimum. This contributes to a reduction in demand. Our policy is to raise customer awareness of supply pipe ownership and give options to manage the associated responsibility. Under the policy, we repair a leaking supply pipe free of charge for household customers, however further repairs may be at the customer's own expense in line with our policy and eligibility criteria.

We have developed a bespoke and dedicated team of Customer Side Leakage Reduction Experts to own the end-end customer side experience and are better equipped to ensure a right first-time resolution and promote the more efficient use of water.

We proactively engage and partner with innovative water technology companies to trial more effective ways of working.

5.6 Metering

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 5.6 of this WRMP.

For new properties Yorkshire Water is adopting a policy of future proofing by installing Smart capable meters as standard, 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 a smart capable AMI 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 8.4.2). 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.

5.7 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.

5.8 Reducing our own water use

Included in our water efficiency strategy, is our goal to reduce the water that we use and the water that is lost through leakage. We have a target to achieve a 50% reduction in leakage by 2050 and have already started to implement initiatives which are enhancing our ability to reduce leakage beyond existing find and fix activity (see Section 8.4).

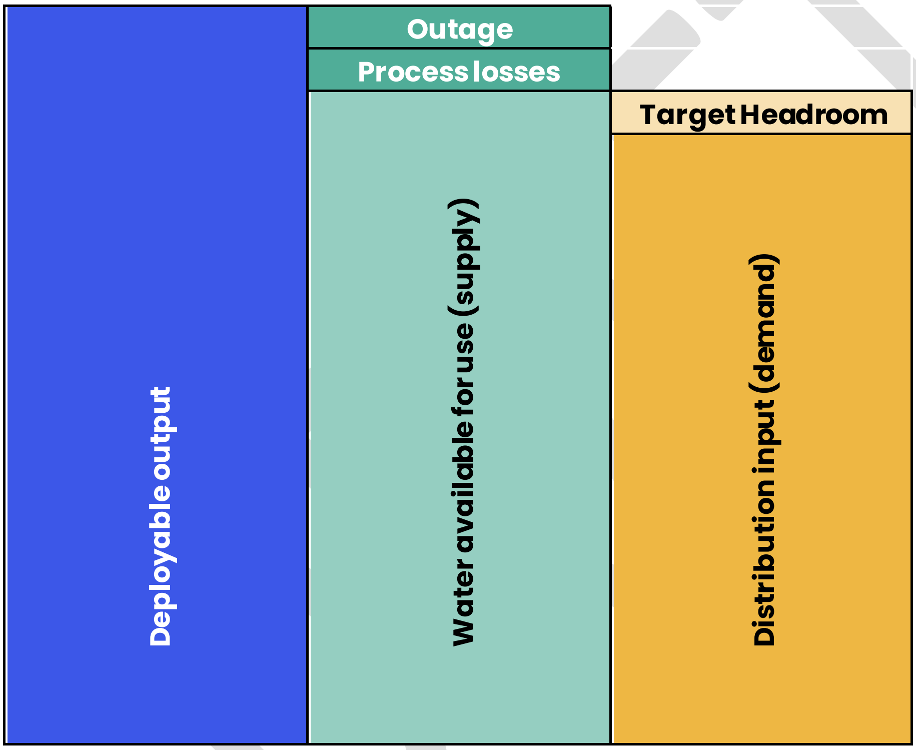
In addition to reducing leakage, we are currently exploring opportunities to reduce our water use across Yorkshire Water's operational sites and asset base. Our head office utilises rainwater harvesting in the toilets across the site to reduce our own water use by recycling water captured when it rains. This is a scheme which we hope to roll out across all Yorkshire Water offices.

6. Allowing for uncertainty

Headroom is an accepted term 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. We calculate target headroom to provide a buffer between forecast supply and forecast demand. The headroom planning allowance is separate to the outage planning allowance, as outage accounts for temporary reductions in supply.

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 can be made available on request.

Figure 6.1: Supply-demand balance components



We calculate target headroom and available headroom to ensure demand will be met over the planning period. Available headroom is the water available once the forecast demand is met. Target headroom is a buffer we allow between supply and demand for specified uncertainties that could impact permanently on our ability to meet demand in a water resource zone.

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.

As for previous plans, we have calculated target headroom following the UKWIR guidance *An Improved Methodology for Assessing Headroom* (UKWIR, 2002) and used a stochastic model to produce an estimate of target headroom at a range of percentiles. This is included in the UKWIR *WRMP 2019 Methods – risk-based planning guidance* (Atkins, 2016) as an accepted methodology for calculating target headroom.

For WRMP24, we have worked with other companies in the Water Resources North 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.

The East SWZ supply-demand forecast showed a surplus throughout the WRMP19 planning period and our problem characterisation concluded that the traditional target headroom method was appropriate. This was confirmed in the development of the WRMP24 supply-demand balance for the zone and the sensitivity testing scenarios (Ofwat common reference scenarios) that did not highlight a risk if deficit, see Section 7.1.1.

The Grid SWZ was identified as having a small strategic needs and high complexity based on the WRMP19 risks and the information available when the problem characterisation was produced. As the WRMP24 needs were developed further, the scale of the need in the zone became greater than the initial evidence suggested. The outputs of the regional reconciliation process in relation to the STW transfer and the regulatory requirements for representing the Environmental Destination risk changed significantly postproduction of the emerging regional plan in January 2022.

However, the initial problem characterisation had concluded a "scenario-based method" should be used for representing uncertainty in the Grid SWZ, and the increased risk to the zone confirmed this was the most appropriate approach for the zone. We therefore considered it appropriate to use the UKWIR 2002 headroom methodology to calculate the Grid SWZ baseline target headroom and to represent the uncertainty in the final plan through alternative futures that can be addressed by adaptive pathways.

We did not re-evaluated 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. 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.

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, 2003). 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.

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.

6.1 Headroom components

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 (Environmental Destination). 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.

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.

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 Grid SWZ headroom calculation also includes a component for uncertainty in the bulk raw water transfer from Severn Trent Water due to climate change.

We have also calculated headroom without the impact of climate change to understand how much this component contributes to the total target headroom values.

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 Accuracy of supply side data	✓	✓
S8 Climate change impact on supply	✓	✓
D1 Accuracy of sub-component data	✓	✓
D2 Demand forecast variation	✓	✓
D3 Uncertainty of impact of climate change on demand	✓	✓

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 and climatic variations. In both the Grid SWZ and the East SWZ we estimate the uncertainty due to supply data accuracy is between +6% and 10% of WAFU throughout the planning period.

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.

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.

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.

6.2 Target headroom calculation

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 2049/50. It combines the probability distributions to produce headroom estimates for levels of certainty between zero and 100% in 5% increments.

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 not meet demand (due to the uncertainty factors considered in the headroom assessment). The A Re-evaluation of the Methodology for Assessing Headroom (UKWIR, 2002) methodology does not include guidance on the percentile risk water companies should plan for in the supply-demand balance.

The *EAWRPG* 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.

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 the East SWZ accuracy of supply side data (S6) is the dominant factor in the combined headroom distribution. The relative contribution of supply side climate change uncertainty increases over the planning period from around 7.4% in 2025/26 to 22.2% in 2050/51. Similarly, the contribution of demand forecast variation increases from around 2% in 2025/26 to 9.4% in 2050/51. This is based on Crystal Ball 'contribution to variance' output, which is calculated from the 50th percentile values of headroom distributions and does not equate to the percentages of these components at different percentile values.

Like the East SWZ, the headroom component that has the greatest impact on target headroom in the Grid SWZ is accuracy of supply side data (S6). This factor makes up the largest proportion of headroom across the planning period, although the relative contribution does reduce over time (from 92.1% in 2025/26 to 76.6% in 2050/51). The uncertainty is based on a percentage of deployable output, therefore the reduction is due to decreasing deployable output in the baseline forecast due to climate change reducing deployable output, as well as the relative increase in contribution of other factors.

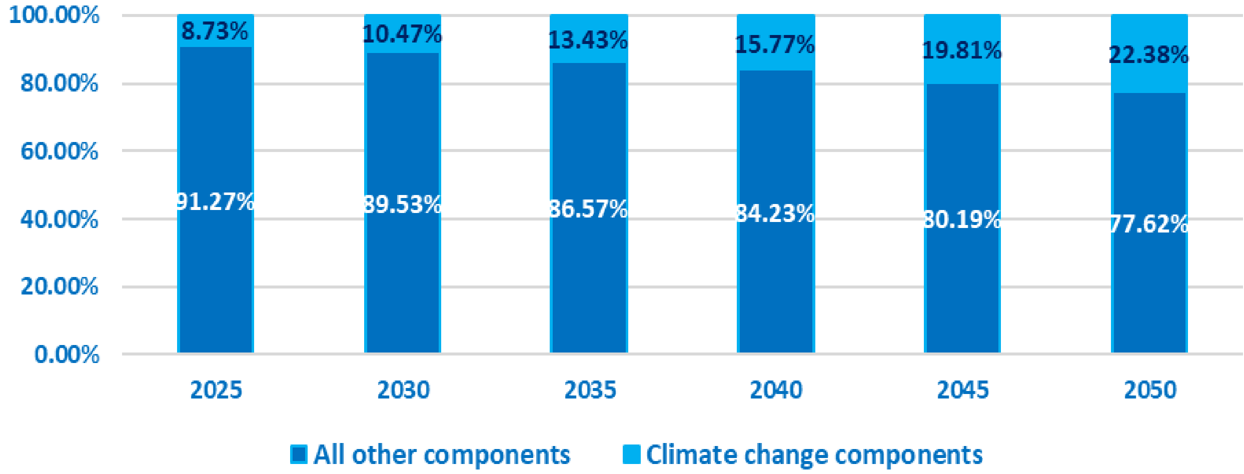
In 2025/26, the second greatest impact on Grid SWZ target headroom is from the accuracy of sub-component data (factor D1), at just over 5%; this reduces slightly to 4.5% in 2050/51. The impact of demand forecast variation (factor D2) contributes only around 1% of the headroom variance in 2025/26, however this increases to around 10% in 2050/51. Similarly, the impact of climate change on supply contributes only around 1% in 2025/26, increasing slightly to around 6% in 2050/51. All other factors contribute less than 5% each of the headroom variance across the 25-year planning period.

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 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, the probability distribution representing the supply impacts of UKCP18 climate change projections is asymmetrical, so that the 'most likely' parameter of the triangular distribution is significantly closer to the maximum than to the minimum value. This reflects a relatively higher magnitude of supply-side climate change impacts incorporated in the baseline supply-demand balance, and therefore a reduced impact of the uncertainty range for this factor on the headroom distribution. This is offset by a small positive impact on headroom uncertainty of the impacts 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. The climate change component of target headroom is therefore reported as zero for the Grid SWZ WRP tables.

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 6.2 shows that the percentage contribution to the target headroom allowance is between about 9% in 2025/26, rising to about 22% in 2050/51.

Figure 6.2: Percentage contribution of climate change – East SWZ



6.3 Headroom assessment results

Table 6.2 shows the target headroom results using the selected percentile profile for each zone. 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 around 5% 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. 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.

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	61.31	51.48	41.41	33.52	25.77	**19.16**
		% of WAFU	**5.1**	**4.3**	**3.7**	**3.0**	**2.3**	**1.7**

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 Reducing uncertainty

Our catchment management programme discussed in Section 3.13 will be our primary solution to mitigating pollution risks.

Risks due to data accuracy and climate change cannot be reduced due to implementation of any specific options, but it is recognised that by reducing demand at a regional level we can reduce the risks to our level of service. In future WRMPs our understanding of the impacts of climate change on water resources in our region may change.

Demand forecast variation (D2) is largely due to customer behaviour (PCC), population growth and new property development. Our leakage reduction and water efficiency and demand reduction strategies are aimed at reducing our baseline demand; the impact of these programmes will be monitored to assess whether any future reductions in headroom uncertainty ranges for demand forecast variation may be appropriate.

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

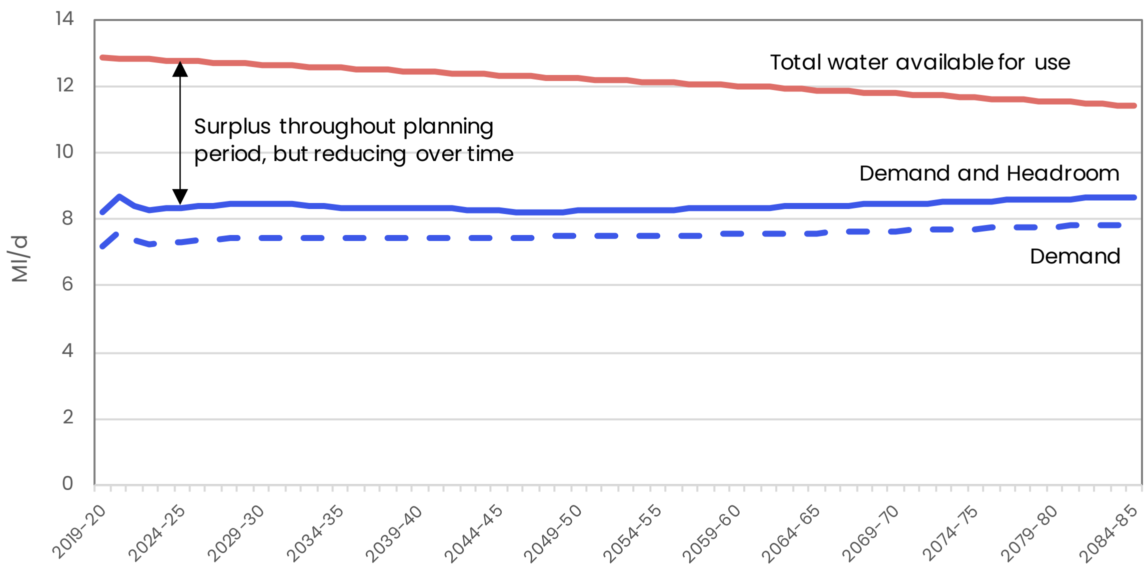
A supply-demand appraisal has been undertaken for the East SWZ dry year annual average (DYAA) planning scenario. The scenario is based on a 1 in 500 level of service for Level 4 drought restrictions (emergency drought orders). The forecast in this zone, as shown in Figure 7.1, shows a surplus throughout the planning period.

We have not identified any potential impacts on regional 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 4.37Ml/d in 2025/26 and reduces over the planning period to 2.74Ml/d by 2084/85, mainly as a result of the climate change impact. The surplus equates to 52% of the distribution input plus target headroom in 2025/26, reducing to 32% 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 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 33 Ml/d of supply loss due to climate change at the outset i.e. in our base year. Inclusion of the 1 in 500-year drought resilience with climate change (in combination), makes up the majority of the 164 Ml/d reduction in WAFU compared to the WRMP19 base year deployable output (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 reduces our forecast supply by 41.67Ml/d in 2025/26, increasing to a 77.31Ml/d reduction in 2049/50 and around 134Ml/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 47 Ml/d. However, around 8Ml/d can be made up from other resources (the precise figures in both cases change slightly over time due to the impacts of climate change). In 2035/36 the net impact is 39.27 Ml/d, reducing marginally to 37.07 Ml/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 11.28Ml/d in 2035/36, with the impact increasing to 141.20Ml/d in 2049/50 if the abstraction on the River Derwent is reduced to meet the CSMG target. By 2084/85, the combined impact is 137Ml/d, a reduction which reflects the underlying loss of availability of the River Derwent supply over time due to climate change.

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 1240.88 Ml/d in 2025/26 to 1258.21 Ml/d in 2049/50, and around 1311 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.

Figure 7.2: Grid SWZ baseline forecast supply-demand balance (DYAA)

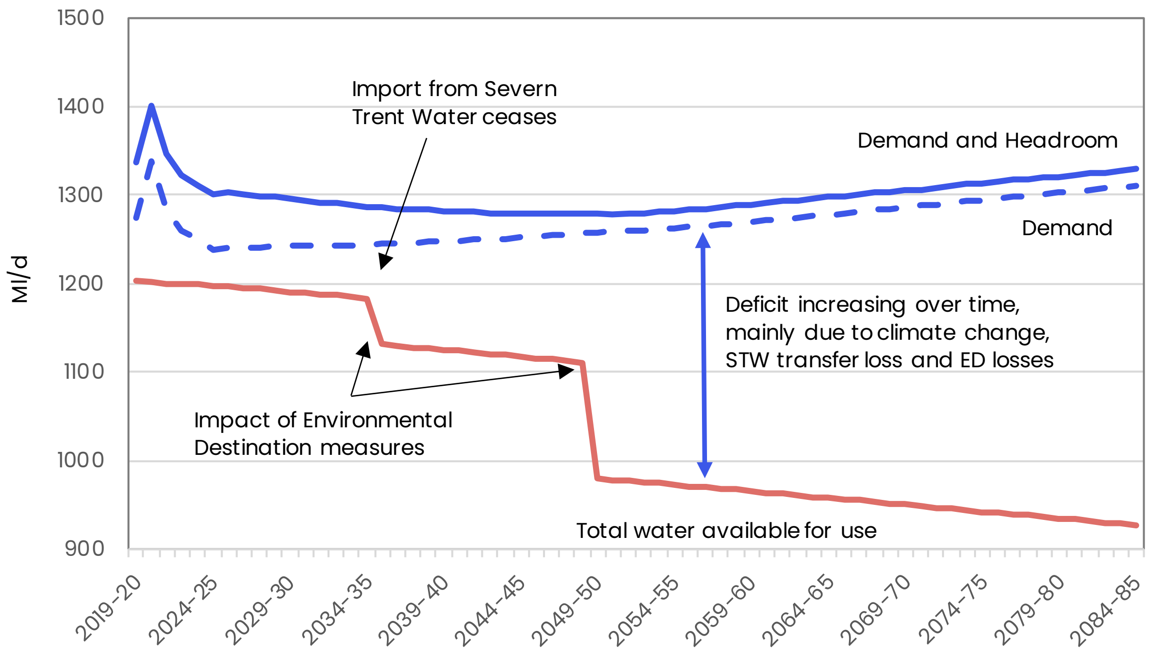


Table 7.1: Summary of the Grid SWZ DYAA deficit and key drivers of changing need over time

^ 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)	41.67	48.81	56.61	63.56	69.62	77.31	134.16
Impact of terminating the STW transfer (Ml/d)	0	0	39.27	39.06	38.89	38.67	37.07
Environmental destination reduction (Ml/d)	0	0	11.28	11.28	11.28	141.20	137.16
Overall Grid SWZ dry year annual average deficit (Ml/d)	105.58	104.28	154.91	158.17	161.81	298.81	402.84

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 at the latest, based on the Water Resources National Framework. 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 53.69 Ml/d in 2025/26, rising to 105.56 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.

Figure 7.3: Grid SWZ baseline with 1:200-year resilience level up to 2039-40

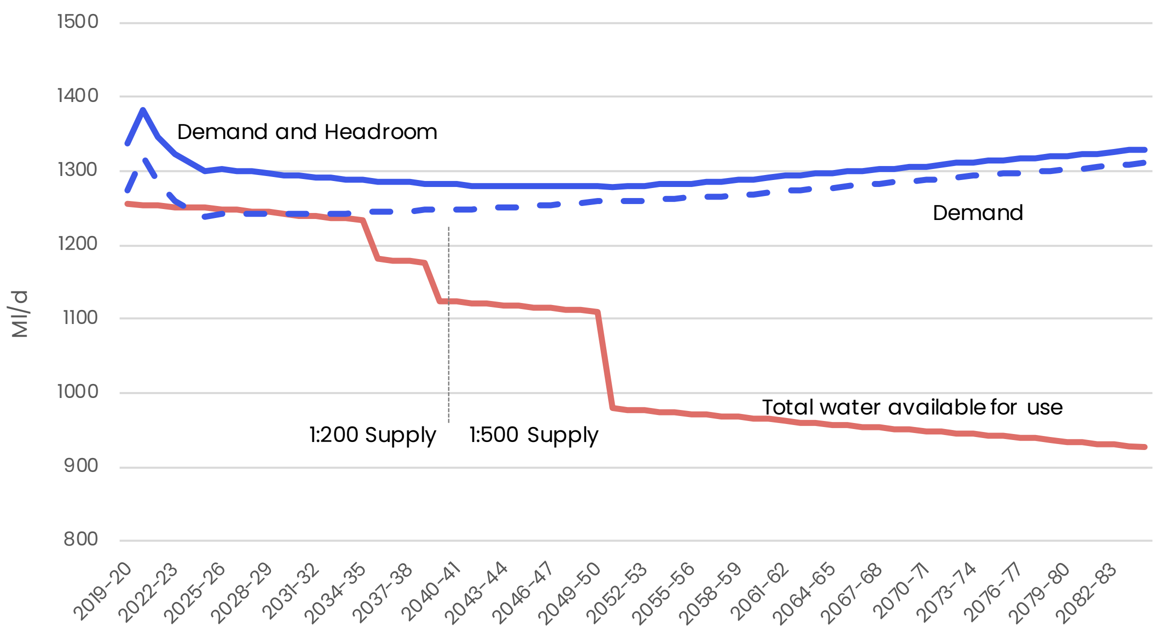


Table 7.2: Summary of the Grid SWZ supply-demand deficit under 1:200-year drought resilience level before 2040

	2025/26	2030/31	2035/36
Grid SWZ dry year annual average deficit (Ml/d)	53.69	52.86	105.56

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 shall reassess the critical period using 2022 water availability and demand data. The critical period assessment, as with that for the dry year annual average, shows significant deficits throughout the planning period. Prior to 2040, the deficit levels are comparable to the dry year annual average scenario, but by 2049/50 the deficit is around 24 Ml/d higher (falling to 23 Ml/d by 2084/85).

Climate change has a relatively smaller 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

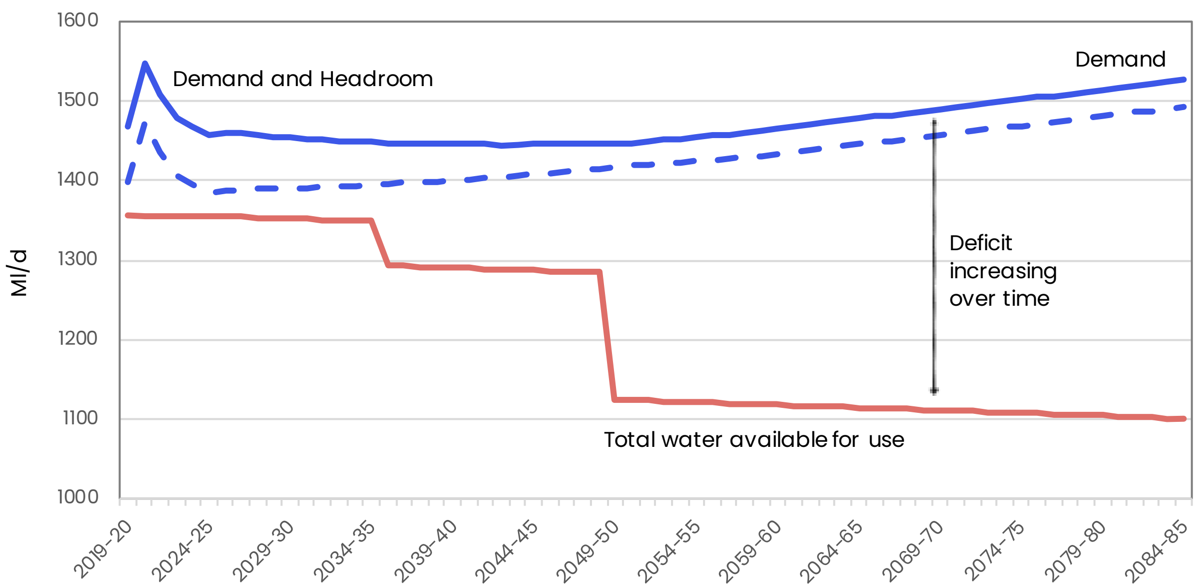


Table 7.3: Summary of the Grid SWZ Critical Period deficit across the planning period

	2025/26	2030/31	2035/36	2040/41	2044/45	2049/50	2084/85
Climate change reduction on supply (Ml/d)	17.65	20.68	23.77	26.93	29.49	32.75	56.84
Impact of terminating the STW transfer (Ml/d)	0.00	0.00	44.07	43.97	43.89	43.79	43.01
Environmental destination reduction (Ml/d)	0.00	0.00	11.28	11.28	11.28	170.37	170.37
Overall Grid WRZ Dry Year Critical Period Deficit (Ml/d)	105.11	101.36	154.60	155.79	158.04	322.80	426.17

7.3 Common reference scenarios

The supply-demand balance position above is based on forecasts that represents 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 comparable to the dry year annual average scenario until 2040 when the deficit risk increases. This longer-term risk is partly linked to the environmental destination risk to the River Derwent. 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
- Demand – reflecting different positions 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).

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 in particular in the immediate period of our plan later in this document.

Figure 7.5: Yorkshire Water's scenario testing framework - Baseline Vs Ofwat Common Reference Scenarios

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	Maintain

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

The following sub-sections explain the outcomes of scenario testing for each water resource zone.

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 future.

