Water Resources Management Plan 2019

Annex 10: Strategy for the Central area

December 2019

Version 1

from Southern Water

Contents

Southern Water

1. Executive summary

1.1 Central supply area at a glance

Central Supply Area

SUMMARY

The Central Area supplies 347,000 homes and 813,000 people across 3 water resource zones. During the course of the next 50 years we anticipate that each of these zones would face a water shortage if we did nothing at all.

SCHEMES WE ARE PROPOSING TO MEET THE FUTURE CHALLENGES

Reduce leakage by 50% by 2050
This will reduce the need to generate more water by using what we have more efficiently

Work with customers to save more water
Our customers are already some of the most efficient in England and Wales. Over the next couple of decades we will work with them to help save more water so that average water use falls to 100 l/h/d.

Pulborough licence variation by 2025
This variation seeks to allow the groundwater source, during more extreme droughts.

Water reuse scheme from Littlehampton WTW by 2030.
This scheme is critical to ensuring continuation of supplies under a wide range of drought conditions.

Coastal desalination by 2030.
This scheme is critical to ensuring continuation of supplies under a wide range of drought conditions following licence reductions in order to protect the environment.

Asset enhancement schemes
Develop additional nitrate treatment at identified sources and implement catchment management activity at these sources Also develop treatment for pesticides at surface water works potentially at risk and implement catchment management activity at these sources. Rehabilitation of existing boreholes

In-stream catchment management
Gather evidence to implement in-stream river restoration measures on the River Arun and Western Rother

Additional metering
Undertake extension of the universal metering programme to achieve 92% metering of households through implementation of a compulsory metering programme in AMP7.

INCREASING DROUGHT RESILIENCE

There is a 22% chance that a Southern Water customer will live through a severe drought and a 15% chance they will experience an extreme drought. This WRMP, coupled with our Drought Plan, seeks to put in place measures to ensure a continuity of supplies during these events.

While climate change and population growth put further pressure on water supplies, our existing infrastructure coupled with our leakage reduction programme and water efficiency would be sufficient to ensure we can maintain supplies during severe and extreme droughts. The biggest driver for investment is the need to replace existing sources whose outputs either have to reduce or be switched off in order to protect the environment. The deadline to complete this work is 2027. Our new resource developments, and reductions in demand, will increase the resilience of our supplies to customers.

Reduce leakage by 50% by 2050

Consume 100l/h/d by 2040

Improve water quality

Pulborough Licence variation

Desalination at Shoreham

Littlehampton water reuse

Southern Water

1.2 What has changed since the draft plan was submitted in November 2017?

The following have been taken into account in the derivation our Water Resources Management Plan (WRMP) that have occurred since submitting our draft WRMP:

1) HM Government published their 25 year Environmental Plan (2018);
2) The National Infrastructure Commission published a report entitled: Preparing for a drier future (April 2018);
3) Updated WRMP guidelines were issued (July 2018);
4) WRSE group publication entitled: From source to tap: the south east strategy for water (2018);
5) Environment Agency (EA) publications entitled: The State of the Environment (2018);
6) The Global Risks Report 2018: highlighting that extreme weather reports are the highest risk to occur;
7) Consultation on our Drought Plan (2018), and publication of the final Drought Plan (July 2019).
8) Defra letter (dated 19 March 2019) requesting further information in support of the statement of response
9) Accompanying Defra's letter of 19 March 2019 was the EA's Statement of Response Review Annex: setting out issues that the EA do not consider material to the plan, but which they feel could improve it.
10) We responded to the 19 March 2019 Defra Letter on 14 June 2019 and published an Addendum to our Statement of Response providing further information and addressing some issues in the Annex to the Defra letter
11) We received permission to publish our WRMP in a letter from Defra dated 4 November 2019.

We have also been consulting with the public and our customers (over 3000) to understand what they liked and didn't like about our plan.

The consultation responses and the publications have all been reflected in our final WRMP; consequently we have made some changes to our preferred plan from the draft WRMP.

These key changes are:

1) **Stronger leakage reduction targets**: The Company has adopted a targeted reduction in leakage of 15% by 2025; 40% by 2040 and 50% by 2050. These targets reflect the challenge set by Ofwat, which was also reflected in the 25 year Environmental Plan, and the NIC report;
2) **Decrease the amount of water from water reuse** but we keep one of the two schemes in our preferred plan to provide a resilient supply in Sussex North (SN) water resource zone (WRZ);
3) **Decrease the amount of water from desalination**: Due to the extra water we save and the decreased need from our neighbouring water company we are able to reduce the number of desalination plants to one in our Sussex Brighton (SB) WRZ;
4) **Pulborough groundwater licence variation** to allow the groundwater to continue to be abstracted during severe droughts.

But we have kept:

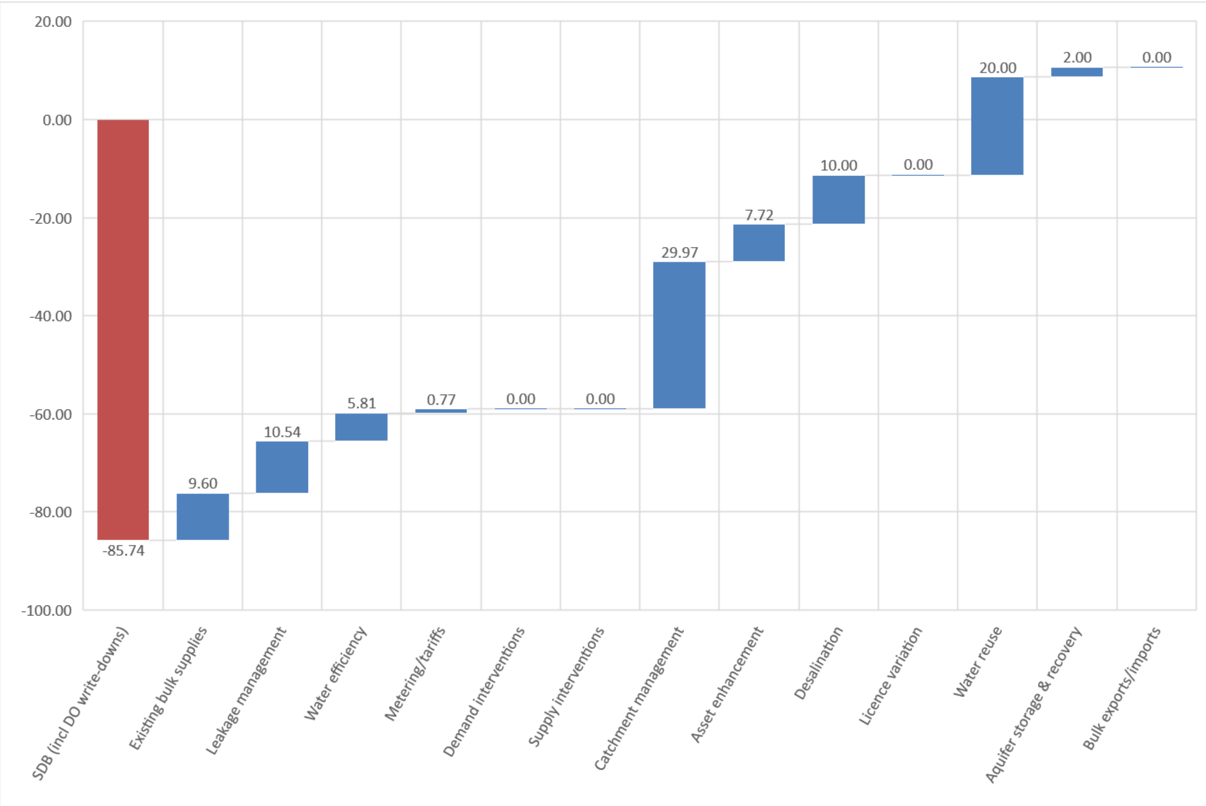
1) **Target 100**: our water efficiency programme of work to help customers save water and money has been improved but the overall goal remains the same;

2) The interim use of **Drought Permits and Orders** in the Central area, as set out in our Drought Plan, to meet our supply duties during severe drought conditions;
3) **Catchment management** in Sussex to improve the quality of the water in the rivers and aquifers we abstract water from. We are also looking to improve the habitats along some of the rivers in Sussex as part of our catchment first approach to help improve their resilience to drought;
4) **Aquifer Storage and Recovery** remains which will help us store water in the winter below ground so that we can use it later in the year;
5) **Pulborough winter transfer scheme** remains to allow us to transfer more water between our water resources zones to make best use of available supplies.

1.3 What is driving the changes and how do all these schemes fit together to solve it?

This chapter sets out, in detail, how we solve the supply demand deficits we face over the next 50 years. Figure 1, below, shows in red the supply demand balance deficit (primarily as a result of the sustainability reductions/changes to our licences) and in blue what we are proposing to develop by 2030 (AMP8) in order to solve the deficits created by the adoption of the licence changes and the estimated amount that each measure will contribute. While we develop these schemes we will rely on Drought Permits and Orders to maintain public water supplies.

Figure 1 Deficits and solutions plot for Central area at the end of AMP8 (severe drought MDO)



In the rest of the chapter we describe how we derived our preferred solution; looked at different scenarios that could occur in the future; and undertook detailed sensitivity testing of our preferred plan.

1.4 Development of the strategy for the Central area

The Real Options approach that has been used to inform the decision making for the plan solves the supply-demand deficits simultaneously for seven different 'states of the world' (which represent a snapshot of different climatic conditions and intra-annual pressures on water resources) across five different 'futures' or 'branches' (which represent a plausible set of future SDBs for a range of possible future scenarios, for which different solutions may be appropriate or necessary).

The use of different futures in the Real Options approach effectively recognises that the future is not certain, and so the method tries to identify how solutions may change through time in the face of different possible future water resource pressures, and also identifies a common set of 'no regrets' options in the short term which should be developed regardless of which future may materialise.

These uncertain futures are a key reason why we have adopted the Real Options approach – so that key schemes and alternatives which address these uncertainties can be investigated and progressed in parallel to the preferred plan. Should the magnitude of the future uncertainties be less severe, then some of the schemes would not need to proceed past feasible investigation and planning / promotion stages. However, the company has little choice but to conduct these investigations of alternative and preferred schemes through AMP7 (and AMP8), given the scale of uncertainties the company faces in the next 10 years.

An **initial 'least cost'** run was undertaken to develop a 'basic solution', without further consideration of potential constraints. This was then tested by modifying assumptions about the availability of certain options to progress our understanding of the impacts these assumptions might have on the strategy. From examination of the various model run outputs, and taking into account the pre-consultation discussions with regulators and stakeholders, consultation representations, and policy decisions, refinements were introduced to reflect **a 'constrained' least cost strategy**.

The constrained least cost strategy was then examined and tested against environmental criteria, outcomes from regional planning exercises (Water Resources in the South East - WRSE), and the preferences arising from customer engagement activity. Following this review, any refined decisions on the feasible options were fed into the Real Options model to derive the **strategy for this plan**.

The strategy was then subjected to scenario and sensitivity testing to understand what alternative strategic schemes may be needed, should it not be possible to implement the schemes in the preferred plan. This is particularly important for those schemes in the strategy that are required early in the planning period, in AMP7 or AMP8.

The strategy for the Central area is **dominated by the potential future sustainability reductions**. This is highlighted by comparing the two strategies with and without the potential sustainability reductions. **As the sustainability reductions still have to be investigated and confirmed then both the investigations and the feasibility/design of the potential solutions to resolve any deficits caused by the sustainability reductions will need to be developed at the same time**.

The **key strategic schemes selected in the next 10-15 years that potentially need to be developed, depending on the future sustainability reductions**, are as follows:

- **Pulborough groundwater licence variation** in early AMP7
- **Water reuse scheme from Littlehampton WTW** by AMP8. This scheme is critical to ensuring continuation of supplies under a wide range of drought conditions
- **Coastal desalination scheme at Shoreham** by AMP8.
- **ASR (Sussex Coast - Lower Greensand)** by AMP8
- **Asset enhancement schemes** in AMP7 and 8

- Develop additional **nitrate** treatment at identified sources and implement catchment management activity at these sources over AMP7 and 8
- Develop treatment for **pesticides** at surface water works potentially at risk and implement catchment management activity at these sources in AMP7
- **In-stream river restoration** on the Arun / W. Rother by AMP8.
- **'Target 100' water efficiency activity** that aims to reduce per capita consumption to 100 litres per day by 2040, commencing at the start of AMP7
- **Leakage reduction activity** to achieve 15% reduction by the end of AMP7 and 50% reduction by 2050
- Undertake **extension of the Universal Metering Programme (UMP**)

For new resource developments, it will be necessary for detailed engineering and environmental assessments to be undertaken, for planning and other consents to be secured and for the schemes to be constructed and commissioned. The timings within this plan are our best estimates for delivery at this point in time.

If the future turns out to have limited demand growth, limited climate change impacts and/or limited sustainability reductions – reflecting a future SDB like those modelled in the 70th or 90th percentile branches – then a number of the preferred plan options may not be required. This is particularly true with regards to the impact of possible future sustainability reductions in AMP8, which in the Central area could drive significant new water developments in AMP8.

As we prepare for our next plan, it may be possible to confirm that the implementation of some of the AMP8 options will not actually be required. However, the timescales are such that we will need to have done much of the feasibility and environmental investigations and the preparation of planning documentation in AMP7 (before it can be confirmed whether the schemes are necessary) even if the scheme is not ultimately needed in AMP8.