Figure 7.6: East Zone Scenarios SDB over time

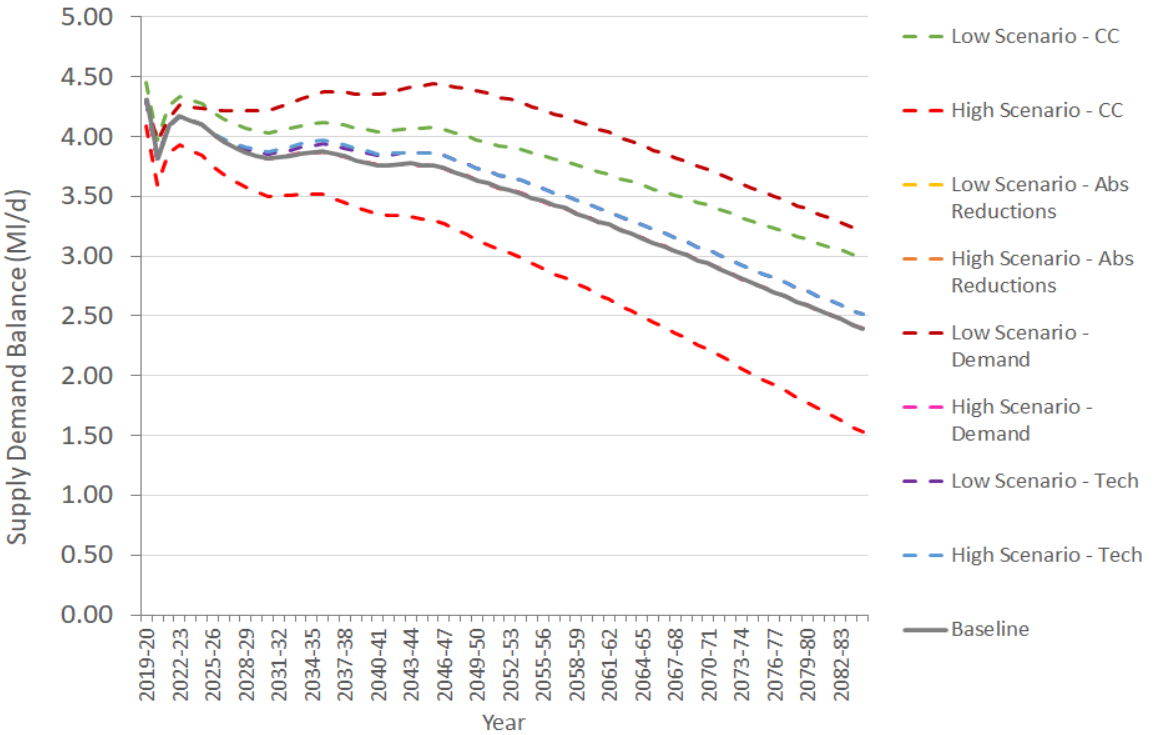
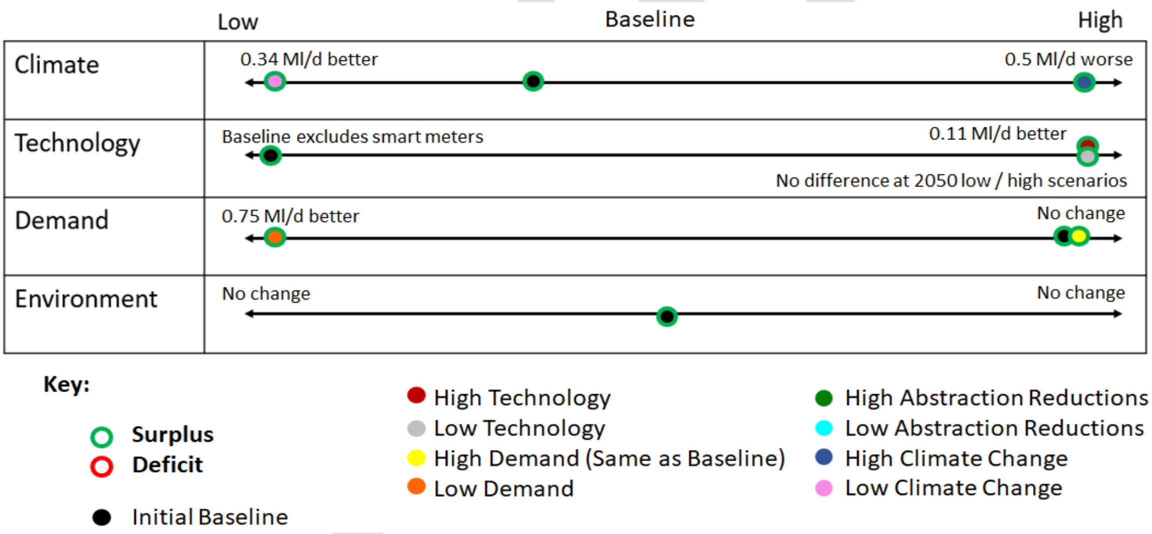


Figure 7.7: East zone scenarios Vs baseline in 2049/50



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).

Figure 7.8: Grid Zone Scenarios SDB over time

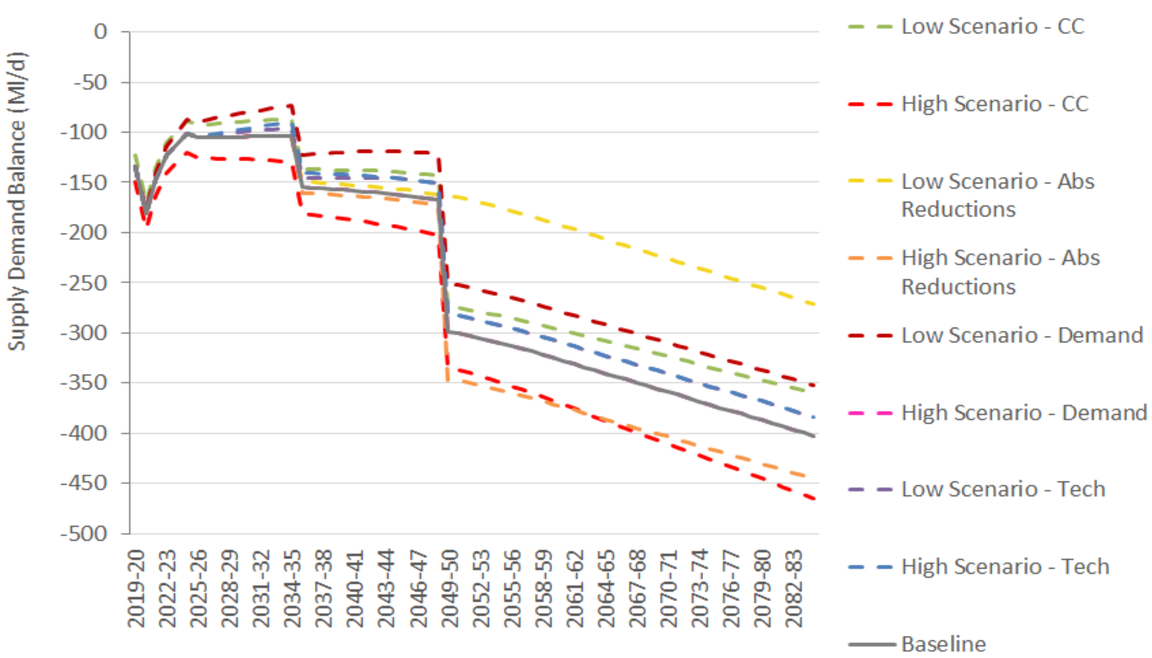
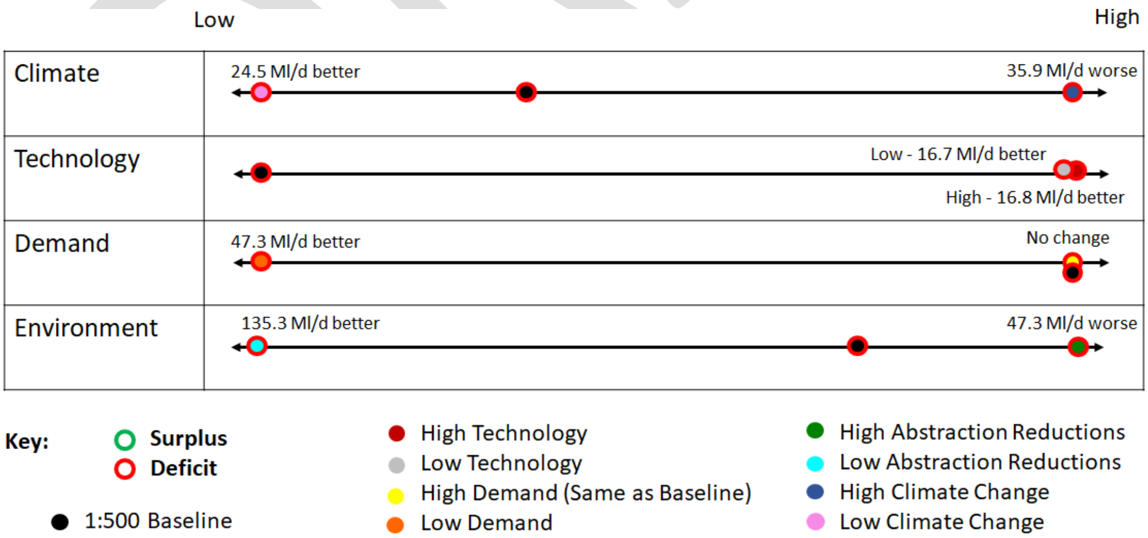


Figure 7.9 is informative, as in combination with Figure 7.8 it shows the relative position of the baseline to the low and high scenarios, and which scenarios represent the greatest uncertainties. The environment scenarios have the greatest bearing on the overall supply-demand position in the long-term, with a low scenario reducing the supply-demand deficit by 135.3 Ml/d; this demonstrates the importance of further investigation and evidence gathering as part of our future plans to reduce uncertainties in this part of the plan. The timing and pace of implementing licence change has the potential to avoid or change future solutions. Beyond this, the climate change scenarios show the largest overall range, although the high scenario has a marginally greater adverse impact than the more benign low scenario.

Figure 7.9: Grid zone scenarios Vs baseline in 2049/50



The findings of our scenario testing are important in defining our preferred plan, later in this document.

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:

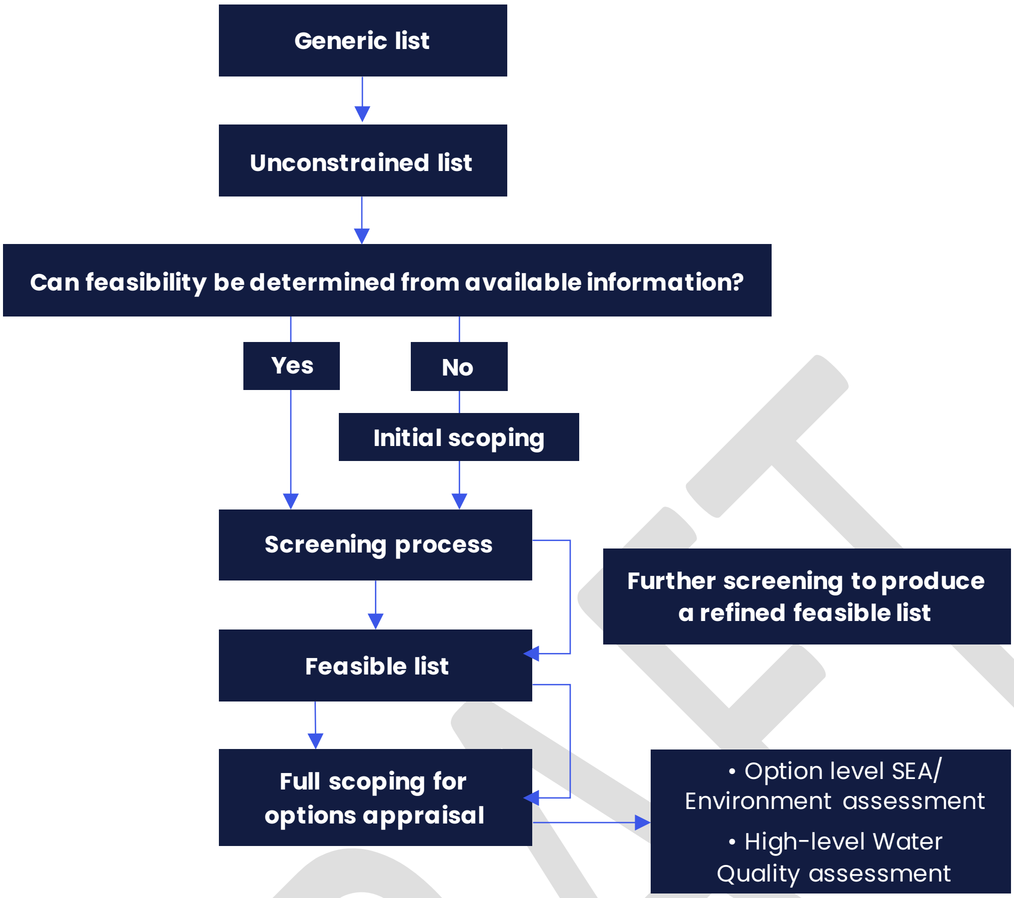
- EA WRPGL;
- The economics of supply and demand (UKWIR, 2002);
- The UKWIR Water resources planning tools 2012: summary report;
- UKWIR WRMP 2019 methods - Decision Making Process: Guidance.

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 unconstrained options are feasible options that have potential to meet 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 WFD and HRA assessment where applicable) of all feasible options was carried (see Section 9 and 10).

Figure 8.1: Options appraisal process summary



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.

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 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 likely that STW will terminate the transfer in 2035. 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 2050 when there is a risk, we will lose a large proportion (130-160Ml/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.

During 2022 we are also experiencing a drought in our supply area, and it is too early to fully assess the severity of the drought and how this might impact our plan. We therefore intend to investigate further options as we progress towards our final plan, and this might change our WRMP24 preferred solution. We shall continue this work in AMP8, whilst delivering our WRMP24 solution, to understand if there are alternative options available to us in the medium to long-term that can be assessed 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.

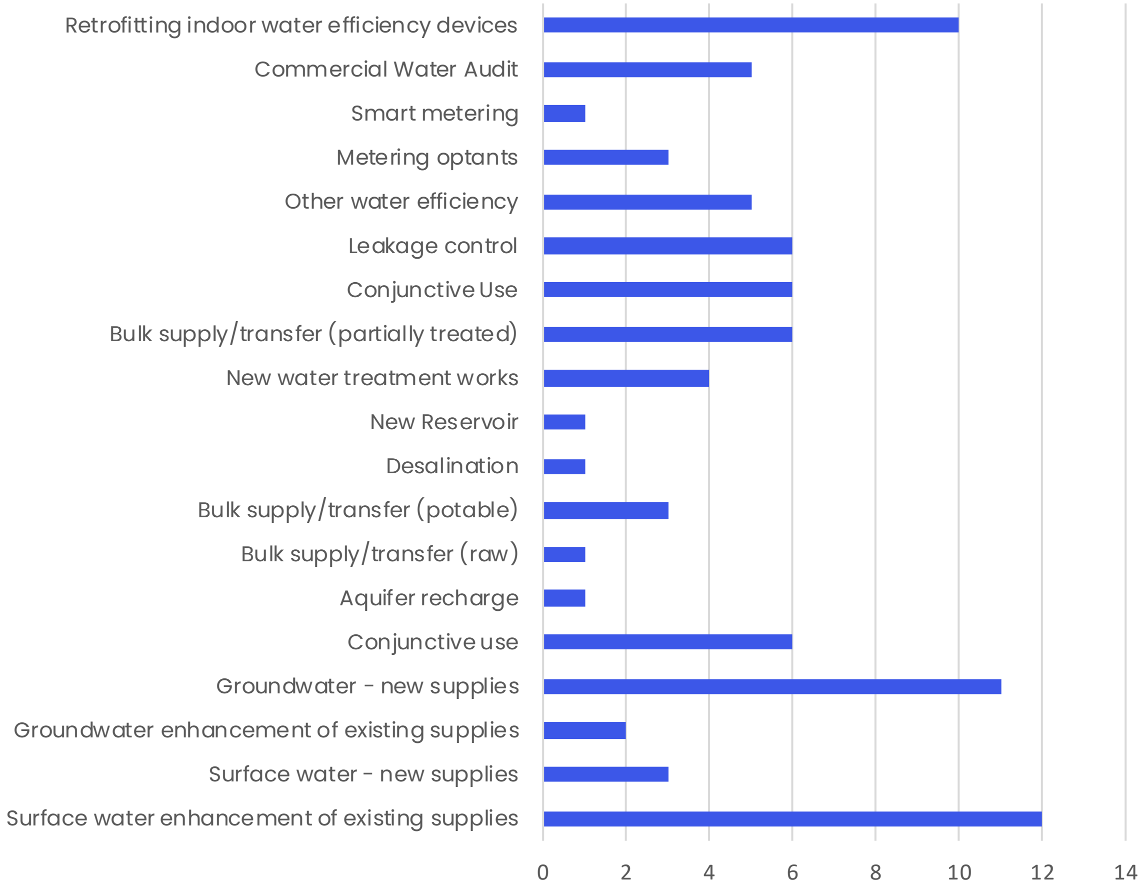
In general, we classify WRMP options as new supply or demand reduction options, but they can be split further by the type of supply or demand options. They are grouped into the following categories:

- **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[28].

[28] https://www.yorkshirewater.com/about-us/water-bidding-market/

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 options to meet the Grid SWZ deficit



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 to carry out a review of demand reduction options (excluding leakage).
- 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 (e.g. planning approvals, biodiversity net gain) and are resource specific. Demand option criteria is usually evidence based and we will draw on our own data and other companies' studies 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.

8.2 Resource options

There are various types of resource options we consider, including new groundwater and surface water abstractions, additional connections to make more use of existing sources, 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 yield increase/demand decrease; construction/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 that were taken through to the best value plan were deliverable and appropriate for closing the deficit.

Criteria for screening out options included any options below a 5Ml/d de-minimis as disproportionate to our need. In addition, in most cases there were additional reasons for excluding, such 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 for short periods and it provides a resilience benefit during periods of peak demand.

Two options to make more use of groundwater licences that are under ongoing WINEP investigations due to be completed in 2025. We cannot plan to use these licences as there is a potential the abstractions are detrimental to the environment.

Options where a risk has been identified (e.g. water quality) and there is an alternative option utilising the same source that is considered to have lower risk.

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 3.13. 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). The lead in time for implementation of any new sources, and 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 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.

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 Northumbrian Water 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 Northumbrian Water. 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 EA. 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.

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 Severn Trent Water identified one export and no import options. Our export would transfer up to 20Ml/d of treated water from South Yorkshire to Severn Trent Water via a new pipeline. Discussions with Anglian Water did not identify any imports or exports for WRMP24. There could be some potential in the future but the location of need in AWS' supply area does not border with our supply area and our WRMP24 deficit limits our spare capacity for trading. 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.

There has been no requirement from other water companies for new transfers from our supply area. The outcome of the regional planning reconciliation process was that STW is likely to terminate the existing transfer it currently provides to our South Yorkshire area. We have investigated options for offsetting this loss and discuss this in Section 8.2.3.

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. STW has informed us that it is planning to terminate the transfer in 2035. The SRO to raise the Derwent Valley reservoirs could enable the transfer to be retained in the future, however the most likely scenario is that it will cease.

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 increases the deficit in the Grid SWZ by 40Ml/d. To include very low volume schemes would not negate the need for larger schemes and so the de-minimis is applied.

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	Sustainable resource option (SRO) being developed in collaboration with STW
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)*	North to south internal transfer connection	Feasible - enables water to be transferred via a new interconnection but no associated yield benefit
DV8(v)	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) new internal transfer from York to South Yorkshire. This option does not provide a benefit but enables the South Yorkshire demand to be met by sources in the North Yorkshire area.

We will carry out further option identification studies in AMP8 before the transfer termination decision date of 2030. This could include further assessment of the River Trent and more innovative solutions such as effluent reuse. 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.

8.2.4 Impact of climate change on resource options

We have modelled how our options might be affected by climate change. The options in our preferred solution have been modelled for the 1990s 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. 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.

8.3 Options for reducing outage and increasing resilience

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 will therefore be considered for our PR24 business plan, and any benefit of planned capital schemes will be built into our final WRMP24 outage allowance.

8.3.1 Resilience options

Our WRMP19 considered the resilience benefits of our WRMP options. Our Asset Planning Team carried out work to identify 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 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. 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.

We have expanded on this work through our Water Supply Systems Resilience 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.

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 the WRMP and system resilience need. These options are classed as resilience 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. It's 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 Harrogate and the Dales 'share' a reservoir supply.	Northern Grid Extension (R1d and R1di-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 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 the 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 hrs 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 R1a as a pre-requisite) New WTW (York) supplied by the River Ouse (DV8(v))
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 River WTW (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 he 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. If this was to be a permanent agreement with the EA, we would need an alternative supply to make up the loss.	New Abstraction from River Aire (R37b(ii)) or a new West Yorkshire (R86) could support this scheme but additional network connections would also need to be included in our PR24 business plan.

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 to use less water on average in their homes and places of work.

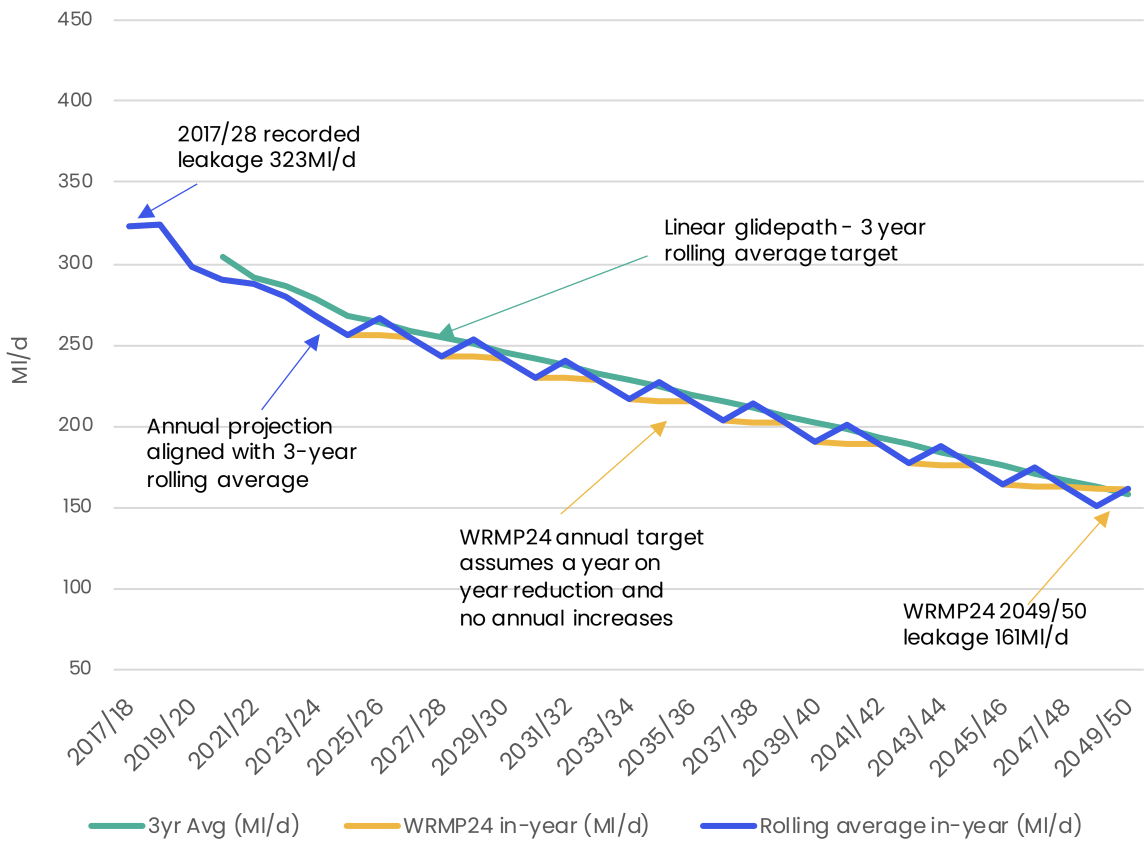
8.4.1 Leakage options

Our WRMP19 included a challenging leakage target to reduce leakage by 15% in the first 25 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 created an option for achieving the 50% reduction in 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. The WRMP forecasts leakage reduction annually and does not plan for increases in total leakage. We have therefore not built this assumption into our WRMP24 and have presented a 'flatter' target that does not align with the three-year rolling average target. The three-year rolling average target is shown in Figure 8.3 alongside the equivalent annual projected values and the WRMP annual projection.

Figure 8.3: Three year rolling average and annual leakage reduction glidepaths to achieve the 2050 leakage target



Our PR24 business plan is still being developed and the AMP7 targets have not yet been agreed with regulators. Further work is needed to finalise our leakage target and ensure the business plan and WRMP leakage targets are fully aligned. Due to the nature of the Ofwat performance commitment three year rolling average approach and the need for an annual target in the WRMP that does not allow leakage to increase, further work is needed to align the plans. This will be completed for our final WRMP24.

As part of our decision-making process, we have created alternative leakage reduction profiles to the policy requirement profile. Each profile achieves a lower leakage target than the policy requirement by 2050. For each target we have assigned annual unit costs that increase with each AMP period. The increasing cost represents the increasing challenge and how future leakage reduction will become more expensive. The options included are presented in Table 8.4.

Table 8.4: WRMP24 leakage reduction options

Leakage objective	Option ID	Option Name	Benefit by 2050 (Ml/d)
Achieve a 20% leakage reduction compared to 2017/18 leakage	L1	Active Leakage Control 14 Ml/d	14.05
Achieve a 30% leakage reduction compared to 2017/18 leakage	L2	Active Leakage Control 30 Ml/d	30.20
Achieve a 30% leakage reduction compared to 2017/18 leakage	L3	Active Leakage Control 46 Ml/d	46.35
Achieve a 35% leakage reduction compared to 2017/18 leakage	L4	Active Leakage Control 63 Ml/d	62.50
Achieve a 45% leakage reduction compared to 2017/18 leakage	L5	Active Leakage Control 79 Ml/d	78.65
Achieve a 50% leakage reduction compared to 2017/18 leakage	L6	Active Leakage Control 95 Ml/d	95.30

The 50% leakage reduction target will be incorporated into our preferred plan for WRMP24. However, there is high uncertainty over whether or not the 50% leakage target can be met and if it will be affordable in the future. Therefore, we have not included any options for over-achieving the target. Although we consider the objective to be feasible, it is extremely challenging and with current leakage reduction techniques and costs it would not be possible to achieve the target by 2050. To ensure we can continue to reduce leakage annually from now until 2050, we need to enhance our existing leakage techniques and identify new techniques.

Leakage reduction actions

Since committing to our WRMP19 leakage target we have been assessing our leakage reduction activity and ways to improve both the number of leaks we reduce each year and the efficiency of achieving the reductions. We have investigated the types of leakage reduction options available to us through further delivery of our existing leakage control measures and through identification of new measures, some of which we have started to implement. As the planning period progresses, we will actively seek measures to make current leakage reduction techniques more efficient and we expect new technology to make further reductions feasible at a lower cost. We produce WRMPs and business plans every five years and with each iteration, we will review the leakage techniques available and the costs and benefits.

To achieve both the leakage policy requirement and the PCC policy requirement, we are creating an integrated approach to demand reduction. This innovation programme helps us drive down the cost of identifying and repairing leaks through point of interest focused analytics and an increased acoustic coverage of our network to identify potential leaks, so that we save water and money.

We have developed a Water Network Strategy named Smart, Calm and Resilient. Together these strands enable leakage, water efficiency, asset health, water quality and interruptions to supply performance to improve.

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.

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.

Resilient – aims to ensure asset health is maintained through network investment, by proactive control of the network 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.

The types of leakage intervention within the Smart, Calm and Resilient strategy are listed in Table 8.5.

Table 8.5: Leakage techniques to achieve the 50% policy reduction by 2050

Smart	Calm	Resilient
Fixed Acoustic loggers	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	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		

8.4.2 Per capita consumption (PCC) reduction

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 that will reduce the company DYAA average PCC to 116.9 l/h/d by 2050, as shown in Table 8.6. This reduction assumes no additional household demand reduction interventions.

Table 8.6: 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	155.87	155.23	154.53	153.92	153.37	153.21
Average Household - PCC	**130.39**	**144.37**	**134.14**	**129.65**	**128.72**	**127.79**	**124.21**	**121.50**	**119.36**	**117.77**	**116.88**
Regional NYAA PCC with covid impact (l/h/d)											
Measured Household - PCC	106.47	106.27	106.08	105.91	105.75	105.60	105.36	105.18	104.98	104.87	105.00
Unmeasured Household - PCC	151.34	151.11	150.86	150.62	150.38	150.14	149.53	148.85	148.27	147.74	147.58
Average Household - PCC	**127.71**	**126.82**	**125.83**	**124.89**	**123.99**	**123.10**	**119.65**	**117.04**	**114.98**	**113.45**	**112.59**

As with the leakage policy requirement, our WRMP24 has an objective to achieve the demand reduction national policy requirement to reduce PCC to an average of 110 l/h/d by 2050. We have built the demand reduction benefits of this assumption into our final plan 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. We commissioned Artesia consultants to carry out a project to further review the options and identify any gaps. The outputs of the project did not produce any additional options to WRMP19. However, it did provide new ways of delivering some of our existing options and highlighted measures that may not have sufficient evidence to be included as feasible options in WRMP24 but could, through trials, become future WRMP options.

The PCC reduction options we included as feasible options in our optimiser model include campaigns to encourage unmetered customers to move to a metered supply and initiatives to provide customers with water efficiency devices. These options are listed in Table 8.7. The combined benefit is a PCC reduction of 0.89 l/h/d and would not achieve the PCC target.

Table 8.7: Customer PCC reduction options included in the WRMP24 optimiser model

Option ID	Option Name	Option type	PCC Reduction l/h/d
C1a- C1abcde	Domestic Customer Audits and Retrofit	Household water audit	0.004-0.055
C2a- C2c	Enhanced Metering Domestic optants*	Metering optants	0.044-0.087
C6a-C6abcde	Water User Audits	Non-household water audit	0.038-0.543
C15a-C15acdeb	Household Flow Regulators	Other water efficiency	0.005-0.075
C21a-C21abcde	Housing Associations Targeted Programme	Retrofitting indoor water efficiency devices	0.005-0.130

As the PCC reduction options are not sufficient to achieve the target, we have created a year-on-year PCC reduction profile in a similar approach to how we derived the leakage target. The profile assumes PCC will reduce due to the combined benefits of technology (smart metering/networks) and water efficiency initiatives. This creates a scenario for inclusion in our options assessment to represent our ambition to achieve an average PCC of 110 l/h/d by 2050. Our assumption is that by installing smart meters into new households, meter optant properties and switching existing meters to smart we can reduce the PCC of metered customers by 3% on average. The saving is related to customers having access to additional data that would highlight plumbing losses and lead to repairs.

Smart metering will be installed to both household and non-household properties from 2025 onwards. We have already installed smart meters into some properties as part of a trial to gather data on the costs and benefits. From 2025 all new developments will be provided with smart meters and any customers choosing to switch from an unmetered to metered supply (optants) will be fitted with a smart meter. We shall also start a smart meter retrofit programme with all existing household and non-household properties that already have an AMR (automatic meter reader) meter installed being provided with a smart meter over a 15-year delivery programme.

At the point of installation of the smart meter we will offer a flow regulator device. We shall also provide educational material to encourage efficient water use in the home and maintain a customer communications campaign that is aimed at all our customers. We have assumed this will increase the 3% average reduction to 5%. This would achieve an average PCC of 112l/h/d by 2050. Our assumption is that by combining water efficiency initiatives with smart metering and customer communications we will achieve a greater saving than implementing water efficiency options on their own.

We created an option to represent the costs and benefits of technology (smart metering) and water efficiency initiatives in the optimiser model. We consider this to be a scenario rather than an option, but by creating as an option it helps us assess inclusion of the PCC objective in our best value plan assessment. This 'dummy' option has assumed benefits allocated to it but they are not fully evidenced. The optimiser scenario was created at the start of our decision-making process and at that point it was considered likely we would deliver smart metering to existing metered customer over 10 years and that the total household customers savings of the smart metering and water efficiency delivery would be 3%. Subsequently this has been extended to 15 years with a 5% combined benefit. The savings, delivery period and the costs to deliver included in the WRP tables represent the latest scenario.

It is possible we have underestimated the benefits of smart metering and could achieve the 110 l/h/d target. We have not built this into our final plan as in a dry year PCC will be higher than normal years. However, we have built in an additional assumption linked to 'white goods labelling'. With this additional benefit we project PCC in a DYAA scenario will be 106l/h/d by 2050, overachieving the policy requirement.

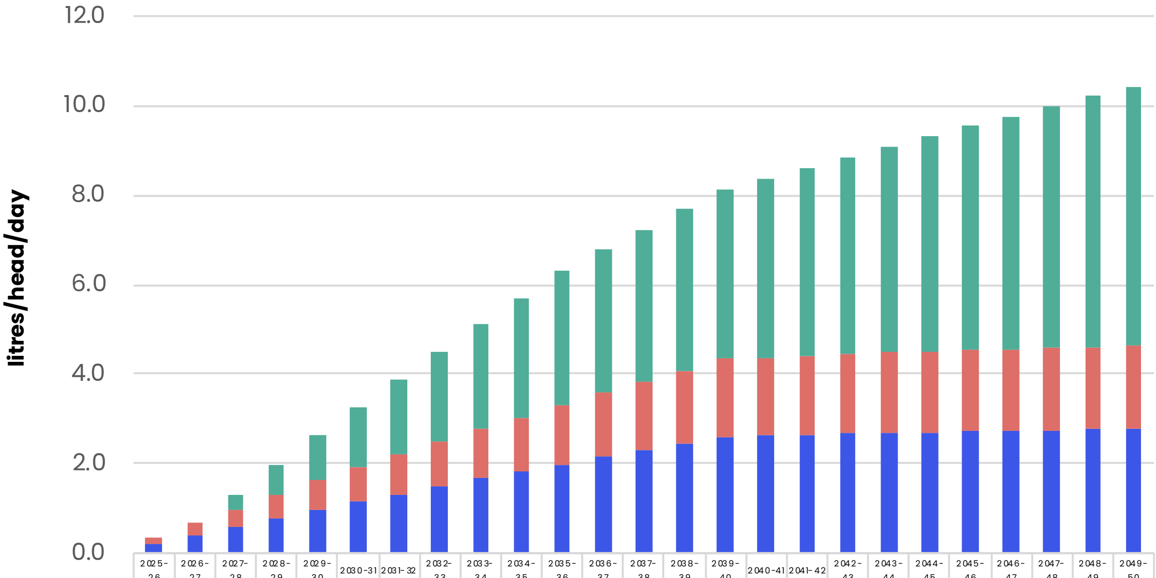
Water efficiency labelling is a government-led initiative to reduce PCC that will be introduced through legislation in 2026. The introduction of water labelling would instigate a slow change to more efficient white goods that would reduce PCC over time. In addition, there is potential the government will introduce mandatory standards to limit water using appliances in new build and retrofit properties that could reduce PCC further.

A Water UK/Defra project[29] 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 2021[30] 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 6l/h/d was proposed.

We have built the 6 l/h/d benefit by 2050 into our preferred plan and allocated the benefit to both metered and unmetered consumption. We do not consider the 11 l/h/d used by other companies including the other WReN companies to be realistic for our area, which already has one of the lowest average PCCs in England. We consider 6 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 benefit of the PCC reduction to our supply-demand balance is shown in Figure 8.4. Initially YW initiatives have the largest impact but over time water labelling benefits increase and by the 2040s has the greater impact.

Figure 8.4: 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
Waterlabelling benefit (l/h/d)	0.0	0.0	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.2	3.4
Waterefficiency intitiativesbenfit (l/h/d)	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
Smartmetering benefit (l/h/d)	0.2	0.4	0.6	0.8	1.0	1.1	1.3	1.5	1.7	1.8	2.0	2.1	2.3

	2038-39	2039-40	2040-41	2041-42	2042-43	2043-44	2044-45	2045-46	2046-47	2047-48	2048-49	2049-50
Waterlabelling benefit (l/h/d)	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8
Waterefficiency intitiativesbenfit (l/h/d)	1.6	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9
Smartmetering benefit (l/h/d)	2.5	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7	2.8	2.8	2.8

■ Smart metering benefit (l/h/d) ■ Water efficiency intitiatives benfit (l/h/d) ■ Water labelling benefit (l/h/d)

[29] Water UK 'Pathways to Long-Term PCC Reduction' 2019

[30] Water UK 'Pathways to Long-Term PCC Reduction'

8.4.3 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.

8.4.4 Non-household water efficiency

As discussed in Section 5.2 we are still developing our non-household strategy for contributing to the Defra requirement to achieve a 9% non-household reduction in use by 2039. Our smart metering programme will retrofit all non-household properties over a 15 year period at the same time as household properties. We shall provide further information in our final WRMP24.

8.4.5 Drought measures

Our baseline forecasts for both the DYAA and critical period scenario make no assumptions for drought measure benefits. For our final plan we have included drought measures as a potential option and assessed the impact on the supply-demand balance with and without the benefits.

8.4.6 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.

8.4.7 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

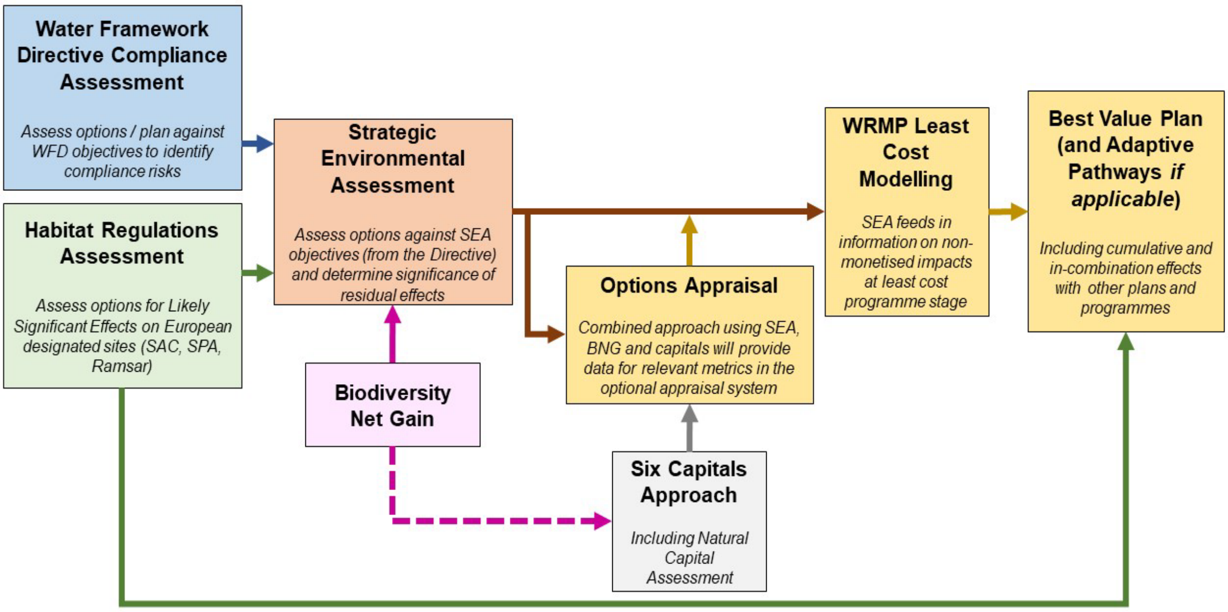
The non-monetised environmental, social and carbon impacts of each option have been considered in a Strategic Environmental Assessment (SEA). The full output of the SEA is provided in an Environmental Report, which is published on our website alongside this document.

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) and supplementary guidelines on *Best Value Planning and Environment and Social Decision Making* (Environment Agency and Natural Resources Wales, 2021). 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 8.5 outlines the process for integrating the SEA, HRA and WFD into the options appraisal.

Figure 8.5: 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 8.8 summarises the topics and associated objectives.

Table 8.8: 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 will be submitted for consultation with the draft 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 (YW), Northumbrian Water (NW) and Hartlepool Water (HW).

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 8.9 shows the ranked output for Yorkshire Water's WRMP options.

Table 8.9: Ranked output of WRMP options

Ranking	Option
1	Leakage
2	Water efficiency (providing water saving products)
3	Meter optants
4	Commercial (ie 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 8.9. However, when it comes to supply options we find that other metrics are more influential in determining the plan outcome than customer views.

9. Best value planning

The outcome of our WRMP24 should be a best value plan for our customers and stakeholders, which achieves our stated objectives. Our WRMP24 objectives are aligned with the WReN Regional Planning pro-cess, the Water Resources National Framework and WRPGL. A summary of the WReN objectives mapped to YW WRMP24 objectives is provided in Figure 50. 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 area.

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 describes 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 alternative solution programmes and measure performance against our objectives (using metrics) at a programme level. The best performing programmes provide a portfolio of options to consider for inclusion in the preferred plan. 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 can be constrained into a planning scenario and the solution programme impacts and benefits compared (using metrics) against programmes for alternative scenarios. 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 and environmental impact and mitigation is an essential component of regional plans and WRMPs. The Strategic Environmental Assessment (SEA), Habitats Regulation 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.

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 1:500 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 110x l/h/d by 2050
4. Become resilient to 1 in 500 drought events without reliance on drought measures
5. Increase resilience in the Grid SWZ and localised growth hot spots
6. Offset the ED BAU+ Groundwater loss
7. Offset the STW transfer termination
8. Offset the ED BAU+ Surface water 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 3.8. Our approach includes the environmental destination and RBMP objectives (when available) 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. At the time of producing this draft WRMP24 the latest RBMP data was not available and has not been incorporated into the scenarios. If, the latest RBMP does create a supply reduction scenario we shall include in our final WRMP24.

9.1 Decision-making approach

As part of the Grid SWZ problem characterisation assessment we reviewed the possible methods we could use to determine the best value solution to the deficit and developed our approach using the following guidelines:

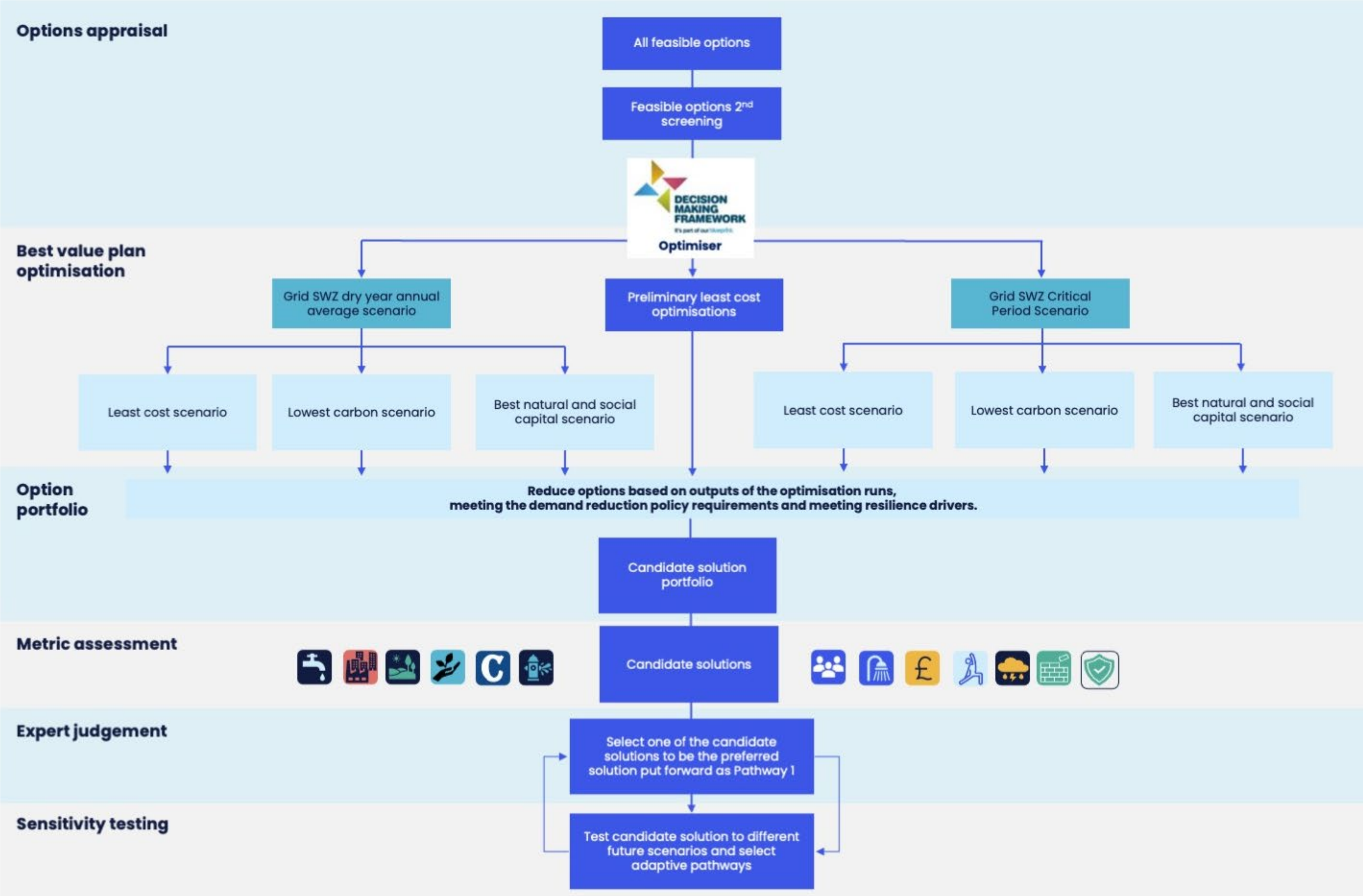
- WRMP24 WRPGL;
- The economics of balancing supply and demand (UKWIR, 2002);
- UKWIR WRMP 2019 methods - Decision Making Process: Guidance;
- UKWIR WRMP 2019 methods - Risk Based Planning: Guidance; and
- UKWIR Deriving a Best Value Water Resources Management Plan (HR Wallingford 2020).

The outcome of our problem characterisation was that we would use an EBSD approach extended to include multi-criteria analysis (MCA) to determine a best value solution for our WRMP24. The MCA approach allows us to compare both monetised and non-monetised costs and impacts to develop a best value plan as opposed to a least cost plan using the traditional EBSD approach. 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.

Following the option screening, we used an optimiser model to optimise on financial capital to produce least cost solutions to both the DYAA and critical period baseline scenarios for the Grid SWZ. The least cost programmes were assessed using the MCA approach to measure their performance. This provides a benchmark for our decision-making which we aim to improve on to achieve best value. We then produced least cost runs for alternative scenarios. Next, we ran the optimiser model to produce solutions for both the DYAA and critical period scenarios to minimise carbon impacts, then maximise natural and social capital benefits and finally we optimised for all the capitals. These optimisations provided additional benefits but resulted in a higher cost.

We assessed these preliminary runs to create a reduced list of options based on those selected most frequently. This provided a portfolio of options to be considered for inclusion in the best value plan. Some options were removed from the portfolio where there was a risk the option could become unfavourable over the long-term (i.e. they could not be considered low regrets). We then created alternative solution programmes to those created by the optimiser. These alternatives included mandated options to meet the policy requirements alongside supply options selected from the portfolio. These alternative programmes, referred to as candidate solutions, were compared against the optimised solution programmes using the MCA approach.

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 WRPGL.

The WRMP24 model inputs include the following data for each individual option:

Service Impacts/Benefits:

- Ml/d benefit as a supply increase or a demand reduction, taking into account how this is delivered (e.g. additional resource, 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 i.e benefit available each year until 100% is achieved;
- Time to benefit i.e. 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;
- Build profile i.e. percentage of capital cost invested each year before and after the first year of utilisation;
- Operational costs i.e. fixed and variable operating costs such as cost of energy, chemical use and labour. This also includes any opex savings related to demand reduction e.g. 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 scenario. 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 model utilises a linear/integer programming approach, as described in the report, *The Economics of Balancing Supply and Demand* (Environment Agency and UKWIR, 2002). 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 WRPGL. 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.

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). A summary of the metrics is given in Table 9.1 and further information.

We compare the metric performance of candidate solution programmes to identify if there is a best performing solution programme that should be put forward as the preferred or best value plan. 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. All other programmes are applied a normalised score that is relative to the optimum programme for that metric.

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 (e.g. 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 planning period the PWS drought resilience to 1 in 500 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 Capital	Monetised (£NPV) impact of the option on natural capital e.g. 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.
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.

9.2 Building the best value plan

We have created a best value plan that addresses both the DYAA and critical period scenario deficits over a 60-year planning period. During the process of determining the best value plan we produced multiple optimised solutions using our DMF optimiser model. Initially we used the optimiser to create least cost solutions that optimised based on cost (financial capital) alone.

9.2.1 Preliminary optimisation runs

The optimiser was run with all feasible options that had passed the second screening step available for selection. We also created least cost runs where we assumed demand policy requirements for leakage and PCC would be met. To meet the demand policy requirements, we are assuming that technology for leakage reduction will improve and become more economic over time and that customers will respond positively to water saving initiatives. These assumptions create uncertainty in the solution programmes as we cannot be confident that the policy reductions will be achieved. For this reason, we have not included any options to achieve demand reductions that go beyond the policy requirements[31]. For the scenarios with the policy requirement reductions built into the supply-demand balance, we optimised on supply options only to close the remaining deficit.

We created preliminary solution programmes by using the optimiser to meet scenarios including the Grid SWZ DYAA baseline and the Ofwat common reference scenarios that resulted in a deficit materially different to the baseline deficit. These preliminary runs optimised on cost provided information on which options were selected most frequently and should be included in a portfolio of options for consideration when creating the best value plan. The assumed time to benefit of all the supply options was based on the time to build applied by the optimiser and assumed no additional lead in time for options that required lengthy pipeline routes or preliminary investigations, such as the Tees transfer options, or the estuary options. As these timescales are uncertain at this stage, we assumed average build time to optimise on a consistent basis initially. When creating candidate solutions, lead in times were extended where there was evidence to suggest there would be considerable planning and / or environmental investigations prior to the build start.

The preliminary runs included:

- DYAA baseline scenario 1 in 500 level of service
- DYAA baseline scenario 1 in 200 level of service until 2039 then 1 in 500 until 2085
- Critical period baseline scenario
- Low Environmental destination DYAA scenario 1 in 500 level of service
- Enhanced environmental destination DYAA scenario 1 in 500 level of service
- High climate change DYAA scenario 1 in 500 level of service
- High climate change and enhanced environmental destination combined DYAA scenario 1 in 500 level of service.

[31] Our preferred plan incorporates assumed benefits of water labelling that do ultimately create a scenario that overachieves the PCC policy requirement, but this was added after the optimisation runs.

The baseline scenario deficits were adjusted to compare outputs of:

- DYAA baseline scenario 1 in 500 level of service with and without demand policy and drought measure benefits included
- DYAA baseline scenario 1 in 200 level of service with and without demand policy and drought measure benefits included
- DYAA baseline scenario 1 in 500 level of service with the STW transfer terminated in 2035 and with the STW transfer maintained throughout the planning period.

For all scenarios that included the STW transfer termination we mandated an internal transfer option (DV8(iv) - New north to south internal transfer connection to South Yorkshire treated water transfer - 50 Ml/d capacity 0 Ml/d benefit) that is required to ensure new supplies can be transferred to South Yorkshire, the demand area directly impacted by the transfer termination. The internal transfer option is essential to the solution but does not increase available supplies.

Figure 9.3 shows the number of times the feasible options were selected during the preliminary least cost runs. In total we produced 26 optimised runs with the options available following the second screening. If any options are not selected, we can consider excluding from future runs. Similarly, options that are selected most frequently can be considered better value than the others. However, as these runs were optimised on cost alone, further analysis was needed to identify if any of the options not selected in the least cost runs should be included in the candidate solution portfolio.

We have three variations on an option to transfer water from the River Tees as a new bulk transfer from Northumbrian Water (NWL) to our York area. The option was selected in 22 of 26 preliminary least cost runs and 14 of these selections were the DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d option, which provides the largest volume benefit of all our options.

The most frequently selected option was East Yorkshire Groundwater Option 2 selected 21 times. R51 supply the Dales from the Tees-treated, DV8(v) New WTW (York) supplied by the River Ouse capacity to existing site footprint capacity and R8f Sherwood Sandstone and Magnesian Limestone Boreholes option 6 were each selected 16 times. Other Sherwood Sandstone and River Ouse options were also selected more than 10 times as were other new groundwater options and a new WTW in the Kirklees area.

Customer demand reduction options were not selected in as many runs but it should be noted that many of the runs optimised supply options only and the policy requirement benefits were built into the supply-demand balance. This has impacted on the frequency of demand option selection.

Figure 9.3: Option selection frequency based on cost optimisation runs

9.2.2 Best value optimisation and common reference scenarios

The preliminary runs provide information on least cost selection across a range of scenarios. It is important that our plan considers cost and that we aim to meet the 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 objectives. In addition to the least cost runs we have produced runs for both the DYAA and critical period baseline scenarios that optimise to minimise carbon and to maximise the environmental and social benefits of the options.

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. Whereas 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 (e.g. 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 (e.g. due 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 optimisations based on factors other than financial costs that we considered in formulating our best value plan.

In the preliminary runs the time to benefit of all supply options was based on the build time only. However, the time to benefit of a number of the feasible supply options is dependent on additional investigations needed to confirm the option is deliverable. Where this is applicable, the time to benefit has been adjusted for the best value optimisation runs. This additional lead in time is to ensure we have completed environmental investigations and planning requirements and have been granted all the necessary permissions and consents before the construction phase is started.

We have only applied an additional lead in time to options that are consider more contentious or require a greater level of investigations that could extend the lead in time. This includes the Tees bulk transfer, desalination, and tidal abstraction options. The desalination, tidal abstraction, and the 50Ml/d Tees bulk transfer options time to benefit has been extended to 10 years. The 80Mld/ and 140Ml/d alternatives to the Tees bulk transfer options have been extended to 15 years. As this adjustment was not made to the preliminary runs the baseline DYAA and critical period scenarios were rerun at this stage to ensure comparable to the best value optimisations.

Another factor to consider in building a best value plan is whether the plan is flexible to alternative futures and that it presents a no or least regrets solution. We have therefore considered the common reference scenarios that could alter the baseline DYAA scenario and the impacts and benefits of panning to a 1 in 200 baseline DYAA level of service and assuming benefits of drought measures. We produced optimised solutions for these scenarios to support our final decision making.

Table 9.2 lists the key scenarios and optimisation runs completed for this stage of the process. All scenarios are based on a 60-year planning period from 2025/26 to 2084/85, derived from a baseline of 2019/20. Each solution produces a programme of options scheduled to be delivered in specified years during the planning period (a solution programme). The solution programmes differ as each scenario aims to meet a different deficit or has been optimised on different criteria.

Table 9.2: Grid SWZ key scenario optimisation runs – all options available

Scenario	Optimisation	Deficit (Ml/d)
Baseline dry year annual average 1 in 500 level of service	Minimise financial cost Minimise carbon cost Maximise natural capital and social benefits	2025/26 - 106 2049/50 - 299 2084/85 - 403
Baseline dry year annual average 1 in 200 level of service	Minimise financial cost	2025/26 – 62 2049/50 - 192 2084/85 - 327
Enhanced environmental destination dry year annual average 1 in 500 level of service	Minimise financial cost	2025/26 - 106 2049/50 - 347 2084/85 - 446
High climate change dry year annual average 1 in 500 level of service	Minimise financial cost	2025/26 - 125 2049/50 - 336 2084/85 - 465
Enhanced environmental destination and high climate change dry year annual average 1 in 500 level of service	Minimise financial cost	2025/26 – 125 2049/50 - 383 2084/85 - 465
Baseline critical period	Minimise financial cost Minimise carbon cost Maximise natural capital and social benefits Maximise six capital benefits	2025/26 - 107 2049/50 - 325 2084/85 - 428

9.2.3 Optimisation outputs

The options selected in the DYAA and critical period optimisation runs listed in Table 9.3 are shown in Table 9.3. The DYAA optimised solution programmes included only one demand reduction option, which is leakage reduction to achieve the 50% leakage target (L6). This option was selected in all of the critical period optimisations also, suggesting leakage reduction is a best value solution. A PCC reduction scenario has been created (see Section 8.4.2) and entered into the optimiser but as the scenario represents an ambition and not a fully costed option, it was not available for selection in the optimisation runs.