2. Real options modelling

We have developed an economic least cost model (the 'investment model') to help select the combination of options – the portfolio of options – to ensure that there are always enough supplies available to meet anticipated demands in all water resource zones (WRZs) under every planning scenario or design condition, throughout the planning period.

Separate investment models have been developed for each of the three supply areas (Western, Central and Eastern), which are geographically separate (with each supply area consisting of between three and seven WRZs). Although the building blocks for the strategy are the individual WRZs, there are inter-connections (either current or potential) between them, and thus interventions in one WRZ can have an impact on other inter-connected WRZs within that supply area. The model must take account of the SDBs for each planning scenario, including transfers and bulk supplies, in all the WRZs in each supply area at the same time in order to develop a consistent solution for the supply area.

Annex 8 describes the rationale and approach for selecting and using a Real Options modelling approach to support the decision making for this plan. It is important to review this Annex, which explains the development of the strategy for the Central area, alongside Annex 8 (which provides more detail about the Real Options modelling process).

There are two key aspects of the Real Options investment model:

- **'States of the world'**: which represent a snapshot of different climatic conditions and intra-annual pressures on water resources, from normal year through to severe and extreme droughts, and looking at periods when water supplies are at their minimum, and at periods of peak demand for water during summer months
- **Different possible 'futures' modelled by different 'branches'**: these represent a plausible set of future SDBs for a range of possible future scenarios, for which different solutions may be needed

This approach **solves the supply-demand deficits simultaneously for seven different 'states of the world' across five different 'branches'**. The investment decisions are optimised to ensure we can meet our target level of service across a range of drought severities at different times of the year, whilst still considering the operation of schemes during normal climatic conditions.

The objective of our approach is to ensure that the plans cover a wide, yet appropriate, range of futures to ensure that all the key strategic options are identified, which is particularly important where the scale of the uncertainties is large (for example from potential 'sustainability reductions' of licensed abstractions). This approach is critical because there may not otherwise be sufficient time from when the sustainability reductions are confirmed for implementation to develop appropriate schemes. These uncertain futures are a key reason why we have adopted the Real Options approach – so that key schemes and alternatives which address these uncertainties can be investigated and progressed in parallel to the preferred plan. Should the magnitude of the future uncertainties turn out to be less severe than assumed in the plan, then some of the schemes would not need to proceed past feasibility investigation and planning / promotion stages. However, given the scale of uncertainties the company faces in the next 10 years the company has little choice but to conduct these investigations of alternative and preferred schemes through AMP7 (and AMP8).

This plan is focused on solving SDBs for the period from 2020 to 2070. We have not considered solutions needed at the end of AMP6 (2018-2019).

2.1 'States of the world'

The various states of the world, or planning scenarios, allow differing drought conditions to be considered in combination with inter-annual variability in supplies available to meet demand for water. Each state of the world will therefore have its own SDB – i.e. its own profile of surpluses or deficits over the planning period. The **model must solve each of the states of the world simultaneously** (i.e. so that any deficit in any state of the world is solved).

Inclusion of the states of the world is useful for a number of reasons:

- It ensures that the plan is robust against a range of supply and demand conditions that could be faced in any given year across the planning horizon
- It allows consideration of how the water available from different options may vary in different drought events
- It allows additional drought intervention options to be considered alongside the water resources options in more extreme droughts
- It ensures that the costs are appropriately weighted in relation to how options are likely to be used under each state of the world (known as utilisation – see Annex 8). Hence an option that is only required to meet an extreme event is likely, on average, not to have significant total variable operational costs, as it would only be required to supply water very infrequently (note that the capital costs of the option and any fixed operational costs would still need to be paid for regardless of how frequently the scheme may actually be used in practice – i.e. the capex and fixed opex are independent of the utilisation)

The states of the world are related to the following climatic conditions, or **design drought events** (these are described more fully in annex 3):

- **Normal** year – 50% annual probability – relating to typical non-drought climatic conditions, with average customer demand
- **Drought** condition – a 1 in 20 year drought, or 5% annual probability
- **Severe** drought condition – a 1 in 200 year drought, or 0.5% annual probability
- **Extreme** drought condition – a 1 in 500 year drought, or 0.2% annual probability

For each of these climatic conditions (except the normal year) there is a state of the world for each of the **minimum resource period** and **peak demand period**. These are described as follows:

- The **critical period** – corresponds to the **period of peak water demand**, which normally occurs during the summer months of June, July and August. The peak period of demand is generally defined in terms of the average day peak week (ADPW) demand. The peak demand is compared to the supplies available during that same summer period. This may also be known as the peak-period deployable output (PDO) planning scenario
- The **minimum deployable output** period – this is used to assess the period where available supplies are expected to be at their lowest or most stressed – i.e. it represents the "**minimum resource period**". This normally occurs during late summer/early autumn when river flows are at their minimum following the summer, and groundwater levels are at their lowest prior to the onset of winter recharge. The demands under this scenario are based on the minimum rolling 30-day average daily demand over the same relevant period

The exception to this is for the normal year, for which there is not generally a deficit. Under this condition only the annual average period is used (not the critical period) – this compares the average daily demand over the year against the average daily supplies that are available over that same year. The inclusion of the normal year annual average state of the world is to ensure the appropriate calculation of variable costs based on expected utilisation. We therefore have seven states of the world in total.

2.2 Plausible 'futures' modelled by branches

This is a key component of a Real Options model; it effectively recognises that the future is not certain and so it tries to identify how solutions may change through time in the face of different possible future water resource pressures.

The futures (also referred to throughout this Annex as 'branches') are built up from a combination of possible demand growth scenarios, climate change impacts on water supplies, and sustainability reductions (changes to the licenced amount of water that a water company can abstract, with the aim of ensuring that the abstraction does not pose an unacceptable risk to the water environment). Annexes 2, 3, and 5 describe how the demand and supply elements have been combined to derive the different futures.

The baseline SDB forecast is generated as a series of probability distributions from which we can select different percentiles to represent a range of possible futures (as described in Annexes 5 and 8).SDB These SDBs are used as the input to the Real Options decision-making model with selected percentiles making the 'branches' of the Real Options model. Each of the branches is assumed to be equally likely in the Real Options model.