Table 9.3: Grid SWZ optimisation runs outputs

Option	DV3 Magnesium Limestone new GW supply	DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d	DV8(iv) New north to south internal transfer connection	DV8(v) New WTW (York) supplied by the River Ouse	C15 a Household Flow Regulators A	Housing Associations Targeted Programme ABCD	R3 Increased River Ouse pumping capacity	L6 Active leakage control 95Ml/d	R13 East Yorkshire Groundwater Option 2	R29 Reservoir De-silting	R31a Additional bankside storage at York WTW	R3a River Ouse licence transfer	R5 Aquifer Storage and Recovery Scheme 1	R51 Supply Dales from the Tees - treated	R78 Tidal Abstraction Reservoir	R85 Rebuild Kirklees WTW	R86 West Yorkshire new WTW	R87 Rebuild Northallerton WTW	R8b Sherwood Sandstone and Magnesian Limestone	R8c Sherwood Sandstone and Magnesian Limestone	R8f Sherwood Sandstone and Magnesian Limestone	R8g Sherwood Sandstone Boreholes support to North	C1abc Water User Audits ABC	C1 abcd Water User Audits ABCD
Critical period least cost	✓	✓	✓	✓	✓	•	•	✓	✓	✓	✓	•	✓	✓	•	•	✓	•	✓	✓	✓	✓	•	•
Critical period Natural and Social capital maximised	✓	✓	✓	✓	•	•	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	✓	✓	•	✓
Critical period Carbon minimised	✓	✓	✓	✓	•	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	•	✓	✓	✓	✓	✓	✓	•
Critical period maximise 6 capitals	✓	✓	✓	✓	•	•	✓	✓	✓	•	✓	•	✓	•	✓	•	✓	•	✓	•	✓	✓	•	•
DYAA least cost	✓	✓	✓	✓	•	•	•	✓	✓	•	✓	•	•	✓	•	•	✓	•	•	•	✓	✓	•	•
DYAA Natural and Social capital maximised	•	✓	✓	✓	•	•	•	✓	•	•	✓	•	✓	✓	•	•	✓	•	✓	•	✓	✓	•	•
DYAA Carbon minimised	✓	✓	✓	✓	•	•	✓	✓	✓	•	✓	✓	✓	•	•	•	✓	•	✓	•	✓	✓	•	•

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.

DV7 (vi) - Tees -York Pipeline Option 1 and DV8 (iv) Tees -York to South Yorkshire Pipeline have major adverse impacts across a number of SEA objectives, including biodiversity, and in addition both R8f Sherwood Sandstone and Magnesian Limestone Boreholes Option 6 and R29 Reservoir De-silting have major adverse impacts in relation to the biodiversity SEA objective.

There is uncertainty associated with a number of schemes around 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. This is associated with uncertain impacts on multiple water bodies in the context of WFD compliance and further investigations would need to be carried out to confirm these impacts 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. This includes reservoir desilting, Sherwood Sandstone and Magnesian Limestone Boreholes option 6, Tees to York and York to South Yorkshire options. 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 would 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 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
C15a Household Flow Regulators				None		None						None				None	None
L6 Active Leakage Control 95Ml/d				None													
DV3 - South Yorkshire Groundwater				None							None						
DV7a(vi) - Tees -York Pipeline Option 1				None							None						
DV8(iv) - York to South Yorkshire Pipeline				None					None		None						
DV8(v) - York WTW Capacity increase				None							None						
R5 Aquifer Storage and Recovery Scheme 1				None													
R8b: Sherwood Sandstone and Magnesian Limestone Boreholes Option 2				None							None						
R8c: Sherwood Sandstone and Magnesian Limestone Boreholes Option 3				None							None						
R8f Sherwood Sandstone and Magnesian Limestone Boreholes Option 6				None							None						
R8g Sherwood Sandstone Boreholes support to North Yorkshire				None							None						
R13 East Yorkshire Groundwater Option 2				None							None						
R29 Reservoir De-silting				None													
R31a Additonal bankside storage on the River Ouse				None							None						
R51 Supply Dales from the Tees - treated				None													
R86 Aire and Calder new WTW											None						

Scheme	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
C15a Household Flow Regulators				None		None						None				None	None
L6 Active Leakage Control 95Ml/d				None													
DV3 - South Yorkshire Groundwater											None						
DV7a(vi) - Tees -York Pipeline Option 1											None						
DV8(iv) - York to South Yorkshire Pipeline									None		None						
DV8(v) - York WTW Capacity increase											None						
R5 Aquifer Storage and Recovery Scheme 1																	
R8b: Sherwood Sandstone and Magnesian Limestone Boreholes Option 2											None						
R8c: Sherwood Sandstone and Magnesian Limestone Boreholes Option 3											None						
R8f Sherwood Sandstone and Magnesian Limestone Boreholes Option 6											None						
R8g Sherwood Sandstone Boreholes support to North Yorkshire											None						
R13 East Yorkshire Groundwater Option 2											None						
R29 Reservoir De-silting				None													
R31a Additonal bankside storage on the River Ouse											None						
R51 Supply Dales from the Tees - treated																	
R86 Aire and Calder new WTW											None						

Key	
None	No effect
	Negligible adverse
	Minor adverse
	Moderate adverse
	Major adverse
	Negligible beneficial
	Minor beneficial
	Moderate beneficial
	Major beneficial

9.4 Candidate best value solution programmes

We used the outputs of the least cost and best value optimisation runs to create a portfolio of supply options for consideration in the preferred plan. The portfolio was used to create candidate solution programmes to be considered as the best value plan. As our preferred plan is to meet the demand reduction policy requirements, the L6 Leakage reduction 95Ml/d and the C5 Smart Metering and Water Efficiency options were included in the portfolio. At this stage we also considered the level of service reduction option and the assumed benefits of drought measures. Table 9.5. lists all options included in the portfolio and provides a high-level SEA assessment summary.

Table 9.5: Portfolio of options

Option Ref	Feasible options	SEA high level assessment
-	Demand side and supply side drought measures	n/a
R48	Level of service reduced to 1 in 200 from 2025 to 2039	n/a
L6	Active Leakage Control 95 Ml/d	n/a
C5	Smart Metering and Water Efficiency	n/a
DV8(iv)	New north to south internal transfer connection	Mitigation measures will need to be identified and agreed with Natural England. Detailed scheme design will need to consider risks which have been identified in relation to permitted waste sites and historic landfills, air quality impacts on local populations, heritage assets and the Peak District National Park.
R3	Increased River Ouse pumping capacity	Potential construction phase impacts to a range of heritage assets have been identified which would need consideration during the detailed scheme design; scope of investigations would need to be agreed with Historic England.
R8b	Sherwood Sandstone and Magnesian Limestone Boreholes option 2	Further investigation to understand the current flows in the Tutt catchment, as well as the potential impact on river flows associated with the proposed groundwater abstraction, is required in order to understand whether there is the potential for deterioration in the biological status elements of associated WFD water bodies.
R13	East Yorkshire Groundwater Option 2	Further investigations are needed to assess the impact on water quality in the WFD groundwater body and potential impacts of the abstraction on the associated surface water bodies.
DV7a(iv)	Tees to York Pipeline - NWL import 50 Ml/d	Mitigation measures will need to be identified and agreed with Natural England. Detailed scheme design will also need to consider risks which have been identified in relation to historic landfills, heritage assets and an AONB.
DV7a(v)	Tees to York Pipeline - NWL import 80 Ml/d	Mitigation measures will need to be identified and agreed with Natural England. Detailed scheme design will also need

		to consider risks which have been identified in relation to historic landfills, heritage assets and an AONB.
DV7a(vi)	Tees to York Pipeline - NWL import 140 Ml/d	Further investigation is required in order to determine whether this option would be WFD compliant. Mitigation measures will also need to be identified and agreed with Natural England. Detailed scheme design will also need to consider risks which have been identified in relation to historic landfills, heritage assets and an AONB.
DV8(v)	New WTW (York) supplied by the River Ouse	Potential construction phase impacts on designated biodiversity sites and further surveys/studies may be required to better understand likely impacts and to identify mitigation measures.
R8c	Sherwood Sandstone and Magnesian Limestone Boreholes option 3	This site is a WFD groundwater body and further investigation is required to assess the potential impacts and connectivity to the River Swale. During construction, impacts on heritage assets would need consideration and scope of investigations agreed with Historic England.
DV3	Magnesium Limestone new GW supply	The assessment identified issues of minor significance only.
R3a	River Ouse licence transfer	Potential impacts on the Humber Estuary marine sites have been identified and while these are not anticipated to be significant, further investigation is required.
R37b(ii)	River Aire Abstraction option 4	A water-dependent SSSI is downstream of the proposed abstraction and may be influenced by reduction in flows during operation of the scheme, further investigation is needed.
R78	Tidal Abstraction Reservoir	Likely significant effects associated with both construction and operational phases have been identified in relation to the Humber Estuary marine sites. A number of investigations would be required to provide sufficient evidence of no adverse effects on these sites (e.g. hydrodynamic modelling, water quality modelling, habitat surveys).
R8f	Sherwood Sandstone and Magnesian Limestone Boreholes option 6	There are a number of chemical pressures in the relevant WFD groundwater body that may be increased as a result of additional abstraction and further investigation is required. Rerouting of proposed pipeline and agreement of mitigation measures in consultation with Natural England would be required to be informed by further surveys and investigations. Potential construction phase impacts to a range of heritage assets have been identified which would need consideration during the detailed scheme design; scope of investigations would need to be agreed with Historic England.
R86	West Yorkshire WTW	A new abstraction licence would need to be agreed with the EA. Further investigation is required to assess the impact of the new abstraction on lamprey. Bird and habitat surveys would also be required to better understand likely impacts, and inform mitigation measures to be agreed with Natural England.

R85	Rebuild KirkleesWTW	The assessment identified issues of minor significance only.
R8g	Sherwood Sandstone support to grid	Further investigation is required to understand the impact of the proposed abstraction on the River Wiske and the River Swale.
R31a	Additional bankside storage at York WTW	Bird surveys are required to better understand likely impacts and inform mitigation measures to be agreed with Natural England.
R88	Increase storage at an existing WTW in North Yorkshire	The assessment identified issues of minor significance only.

The options included in the portfolio were assessed to identify any risks that would make the option benefit unsustainable over the longer term or any environmental impacts that made the option less favourable than the alternatives. A number of risks were highlighted by the SEA assessment and further investigation of the supply options would be needed if they were to be included in the final solution. This information was considered when formulating the candidate solutions.

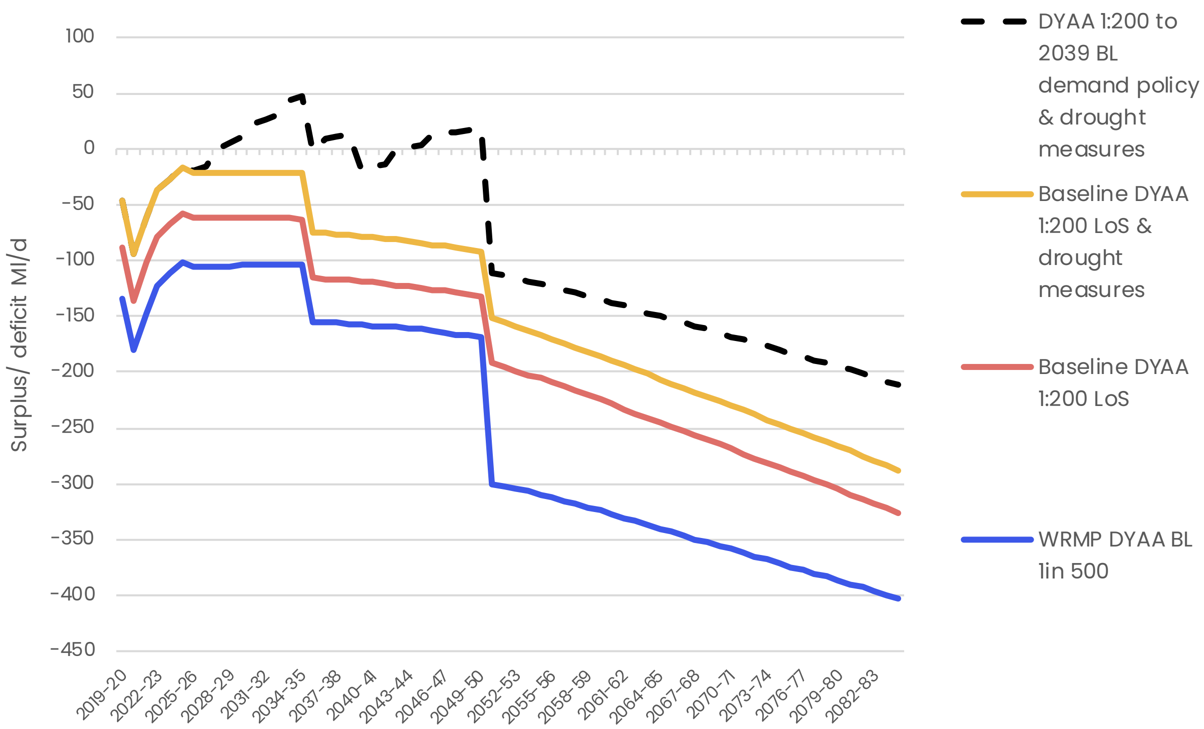
Table 9.6: WRMP24 public water supply objectives and high-level solutions

Objective	Benefit delivery year(s)	Solution	Justification of need
1. Objective: Close the supply-demand deficit (25 years minimum)	2025-2035	• Plan to 1 in 200 level of service (DYAA scenario) and rely on drought measures until no later than 2039. • Invest in new supplies that close the WRMP deficit and provide additional resilience to the Grid SWZ conjunctive use system.	Both the 1 in 500 LoS DYAA baseline scenario and the critical period scenario show an immediate risk of deficit. Early interventions are needed to mitigate this risk 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	• L6 Leakage reduction 95Ml/d	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 water saving initiatives • 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	• This should be achieved once objectives 1, 2 and 3 are met but careful monitoring is required and an alternative pathway could be triggered in the future.	Policy requirement: resilience to a 1 in 500 drought event no later than 2039 and reduce reliance on drought measures.
5. Objective: Increase resilience in the Grid SWZ and localised growth hot spots	2025-2035	• Invest in new supplies that meet objectives 1 and 4 and provide additional resilience to the Grid SWZ conjunctive use system.	We have identified 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	• Met by combined benefits of demand reduction and new supplies delivered to achieve objectives 1 to 4.	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) New north to south internal transfer connection • Invest in DV8(v) 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	2050	• Invest in option DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d	Environmental Destination BAU+: licence reduction on the River Derwent by 2050 to meet a CSMG target.

The candidate solution programmes were created by selecting different combinations of options from the portfolio and manually creating programmes to address wider risks and objectives, including our WRMP24 objectives. Table 9.6 shows the WRMP24 objectives mapped to the candidate solutions.

Our baseline 1 in 500 DYAA scenario shows that in extreme drought events we are at risk of a deficit and we must invest in demand reduction and new supply options to address this risk. The only options that provide an immediate benefit are to plan to a 1 in 200 drought event (for level 4 restrictions) and to rely on drought measures during dry weather. Figure 9.4 hows the impact these measures have on the Grid SWZ supply-demand balance. By planning to a 1 in 200 level of service (red line) the zone has a lower deficit than the 1 in 500 (blue line). With the assumed benefit of drought measures applied to the 1 in 200 scenario (orange line) the deficit reduces further but is not in surplus and objective 1 is not met.

Figure 9.4: Impact of 1 in 200 level of service, drought measures and demand reduction on the DYAA scenario in the Grid SWZ deficit



Our preferred plan is to meet the demand reduction policy requirements and be resilient to a to be resilient to a 1 in 500 drought event without reliance on drought measures by no later than 2039 (objectives 2, 3 and 4). The combined benefit of these interventions is that the zone now shows a surplus intermittently (dashed black line in Figure 9.4) until the environmental destination impact on the River Derwent takes effect.

The assumed benefits of option L6 Leakage reduction 95Ml/d and the C5 smart metering with water efficiency (PCC reduction profile) have been incorporated into all the candidate solutions. The L6 Leakage reduction 95Ml/d option was selected in the least cost and best value runs. Reducing leakage benefits the environment by reducing the volume we abstract, treat and put into supply and is therefore considered a best value option. However, the option relies on future success of leakage techniques and the certainty of achieving the benefits reduce over time.

The C5 smart metering and water efficiency option also benefits the environment by reducing the water we abstract. The option represents a PCC reduction scenario and assumes that by combining new technology (smart metering) with water saving initiatives we will reduce PCC. Although it can be considered best value, it is dependent on consumer behaviour and carries significant uncertainty, particularly in dry years when demand increases.

These steps show that we can achieve some significant benefits from demand reduction, a reduced level of service and drought measures but we do not fully remove the risk of deficit or create a resilient supply-demand balance. The 1 in 200 level of service option is only available in the short term to align with objective 4. The measures also present a significant consequential risk of relying on demand (leakage and PCC) reduction and drought actions. These benefits are highly uncertain and do not on their own provide a secure supply of water for our customers.

Planning to a 1 in 200 level of service until 2030s can also be considered a high-risk strategy and leaves us vulnerable to extreme dry weather such as that we are currently experiencing in 2022. We therefore must invest in additional options to ensure we improve our resilience to droughts in the short term. In the medium to long term, the loss of the STW import in 2035 and the reduction in the River Derwent licence in 2050 need to be addressed through new supplies as they have a significant impact on supply that cannot be offset through demand reduction.

9.5 Twin track solution

We are presenting a twin track approach as our best value plan for closing the Grid SWZ WRMP24 deficit. Alongside the options to achieve the demand reduction policy, we are planning to implement supply options to provide a more secure solution that results in a surplus supply-demand balance and addresses resilience needs identified in Section 8.3.

The supply options will be implemented in AMP8 and AMP9 and address objectives 4 to 7. They will increase our level of service to 1 in 500 (objective 4) by the mid-2030s and create resilience in the short term (objective 5). We have selected the supply options from the option portfolio collated from the best value runs and assessed candidate solution programmes using the best value metrics (see below).

If all of the assumed benefits of the AMP8 and AMP9 solutions are realised we will not require any additional supplies to meet the groundwater environmental destination need (objective 6). However, if the benefits from the planned solution are not achieved, we may be required to support the Doncaster demand area that is directly connected to the licences that would be reduced. This may lead to additional options being triggered to strengthen the link between the Doncaster demand area and our grid system.

The STW loss (objective 7) would be met by the AMP8 and AMP9 investment but it would require a new internal transfer main (option DV8(iv) new internal transfer connection) to be constructed to transfer water from the north of our grid network to the South Yorkshire demand area. The main duplicates existing infrastructure that does not have the capacity to transfer the required volume to meet the South Yorkshire demand. As there is limited water available in the South Yorkshire area this main has been mandated into all our solution programmes but it does not provide any increased supply. We have also mandated option DV8(v) New WTW in York supplied by the River Ouse into our candidate solutions. This option provides an additional 50Ml/d and makes use of an existing licence we have on the River Ouse. The option was selected in 16 of the 26 preliminary runs and in the best value runs. The new main would connect the new WTW to the existing network in the South Yorkshire area and reduce the amount of network changes required to connect a new supply to the South Yorkshire area. However, it is noted that a new source of supply closer to the demand area would reduce pumping from the new works and we are continuing to explore potential new supply options more local to the South Yorkshire area.

Depending on the success of the demand reduction activities we may require further new supply investment in AMP9 to either support South Yorkshire or to increase resilience in our system as there is a risk that we are becoming over reliant on the River Ouse. Once the water is used on a daily basis to supply South Yorkshire, we reduce the resilience benefit of the new works. We will monitor the demand reduction delivery and reassess this risk in WRMP29.

Our final objective is to offset the loss of the long-term environmental destination, which results in a significant loss of supply by reducing our licence on the River Derwent by 130Ml/d in the baseline DYAA BAU+ scenario and 160Ml/d in the enhanced environmental destination scenario. To address this risk our preferred plan will include a new transfer from Northumbrian Water (option DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d). The transfer will require significant additional assets and infrastructure alongside support from Kielder Water operated by Northumbrian Water. It will require a new electricity supply to be connected to a large pumping station in the northeast, an additional rising main pump at the pumping station, a new sub-potable WTW at source to remove the INNS risks, a new main to our York WTW where further treatment capacity will need to be installed. The DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d has appeared in 14 of preliminary runs and in the best value runs, and we have mandated it into our candidate solutions. However, it is our only large new supply option and we shall continue to investigate alternatives during AMP8 to understand if a better value solution could be available and included in future WRMPs.

9.5.1 Candidate solution options

Once the options to meet objectives 1, 2, 3, 7 and 8 were mandated into the preferred plan we selected additional supply options from the portfolio to implement in the near term (AMP8) and help to address the immediate deficit. We produced four candidate solution programmes to close the baseline critical period deficit. This scenario shows a similar deficit to the DYAA baseline scenario until 2040 when the deficit is slightly greater. Any solution programmes that close the critical period also close the DYAA deficit.

The options included in the candidate solution programmes are listed in Table 9.7 alongside the critical period least cost (benchmark) solution programme.

Table 9.7: Candidate solutions for the critical period scenario

Option	DV3 Magnesium Limestone new GW supply	DV7a(v) Tees to York Pipeline – NWL import 80 Ml/d	DV7a(vi) Tees to York Pipeline – NWL import 140 Ml/d	DV8(iv) New north to south internal transfer connection	DV8(v) New WTW (York) supplied by the River Ouse	C15a Household Flow Regulators A	R3 Increased River Ouse pumping capacity	L6 Active Leakage Control 94.5 Ml/d / Active leakage control 95Ml/d	R13 East Yorkshire Groundwater Option 2	R29 Reservoir De-silting	R31a Additional bankside storage at York WTW	R3a River Ouse licence transfer	R5 Aquifer Storage and Recovery Scheme 1	R51 Supply Dales from the Tees – treated	R85 Rebuild Kirklees WTW	R86 West Yorkshire new WTW	R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2	R8c Sherwood Sandstone and Magnesian Limestone Boreholes option 3	R8f Sherwood Sandstone and Magnesian Limestone Boreholes option 6	R8g Sherwood Sandstone Boreholes support to North Yorkshire	C5 Smart metering and water efficiency promotion	R37b (ii) River Aire Abstraction option 4	R6d Grid South Yorkshire Groundwater Option 4	R85 Rebuild Kirklees WTW
Critical period least cost	✓	•	✓	✓	✓	✓	•	✓	✓	✓	✓	•	✓	✓	•	✓	✓	✓	✓	✓	•	•	•	•
Candidate solution 01	✓	•	✓	✓	•	•	✓	✓	✓	•	✓	✓	•	•	•	✓	✓	✓	✓	✓	✓	•	✓	✓
Candidate solution 03	✓	•	✓	✓	✓	•	•	✓	✓	•	✓	✓	•	•	•	✓	✓	•	✓	✓	✓	•	✓	•
Candidate solution 04	✓	•	✓	✓	✓	•	•	✓	✓	•	✓	✓	•	•	•	•	✓	•	•	✓	✓	✓	•	•
Candidate solution 04.01	✓	•	✓	✓	✓	•	•	✓	✓	•	✓	✓	•	•	✓	•	✓	•	•	✓	✓	✓	•	•

The candidate solution programmes included supply-side options from the portfolio of options that were selected in the least cost and the best value optimisation runs for both the critical period and the DYAA scenarios. The candidate solutions were made up from different combinations of these options and included:

- R8b Magnesium limestone Sherwood Sandstone and Magnesian Limestone Boreholes option 2
- R8c, R8f and R8g – Sherwood Sandstone new groundwater abstractions
- R13 –East Yorkshire Groundwater Option 2
- DV3 – Magnesium Limestone
- R31a – Bankside storage on the River Ouse
- R37d(ii) and R86 – abstraction from the River Aire either to treat at an existing WTW or at a new WTW.
- We also included option R3a in the candidate solutions which was not included in the least cost solution programme but was included in three of the best value solution programmes.

The R78 tidal abstraction and R85 Rebuild Kirklees WTW were not included in the candidate solutions for the baseline scenarios but were considered in the stress testing scenarios. The R87 Rebuild Northallerton WTW option was excluded as the benefit is low (4Ml/d) and preference was given to the Sherwood Sandstone boreholes, which could supply a greater volume in a similar location (North Yorkshire).

Two options selected in both the least cost and the best value optimisations were excluded from the candidate solutions as they are not considered low regrets, these are R5 and R51. R51 Tees to Dales has been excluded as it is a transfer from NWL that would import 15Ml/d of treated water to the North Yorkshire area of our Grid SWZ. We are mandating in the larger transfer of 140Ml/d and to do both would create a risk that the combined benefit may not be available in dry years.

R5 is an aquifer storage reservoir that would store water abstracted from the River Derwent (Aquifer Storage and Recovery Scheme 1)
when the river was in the higher flow bands but demand was low. It could then be used later in the year when the river was in the lower flow bands and demand high. Under the terms of our permitted abstract rights we can take more water from the river when the river is high (higher flow bands) than when it is low (lower flow bands). By storing water when we can abstract, we conserve the supply for when we can abstract less. However, as our River Derwent licence could be reduced in the future and this risk is included in the BAU+ baseline environmental destination scenario. This creates a risk to the aquifer storage reservoir option as by 2050 the licence is unlikely to provide sufficient surplus to provide the water to be stored during lower demands.

The R3 option to increase River Ouse abstraction to full licence capacity was also not considered in the candidate solutions. This option would allow us to use an existing source more frequently but would not be available when the river was at its lowest flows and was therefore not considered best value. However, the recent dry weather has highlighted that although not available all year this option could help support our conjunctive use system whilst reservoirs are low when recovering from dry periods and rivers have started to recover. We shall therefore reassess for the final WRMP24.

R29 reservoir desilting, which was selected in the critical period optimisations but not the DYAA was excluded as there is high uncertainty over the impacts this scheme may cause on a number of designated sites.

Our candidate solutions aimed to reduce the number of Sherwood Sandstone options included in the preferred plan compared to the optimised solution programmes as the SEA highlighted a risk to WFD compliance. These options would be abstracting from the same aquifer, which is the Sherwood Sandstone in the Dales and Harrogate area. There is no evidence that one option is any more impacting than the others, however there is a risk the combined impact of all the Sherwood Sandstone groundwater abstraction options will be detrimental to the aquifer. We discussed the potential for abstracting from the aquifer with the EA during the WRMP24 pre-consultation phase. The EA was not able to provide an exact volume that could be abstracted but did agree that applications would be considered. We have therefore limited the volume we propose to take in our candidate solutions as there is a risk the licences will not be granted.

Before applying for any new abstraction permits, we investigate the impacts of the proposed abstractions on the environment. During AMP8 we plan to carry out investigations in the locations identified for all the Sherwood Sandstone options. This will clarify if our preferred plan location is the most optimum and if a greater volume than we have assumed (15Ml/d) could be made available. This will support our feasibility assessments of the Sherwood Sandstone options in future plans.

Option R86, a new WTW and new licence to abstract from the River Aire and Calder, has been selected in the least cost solution programmes and the DYAA best value solution programmes. We have replaced this option in some of our candidate solutions with an option to abstract from the River Aire and transfer to an existing works (R37b) as it requires les construction and could be made available in a shorter timeframe. The trade off in this choice is that we do not achieve the same benefit as the single abstraction point is likely to have less water available for new licences compared to the combined Aire and Calder abstraction. The existing works also has constraints that mean it will limit the increased volume that could be put into supply. However, as we have mandated demand reduction options into our plan consequently reducing the volume of new supplies required, the R37b option was considered in preference to the new WTW option.

One of our candidate solutions included the R6d Grid - South Yorkshire Groundwater Option 4, which was not selected in the least cost and candidate solutions. This option would help reduce outage risks in our Grid SWZ by installing a new interconnection that allows water to flow in two directions. This would be either from the Doncaster area to our core grid network or from the grid network into Doncaster, depending on which area was experiencing an outage. This option has not been included in the preferred plan as there Doncaster area is still under WINEP investigations[32].

9.5.2 Candidate solution metric assessment

We created several candidate solutions, which included variations on the options discussed in Section 9.5.1 and therefore resulted in very similar combinations. The candidate solution programmes were compared against each other and against the critical period least cost solution using the MCA approach of comparing metric values at a programme level. We did not assume any benefit from planning to a reduced level of service or implementing drought measures in the candidate solutions. This was to ensure they were comparable to the least cost solution programme for meeting the baseline critical period deficit. The least cost critical period is not linked to levels of service therefore does not benefit from planning to a lower level of service. If we were experiencing extreme dry weather, it is reasonable to assume drought measures would be in place during the critical period. This is considered in our stress testing (see Section 9.6).

[32] There is a possibility the WINEP investigation could result in a reduction in the Doncaster area water availability. This would not make this option infeasible for reducing outages but would reduce the assumed 20Ml/d benefit in the WRMP.

The aim of the candidate solution programmes was to improve on the metric values compared to the least cost solution and create a best value plan. The candidate solutions were created through the DMF optimiser model by mandating options into the solution to meet key objectives. We produced five candidate solutions but only four were taken forward to the metric assessment stage. The candidate solutions are described in Table 9.8.

Table 9.8: Description of candidate solution programmes

Solution programme reference	Description
Candidate solution 01 – partial-optimisation	Options were mandated into the programme to: • meet the policy demand reduction requirements • address the loss of the transfer • address the River Derwent environmental destination risk • address resilience needs - Sherwood Sandstone and Magnesian Limestone Boreholes option 2, R8g Sherwood Sandstone support to grid, R3a River Ouse licence transfer and R86 West Yorkshire new WTW The optimiser could then select based on cost from the remaining options in the portfolio.
Candidate solution 02	This solution was a variation of solution 01 but was not assessed any further as the results were no different.
Candidate solution 03 - maximise resilience benefits	This solution programme included the same mandated options as candidate solution 01 plus the following additional options were mandated to increase the resilience benefits: • R13 East Yorkshire Groundwater Option 2 • DV3 Magnesium Limestone • R8f Sherwood Sandstone and Magnesian Limestone Boreholes option 6 • R31a Bankside storage at York WTW The optimiser had limited scope to optimise and selected one additional option which was a new interconnecting pipeline.
Candidate solution 04 – fully mandated	This solution programme was a variation on candidate solution 03 with fewer groundwater options mandated and the R86 West Yorkshire new WTW replaced with a R37b(ii) River Aire Abstraction option 4. As a result the total new supply benefit was reduced.
Candidate solution 04.01 – fully mandated	This solution programme was the same as candidate solution 04 except that an additional option, R85 Rebuild Kirklees WTW, was mandated into the programme to treat existing reservoir supplies and to remove a risk of deficit in the longer term (2060s).

Figure 9.5 compares the candidate solution programme using the best value metric normalised scores. The solution programme metric values are provided in Appendix C. As it is not possible to optimise for each individual metric, we apply "trade-offs" to select a plan that can be considered best value. Table 9.9 compares the metric values.

Figure 9.5: Candidate solution normalised metric value comparison

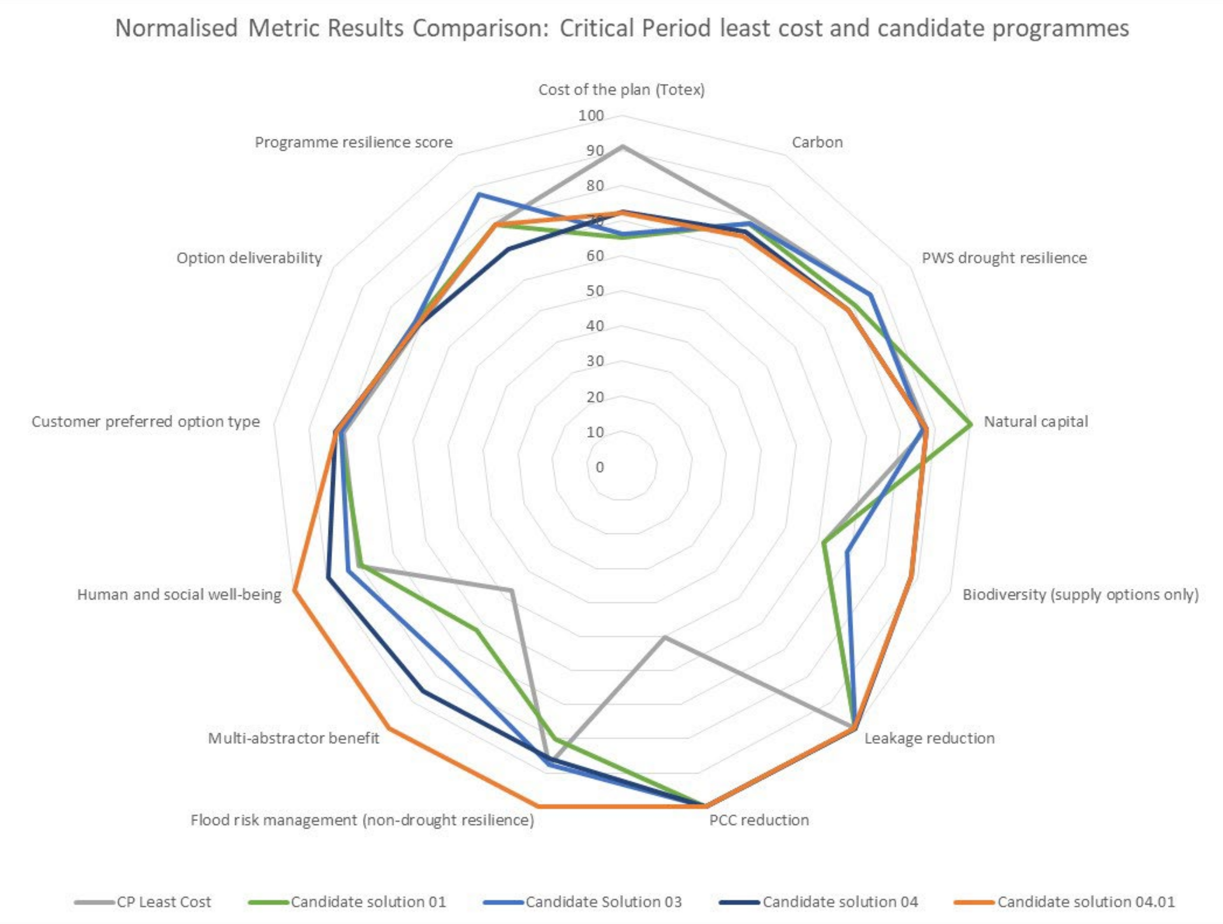


Table 9.9: Description of candidate solution best value metric scores

Best value metric	Candidate solution comparison
PWS Drought resilience	The scores range from 58 to 68 and none of the solutions were able to close the immediate deficit. The best performing were the least cost and candidate solution 3.
Biodiversity	This metric is only applied to the supply options and by assuming the PCC policy requirement and reducing the number of supply side options the least cost score of 15 is raised slightly but the highest scoring is only 20. When delivering schemes requiring planning permission, we shall plan to achieve a 10% biodiversity net gain[33].
Natural Capital	The scores range from 88 to 100 with candidate solution 01 the best performing.
Leakage reduction	All programmes score 100 on leakage as the least cost selected the 50% reduction option and it was mandated into the candidate solution programmes.
PCC reduction	The policy PCC reduction was mandated into the candidate solutions which all scored the maximum value of 100. The least cost performed poorly in comparison with a score of 50.
Flood risk management (non-drought resilience)	The scores range from 62 to 73 with the least cost solution preforming lowest and candidate solution 04.01 the highest.
Multi-abstractor benefit	The scores range from 20 to 42 with the least cost preforming lowest and candidate solution 04.01 the highest.
Carbon	The metric scores showed little variation from 72 (candidate solution 04.01) to 78 (least cost solution).
Customer preferred option type	There was virtually no variation on this metric with all scores just over 80.
Human and social well-being	The metric scores show a small range from 46 (least cost) to 55 (candidate solution 04.01).
Financial Cost	The least cost plan scores best at 63 and the lowest scoring is 58, candidate solution 03.
Option Deliverability	There is little variation in this metric with all programmes scoring around 70.
Resilience	The scores range from 70 to 88 with candidate solution 04 scoring lowest and 01 scoring highest. The rest were even scoring 78. Candidate solution 03 was designed to maximise resilience benefits.

[33] To be a legal requirement when Environment Act 2021 is implemented and legal requirement of the Natural Environment and Rural Communities Act 2006 (Section 40).

Our assessment concludes Candidate Solution 04.01 (orange line in Figure 9.5) is best value. This solution programme has the highest normalised score for five of the 13 best value metrics (customer preference, human and social wellbeing, biodiversity, multi abstractor benefit and flood risk management) and has been identified as the best value plan. All candidate solutions score 100 on PCC and leakage as the benefits have been mandated into the programmes. Candidate solution 04.01 presents the lowest cost solution of the candidate solutions.

Candidate solution 04.01 scores mid-way between the highest and lowest programme resilience scores and scores lowest on public water supply drought resilience. Candidate solution 03 (blue) scored highest on programme resilience and public water supply drought resilience as it was designed to maximise resilience benefits. Implementing more supply options has a clear benefit to resilience and securing supplies but this must be balanced with the potential for successful delivery.

Our SEA assessment has highlighted risks that we need to investigate further before we could conclude whether the combination of options included in Candidate solution 03 is deliverable. The 03 programmes include increased abstraction from the Sherwood Sandstone aquifer. The SEA and WFD assessments show this could be detrimental to the environment and further work is needed to understand if there would be a risk to the aquifer. Candidate solution 04.01 selects a reduced number of Sherwood Sandstone options and we will review in the next plan once investigations are complete if more of the options can be developed.

The other trade-offs are natural capital, carbon and public water supply drought resilience. Option reliability shows little variation. Although candidate solution 04.01 does not have the lowest natural capital score it is equal to all but candidate solution 03 and scores highest of all programmes on biodiversity. The carbon results of all solution programmes show a very small range (72 to 78) and this is not considered material.

Both candidate solution programmes 01 and 03 included the R6d Grid - Grid - South Yorkshire Groundwater Option 4 and R86 West Yorkshire new WTW (50Ml/d). The benefits of the R6d Grid - Grid - South Yorkshire Groundwater Option 4 are uncertain while a WINEP study is still ongoing. This option could help reduce the resilience risk of outages at large works even if the licence was reduced in the future. It has been constrained out of the final programme but will be given further consideration if the preferred option does not achieve the assumed benefits.

R86 West Yorkshire new WTW included in candidate solution 01 and 03 was replaced by R37b (ii) River Aire Abstraction option 4 in candidate solution 04 and 04.01. Although this contributes to the lower PWS drought resilience score, it provides a more deliverable overall solution based on time to build and can be accelerated as it requires less construction than the R86 new WTW scheme.

To offset the public water supply drought resilience risk, we shall plan to a lower level of service in the short term (a drought return period of 1 in 200) and will be resilient to 1 in 500 drought events no later than 2039. Although the alternatives to candidate solution 04.01 improve the public water supply drought resilience score, they do not score 100, and we would still be required to plan to a 1 in 200 return period in the short term. Our preferred programme reduces the number of new supply options at the start of the planning period, which makes it more deliverable overall. It also reduces the risk of investing in supplies that may not be needed in the future once the benefit of the demand reduction options accumulates.

9.5.3 Best value plan supply-demand balance

The best value plan (Candidate solution 04.01) benefits (Ml/d) are represented in Figure 9.6 and compared to the DYAA and critical period baseline scenarios. The benefit of a reduced level of service is incorporated into the DYAA and the benefits of drought measures incorporated into both scenarios alongside the supply option benefits. The benefit of the government water labelling initiative has also been built into the solution. The critical period scenario relies on these benefits in the final year of the planning period. Although we do not consider water labelling a reliable solution to closing a supply-demand deficit we would not bring in any further solutions as there is sufficient time to address the risk in the future.

Figure 9.6 highlights the near-term risk that the solution does not close the immediate deficit. The planning period is 2025 to 2085 and the solution start dates in the optimiser model are aligned with this period i.e. they cannot start earlier than 2025. With the best value solution incorporated the DYAA baseline scenario is in deficit until 2027 and the critical period baseline scenario until 2028. Any supply interventions that start in 2025 will take several years to implement and provide a benefit. The demand reduction options do provide a benefit from 2025 which increases over time but there is not sufficient benefit in the early years to close the near-term deficit.

To reduce the risk of deficit from 2025 onwards we shall start option implementation of five of the supply options earlier than 2025. Early start options are listed in Table 9.10. R13 and R57b(ii) will create a benefit from 2025 if they can be constructed during the current AMP. The remaining three have been brought forward a year as we plan to deliver investigations in AMP7 that will enable the build to start in 2025.

Table 9.10: Supply options with an early start date

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 support to grid	2024/25	2028/29
DV8(v) Increase York WTW capacity to existing Site footprint capacity	2025/26	2029/30

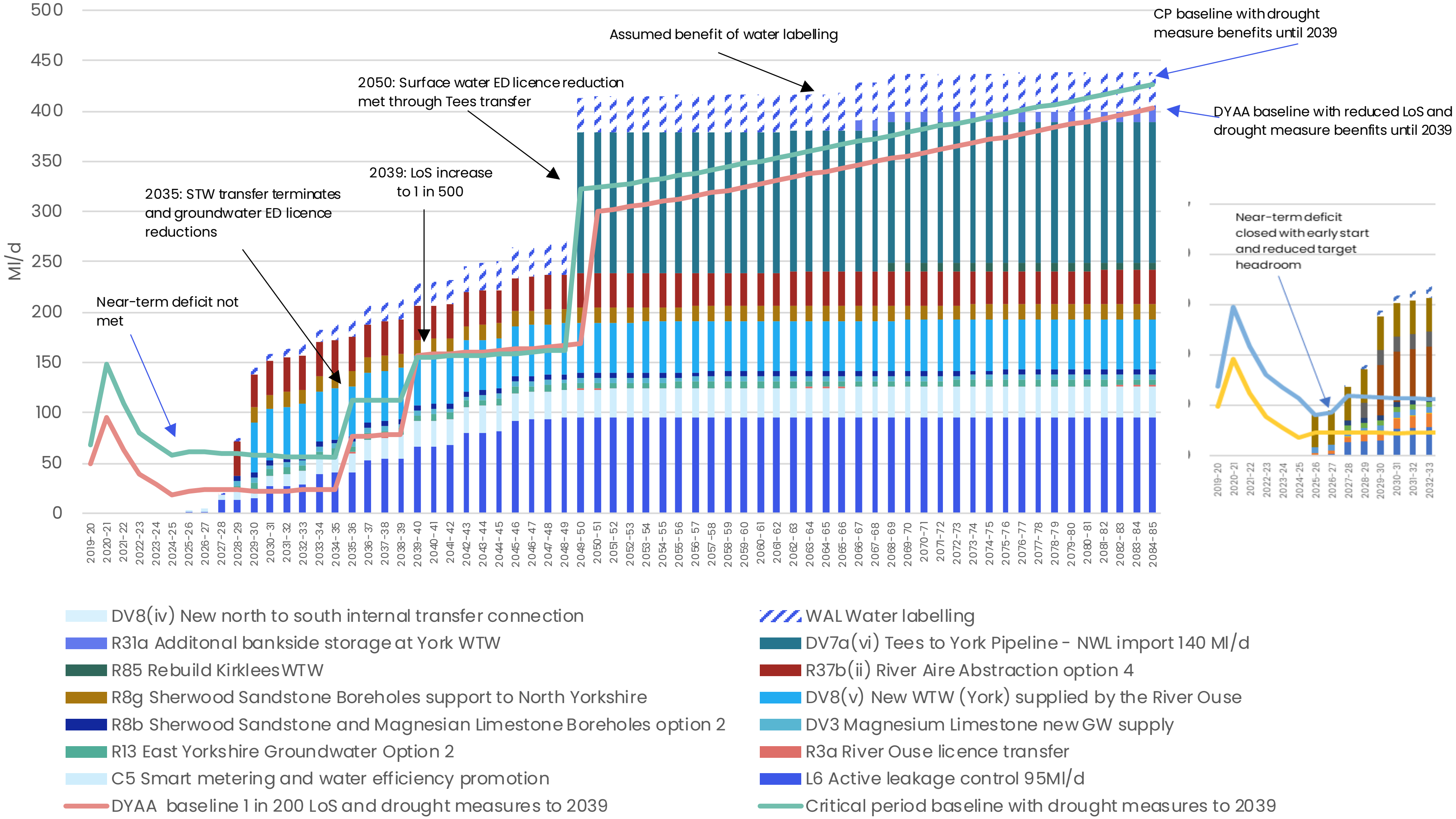
Option DV8(v) has also been brought forward. The new works would be constructed in AMP8 in advance of the STW transfer termination in 2035. In the short term it would provide resilience to outages and peak demands in the Grid SWZ and is considered a no regrets option. If the final decision on the STW transfer was that it would be maintained we would still benefit from this option during peak periods, as experienced in 2018, 2020 and 2022, as it would provide a reliable resource that our grid network could transfer to different parts of our system either directly or indirectly through displacement.

The inset image in Figure 9.6 shows the start of the planning period with the benefit of the five early start options brought forward. This shows the DYAA deficit is closed from 2025 onwards. However, we are still at risk in the early years of our critical period scenario as the early start options only bring the surplus forward to 2027. The critical period scenario includes the benefit of drought measures until 2038/39 but it is not linked to levels of service and so, unlike the DYAA scenario, we the deficit is not reduced through planning to a lower drought return period in the short term.

During a critical period, we are able to draw on some resources more than we can in the annual average scenario. We have assumed this for R13 East Yorkshire Groundwater Option 2 and R3a River Ouse licence transfer. Our plan aims to make the R13 East Yorkshire Groundwater Option 2 available by 2025 but the additional benefit would only be 2Ml/d greater than the annual average which does not close the critical period deficit in 2025/26 to 2026/27. The R3a River Ouse licence transfer provides a benefit at low flows only. It is estimated to provide a marginal benefit of 0.3Ml/d in the DYAA scenario but in the critical period scenario 15Ml/d. The source for this option is the River Ouse and an ongoing WINEP investigation on the abstraction is due to complete in 2025. This means we cannot bring the start date for this option forward.

The only means of closing this gap is to plan to a reduced headroom in 2025/26 and 2026/27 which means there is still a risk of deficit. This risk was more severe during the Covid-19 pandemic but since demand returned closer to pre-Covid levels the risk is that supply cannot meet demand plus target headroom, rather than supply cannot meet demand. We shall therefore operate to a reduced target headroom in 2025/26 and 2026/27 and we have represented this in the critical period final plan WRP tables. We shall continue to review the critical period risk as we develop our final WRMP24 and this may lead to a change to our solution.

Figure 9.6: Best value plan benefits compared to DYAA and critical period baseline scenarios with drought measures



9.5.4 WRAPsim modelling of options

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 WRAPsim 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. WRAPsim modelling is used to determine the option yield, taking into account the hydrological conditions and infrastructure constraints of the Grid SWZ at the given deficit.

We cannot confirm the option yield in WRAPsim until after the supply-demand deficit is known. WRAPsim 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 WRAPsim in correlation with each other to account for any interdependencies

We have run the median stochastic variate for the 1990s and the 2070s with our best value solution in WRAPsim to ensure that the options selected increase the deployable output enough to remove the supply-demand deficit. We estimate deployable output of our system with the solutions in place as described in the deployable output assessment Section 3.

9.6 Stress testing

Candidate solution 04.01 has been selected as the best value plan for closing the DYAA and critical period baseline deficits. The plan has been adjusted to bring forward five supply options to meet the risk at the start of the planning period. However, before we finalise our preferred plan, we must consider alternative scenarios. The deficit presented in our baseline scenarios is driven by three key risks:

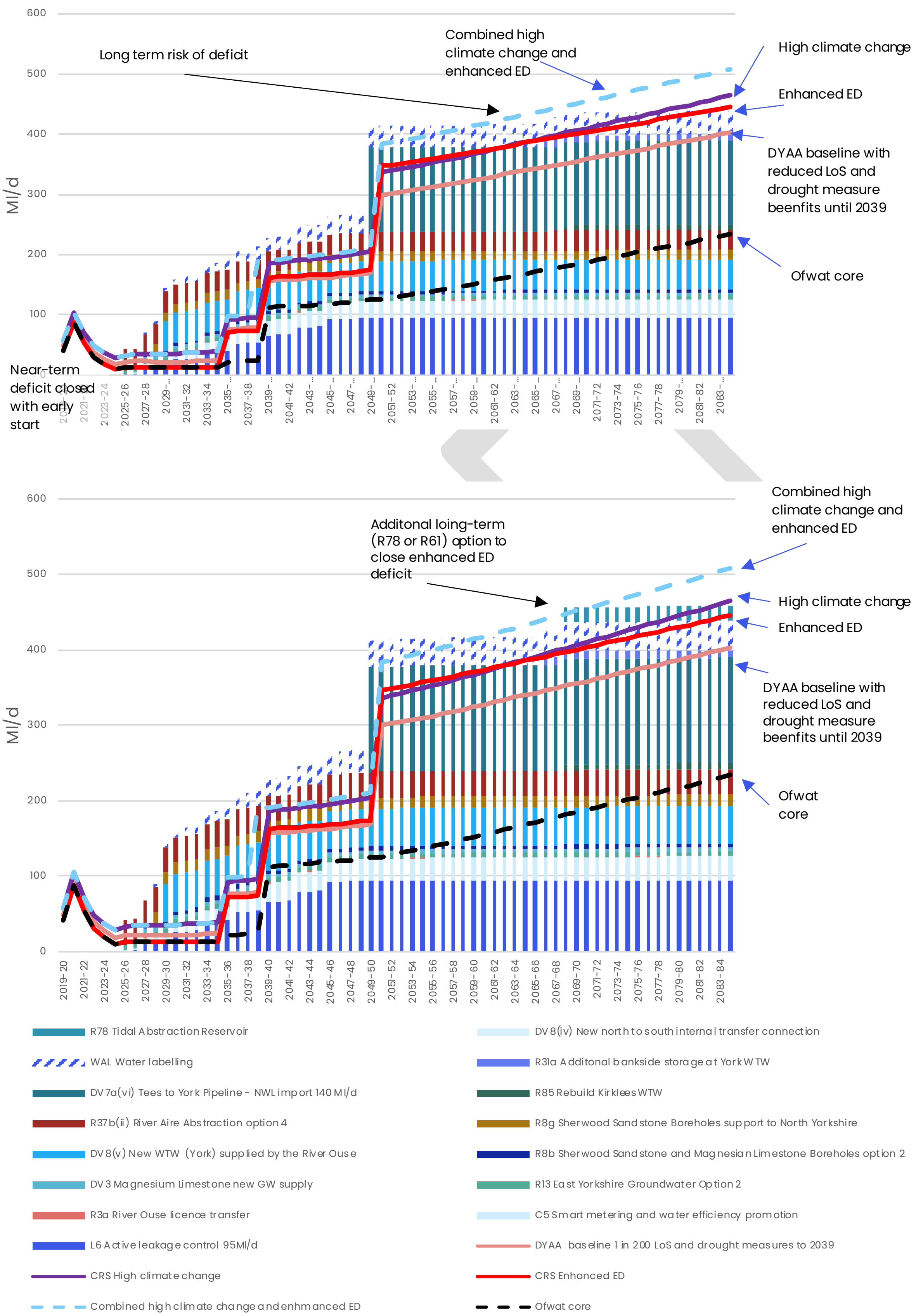
- Climate change impact on future supply
- The loss of the STW transfer
- Environmental destination.

Each of these risks is based on the most up to date information we have at the time of producing our plan. 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 the Common Reference Scenarios discussed in Section 7.3. In addition, we consider the risks linked to the delivery of our best value solution.

9.6.1 Common Reference Scenario stress tests

We have tested our plan against the Common Reference Scenarios that create a greater deficit than the baseline, and against the Ofwat Core Scenario which represents a lower deficit. The higher deficit scenarios are due to high climate change and the enhanced environmental destination. We have also created a scenario that includes the combined risk of the enhanced environmental destination and the high climate change scenario.

Figure 9.7: Grid SWZ best value plan stress testing to alternative DYAA scenarios



The stress testing scenarios have also been adjusted to incorporate the benefit of planning to a 1 in 200 drought return period and the assumed benefit from drought measures until 2038/39. From 2039/40 onwards the deficit represents a DYAA 1 in 500 level of service and no assumed benefit from drought measures. Figure 9.7 shows a marginal surplus in 2025 in both the DYAA high climate change and high environmental destination scenarios. This surplus increases as more option benefits take effect until 2035 when the STW transfer terminates. This reduces the headroom in the Grid zone, but it does not create a deficit in either scenario, therefore no further supply options are brought in at this point.

From 2035 the surplus increases again due to the benefit of demand reduction options until in 2039 when we move to a 1 in 500 level of service. Again, the loss does not create a deficit in either the high climate change or high environmental destination scenarios. In 2050 the River Derwent CSMG target is applied, and the loss is offset by the DV7a(vi) - Tees to York Pipeline - NWL import 140 Ml/d option. The climate change and high environmental destination scenarios remain in surplus until the mid to late 2070s but without the benefit of water labelling they would be in deficit in the early 2060s.

The combined high climate change and enhanced environment destination scenario can be met by the best value solution in the first 25 years of the planning period. With the assumed benefit of water labelling it has a marginal surplus from 2050 to 2060 and without any benefit from labelling it would be in deficit from 2050 onwards.

The Ofwat Core scenario represents a lower deficit future which could occur if the STW transfer is maintained, and we do not lose any of our River Derwent licence through the environmental destination (CSMG target). Under this scenario the internal transfer main from York to South Yorkshire (DV8(iv)) would not be required in 2035/36, the Tees transfer (DV7a(vi)) option would not be required in 2049/50 and the R31a Additional bankside storage at York WTW option would not be required in 2066/67.