The SDBs used as the 'futures' or 'branches' in the Real Options model reflect the following percentiles:

- 10th percentile (larger deficits)
- 30th percentile
- 50th percentile (the middle branch – representing the more traditional SDB that would have been investigated through a traditional investment modelling approach)
- 70th percentile
- 90th percentile (smaller deficits, or in surplus)

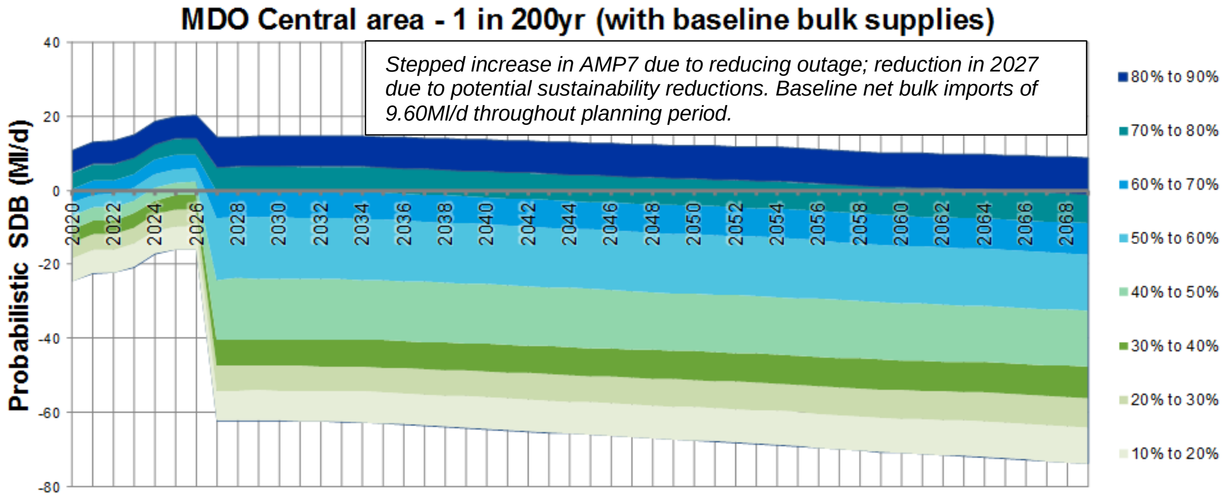
As the **'futures' are derived from a combination of the probability functions of the three key uncertainties**, it is **not possible to identify exactly what is contributing to a given future**, as represented by one of the five percentiles. The key point is that **the branches represent plausible potential future deficits in the face of uncertainty, and we try to solve these, without needing to know exactly what is driving the future deficit**. We have purposefully not chosen the most extreme combination of futures (which would represent the worst case for all of the drivers combined); instead we have curtailed the selection to 'plausible' futures within the 10th and 90th percentile ranges.

An example SDB plot (described more fully in Annex 5) is shown in Figure 2, which demonstrates the range of possible supply-demand futures from which the above five branches are selected.

A probability is assigned to each of the potential futures or branches to represent the perceived likelihood of that future. This probability is applied as an expected cost weighting to the total cost calculation. For the purposes of this plan, we have assumed that each branch will have an equal probability, because there was little information on which to base an alternative weighting scheme.

The development of the branches and their underlying assumptions and generation of the subsequent range of SDBs (surpluses or deficits over the planning period) for each of the futures is described in Annex 5.

Figure 2 Example plume plot showing range of possible future SDBs



2.2.1 Sustainability reductions

Table 1 below shows the potential impact of uncertain sustainability reductions within the Central area. These potential sustainability reductions are incorporated with other uncertainties relating to climate change impacts and demand growth to develop the SDB distribution from which the different 'futures' are selected.

The key thing to note is the magnitude of potential sustainability reductions that are, at present, uncertain: Central area total reductions are about 36% of current MDO in the severe drought scenario. These possible sustainability reductions have yet to be investigated and confirmed; this must be undertaken in discussion with the Environment Agency (EA) agreed as soon as possible to allow sufficient time to design and implement the potential solutions to resolve the deficits caused by the sustainability reductions.

Table 1 Summary of possible sustainability reductions by WRZ (in severe drought conditions)

WRZ	Lower scenario	Middle scenario	Upper scenario
Sussex Brighton	None	None	Varies by return period Severe MDO: 23.3Ml/d Severe PDO: 27.6Ml/d
Sussex Worthing	None	None	Varies by return period Severe MDO: 20.0Ml/d Severe PDO: 27.4Ml/d
Sussex North	None	None	Varies by return period Severe MDO: 9.1Ml/d Severe PDO: 17.1Ml/d
Central area total	None	None	Varies by return period Severe MDO: 52.4Ml/d Severe PDO: 72.1Ml/d

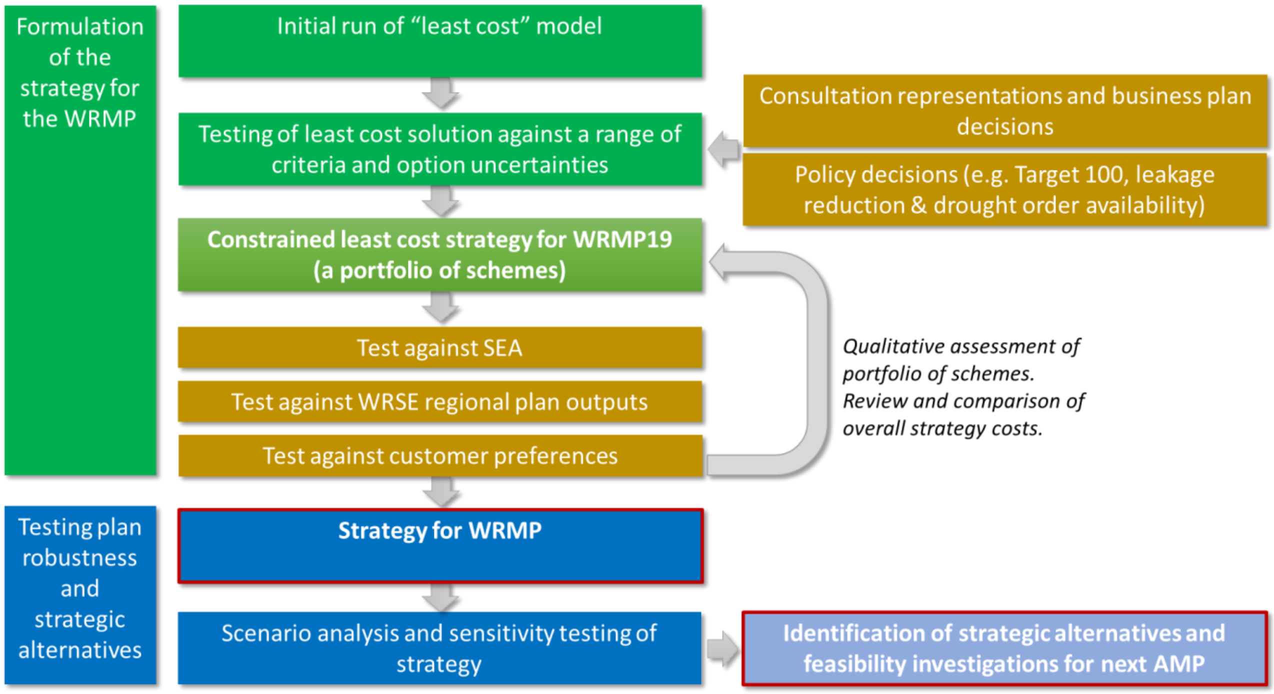
3. Development of the preferred plan

As described in Annex 8, an initial phase of scenario testing was conducted to help understand the sensitivity of the strategy to various possible constraints. The purpose of this testing was ultimately to inform the selection of our plan.