As the high stress test scenarios risks are beyond the first 25 years of the planning period there would be time to monitor the impacts of climate change and to plan for the enhanced environmental destination outcome. However, to demonstrate mitigation of the risks we are including an additional option as an alternative scenario to our best value plan. This alterative would include the tidal abstraction reservoir (R78) option to abstract from the Tidal Abstraction Reservoir when the water quality is less saline. We have selected this option as it appears in three of our best value runs, including the maximise six capitals run. It is located in East Yorkshire, an area that would be impacted by a reduction in the River Derwent licence, and it could connect to existing networks.

The second chart in Figure 9.7 incorporates the 20Mld benefit of the R78 tidal abstraction reservoir into the best value solution. The enhanced environment destination scenario deficit is closed by including this option and the high climate change deficit is closed until 2084. The option does not remove the long-term risk of the combined high climate change and enhanced environment destination scenario. As the impact of climate change in our baseline scenario is already representative of an extreme climate change scenario, our alternative pathways (see Section 10) include an enhanced environmental destination pathway as we consider this a more likely scenario than the high climate change scenario.

The R78 tidal abstraction reservoir would require significant investigations and its possible the tidal abstraction would not achieve the assumed benefit (20Ml/d) and instead we would require a desalination plant at the same location. We consider 20Ml/d to be a conservative estimate of the benefit of desalination and depending on the outcome of investigations, it is possible we could achieve a greater benefit from both the estuary options. By adding this option to our plan to address the longer-term risks it gives us time to complete the investigations before the risks emerge.

9.6.2 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. As described above for our critical period scenario we will temporarily reduce the headroom uncertainty to remove the deficit. If we increase target headroom to account for uncertainty of the solution programme the deficit will increase. We would then still have the problem that additional options cannot be implemented in time to close the gap therefore an increased headroom is not an option for this plan.

Demand reduction solution uncertainty

Our best value preferred plan (candidate solution 04.01) includes leakage reduction and customer demand reduction options that will be implemented from the start of the planning period in 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.

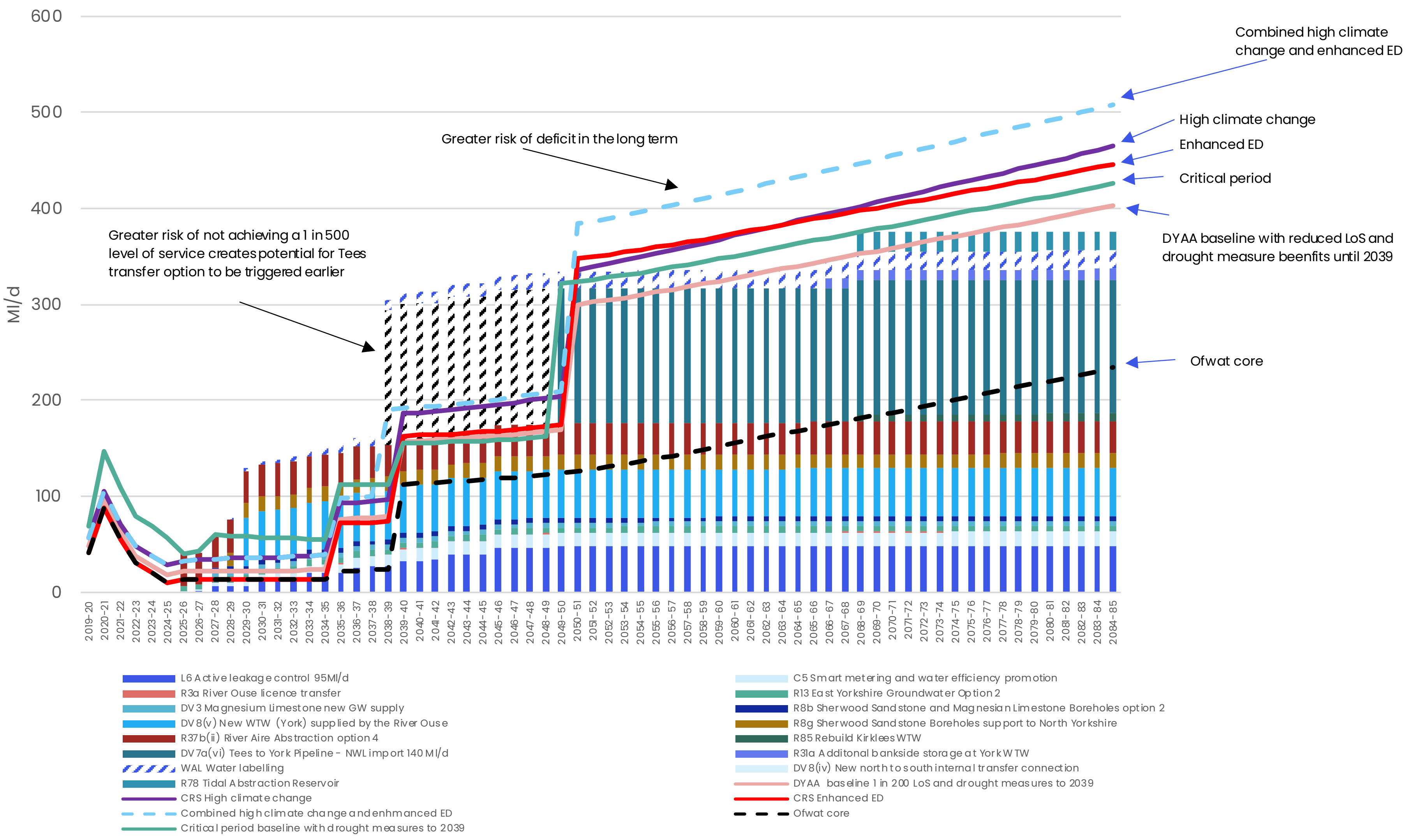
By the end of the planning period (2084/85) the total benefit from demand reduction is 165Ml/d in the Grid SWZ. With water labelling our average PCC is projected to be 106 l/h/d by 2050, without labelling it is projected to be 112 l/h/d. This equates to demand reduction benefit of 63Ml/d in our Grid SWZ (0.5Ml/d in our East SWZ) by 2049/50. With the addition of leakage reduction benefits this increases to 158Ml/d.

We have created glidepaths for achieving the demand reduction objectives and the certainty of achieving this benefit reduces over time as the costs increase. To test the sensitivity of our preferred plan to demand reduction uncertainty we have created a final plan scenario that halves the assumed benefits included in the preferred plan for leakage and PCC reduction, see Figure 9.8.

In this scenario we become vulnerable in 2039 when we move to a 1 in 500 level of service. We would still have a marginal surplus in the DYAA baseline scenario until 2060. This allows time to monitor the success of the demand reduction options and invest in further options in the future if the need is triggered. However, the surplus is very small, and the higher scenarios shows a risk of a deficit.

If we were following this lower demand reduction scenario and the high climate change scenario, we would require additional supply by the late 2030s to be resilient to a 1 in 500 drought return period. Our solution to this is to monitor the impact of demand reduction and climate change and prepare for bringing the Tees transfer option forward. We are assuming a 10-to-15-year lead in time for delivering the transfer to allow for additional option scoping and investigations prior to construction. We shall start this work in AMP8 to ensure the option can be brought online for 2039/40 if our plan (WRMP29) shows we are following a low demand reduction pathway. We have selected this option as it is already part of our longer-term solution, and it would be required by 2049/50 under the baseline scenario. We would need to develop further options for the longer-term deficit, and we shall consider this in our next WRMP.

Figure 9.8: 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. The near-term solution risks were considered when forming the preferred plan however, the success is still very much dependent on the outcome of investigations and there is still a risk the combined total benefit is less than predicted. 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 desk top studies to collate the data needed to meet the WRPGL 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. Assuming all preliminary permissions are granted there is then a construction phase before the water would be available for supply.

The preferred plan solution and the delivery risk are summarised in Table 9.11.

Table 9.11: Preferred (best value) plan delivery risks

Preferred plan solutions	First year of benefit	Delivery risk
LoS reduced to 1 in 200 until 2030s	Base year (to 2039 at the latest)	Reduced ability to meet demand in extreme events
Drought measures	Base year (to 2039 at the latest)	Unreliable benefits that will vary in different circumstances. Impacts the environment.
L6 Active Leakage Control 95 Ml/d	2025	Benefits uncertain and increases over time and in dry weather
C5 Smart Metering and Water Efficiency	2025	Benefits uncertain and increases over time and in dry weather
Labelling	2027	Benefits uncertain
DV8(v) New WTW (York) supplied by the River Ouse	2029	This option makes use of an existing licence but water availability dependent on the outcome of a WINEP investigation and HD appropriate assessment.
DV8(iv) New north to south internal transfer connection -50Ml/d capacity 0 Ml/d benefit	2035	Low risk but is a transfer capacity option and does not increase available supply
DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d	2050	Water is available but requires significant new infrastructure and assets and assumed delivery time up to 15 years.
R13 East Yorkshire Groundwater Option 2	2028	Water quality could be a risk but locations assumed favourable
DV3 Magnesium Limestone new GW supply	2028	Low risk and may be more water available than assumed (5Ml/d)

Preferred plan solutions	First year of benefit	Delivery risk
R31a Additional bankside storage at York WTW	2066	Low risk as utilises existing resources and stores for dry periods
R8g Sherwood Sandstone support to grid	2029	WFD assessment needed but we have assumed a conservative benefit from the aquifer
R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2	2028	We have assumed a conservative benefit from the aquifer
R3a River Ouse licence transfer	2027	Dependent on the outcome of a WINEP investigation
R85 Rebuild Kirklees WTW	2068	Low delivery risk but makes use of exiting sources and does not provide a new supply
R37b(ii) River Aire Abstraction option 4	2031	Further modelling needed to confirm water availability and address potential system constraints.

The risk of delivery is 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. If early investigations show any of the supply options included in our best value plan will not achieve the assumed benefit, we shall divert to options such as increase R3 River Ouse pumping capacity to full licence capacity and R6d South Yorkshire Groundwater Option 4. These options make use of existing supplies and could be implemented sooner than some of the best value options. However, R6d South Yorkshire Groundwater Option 4(20Ml/d) may not be available in the future as the resource is under WINEP investigation and at risk under the environmental destination – this does not present a low regrets solution but could achieve a short-term benefit. We shall also continue to explore further options to address this in our final WRMP24.

For the longer-term risks from 2050 onwards 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 STW transfer in 2035 and the River Derwent licence in 2050 will be made in advance of the final dates, which would also influence the longer term options.

The DV7a(vi) - Tees to York Pipeline - NWL import - 140Mld option will take considerable time to implement and we have assumed up to 15 years. The first five years 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.

As we are experiencing a severe dry year in 2022, we would also need to work with NWL to understand if this impacted on their modelling of the 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. We shall discuss the option further with NWL including the potential for the option becoming an SRO and entering the RAPID gated process. 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 and design and construction commence.

10. Grid Surface Water Zone preferred plan

This section of our WRMP describes how we have used all the information presented within this plan to identify our final planning scenario – our preferred plan. It also presents adaptive pathways to alternative futures.

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 for determining a best value plan and candidate solution 04.01 performed best against our best value plan metrics.

We have stress tested the best value plan to key uncertainties. The stress tests are based on known risks that create significant future uncertainties. The final step in formulating our preferred plan is to create an adaptive plan that enables it to be flexible to the uncertainties.

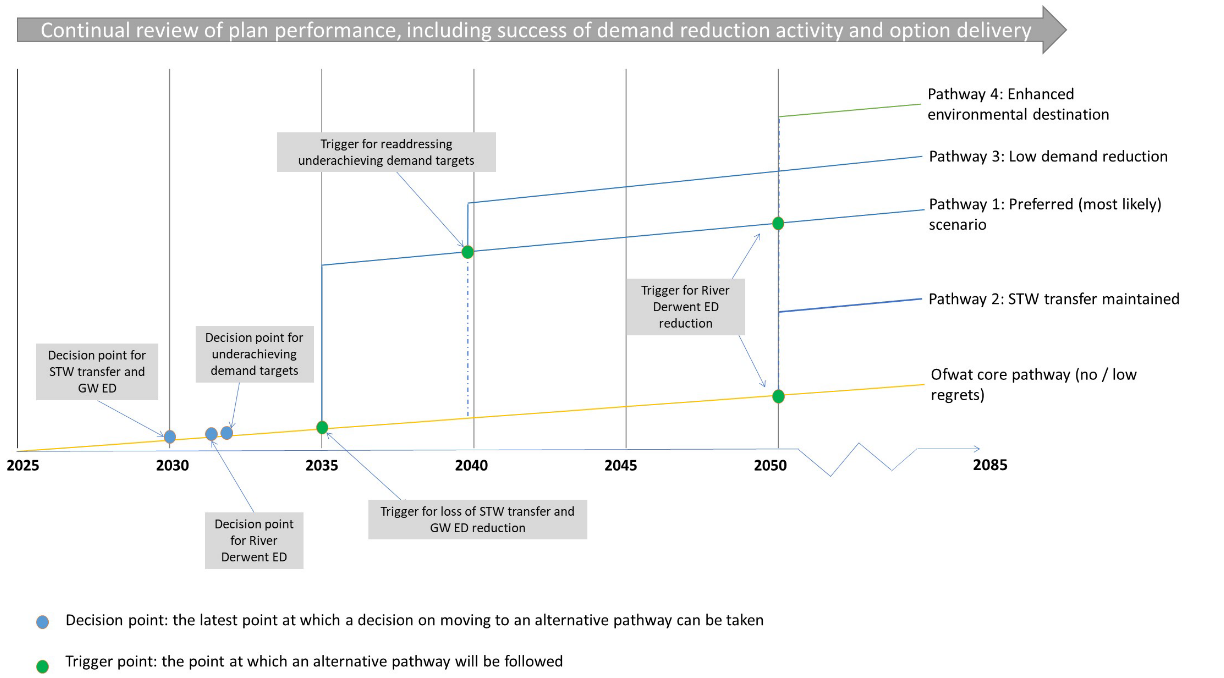
10.1 Adaptive planning

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 we must consider this in our final preferred plan. The known risks in our plan allow us to incorporate an appropriate level of flexibility and divert to an alternative future if required.

Risks, including the loss of the STW import and 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 best value plan to the common reference scenarios (see Section 9.6). Not all the common reference scenarios are showing a deficit and for others, the deficit is smaller than the baseline. This means no additional options are required beyond those included in our preferred plan. However, these alternative futures can still change our plan and result in planned interventions not being required. To prepare for the alternative futures we have created five potential pathways.

Figure 10.1: WRMP24 core adaptive pathways



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.

For example, the STW transfer is most likely to terminate in 2035. There is an alternative pathway with the STW transfer maintained from 2035 onwards. Our preferred plan (Pathway 1) is to implement a solution that offsets the loss and ensures the South Yorkshire Water demand can be met. The decision point is in 2030. This the final date in the agreement between Yorkshire Water and STW that allows for either party to give notice of termination in 2035. At this point we will know which pathway we are following and whether or not we need to install the new interconnecting pipeline from York to South Yorkshire (DV8(iv)).

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 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. We have stress tested a combined high climate change and enhanced environmental destination scenario, but we have not planned to meet this deficit. The baseline climate change impact already represents a severe reduction in supply and to plan for 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.

Pathway 1: Preferred plan (most likely) scenario: This is the most likely pathway represented by the baseline supply-demand balance in the YWSEST and YWSGRD WRP tables. The best value 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. The options included are listed in Table 10.1.

Pathway 2: STW transfer maintained: This pathway assumes the STW transfer could be maintained in the future. Under this scenario there are two options included in the preferred plan we would not implement. These are the internal transfer main from York to South Yorkshire (DV8(iv)) and the additional bankside storage on the River Ouse (R31a). The decision would be made in 2030 and the pathway triggered in 2035.

Table 10.1: Preferred plan solution programme

Option	First year of benefit	Benefit (Ml/d) on full implementation
Plan to a 1 in 200 level of service until 2039	Immediate effect	52 (reduces slightly each year due to climate change impacts)
Drought measures until 2039	Immediate effect	Assumed benefits circa 40
L6 Active Leakage Control 95 Ml/d (halving leakage by 2050)	2025/26	95
C5 Smart Metering and water efficiency	2025/26	32**
Labelling of water use appliances*	2027/28	39**
R13 East Yorkshire Groundwater Option 2 - new groundwater supply and WTW	2025/26	6 (8 maximum)
R37b(ii) River Aire Abstraction option 4	2025/26	34
R3a River Ouse licence transfer at low flows	2027/28	0.3 (15 maximum)
DV3 Magnesium Limestone new GW supply	2027/28	5
R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2	2027/28	5
R8g Sherwood Sandstone Boreholes support to North Yorkshire	2028/29	15
DV8(v) New WTW (York) supplied by the River Ouse new treatment stream adjacent to existing site	2029/30	50
DV8(iv) New north to south internal transfer connection -50Ml/d capacity 0 Ml/d benefit	2035/36	n/a – required to transfer new source of supply to South Yorkshire
DV7a(vi) Tees to York Pipeline - NWL import - transfer from Northumbrian Water supported by Kielder Water	2049/50	140
R31a Additional bankside storage at York WTW	2066/67	11
R85 Rebuild Kirklees WTW – new WTW	2068/69	8

* this is not a YW option

**provides a benefit in the East SWZ as well as Grid SWZ

Pathway 3: Low demand reduction: 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 will be half that assumed in our preferred plan pathway.

This pathway would bring forward the Tees transfer option and leave us vulnerable in the longer term. We have not identified the longer-term solution in this pathway as our WRMP24 plan to build on our available options and understand alternatives to the Tees transfer will be incorporated into WRMP29 when we will readdress this risk.

We have included a decision point in 2032 and a trigger in 2038 for this pathway. However, the uncertainty cannot be defined to a single year, and we will monitor our progress each year and review in each iteration of our WRMP and alter our plan accordingly.

Pathway 4: Enhanced environmental destination: This pathway represents the enhanced environmental destination and the risk of additional deficit if the outcome of the River Derwent investigations is more severe than assumed in our preferred pathway. Under this scenario we would be required to invest in additional option in 2060s. We have selected a new abstraction from the Humber Estuary that would be stored in a tidal abstraction (R78) reservoir 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.

The trigger for the pathway is 2049 when the CSMG target will be applied. The decision point is well in advance of this date in 2032. The time between the decision and the trigger allows for the complexities of this pathway to be resolved. Currently the scale of the loss is unknown but could be high (130Ml/d or more). This reduction in our available supply would have a significant impact particularly if we were also following the low demand pathway. We have allowed time for understanding the impact and ensuing we have sufficient options implemented that can reliably secure supply to our customers.

Ofwat core pathway: This pathway represents the minimum interventions required to ensure the future risks are mitigated and we are resilient to future drought events. It assumes all options planned for AMP8 and 9 will be implemented. However, as in Pathway 2, there is potential that the STW transfer could continue if STW's plan diverts to a different pathway. There is also a possible outcome from the River Derwent environmental destination investigations that the licence is not reduced. This alternative outcome would negate the need for three options included in the preferred pathway. These options are - internal transfer main from York to South Yorkshire (DV8(iv)), the Tees to York transfer from NWL (DV7a(vi)) and the additional bankside storage on the River Ouse (R31a).

The options included in each of the alternative pathways are presented in Table 10.2.

Table 10.2: WRMP24 Adaptive pathway options

Option Name	Preferred (Most Likely) Programme	Least Cost CP Programme	Least Cost DYAA	Ofwat Core Programme	Alternative 1 – STW transfer maintained	Alternative Programme 2 – Pathway 3 Low demand reduction	Alternative 3 – enhanced environmental destination
C5 Smart Metering and Water Efficiency	✓	✗	✗	✓	✓	✓	✓
DV3 Magnesium Limestone	✓	✓	✓	✓	✓	✓	✓
DV7a(vi) Tees to York Pipeline - NWL import 140 Ml/d	✓	✓	✓	✗	✓	✓	✓
DV8(iv) New north to south internal transfer connection	✓	✓	✓	✗	✗	✓	✓
DV8(v) New WTW (York) supplied by the River Ouse	✓	✓	✓	✓	✓	✓	✓
L6 Active Leakage Control 95 Ml/d	✓	✓	✓	✓	✓	✓	✓
R3a River Ouse licence transfer	✓	✗	✗	✓	✓	✓	✓
R8b Sherwood Sandstone and Magnesian Limestone Boreholes option 2	✓	✓	✗	✓	✓	✓	✓
R8g Sherwood Sandstone Boreholes support to North Yorkshire	✓	✓	✓	✓	✓	✓	✓
R13 East Yorkshire Groundwater Option 2	✓	✓	✓	✓	✓	✓	✓
R31a Additional bankside storage at York WTW	✓	✓	✓	✗	✗	✓	✓
R37b (ii) River Aire Abstraction option 4	✓	✗	✗	✓	✓	✓	✓
R85 Rebuild Kirklees WTW	✓	✗	✗	✓	✓	✓	✓
R78 Tidal Abstraction Reservoir	✗	✗	✗	✗	✗	✗	✓

10.2 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 10.2 summarises our WRMP24. 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 10.3 and we shall report progress to Defra in annual reviews of our WRMP.

Figure 10.2: WRMP24 key dates and actions

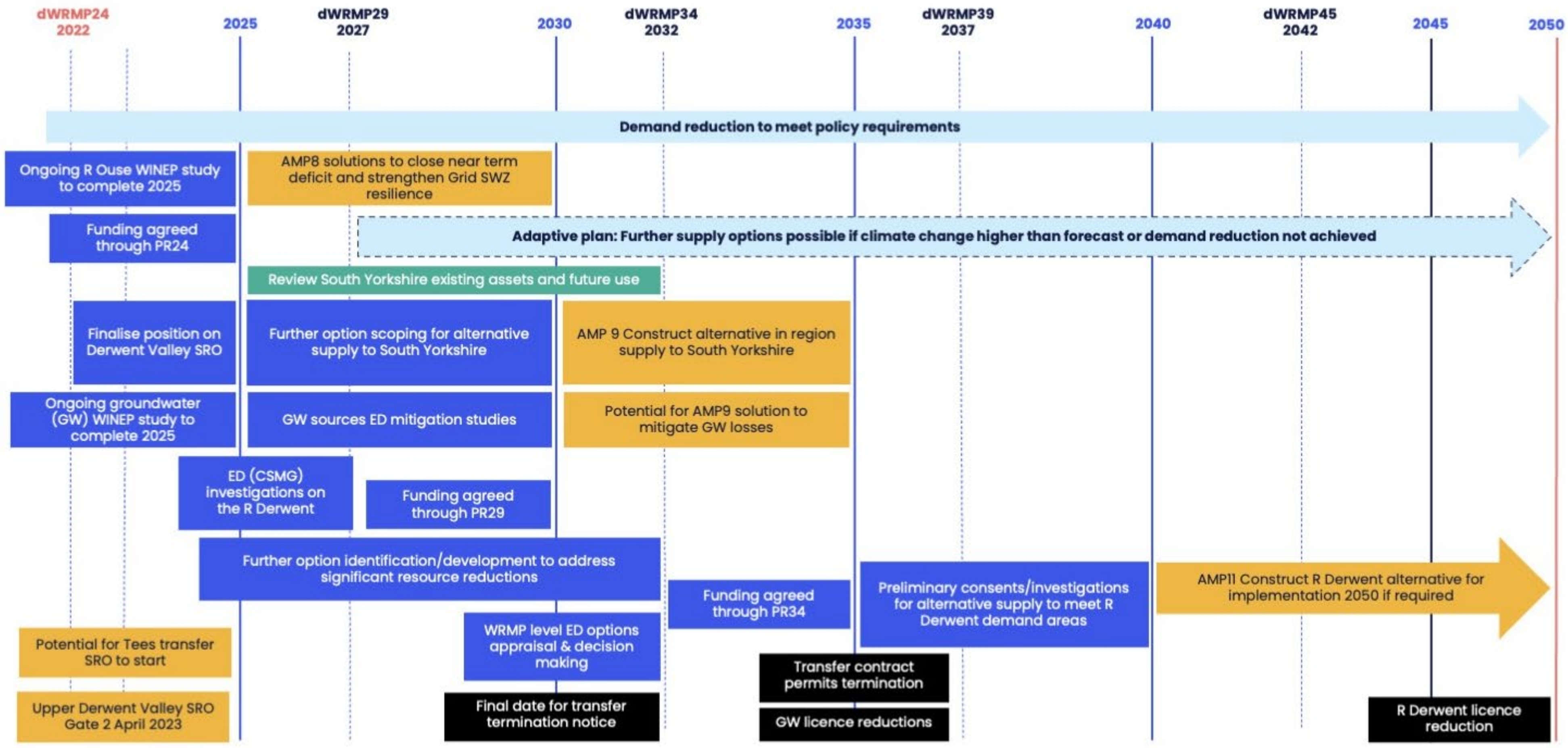


Table 10.3: WRMP24 adaptive plan monitoring

Option	Decision point	Trigger	Monitoring
Plan to a 1 in 200 level of service until 2039	2027 (and each iteration of draft WRMP)	2030 (and the start of each AMP)	• Our levels of service are reviewed with each iteration of our WRMP and drought plan and following dry weather events. We shall review the date for achieving the 1 in 500 level of service in our final WRMP24. Our current plan suggests we could achieve this objective prior to 2039 but as our area is currently in a drought our preference is to first review data from the summer of 2022 and how these impacts on our plan. • The level of service risk will be reviewed for each draft WRMP. 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.
Drought measures until 2039	2027 (and each iteration of draft WRMP)	2030 (and the start of each AMP)	• Our plan shows we should be resilient to a 1 in 500 level of service without the need for drought measures by 2039. We shall review this with each iteration of our WRMP and drought pan. • Once the solution is implemented, we shall use our simulation model to confirm our level of service. If our modelling shows we are resilient to 1 in 500 drought we will review our drought plan and the triggers for actions.
L6 Leakage reduction (95Ml/d 50%)	2032 (and each iteration of draft WRMP)	2038	• A delivery assurance group meets monthly to track leakage against the annual target and weather conditions to adjust the approach if required. • 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. • 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.

C5 Smart Metering and water efficiency	2032 (and each iteration of draft WRMP)	2038	• 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. • 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.
Labelling of water use appliances	2032 (and each iteration of draft WRMP)	2038	• 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	-	-	• Decision and trigger points are not included as the decision is already reached for implementing these actions. • For the final WRMP24 we shall review our critical period needs against the summer of 2022 and learning from the current drought and impacts on demand and supply availability. • We shall start preliminary investigations and construction of options this AMP. • If there is a risk of not closing the deficit, we shall implement further solutions e.g. bring forward the Ouse bankside storage (R31a) and implement the Increased River Ouse pumping capacity (R3) scheme. • Our preferred plan includes additional headroom to allow for the solution under achieving and to provide resilience benefits during short duration (less than seven days) peak demands.
STW transfer	2030	2035	• Gate 2 (2023) of the UDVSRO will determine if there is a pathway to maintain the transfer. • The final decision, in accordance with the current transfer agreement will be 2030 and if the transfer is to terminate, we shall implement the interconnecting pipeline in AMP9.