As shown in Figure 3, an initial 'least cost' run was undertaken to develop a 'basic solution', without further consideration of potential constraints. This was then tested by, for example, modifying assumptions about availability of certain options to progress our understanding of the impacts these assumptions might have on the strategy.

From examination of the various model outputs, and taking into account our policies, business planning decisions and pre- and post-consultation discussions with regulators and stakeholders, policy decisions and refinements were introduced to reflect a **'constrained' least cost strategy**. The policy decisions were in regard to the inclusion of water efficiency assumptions, the policy of leakage reduction (aiming to achieve a 15% reduction by 2025 and 50% reduction by 2050) and the availability of Drought Permits / Orders in severe and extreme drought events.

Figure 3 Development of final WRMP strategy



As discussed in detail in Annex 8, the constrained least cost strategy was then examined and tested against:

- Strategic Environmental Assessment (SEA) criteria
- Outcomes from regional planning exercises (Water Resources in the South East - WRSE)
- The preferences for different option types arising from customer engagement activity

Overlaying the environmental, regional planning and customer preference considerations on the constrained least cost strategy does not necessarily mean it will need to be changed – i.e. it may already adequately address key considerations from these criteria. Additionally, although some schemes may score less favourably against the SEA, regional plans or customer preference considerations, the non-availability of suitable, better alternatives or the size and timing of the deficit faced may mean that some options nevertheless need to be retained in the feasible list. It is also possible that these criteria could sometimes contradict each other – e.g. a scheme identified from WRSE may not align with, say, customer preferences; in which case, the company must exercise its judgement to weigh the pros and cons of a given scheme and the alternatives that would otherwise be needed. This represents a process of **qualitative multi-criteria assessment**.

The process of testing the constrained least cost plan against the environmental, regional and customer preferences criteria was therefore iterative. The other key element considered was the relative impact of the changes influenced by testing against criteria in terms of the overall strategy cost, compared to the least cost model and to the constrained least cost strategy. For example, where there is little cost difference and the change of option provides a more positive outcome to one or more of the testing criteria, then there is a stronger case for including the option change as part of the strategy.

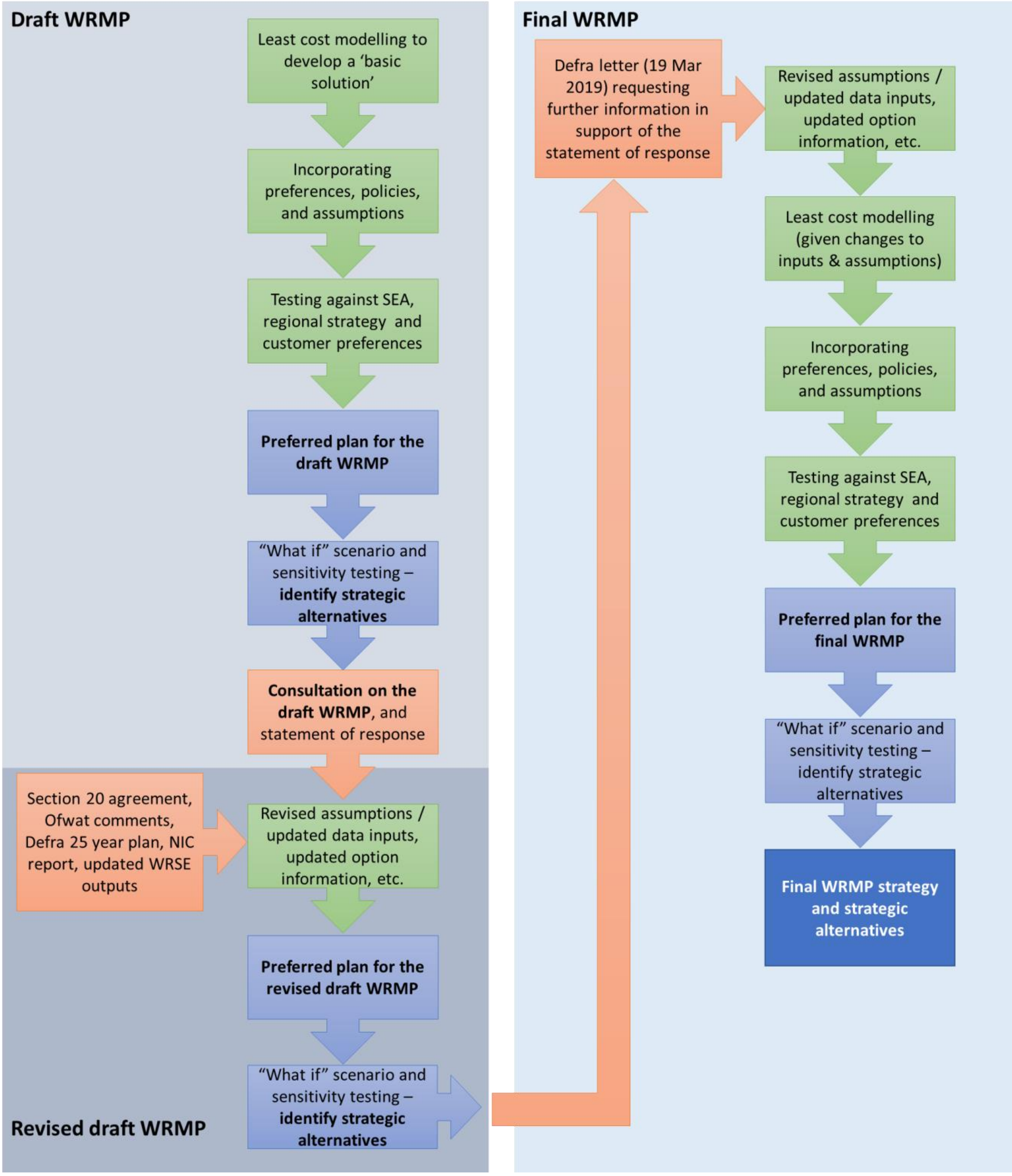
Following this review, any refined decisions on the feasibility or applicability of options was fed back into the Real Options Appraisal model to solve the SDBs for each future to derive the **strategy for this plan**.