Groundwater ED	2030 (draft WRMP29)	2035	• The WINEP investigations on our groundwater sources will be complete by 2025. This will determine if any licence reductions are required. • We have assumed any reduction in licence will be delayed until 2035 when we have implemented AMP8 solutions (supply and demand) and reviewed if any additional interconnections are required in AMP9 to support the demand areas that will be directly impacted by licence reductions.
Surface water ED (River Derwent)	2032 (draft WRMP34)	2049	• Environmental and option development investigations will be carried out in AMP8 for determining both the scale of loss on the River Derwent and the final solution for mitigating the loss. • We expect to have confirmation of which ED pathway we are following by 2032 when we submit our draft WRMP32. The scale of the loss will determine if we are following the low, baseline (BAU+) or enhanced ED pathway. • If the low demand pathway is triggered, we shall require additional options in our plan and we will need to build this into our WRMP29 and WRMP32 accordingly.

10.3 Benefits of the Grid SWZ preferred solution

Our preferred plan is a twin track approach to reduce demand and increase supply and is aimed at achieving 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 10.4 against the objectives set out in Section 9.

Table 10.4: Preferred plan actions

Yorkshire Water WRMP24 Objectives	Preferred plan actions
1. Close the supply-demand balance deficit	The DYAA baseline deficit from 2025 to 2085 has been met but is dependent on options R13 East Yorkshire Groundwater Option 2 being delivered by 2025. The critical period deficit could not be met in the early years, and we will be operating to reduced headroom until 2027. We shall consider these risks further for our final plan.
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. The uncertainty of achieving this target will increase over time and may require us to divert to the low demand pathway. We will monitor our progress.
3. Achieve an average PCC of 110 l/h/d by 2050	Meeting the PCC policy target has been built into our plan to achieve 106 l/h/d by 2050. We shall monitor progress towards this target and whether we divert to the low demand pathway in the future. The success of this objective is partly dependent on the government's water labelling initiative.
4. Become resilient to 1 in 500 drought events without reliance on drought measures	Our plan aims to meet this objective by 2039. We could achieve this earlier in the mid-2030s, however our sensitivity assessment and risk of diverting to an alternative pathway has concluded the 2039 target is most representative of the risks. We shall review this for the final WRMP24.
5. Increase resilience in the Grid SWZ and localised growth hot spots	Our preferred plan includes investment in the Dales (R8g), Howardian Hills (R8b), Bradford (R37b(ii)) and York (DV8(v)) areas that will mitigate some of the risks identified by our WSSS as well as closing the supply-demand balance gap. There is a future risk to the York area once the supply is required to support South Yorkshire. At this stage we have chosen to delay the decision on this additional investment and develop further options for the WRMP29 plan and monitor our demand reduction.
6. 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.
7. Offset the STW transfer termination	This will be met through investment in: DV8(v) New WTW (York) supplied by the River Ouse, a new treatment stream adjacent to the existing site. It will require DV8(iv) New north to south internal transfer connection to provide the supply to South Yorkshire.
8. Offset the ED BAU+ Surface water loss on the River Derwent	We have included the Tees transfer option to offset the baseline loss. 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. The loss of the supply is not triggered until 2049 to allow time to develop the Tees solution or a better value alternative – which we will investigate in AMP8. If we are following our low demand pathway the Tees transfer could be triggered sooner and we would need to find an alternative in the longer term.

The total benefit from the supply and demand options included in our preferred best value solution to the Grid SWZ DYAA scenario deficit will be 144Ml/d by 2025, increasing to 273Ml/d by 2050 and 441Ml/d by 2085. A breakdown of the yield benefits of the preferred solution is presented in Table 10.5.

During the first five years of our planning period, from 2025 to 2030 (AMP8) we will implement seven new supply options to achieve a combined DYAA benefit of 118Ml/d and critical period benefit of up to 127Ml/d. Two of the supply-side options (R13 East Yorkshire Groundwater Option 2 and R37b(ii)) River Aire Abstraction option 4 will be implemented in AMP7 to achieve a benefit from 2025 onwards. We shall also start investigations in AMP7 into new groundwater options (DV3, R8b and R8g) and understand if a greater or lower benefit would be achieved than we have assumed in our desk top studies.

In AMP9 we will invest in the internal transfer to support the new supply to the South Yorkshire area. Assuming we are following our baseline scenario and achieve the benefits we have estimated through our AMP8 supply-side options and 25-year demand reduction options we will not require any further new supplies until 2050 when the Tees transfer is brought in to offset any loss of the River Derwent licence reduction. However, our WRMP24 plan includes additional options identification, as we aim to increase our option portfolio and potentially identify better value options.

Beyond 2050 we have included further supply options to close the longer-term deficit. These include additional bankside storage on the River Ouse (R31a) and rebuilding a WTW in the south east of our region (R85 Rebuild Kirklees WTW). If we are following the enhanced environmental destination pathway, we would invest in a new abstraction on the Humber Estuary requiring a desalination plant (R61) or new tidal abstraction reservoir (R78).

As part of our plan, we are also proposing a licence variation to an abstraction we hold for a reservoir in North Yorkshire. This solution is R90 North Yorkshire annual licence increase. It is included in our solution but it 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.

Table 10.5: Start date and yield of schemes to deliver the Grid SWZ preferred solution

Ref.	Option	First year of benefit	Year full benefit implemented	Benefit on completion (Ml/d)	Critical period benefit (Ml/d)
L6	Active Leakage Control	2025/26	2049/50	95	95
C5	Smart metering and water efficiency	2025/26	2084/85	31 (28 by 2050)	31 (28 by 2050)
WAL	Labelling	2027/28	2084/85	39 (35 by 2050)	39 (35 by 2050)
R13	East Yorkshire Groundwater Option 2	2025/26	2025/26	6	8*
R37b(ii)	R. Aire abstraction	2025/26	2025/26	33.5	33.5
R3a	R. Ouse licence transfer	2027/28	2027/28	0.3	15*
DV3	Magnesium Limestone new GW supply	2027/28	2027/28	5	5
R8b	Sherwood Sandstone and Magnesian Limestone Boreholes option 2	2027/28	2027/28	5	5
DV8(v)	New WTW at York	2029/30	2029/30	50	50
R8g	Sherwood Sandstone support to grid	2028/29	2028/29	15	15
Ofwat core scenario total benefit by 2085				**283**	**300**
DV8(iv)	internal transfer	2035/36	2035/36	n/a	n/a
DV7a(vi)	Tees to York transfer from NWL	2049/50	2049/50	140	140
R31a	Additional bankside storage on the R. Ouse	2066/67	2066/67	10.6	10.6
R85	Rebuild WTW	2068/69	2068/69	8	8*
Pathway 1 Preferred plan total benefit by 2084/85				**441**	**458**
R78 (or R61)	Humber Estuary with a tidal abstraction reservoir or desalination plant	2068/69	2068/69	20	20
Pathway 5 enhanced environmental destination total benefit by 2084/85				**461**	**478**

* Critical period benefits represent an assumed increased benefit that operationally could be put into supply, but the combined total would vary in different drought situation depending on the location of the most affected areas and whether the water was available at the time of need.

10.4 SEA of Preferred Plan

Table 10.6 below provides a summary of the SEA outputs for the preferred plan.

Table 10.6: SEA outputs of Grid SWZ preferred solution

Scheme	Adverse																
	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
C5 Smart Metering and Water Efficiency				None		None						None				None	None
L6 Active Leakage Control 95Ml/d				None													
DV3 - South Yorkshire GW				None							None						
DV7a(vi) -Tees - York Pipeline Option 1				None							None						
DV8(iv) - York to South Yorkshire Pipeline				None					None		None						
DV8(v) - York WTW Capacity increase				None							None						
R3a River Ouse pump storage capacity				None		None											None
R8b: Sherwood Sandstone and Magnesian Limestone Boreholes Option 2				None							None						
R8g Sherwood Sandstone Boreholes support to North Yorkshire				None							None						
R13 East Yorkshire Groundwater Option 2				None							None						
R31a Additonal bankside storage on the River Ouse				None							None						
R37b(ii) River Aire Abstraction Option 4											None						
R85 Recommision Kirklees WTW				None						None	None	None					

Scheme	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
C5 Smart Metering and Water Efficiency				None		None						None				None	None
L6 Active Leakage Control 95Ml/d				None													
DV3 - South Yorkshire GW											None						
DV7a(vi) -Tees - York Pipeline Option 1											None						
DV8(iv) - York to South Yorkshire Pipeline									None		None						
DV8(v) - York WTW Capacity increase											None						
R3a River Ouse pump storage capacity				None		None											None
R8b: Sherwood Sandstone and Magnesian Limestone Boreholes Option 2											None						
R8g Sherwood Sandstone Boreholes support to North Yorkshire											None						
R13 East Yorkshire Groundwater Option 2											None						
R31a Additonal bankside storage on the River Ouse											None						
R37b(ii) River Aire Abstraction Option 4											None						
R85 Recommision Kirklees WTW				None						None	None	None					

Key	
None	No effect
	Negligible adverse
	Minor adverse
	Moderate adverse
	Major adverse
	Negligible beneficial
	Minor beneficial
	Moderate beneficial
	Major beneficial

The preferred plan includes two demand management options: L6 Active leakage control 95Ml/d and C5 Smart metering and water efficiency. The customer option (C5) is assessed within the SEA as resulting in moderate beneficial effects relation to sustainable and efficient use of water resources. The SEA findings also conclude that C5 Smart metering and water efficiency will result in minor beneficial effects across a range of other SEA objectives. The L6 Active leakage control 95Ml/d option is assessed as resulting in major beneficial effects across five SEA objectives in relation to human health and wellbeing, sustainable and efficient use of water resources and climate change resilience. Minor adverse effects have been identified in relation to the air and climate SEA objectives regarding use of material resources, air pollutant and greenhouse gas emissions.

A range of supply side measures are also included within the preferred plan. Major adverse impacts for options DV7a (vi) York Pipeline Option 1 and DV8 (iv) York to 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. However, these options 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 four resource options within the preferred plan are anticipated to result in moderate adverse effects on biodiversity. This is in relation to scheme construction and minor adverse effects across a number of SEA objectives, including for population and human health and cultural heritage. The remaining six supply side options 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.

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 uncertain impacts associated with multiple WFD water bodies in relation to four schemes within the preferred plan: R8b: Sherwood Sandstone and Magnesian Limestone Boreholes Option 2, R8g Sherwood Sandstone Boreholes support to North Yorkshire, R13 East Yorkshire Groundwater Option 2, and DV7a (vi) York Pipeline Option 1. Further investigations will need to be carried out to confirm these impacts before the schemes could be implemented. East Yorkshire Groundwater Option 2 will be within any constraints imposed following Water Industry National Environment Programme (WINEP) investigations.

Implementation of the four options above, as well as options R37b River Aire Abstraction Option 4 and DV3 South Yorkshire GW, will be dependent on meeting EA licensing requirements.

10.5 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. above provides a summary of the SEA outputs for the preferred plan.

There is the potential for cumulative impacts between two schemes which have been included in the preferred plan as the DV7a (vi) Tees - York Pipeline Option 1 and DV8 (iv) York to South Yorkshire pipeline schemes may have overlapping construction phases. However, the geographical extent of the pipeline routes in both schemes are large and until detailed construction plans are developed, it is not possible to confirm the likelihood of any effects. The detailed design for each scheme will include a range of measures to avoid and reduce significant effects and will include a review of need for further measures should the construction works coincide on both temporal and geographical scales.

There is no potential for cumulative effects during operation of the schemes included in the preferred plan, as there are no water bodies that are impacted by more than one option.

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 WRMP19 and any other relevant plans, programmes, and projects.

10.6 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 Bill (2021) which requires any options within the plan that need planning permission to provide biodiversity net gain of 10%. BNG 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[34].

Additionally, the EA have published supplementary guidance on Environment and Society in decision-making[35], 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 1.4 in Table 8.8).

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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[34] 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/

[35] EA (2021) WRPG 2024 supplementary guidance – Environment and society in decision-making. Published 24/03/2021

10.7 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.

Table 10.1 in Section 10.1 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 English Heritage, 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 English Heritage, 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 and PCC targets and on our carbon footprint.

Once we have implemented our preferred solution for the Grid SWZ both our water resource zones will show a surplus supply-demand balance. The 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 WRMP24 has been created ahead of our business plan (PR24). Once we have finalised our WRMP24 there will be direct alignment between our WRMP24 and our PR24 Business Plan, particularly in respect of long-term planning requirements as set out in Ofwat's 'long-term delivery strategies". Our WRMP24 will also be 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

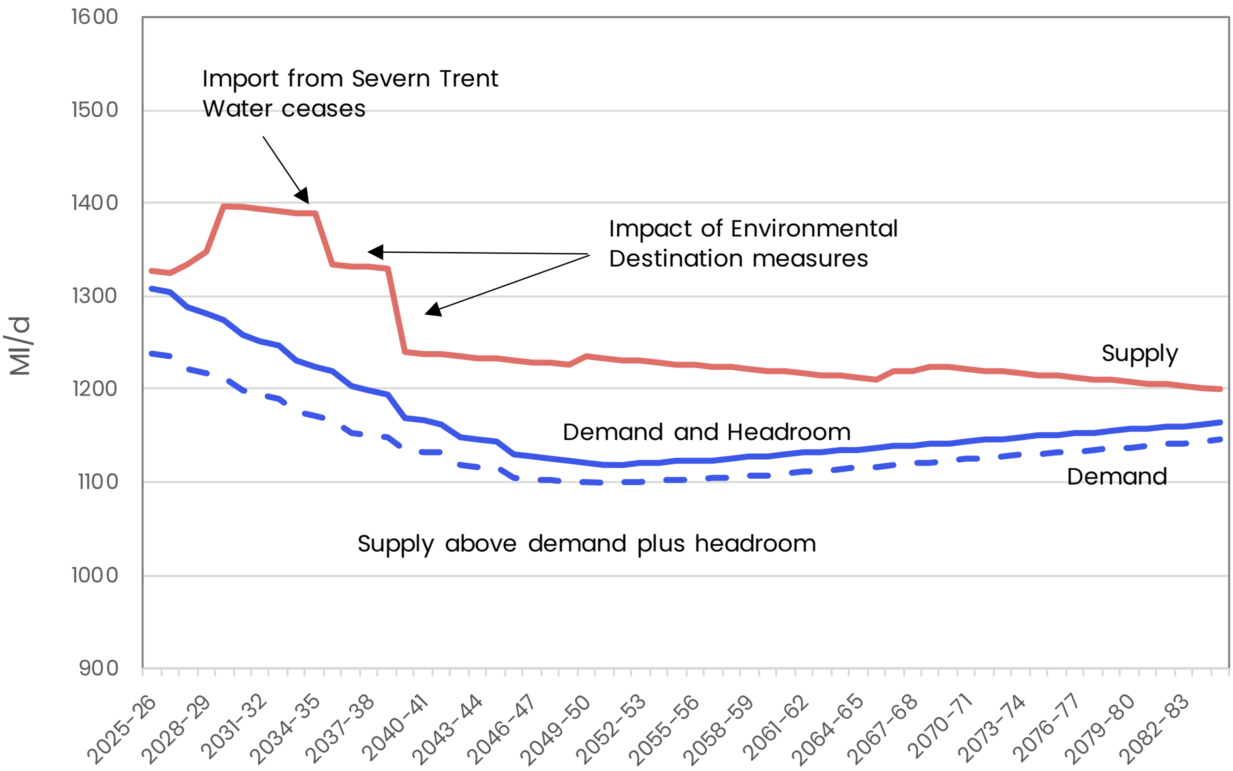
The final plan supply-demand balance for our two zones is presented in WRP tables YWSEST and YWSGRD. The YWSEST final plan scenario shows a minor change due to the benefits (0.5Ml/d) of the demand reduction interventions to reduce PCC. The YWSGRD table shows a much more significant change once the best value solution to close the DYAA and critical scenario deficits is incorporated into the final supply-demand balance calculations.

Table 11.1 gives the WAFU, distribution input and surplus in each zone, with the impact of the preferred solution incorporated. Figure 11.1 shows the Grid SWZ final plan scenario supply-demand balance with the preferred pan benefits.

Table 11.1: Final plan supply-demand balance

Resource Zone Scenario	2025-26	2026-27	2027-28	2028-29	2029-30	2049/50	2084/85
Grid SWZ DYAA FP WAFU (Ml/d)	1327.63	1326.03	1334.72	1348.11	1396.48	1234.68	1200.13
Grid SWZ DYAA FP distribution input (Ml/d)	1238.27	1236.23	1221.32	1217.04	1212.69	1100.19	1145.22
Grid SWZ FP DYAA surplus (Ml/d)	19.58	21.87	47.32	66.83	121.41	114.01	36.01
Grid SWZ CP FP WAFU (Ml/d)	1438.28	1437.64	1447.30	1461.65	1511.00	1379.58	1373.94
Grid SWZ CP FP distribution input (Ml/d)	1385.01	1383.45	1368.97	1365.10	1361.14	1259.06	1327.26
Grid SWZ Final plan CP (Ml/d) surplus (Ml/d)	0.00	0.00	10.29	30.54	85.88	90.01	12.69
East SWZ FP DYAA WAFU (Ml/d)	12.75	12.73	12.71	12.69	12.67	12.24	11.42
East SWZ FP DYAA distribution input (Ml/d)	7.35	7.37	7.38	7.38	7.36	7.09	7.39
East SWZ FP DYAA surplus (Ml/d)	4.38	4.34	4.31	4.29	4.29	4.38	3.19

Figure 11.1: Grid SWZ final plan surplus



11.1.1 Final planning headroom

We have not carried out a final plan headroom assessment for WRMP24. The East SWZ did not require a solution to a deficit and headroom remains the same as the baseline scenario. The Grid SWZ did require solutions but a scenario approach to uncertainty has been applied though the adaptive pathways. 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 table for the Grid SWZ DYAA scenario includes an increased headroom allowance compared to the baseline from 2025 to 2039, which is representative of the 1 in 200 drought return period headroom risk. From 2039 onwards, when we are resilient to a 1 in 500 drought risk, the final plan includes the same headroom risk applied to the baseline for these years.

Due to the immediate deficit, it would not be feasible to bring in further solutions to increase the headroom allowance in the early years of the planning period, as there is insufficient time to implement solutions for increasing headroom. For our critical period scenario, we are operating at a reduced target headroom in 2025/26 and 2026/27. 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 11.2 summarises the final plan leakage targets, incorporating additional leakage reduction in the Grid SWZ to achieve the 50% policy requirement. The leakage target is represented as an annual target in the WRMP. It reduces from 256Ml/d in 2024/25 to 161Ml/d by 2050 and will remain at the level until the end of the 60-year planning period.

The target presented in Table 11.2 is based on the annual target derived for our WRMP and is not completely aligned with the three-year rolling average target we have derived for our PR24 business plan (see Section ⊠). We shall ensure the two plans are aligned for our final WRMP24.

Table 11.2: 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)	-	0.80	1.60	13.20	14.00	14.80	95.30
YW Leakage Target (Ml/d)	256.30	255.50	254.70	243.10	242.30	241.50	161.0

11.3 Per capita consumption target

Table 11.3 shows PCC reduction over the planning period to achieve the 2050 policy requirement. The benefit from the smart metering 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 PCC targets for the next AMP. Our AMP8 PCC target is to achieve reductions in household consumption through installing smart meters and delivering water saving initiatives, which include offering flow regulators and behavioural change advice. Our projections show this will achieve a PCC of 112 l/h/d by 2050 in the DYAA scenario.

To achieve the 110 l/h/d objective we are assuming a benefit from the government's water labelling initiative. This is projected to result in an average PCC of 106 l/h/d by 2050 in the DYAA scenario, over-achieving the target. As the success of water labelling is dependent on government action and appliance manufacturers, we will not include the annual benefit in our AMP8 PCC target. The target will be confirmed in our PR24 Business Plan and will be created using the PCC data calculated for our WRMP24. Table 11.3 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 will present in our PR24 Business Plan, which we submit to Ofwat.

Table 11.3: Future PCC projections

Future PCC projections (Ml/d)	AMP8					2050
	2025-26	2026-27	2027-28	2028-29	2029-30	2049/50
DYAA						
Cumulative household demand reduction (Ml/d)	1.83	3.63	7.24	10.85	14.48	63.12
Measured household PCC (l/h/d)	109.0	108.5	107.6	106.8	106.0	97.6
Unmeasured household PCC (l/h/d)	155.8	155.6	155.2	154.7	154.2	147.4
Average household assuming water labelling benefits PCC (l/h/d)	126.7	125.6	124.3	122.9	121.6	106.4
YW PCC initiatives assuming no water labelling benefits (l/h/d)	126.7	125.6	124.6	123.6	122.6	112.2
NYAA						
Cumulative household demand reduction (Ml/d)	1.79	3.56	7.13	10.70	14.30	62.54
Measured household PCC (l/h/d)	106.8	106.2	105.4	104.6	103.8	95.4
Unmeasured household PCC (l/h/d)	152.6	152.4	152.1	151.8	151.5	144.7
Average household assuming water labelling benefits PCC (l/h/d)	124.1	123.0	121.8	120.5	119.2	104.2
YW PCC initiatives assuming no water labelling benefits (l/h/d)	**124.1**	**123.0**	**122.0**	**121.1**	**120.1**	**109.9**

11.4 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 11.2 and includes emissions for both the East SWZ and Grid SWZ.

Figure 11.2: Baseline and final planning scenario regional greenhouse gas emissions

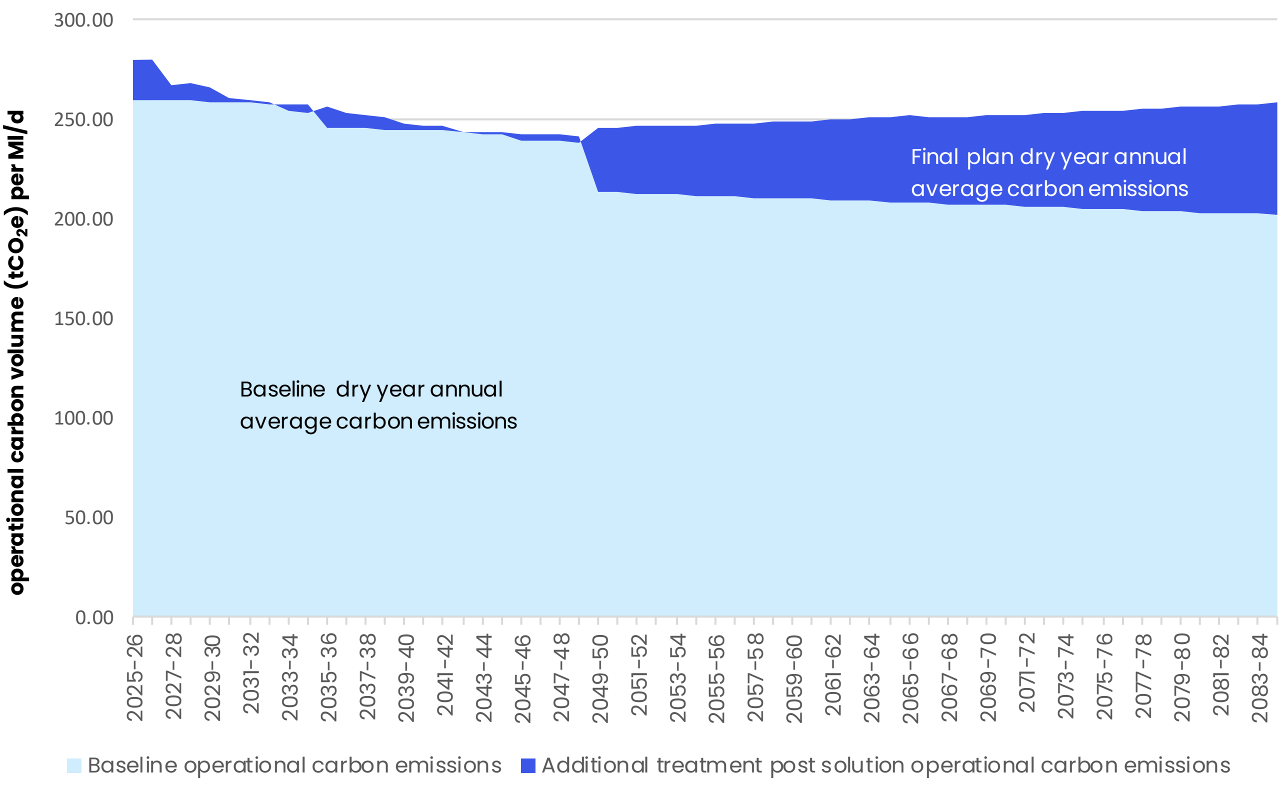


Figure 11.2 shows greenhouse gas emissions increase in the final planning scenario. In the baseline there is insufficient supply to meet demand and therefore we treat a lower volume than the final plan. Once the solution is implemented the volume of water we need to treat and distribute increases therefore 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 11.4.

Table 11.4: Greenhouse gas emissions to deliver the Grid SWZ preferred solution after implementation

Option Ref.	Option name	Operational tCO_2e per Ml/d
L6	Active leakage control 95Ml/d	0.13
C5	Smart Metering and Water Efficiency	0.29
WAL Grid	Water appliance labelling	n/a
WAL East	Water appliance labelling	n/a
R3a	River Ouse licence transfer	0.22
R13	East Yorkshire Groundwater Option 2	0.31
DV3	Magnesium Limestone new GW supply	0.49
R8b	Sherwood Sandstone and Magnesian Limestone Boreholes option 2	0.02
DV8(v)	New WTW (York) supplied by the River Ouse	0.10
DV8(iv)	New north to south internal transfer connection	-
R8g	Sherwood Sandstone Boreholes support to North Yorkshire	1.01
R37b(ii)	River Aire Abstraction option 4	0.01
R85	Rebuild Kirklees WTW	0.21
DV7a(vi)	Tees to York Pipeline - NWL import 140 Ml/d	0.11
R31a	Additional bankside storage at York WTW	0.19
R48	Reduce level of service to 1:200	n/a

11.5 Bill impact

An initial estimate of the effect of our preferred plan on customer bills shows that the investment required for this plan could increase bills by approximately £4 per annum in AMP8. This rises to approximately £14 per annum towards the end of the planning period in AMP12. It should be noted that this is a high-level initial estimate, which is based on necessarily simplistic assumptions, and consequently should be treated with caution at this stage. It is provided here purely to provide some context to the cost of the investment set out in the WRMP plan.

Further, more detailed assessment of the impact on customers' bills will be completed through the full PR24 business planning process.

We note the requirements within WRPG to consider intergenerational equity. Within our Decision Making Framework processes, we can take account of intergenerational equity but should we do this, it would be in the context of our full PR24 programme.

11.6 Carbon net zero

In 2019/20 Yorkshire Water joined other companies in the UK water sector by making a public commitment to deliver net zero carbon emissions by 2030. 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 emissions for the sector by 2030. As an energy-intensive businesses, we have an important contribution to make in tackling the causes of climate change. We can make a real difference through measures such as greater water efficiency, buying green energy as well as generating renewable energy ourselves, planting trees, restoring peatland and working with our supply chain."

In July 2021, in response to the PIC, we published some high-level information setting out our response to the commitment on our website[36]. 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[37] and the Water UK Net Zero 2030 Full Routemap[38].

Implementing our WRMP24 best value solution brings new supply options that have potential to increase our carbon emissions. As demand is increasing our operational use of existing supplies would have increased under normal weather conditions. Increased demand management helps reduce operational carbon emissions but there is still a carbon cost to delivering these solutions. As we progress to 2030 the carbon impacts of our solution will be addressed as part of our overall operational use and the need to achieve carbon net zero target.

[36] https://www.yorkshirewater.com/environment/climate-change-and-carbon/our-carbon-strategy/v

[37] https://www.water.org.uk/routemap2030/wp-content/uploads/2021/03/Water-UK-Net-Zero-2030-Routemap-Summary-updated.pdf

[38] Water UK Net Zero 2030 Full Routemap

12. WRMP24 next steps

Our WRMP24 preferred best value plan has been collated 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. Our WRMP24 is focused on the public water supply needs in our supply area but has been developed to provide a significant contribution to the regional planning framework objectives.

The WRMP24 has highlighted a much greater level of risk than WRMP19 and our plan has been shaped to address these risks. However, much of the risk did not come to light until earlier this year when the public water supply risks became much greater than was apparent for the majority of the period we were collating the data. In January 2022, the Emerging WReN Regional Plan was published and included draft WRMP data for each of the WReN water companies. At this point and throughout the period building the emerging Regional Plan the most likely outcome was that the STW transfer would be retained and the BAU+ environmental destination (baseline scenario) would be zero i.e. no loss of permitted abstraction rights. The assumption to retain the STW transfer was an output of the second phase of the regional planning reconciliation process and the zero environmental destination assumption was made in consultation with the EA as part of the pre-consultation to this plan.

In the emerging regional plan, the retention of the STW transfer was subject to the conclusion of the UDV SRO and we were preparing options for backfilling the loss if it was needed by a date of 2040. 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.

Subsequent to the publication of the emerging WReN Regional Plan the regulatory guidelines on the inclusion of the BAU+ environmental destination in WRMPs changed. This led to the need to assume a most likely BAU+ environmental destination loss of 11Ml/d in 2035 and a further 130Ml/d in 2050. This change in approach also impacted on Water Resources Water and STW's most likely outcome and in spring 2022 it was confirmed that the most likely pathway in STW's plan was that the Upper Derwent Valley SRO was required to meet their needs and would not support maintaining the transfer to YW.

In addition, during the summer of 2022 following a very dry winter/spring our region is experiencing the most severe drought since 1995/96. The full impact and severity of the drought will not be known until we recover and will be dependent on the volume of winter rainfall that we receive later this year and early next. However, as we progress into next year, we shall reassess our critical period scenario and review if the drought of 2022 has altered our WRMP24.

To ensure we take action to address the risks, in addition to the solutions put forward in our WRMP24, we are proposing to undertake further investigations and options development. As we monitor the current drought situation, we will gather more information on the areas in our system most impacted and this helps us identify where options could be required to strengthen our network. We intend to use this learning to inform our final WRMP24 and it is possible the solution put forward in this draft will change.

The Ofwat definition of its 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. We have not included any investment for this in our draft plan, but it is something we intend to explore further for our final WRMP24. Figure 12.1 summarises our strategy for AMP8 and the further work we will do.

Figure 12.1: WRMP24 AMP8 strategy

Ensure	Ensure the plan meets resilience needs e.g. York WTW too big to fail, local demand hot spots, strengthen the grid network
Ensure	Ensure solution meets critical period needs as well as dry year annual average
Prepare	Prepare for termination of the STW transfer – backfill option
Prepare	Prepare for the potential loss of groundwater sources in 2035 and the R Derwent abstraction(s) in 2050
Reduce	Reduce leakage in line with policy requirement to achieve 50% reduction in leakage by 2050
Reduce	Reduce PCC in line with policy requirement to achieve an average PCC of 110 l/h/d by 2050
Create	Create a best value plan that meets a level of service of resilience to a 1 in 500 drought no later than 2039
Include	Include for loss of supply linked to flood mitigation
Identify	Identify options for the South Yorkshire WTW supplied by the STW transfer
Identify	Identify further options to ensure best value plan for loss of import and over the long term

We are also thinking ahead to our WRMP29 and the risks that our WRMP24 has identified. We have a plan for assessing the River Derwent risk and we will work with the EA and Natural England to understand the full impacts of naturalising the river. Our preference is that the investigations will involve other sectors and water users and not be solely focused on PWS needs. The River Derwent investigation will influence the decision on the changes to the river and if the weir and barrage will be removed and by when. As this has a significant impact on our water supply, we feel it is important to gather more information on the scale of the impact before finalising the solution to this loss.

Our options appraisal and decision-making approach for WRMP24 has selected the Tees to York transfer option as part of the best value solution. Until the spring of 2022 we were planning for a much lower deficit that was driven by climate change. This type of deficit has a significant impact across our whole supply network and the loss can be, to some extent, offset by demand reduction options. The options we identified as appropriate for the problem we were aiming to address were mostly low to medium benefit (up to 50Ml/d). It is now clear that we may require much larger scale options and we are planning to investigation if there are options other than the Tees transfer that could provide better value over the long term. Options such as the Tees transfer require significant pumping and energy costs and the alternatives should be considered before making a final decision.

13.List of tables

14. List of figures

15. Bibliography

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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 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.
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.
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.
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/
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 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
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.
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.
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.
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
Ofwat	Economic regulator for the water industry
Per Capita consumption (PCC)	The amount of water typically used by one person per day.
PMZ	Production Management Zone – Yorkshire Water operational planning zone.
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.
PR14	Price Review submission to Ofwat 2014
PR19	Price Review submission to Ofwat 2019
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
SWZ	Surface Water Zone (Environment Agency Water Resource Zone)

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.
l/h/d	Litres per head per day
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.
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.
NPC	Net Present Cost
NPV	Net Present Value
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- Households	Properties receiving portable water supplies that are not occupied as domestic premises.
Non-public water supply (non-PWS)	Non-public water supply is any water supply that is not provided by a water company.
NCL	Normal Control Line
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 Household Consumption (PHC)	The average amount of water used in a household property each day, usually presented as litres per property per day.
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.
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.
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.
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.
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 choices	Strategic choices are the key decisions to be taken in developing the plan and maybe regional or company or zone specific.
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.
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

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.
UKCP09	United Kingdom Climate Projections 2009
UKCP18	United Kingdom Climate Projections 2018
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 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.
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."
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.
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/
WRAP	Water Resources Allocation Plan (water supply network model)
WRAPsim	Water Resources Allocation Plan simulation (water network simulation model).
Water Resources Investment Optimiser	Water Resources Investment Optimiser
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

Table 17.1 Options constrained out of the options appraisal

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
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.
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 sizable benefit.
C11	Rainwater harvesting for domestic customers	Rainwater harvesting	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.
C12	Rainwater harvesting for commercial customers	Rainwater harvesting	Customer Options	**YWSGRD**	Benefits are uncertain as it is not known if industrial uses would participate and accumulate a sizable benefit.
C13	Tariffs/special fees	Tariff	Customer Options	**YWSGRD**	Currently constrained out as a large proportion of customers are unmetered and tariff setting requires customer use to be metered.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
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 stand-alone 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.
C18	Household leaky loo repairs	Other water efficiency	Customer Options	**YWSGRD**	We would consider this activity as part of home audit schemes or linked to smart metering customer communications and not as a standalone option.
DV9a	New groundwater treated supply to South Yorkshire - link to existing connections	Conjunctive use	Resource Options	**YWSGRD**	This is a variation of option R6. 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	Conjunctive use	**YWSGRD**	This is a variation of option R6. As the resource is under WINEP investigation the scheme was not taken forward for scoping.
DV11b	Increase grid supplies to South Yorkshire - raw	Conjunctive use	*Conjunctive use*	**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.*
R1a	River Ouse water treatment works extension	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.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
R1b	Increase River Ouse treatment capacity to maximum 130Ml/d (R. Ouse) + Expansion to Grid	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.
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.
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 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 support to grid	New groundwater	Resource Options	**YWSGRD**	This option was found to be in flood zones and options R8f, g, and h were created to avoid the risk.
R10	Millstone Grit Groundwater Option	New groundwater	Resource Options	**YWSGRD**	Borehole locations have not been identified within a feasible distance to existing WTW.
R11	South Yorkshire Groundwater Option 2	Conjunctive use	Resource Options	**YWSGRD**	R6 was considered to be the preferred and more reliable option for this resource.
R14a	Minewater for potable use option 1	New groundwater	Resource Options	**YWSGRD**	Water treatability concerns - heavy metals in water quality sampling data.
R14b	Minewater for potable use option 2	New groundwater	Resource Options	**YWSGRD**	Water treatability concerns - heavy metals in water quality sampling data.
R16	Reuse abandoned third party GW source option 1	New groundwater	Resource Options	**YWSGRD**	No water is available for new abstraction licences in this area.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
R20	Embankment raising 1	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R21	Dam Raising Option 1	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R22	Dam Raising Option 2	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R23	Dam Raising Option 3	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R24	Dam Raising Option 4	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R25a	Embankment raising 2	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R25b	Embankment raising 3	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R26	Reservoir catchment increase	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R27	Reservoir extension	Reservoir enlargement	Resource Options	**YWSGRD**	No significant additional benefits and environmental impacts high.
R28	Extend reservoirs sideways	Reservoir enlargement	Resource Options	**YWSGRD**	Safety risk of extending an existing reservoir and environmental impact concerns.
R30	Use compensation reservoir as supply	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	Swale new pumped storage reservoir	New reservoir	Resource Options	**YWSGRD**	High environmental impacts and likely to be significant objections from public and local groups.
R33	Storage on the River Hull	New surface	Resource	**YWSGRD**	No onsite location to build storage.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
		water	Options		
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 3	New surface water	Resource Options	**YWSGRD**	Alternative abstraction location closer to WTW identified - R37b(ii).
R38	River Trent river abstraction and bankside storage	New surface water	Resource Options	**YWSGRD**	No new supplies identified from the River Trent.
R39	River Abstraction – Lower Don	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	Reservoir supported abstraction from the River Wharfe	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	East Yorkshire internal transfer 1	Internal potable transfer	Distribution Options	**YWSGRD**	Potential resilience scheme but no water resource benefit.
R44	East Yorkshire internal transfer 2	Internal potable transfer	Distribution Options	**YWSGRD**	Potential resilience scheme but no water resource benefit.
R45	Dales pipeline connection	Internal potable transfer	Distribution Options	**YWSGRD**	There is no potential to increase abstraction from the Dales reservoir without creating a risk of not meeting the compensation requirements. A licence variation (R90) to transfer more water via an existing connection is being considered to reduce pumping from the river but this would mean a corresponding reduction in the river abstraction.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
R47	Reduce outage	Outage reduction	Production Options	**YWSGRD**	We shall review this option for the final plan and if any site refurbishments or water quality schemes could reduce the WRMP outage allowance. No WRMP specific schemes have been identified as outages are temporary and addressed through other strategies.
R50	R50 Tees to Dales	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	Tees to Swale River Transfer - NWL import	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	Constrained out as the environmental impact would not be acceptable - INNS risk.
R55	Tees to Swale River Transfer- YW abstraction licence	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	Constrained out as the environmental impact would not be acceptable - INNS risk.
R56	Tees - Ouse Pipeline Option 2	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	Constrained out as the environmental impact would not be acceptable - INNS risk.
R57(i)	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	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.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
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.
R62	North Yorkshire rural distribution enhancement	Conjunctive use	Resource Options	**YWSGRD**	This option would provide resilience to a localised area but no new resource.
R64	Utilise tidal barrage at Hull	New technology	Resource Options	**YWSGRD**	Environmental concerns over impacts on the Humber Estuary.
R65	River Ure Gravel Pits	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 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 users 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.
R71	Work with Internal Drainage Board (IDB) to increase abstractions	New groundwater	Resource Options	**YWSGRD**	No certainty of yield availability.
R73	Reservoir - lower valves	Surface water enhancement	Resource Options	**YWSGRD**	Option has been used during dry weather. In most circumstances and considering 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.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
R74	Reservoir Transfer	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	Internal raw water transfer North Yorkshire	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 abandoned 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.
R92	Craven Reservoir for supply	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.
E01	Transfer to United Utilities via Huddersfield Canal	External raw water bulk supply/transfer	Resource Options	**Export**	Water would not be available in dry years.
E03	South Yorkshire WTW transfer to STW	External raw water bulk supply/transfer	Resource Options	**Export**	This scheme was considered as a potential outage resilience scheme for STW but not as a WRMP scheme.
WReNB1	Bi-directional South Yorkshire to Anglian Water (AWS) transfer	External raw water bulk supply/transfer	Resource Options	**Export**	Resource under WINEP investigation.
WReNE4	River Ouse to United Utilities (UU) transfer	External raw water bulk	Resource Options	**Export**	Constrained out - not technically viable and source required for Yorkshire Water plan.

Option ID	Option Name	Option type	Option Group	WRZ(s) benefitting from option	Reason for option rejection
		supply/transfer			

17.2 Appendix A.2: Yorkshire Water feasible 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
C1a	Domestic Customer Audits and Retrofit A	Household water audit	Customer Options	**YWSGRD**	0.020	This scheme aims to reduce customer use through installing retrofit devices, such as cistern devices, aerated showerheads and aerated tap inserts, in domestic properties. We have assumed a five-year half-life of savings. The scheme can be delivered in phases.
C1ab	Domestic Customer Audits and Retrofit AB	Household water audit	Customer Options	**YWSGRD**	0.060	
C1abc	Domestic Customer Audits and Retrofit ABC	Household water audit	Customer Options	**YWSGRD**	0.120	
C1abcd	Domestic Customer Audits and Retrofit ABCD	Household water audit	Customer Options	**YWSGRD**	0.200	
C1abcde	Domestic Customer Audits and Retrofit ABCDE	Household water audit	Customer Options	**YWSGRD**	0.300	
C2a	C2a Enhanced Metering Domestic Optants 14000 props	Metering optants	Customer Options	**YWSGRD**	0.123	This scheme aims to increase the number of meter optants Alternative schemes have been created with varying levels of uptake.
C2b	C2b Enhanced Metering Domestic Meter Optants 22,000 properties	Metering optants	Customer Options	**YWSGRD**	0.184	
C2c	C2c Enhanced Metering Domestic Meter Optants 29,000 properties	Metering optants	Customer Options	**YWSGRD**	0.245	
C4	C4 Metering on change of occupancy	Metering change of occupancy	Customer Options	**YWSGRD**	5.702	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.

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
C5	C5 Smart Metering and Water Efficiency	Other water efficiency	Customer Options	**YWSGRD, YWSEST**	32 (28 by 2050)	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	Water User Audits A	Non-household water audit	Customer Options	**YWSGRD**	0.200	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.
C6ab	Water User Audits AB	Non-household water audit	Customer Options	**YWSGRD**	0.600	
C6abc	Water User Audits ABC	Non-household water audit	Customer Options	**YWSGRD**	1.200	
C6abcd	Water User Audits ABCD	Non-household water audit	Customer Options	**YWSGRD**	2.000	
C6abcde	Water User Audits ABCDE	Non-household water audit	Customer Options	**YWSGRD**	3.000	

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
C15a	Household Flow Regulators A	Other water efficiency	Customer Options	**YWSGRD**	0.290	This scheme is an alternative to domestic retrofit programmes and would offer customers a device to reduce the flow of water to their properties. The scheme can be delivered in phases.
C15ac	Household Flow Regulators AC	Other water efficiency	Customer Options	**YWSGRD**	0.377	
C15acd	Household Flow Regulators ACD	Other water efficiency	Customer Options	**YWSGRD**	0.493	
C15acde	Household Flow Regulators ACDE	Other water efficiency	Customer Options	**YWSGRD**	0.638	
C15acdeb	Household Flow Regulators ACDEB	Other water efficiency	Customer Options	**YWSGRD**	0.696	
C21a	Housing Associations Targeted Programme A	Retrofitting indoor water efficiency devices	Customer Options	**YWSGRD**	0.030	This scheme is similar to C1 but delivers a water efficiency retrofit programme in collaboration with housing associations. It can be delivered in phases.
C21ab	Housing Associations Targeted Programme AB	Retrofitting indoor water efficiency devices	Customer Options	**YWSGRD**	0.105	
C21abc	Housing Associations Targeted Programme ABC	Retrofitting indoor water efficiency devices	Customer Options	**YWSGRD**	0.256	
C21abcd	Housing Associations Targeted Programme ABCD	Retrofitting indoor water efficiency devices	Customer Options	**YWSGRD**	0.482	
C21abcde	Housing Associations Targeted Programme ABCDE	Retrofitting indoor water efficiency devices	Customer Options	**YWSGRD**	0.783	

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
DV3	Magnesium Limestone new GW supply	New groundwater	Resource Options	**YWSGRD**	5.000	A new groundwater abstraction and WTW in South Yorkshire.
DV6(iv)	Tees to South Yorkshire WTW - 50Mld	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	50.000	This is a new bulk transfer from NWL to South Yorkshire. There are three variations with different benefits.
DV6(v)	Tees to South Yorkshire SR - 80Mld	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	80.000	
DV6(vi)	Tees to South Yorkshire SR - 140Mld	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	140.000	
DV7a(iv)	Tees to York Pipeline - 50Mld	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	50.000	This is a new bulk transfer from NWL to York. There are three variations with different benefits.
DV7a(v)	Tees to York Pipeline - 80Mld	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	80.000	
DV7a(vi)	Tees to York Pipeline - 140Mld	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	140.000	
DV8(iv)	New north to south internal transfer connection - 50 Ml/d capacity 0 Ml/d benefit	Conjunctive use	Resource Options	**YWSGRD**	0.000	This option is a new interconnection between York and South Yorkshire and requires a supporting option(s) to achieve a benefit.

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
DV8(v)	New WTW (York) supplied by the River Ouse	Conjunctive use	Resource Options	**YWSGRD**	50.000	The scheme would abstract up to 60Ml/d of raw water from the River Ouse for treatment near York. The scheme requires construction of a new river intake, pumping station and pumping main from the point of abstraction to the point of treatment.
L1	Active Leakage Control 14 Ml/d	Other leakage control	Distribution Options	**YWSGRD**	14.050	A range of leakage benefit options have been created to achieve benefits from 95Ml/d (50% reduction) to 14Ml/d.
L2	Active Leakage Control 30 Ml/d	Other leakage control	Distribution Options	**YWSGRD**	30.200	
L3	Active Leakage Control 46 Ml/d	Other leakage control	Distribution Options	**YWSGRD**	46.350	
L4	Active Leakage Control 63 Ml/d	Other leakage control	Distribution Options	**YWSGRD**	62.500	
L5	Active Leakage Control 79 Ml/d	Other leakage control	Distribution Options	**YWSGRD**	78.650	
L6	Active Leakage Control 95 Ml/d	Other leakage control	Distribution Options	**YWSGRD**	95.300	
R1c	Grid network enhancement: New River Ouse WTW to York capped to 30 Ml/d	Surface water enhancement	Resource Options	**YWSGRD**	0.000	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)	Grid network enhancement: New River Ouse WTW up to 60 Ml/d	Surface water enhancement	Resource Options	**YWSGRD**	0.000	This scheme is an alternative to R1c and builds the works to a larger capacity.

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
R1d	Grid network enhancement: New River Ouse WTW to North Yorkshire 1	Surface water enhancement	Resource Options	**YWSGRD**	15.000	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**	0.000	This scheme provides onwards transfer to R1c or R1c(ii).
R1e	Grid network enhancement: New River Ouse WTW to North Yorkshire 3	Surface water enhancement	Resource Options	**YWSGRD**	5.000	This scheme provides onwards transfer to R1c or R1c(ii).
R1f	Grid network enhancement: New River Ouse WTW to North Yorkshire 4	Surface water enhancement	Resource Options	**YWSGRD**	10.000	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**	25.000	This scheme provides onwards transfer to R1c or R1c(ii).
R2	River Ouse to York WTW	Surface water enhancement	Resource Options	**YWSGRD**	60.000	This scheme is an alternative to DV8(v) but would not include the additional treatment capacity. It would include some expansion to the existing treatment and DV8(v) was used in preference to this option as R2 would only be a benefit when other resource was not available to the existing works.
R3	Increased River Ouse pumping capacity	Surface water enhancement	Resource Options	**YWSGRD**	10.000	The scheme involves construction of a new transfer main and pumping station between

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
						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.
R3a	River Ouse licence transfer	Surface water enhancement	Resource Options	**YWSGRD**	0.300	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.
R5	Aquifer Storage and Recovery Scheme 1	Aquifer recharge/Aquifer storage recovery	Resource Options	**YWSGRD**	6.580	This scheme involves the use of new pumped boreholes to artificially 'recharge' the Sherwood Sandstone aquifer, allowing the use of this water supply during drier periods.
R6	South Yorkshire Groundwater Option 1	Groundwater enhancement	Resource Options	**YWSGRD**	12.000	**This option was constrained out on 2nd screening.** Potentially yield can be attained from an underutilised group of groundwater sources in South Yorkshire. A short length of pipeline would be required to link the sources to the grid system for internal transfer.
R6b	South Yorkshire Groundwater Option 2	Conjunctive use	Resource Options	**YWSGRD**	20.000	This is the reverse of R6 that would transfer water into South Yorkshire.
R6c	South Yorkshire Groundwater Option 3	Conjunctive use	Resource Options	**YWSGRD**	10.000	This is an alternative to R6 that would install a bi-directional pipeline allowing flow to be sent both ways and offset outages.
R6d	South Yorkshire Groundwater Option 4	Conjunctive use	Resource Options	**YWSGRD**	20.000	

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
R8b	Sherwood Sandstone and Magnesian Limestone Boreholes option 2	New groundwater	Resource Options	**YWSGRD**	5.000	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**	5.000	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**	20.000	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**	15.000	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	New groundwater	Resource Options	**YWSGRD**	5.500	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.
R12	East Yorkshire Groundwater Option 1	New groundwater	Resource Options	**YWSGRD**	8.000	**This option was constrained out on 2nd screening.** This option utilises an existing licenced groundwater group in East Yorkshire. This scheme would enhance the existing pumping capacity of existing infrastructure to transfer additional water from the boreholes to the grid system.

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
R13	East Yorkshire Groundwater Option 2	New groundwater	Resource Options	**YWSGRD**	6.000	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).
R17	Reuse abandoned third party GW source option 2	New groundwater	Resource Options	**YWSGRD**	2.500	**This option was constrained out on 2nd screening.** This would be a new borehole with water transferred to a WTW in Leeds.
R18	Reuse abandoned third party GW source option 3	New groundwater	Resource Options	**YWSGRD**	1.270	**This option was constrained out on 2nd screening.** This would be a new borehole with water transferred to a WTW in Huddersfield.
R19	Reuse abandoned third party GW source option 4	New groundwater	Resource Options	**YWSGRD**	1.290	**This option was constrained out on 2nd screening.** This would be a new borehole with water transferred to a WTW in the Colne Valley.
R29	R29 Reservoir De-silting	Reservoir enlargement	Resource Options	**YWSGRD**	11.000	This scheme aims to increase the capacity of 26 reservoirs through dredging and desilting. The silt would be taken to a landfill site.
R31a	Additional bankside storage at York WTW	Surface water enhancement	Resource Options	**YWSGRD**	10.600	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**	9.290	**This option was constrained out on 2nd screening.**

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
						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.
R35	River Aire Abstraction option 1	New surface water	Resource Options	**YWSGRD**	9.290	**This option was constrained out on 2nd screening.** This scheme is a new abstraction licence on the River Aire. It would involve the construction of a pumping station and water main in order to abstract and then transport 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**	33.500	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.
R48	Reduce level of service to 1:200	Change in levels of service	Customer Options	**YWSGRD**	Up to 50	This option presents a befit 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.

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
R49	R49 Tees to Dales - raw import NWL	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	15.000	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	R51 Tees to Dales – treated import from NWL	External raw water bulk supply/transfer	Resource Options	**YWSGRD**	15.000	This scheme is a treated water import from NWL to feed the North Yorkshire area of our network. It utilises a NWL WTW.
R61	R61 Desalination Hull	Desalination	Resource Options	**YWSGRD**	20.000	This would require an abstraction on the Humber Estuary, construction of a desalination plant and transfer to an existing WTW in East Yorkshire.
R78	R78 Tidal Abstraction Reservoir	New reservoir	Resource Options	**YWSGRD**	20.000	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**	8.000	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**	50.000	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**	4.000	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.

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
R88	Increase storage at an existing WTW in North Yorkshire	Surface water enhancement	Resource Options	**YWSGRD**	0.320	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**	0.700	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.
R90*	North Yorkshire annual licence increase	Surface water enhancement	Resource Options	**YWSGRD**	Not a WRMP option	This option does not provide a benefit – it is a licence variation to alter the transfer of water from a reservoir to the Bradford area. We would apply to transfer a greater volume directly to the area and reduce releasing from the reservoir to abstract downstream.
E02	YW export to STW	External raw water bulk supply/transfer	Resource Options	**Export**	20.000	This is an export option that would provide a transfer to STW from our grid network. The supply would be from the York area and require additional infrastructure and new service reservoirs at the Yorkshire Water/STW border.

* We shall apply for this licence variation but it is not a WRMP option it is a change for operational purposes that does not impact on water available.

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: Candidate solution programme best value metric values

Solution programme	Cost of the plan £M NPV (Totex)	Carbon 000s tCO_2	PWS Drought resilience	Natural Capital £ NPV	Biodiversity (supply options only)	Leakage reduction Ml/d	PCC reduction l/h/d	Flood risk management (non-drought resilience) (SEA)	Multi-abstractor benefit (SEA)	Human and social well-being	Customer preferred option type	Option Deliverability	Programme resilience score
DYAA least cost	1533	1999	21	-275,598,549	-2109	95	0.00	-1.00	-0.50	-0.97	2.00	3.04	0
Critical period least cost	1685	2308	21	-285,781,973	-3437	95	0.01	-0.57	-0.45	-0.68	2.26	2.90	5
Candidate solution 01	2358	2355	19	-333,393,397	-3426	95	2.65	-0.63	-0.34	-0.69	2.29	3.05	5
Candidate solution 03	2426	2345	21	-332,920,251	-2920	95	2.65	-0.57	-0.25	-0.63	2.29	3.05	6
Candidate solution 04	2113	2440	18	-286,050,497	-2392	95	2.65	-0.58	-0.25	-0.61	2.36	2.92	4
Candidate solution 04.01	2126	2490	18	-286,025,838	-2392	95	2.65	-0.50	-0.21	-0.55	2.35	2.96	5

17.5 Appendix D: Board Assurance Supporting Statement

Board Assurance Statement for draft Water Resource Management Plan

The Board have engaged with the water resource management planning process through the Board Public Value Committee (the "Committee"), which has received regular updates on the developing draft Water Resource Management Plan (dWRMP).

The main engagement began in January 2022 with an overview of the strategic planning framework. At a meeting 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 track[1] approach to ensuring future water resources resilience. The Committee were also taken through the next steps, in line with planning guidance, to continue development of the plan.

In July 2022 the Committee were able to review and discuss the identified risks impacting on 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 development of the draft plan, consider the supporting evidence and analysis and take into account the information presented to it. As a result, the Yorkshire Water Board makes the following statement:

a) The board is satisfied that the Yorkshire Water dWRMP 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.

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.

17.6 Appendix E: Supporting documentation

In addition to this main WRMP document, a number of supporting 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 Forecast Technical Document
- Uncertainty (headroom) Technical Document
- Options Technical Document
- Decision Making Technical Document