The strategy for this plan was then subjected to scenario and sensitivity testing to understand what alternative strategic schemes may be needed, should it not be possible to implement the schemes in the preferred plan. This is particularly important for those schemes in the strategy that are required in AMP7 or AMP8; where there may be some uncertainty around the delivery of these schemes, we may need to conduct feasibility investigations of alternative schemes (and potentially environmental surveys and planning activities) in parallel to developing the portfolio of schemes selected in the preferred strategy.

The **draft WRMP strategy is published for consultation** with customers, stakeholders and regulators. The responses received during consultation may result in changes to the assumptions or inputs used to derive the SDBs, as well as to the set of options that are available to meet forecast deficits. The development of the plan as presented in the final WRMP is thus an iterative process, in which the above decision making approach is repeated and refined in production of a revised draft WRMP and final WRMP following consultation on the draft WRMP.

The process that we followed for the production of our WRMP is summarised below in Figure 4.

Figure 4 Development of the strategy from draft to final WRMP



3.1 Policy decisions to reflect a 'constrained' least cost strategy

3.1.1 Application of 'Target 100' water efficiency policy

In the draft WRMP the company outlined its commitment to delivering its 'target 100' water efficiency policy, which aims to achieve a per capita consumption (PCC) of 100l/h/d by 2040 (for clarity, this relates to average household PCC under normal year annual average conditions). This is well-aligned with Defra's 25 Year Environment Plan (Defra, 2018) which states that "*We will work with the industry to set an ambitious personal consumption target and agree cost effective measures to meet it*".

This policy formed a key component of the draft strategy, yet has been made more explicit in subsequent revisions to the plan, by drawing it out from the baseline demand forecast as a costed option. The Target 100 option developed for this WRMP supersedes many of the discrete demand management options that were included in the draft WRMP. It now comprises a basket of measures that Southern Water will need to adopt in order to deliver the highly ambitious reduction in PCC it is aiming for. The details of the option are described in Annex 6.

The least cost plan did not select the 'target 100' options, and so a policy decision was made that it should form part of the preferred strategy. It was therefore 'forced' into the least cost model.

3.1.2 Application of leakage reduction policy

Managing leakage is an important part of our water resources strategy. A low level of leakage is desirable, both for the environment, and because it defers the need to invest in new resources which would otherwise be required to meet increases in demand over time. However, it is not necessarily economic to reduce leakage to very low levels, because to do so could involve very large additional costs for relatively small savings of water. Our approach, and that of our regulators, is to set leakage at a level that meets the expectations of our customers and society as a whole, but is not necessarily optimal in terms of least cost. Our draft WRMP set out a combined strategy of further active leakage control in the short term followed by mains replacement programmes in the medium to longer term to ensure that we continue our drive down on leakage by 15% by 2025. We have maintained this commitment to meet Ofwat's leakage reduction target of 15% (from current levels) by the end of the next AMP in this plan. We have also now increased this commitment in the final WRMP, following recommendations in the recently published National Infrastructure Commission (NIC) report that companies should aim to be much more ambitious in terms of potential leakage reduction; as a result, we have committed to meeting the aspirations of that report to achieve a 50% reduction in leakage from current levels by 2050.

We also had developed, prior to the NIC report being issued, our own target of achieving 40% reduction from current levels by 2040, and so we have adopted this as an interim target as part of our leakage reduction policy.

The leakage reduction activity proposed to achieve these profiles of reductions are described more fully in Appendix C of Annex 6.

In order to meet our new leakage targets we will require investment in new activities such as using artificial intelligence to control pressure reduction valves to reduce leakage and bursts, and installation of new smart meter devices to help customers both reduce demand and reduce supply side leakage. In common with other companies we have been set very stretching efficiency challenges by Ofwat to deliver all AMP7 targets, but we are committed to making a material reduction in leakage.

The least cost plan was allowed to select from the wide range of leakage options without any constraint (e.g. around how much leakage activity could be delivered in any one year). Under the least cost model runs, relatively large amounts of leakage were being selected in the first year of AMP7 to address a deficit in that year, but further reductions were then not required until 2027.

We have adopted a policy decision that the leakage profile described above should form part of the preferred strategy. It was therefore 'forced' into the least cost model to ensure that 15% reduction is achieved by 2025, and 50% by 2050.

3.1.3 Application of drought interventions

Section 39B(2) of the Water Industry Act, requires the company when planning for drought, to plan to supply adequate quantities of wholesome water, with as little recourse as reasonably possible to drought orders or drought permits. In ensuring compliance with this, previous Water Resource Planning Guidance (WRPG) only required planning to be based on the worst historic event and water resource planning was not required to take into account wider severe drought conditions. The WRPG for WRMP19 has changed to now recognise the need for resilience in a severe drought condition (a 1 in 200 year drought event). Our previous WRMP14 already planned to a severe drought (1 in 200 year drought event) without any recourse to Drought Permits / Orders. **Planning in line with the WRPG therefore already reflects a continuation of our level of service**. We have therefore chosen our States of the World to carefully reflect the levels of service.

However, in this WRMP, we have also sought to understand the impacts of more extreme drought events (1 in 500 year drought event), as this aligns with the latest thinking around drought resilience (e.g. as reported in the recent National Infrastructure Commission report which highlighted the need for increased drought resilience to reduce or minimise the significant economic impacts of 'level 4' drought restrictions (stand pipes and rota cuts)).

In line with our continued practice of moving water resource planning forward, we have **only allowed Drought Permits / Orders to be selected in the investment model in an extreme drought event** (1 in 500 year drought event) so as to ensure that the WRMP can be resilient to a level in line with guidance, in line with our levels of service and in line with the requirement to plan with as little recourse as reasonably possible to drought orders and drought permits. It also means that the selection does not drive excessive infrastructure; but it still allows a progressive and pragmatic approach to exploring extreme drought events.

However, adopting this approach where we do not allow drought Permits / Orders in the severe drought condition could result in small unsolvable deficits in the short term if there are no supply-side options that could be developed quickly enough to solve any initial deficits in the severe drought condition. It could also result in a non-optimal plan, where an option is only selected because of its availability early in AMP7, rather than it being an optimal long-term option. Under the EA's Water Resource Planning Guidelines, allowing Drought Permits / Orders in a 1:200 level of drought is allowed. The only constraint specified is that companies' plans must set out a reference level of service that would ensure resilience to a 1:200 year drought event, where resilience means only avoiding emergency drought orders that allow restrictions such as standpipes and rota cuts. Our approach of allowing Drought Permits / Orders in our severe drought condition is therefore compliant with the WRP Guidelines.

A policy decision was therefore made to **allow an interim period where drought Permits / Orders would be used in both severe and extreme drought conditions**. For the Central area this interim period was until the end of AMP7. **After the interim period, drought Permits / Orders would only be available for selection under the extreme droughts**. This compromise ensures that the target

Level of Service is met and that we continue to work to improve our resilience to drought. The model was therefore allowed to select Drought Permits / Orders on this basis.

In regard to the demand-side drought interventions, we have added a dependency to the selection of a drought permit or order in the model, such that it must have also selected the TUBS and Non-essential use restrictions.

It is important to recall that all the states of the world must be solved simultaneously in the Real Options model. What we are examining when we look at both the severe and extreme states of the world is thus the balance in the solutions between the portfolio of options needed in severe droughts without drought interventions (except in the short term), with that same portfolio of options in combination with drought interventions in extreme droughts. We are effectively examining whether we have sufficient options to meet differing levels of drought when considering that drought interventions would also be available to be used in extreme droughts. But we are also recognising that these drought interventions may not be available in all WRZs in a supply area, and that the connectivity between WRZs may be limited. Our analysis therefore considers the resilience of transfers between the WRZs, and the potential need for increased connectivity.

3.2 Influence of testing criteria on the constrained least cost strategy

3.2.1 Environmental assessment

This type of assessment is used to address whether the combination of options and timing of the need for them present particular risks or have planning and promotional issues that might affect the deliverability of the scheme or schemes. It represents a second stage of the environmental screening that is a key part of the options appraisal process to develop a feasible set of options; however, timing of option implementation and cumulative impacts are clearly important additional considerations, as well as feedback from consultation responses on certain options.

For the Central area, the constrained least cost strategy (as previously described in the start of section 3 and in Annex 8) was reviewed and the following decisions made in relation to the development of the preferred plan due to applying environmental assessment criteria:

- **Tidal River Arun desalination**: Initial variants of the constrained least cost strategy were selecting the Tidal River Arun desalination scheme, however, when this was viewed against environmental criteria it was considered less favourable than equivalent alternatives, such as desalination at Shoreham Harbour. It was also considered to be less favourable in terms of planning. The Tidal River Arun desalination scheme was therefore excluded from the preferred plan model run which triggered the selection of the Shoreham desalination scheme instead
- **Brighton WTW indirect potable reuse scheme**: this joint development with South East Water was identified as a scheme with potential environmental risks, but ultimately was not required on the grounds that there was no driver from South East Water for this scheme. Nevertheless, this scheme will be maintained for future consideration, potentially with feasibility investigation of an alternative arrangement of using it as more of an aquifer storage and recovery option, subject to technical feasibility, testing and securing required consents which may address some of the environmental issues already identified

3.2.2 Regional planning

A cross-check was conducted against the outputs from the WRSE modelling scenarios along with a review against bi-lateral discussions we have held, and continue to have, with neighbouring water companies covering bulk supply needs and timing / need for any schemes that could be jointly developed.

For the Central area, the constrained least cost strategy was reviewed and the following decisions made in relation to the development of the preferred plan from a regional planning perspective:

- **Brighton WTW indirect potable reuse scheme**: this is a joint development scheme with South East Water. It was not selected under most scenarios from the WRSE modelling – i.e. it was not one of the 'prevalent' options which are selected by the WRSE regional model in eight or more of the nine scenarios modelled. We entered into dialogue with South East Water, but they confirmed that it was not required in their preferred plans. Nevertheless, this scheme will be maintained for future consideration

3.2.3 Customer preferences

As discussed in Annexes 1 and 8, the company has undertaken quantitative and qualitative research into customer preferences relevant to the WRMP. Representations were also received from customers, stakeholders and regulators in response to the consultation on the draft WRMP.

The customer preference studies and representations, and those from the previous WRMP (published in 2014), have informed the development of the company's stance on appropriate levels of service and, together with feedback from stakeholders, has helped us to understand views and preferences on the supply and demand management options that make up our options set. It has been applied to the development and formulation of our preferred strategy by excluding options that were not likely to meet customer or regulator expectations in the options appraisal. Where there are some differences in the outcomes from different customer research, we have set out our proposed way forward which either involves aligning with Government and regulatory ambitions, regional strategies or the informed customer position with a provision to gain further insight to help deliver some of these options.

For the Central area, the constrained least cost strategy was reviewed, and the following decisions made in relation to the development of the preferred plan from a customer preference perspective:

- **Aquifer storage and recovery (ASR) in the Lower Greensand**: This was the most favoured option in the pre-draft consultation, but that was not reflected in the same way in the customer preference survey completed during consultation on the draft WRMP. Nevertheless, the option remained popular in the qualitative research groups. It was decided to include it in the preferred plan, as an option that also provides greater resilience
- **Target 100 water efficiency policy and leakage reduction policy**: both broadly supported by customers, which in turn supports the company's decision to implement these policies

3.3 Other decisions to conclude development of the preferred plan

A number of other decisions were also made to derive the preferred plan as part of the iterative and qualitative process of reviewing and updating the constrained least cost plans.

- **Extension of the Universal Metering Programme (UMP) to take household meter penetration from 88% to 92%**: A policy decision was made that, where a desalination option was selected in the short to medium term (i.e. before 2030), then the company would try to maximise its demand management activity. As a result, we 'forced' the option to be selected to extend the compulsory meter programme to take household meter penetration from 88% to 92%. This option commences in 2020, with the aim of reaching 92% metering in each WRZ in the supply area by the end of AMP7. It also aligns closely with our Target 100 water efficiency policy
- **Transfer to Midhurst WSW and Petersfield borehole (BH) rehabilitation**: This asset enhancement scheme was not being selected in the constrained least cost run, but was considered to provide resilience benefits that meant it should be included in the preferred plan

4. Strategy for the WRMP (preferred plan)

4.1 Portfolio of options selected in the strategy

This section is structured to provide an overview on each of the key option categories from the feasible list of options.

For new resource developments, it will be necessary for detailed engineering and environmental assessments to be undertaken and for planning and other consents to be secured and for the schemes to be constructed and commissioned. For transfers from other water companies there may be a need for asset enhancements, and/or for the development of new water resources within those companies in order to free up water to make the transfers available. The timings within this plan are our best estimates for delivery at this point in time.

4.1.1 What is driving the need for investment?

- There are large initial deficits (during AMP7) in the Sussex North (SN) WRZ in the severe and extreme drought conditions
- The Central area investments are being driven by unconfirmed sustainability reductions. These sustainability reductions will be confirmed by the EA following the conclusion of the investigations the Company is proposing to undertake in the next 5 years. Therefore, whilst the options to resolve these potential future challenges need to be investigated and outline designs produced we would only pursue the options following the final confirmation of the sustainability reductions (this is explored further in sensitivity testing in section 5)
- Sussex Worthing (SW) WRZ has an initial surplus in all states of the world. Whilst it is able to support both SN WRZ and Sussex Brighton (SB) WRZ through existing transfers, there is insufficient surplus to allow it to reduce the deficits in these WRZs
- SB WRZ has a small initial deficit in extreme drought conditions and in the MDO state for the severe drought condition
- SW WRZ and SN WRZ are connected through a reversible transfer; and SW WRZ and SB WRZ are connected with a transfer whose capacity is due to be increased and made reversible by 2026

Table 2 shows the supply demand deficit that needs to be solved (for the severe MDO planning condition) across the Central area, and how this varies in the different branches.

Table 2 Initial supply demand deficit in the severe MDO state of the world

Central: Preferred Plan	Initial supply demand deficit (end of AMP) (Ml/d) (Severe drought MDO)					
	2020-25 (AMP7)	2025-30 (AMP8)	2030-35 (AMP9)	2035-40 (AMP10)	2040-45 (AMP11)	2045-2070
10th %ile branch	-4	-90	-91	-93	-94	-103
30th %ile branch		-76	-76	-78	-79	-85
50th %ile branch		-53	-53	-54	-55	-61
70th %ile branch		-29	-29	-30	-32	-38
90th %ile branch		-14	-14	-15	-16	-20

4.1.2 Summary

The cost of this strategy over the planning period, expressed in net present value terms, is £500m. The **key elements of the strategy** are:

- Drought Permits / Orders are likely to be needed in AMP7 in severe as well as extreme drought conditions to solve the initial deficits before resources can be developed. This is the case for Pulborough surface water, Pulborough groundwater, and Weir Wood reservoir in SN WRZ, and East Worthing and North Arundel in SW WRZ;
- Drought Permits / Orders will continue to be available as an option in extreme drought conditions only from 2025 but these are not required after AMP8
- There are a number of significant resource developments needed in 2027 in each WRZ, largely driven by some large and uncertain sustainability reductions
- We have adopted a very strong focus on demand management activity through implementation of the Target 100 water efficiency policy, the adoption of a leakage reduction profile to achieve reductions from current levels of 15% by the end of AMP7, and 50% by 2050, and extension of the UMP to take household meter penetration from 88% to 92%
- Littlehampton WTW indirect potable water reuse scheme in SN WRZ, which is selected from 2027 onwards, and is utilised near to capacity in the 10th (higher deficit) branch, while also being used significantly in the 30th percentile branch
- 10Ml/d Shoreham coastal desalination option in SB WRZ is selected from 2027 is used near to capacity in the severe and extreme droughts but primarily in the larger deficit branches
- A new option, not included in the draft WRMP, allows for a licence variation at the Pulborough groundwater source, which provides a large DO benefit in the extreme drought events only, and is selected from 2021 onwards
- The ASR scheme in SW WRZ is included in the strategy from 2027. It is utilised in the severe and extreme states of the world in the 10th and 30th percentile branches only
- There is a net bulk supply into the SN WRZ: Portsmouth Water to Pulborough at 15Ml/d, against the 5Ml/d export to SEW from Weir Wood. Portsmouth Water's ability to provide 15Ml/d in extreme droughts may present a risk to us, particularly early in the planning period
- Several asset enhancement schemes are implemented in the SN and SB WRZs in AMP7 and AMP8

This strategy is summarised below in Table 3.

Table 3 Summary table of schemes in the Central area

Schemes	WRZ	Strategy (year selected)	Branches
Demand management			
Target 100 water efficiency activity	All	**2020 onwards**	Forced
Leakage reduction (15% reduction by 2025; 50% by 2050)	All	**2020 onwards**	Forced
Extension of UMP to take HH meter penetration from 88% to 92%	All	**2020 onwards**	Forced
TUBS and NEU Ban	All	**2020 onwards**	All branches
Resource development and bulk supplies			
Littlehampton WTW Indirect Potable Water Reuse (20Ml/d)	SN	**2027**	All branches
Coastal desalination - Shoreham Harbour (10Ml/d)	SB	**2027**	All branches
Pulborough groundwater licence variation	SN	**2021**	All branches
ASR (Sussex Coast - Lower Greensand)	SW	**2027**	Forced
Transfer to Midhurst WSW and Petersfield BH rehabilitation	SN	**2025**	Forced
Scheme to bring West Chiltington back into service	SN	**2024**	All branches
Winter transfer Stage 2: New main Shoreham/North Shoreham and Brighton A	SB	**2027**	All branches
Catchment management			
Arun/W Rother - instream catchment management options	SN and SW	2027	All branches
Pesticide catchment management / treatment – River Arun	SN	2024	Forced
Pesticide catchment management / treatment – Pulborough Surface	SN	2024	Forced
Pesticide catchment management / treatment – Weir Wood Reservoir	SN	2024	Forced
Nitrate catchment management / treatment – North Falmer A	SB	2026	All branches
Nitrate catchment management / treatment – North Arundel	SW	2027	All branches
Nitrate catchment management / treatment – North Falmer B	SB	2025	All branches
Nitrate catchment management / treatment – Long Furlong B	SW	2022	All branches
Nitrate catchment management / treatment – Brighton A	SB	2027	All branches
Nitrate catchment management – Steyning	SN	2035	All branches
Drought Permits / Orders in severe and extreme droughts			
East Worthing Drought Permit/Order (2020-25)	SW	2020	All branches
Pulborough surface (Phases 1 to 3) Drought Permit/Order (2020-25)	SN	2020	All branches
Pulborough groundwater Drought Order (2020 onwards)	SN	2020	All branches
North Arundel Drought Permit/Order (2020-25)	SW	2020	All branches
Weir Wood reservoir Drought Permit/Order (2020-25)	SN	2020	All branches
Drought Permits / Orders in extreme droughts only			
East Worthing Drought Permit/Order (2025 onwards)	SW	2025 *2029*	All branches *1 branch*
Pulborough surface (Phases 1 to 3) Drought Permit/Order (2025 onwards)	*SN*	*2027-28*	*1 branch*
Strategic alternatives and investigations			
Coastal desalination - Shoreham Harbour (Modular up to 30Ml/d)	SB	AMP8	
Tidal River Arun desalination (10Ml/d)	SW	AMP8	
Brighton WTW indirect potable reuse (joint scheme with South East Water, 10Ml/d scheme for SWS)	SB	AMP8	
Winter transfer Stage 2: turbidity/sludge handling process improvements at Pulborough	SN	AMP8	

The figures below set out 'snapshots' of the initial supply demand balance situation and the types of options that are selected to address the deficits. These are presented at area level, at two time periods – the end of AMP8 (2029-30) and at the end of the planning period (2069-70). Additionally, each branch and state of the world will have its own solution, so for the purposes of presentation we have focused on the severe drought condition, and also on the 30th percentile as the higher deficit branches do tend to drive the investments needed particularly in the next 5-10 years, and so presenting this branch seems to be most pragmatic lying between the highest deficit future and the 50th percentile future. Note also that because these plots are presented at area level, they do not necessarily reflect the detail for selection of all the options – for example, it may be that an option is needed to meet a deficit in a given WRZ, for which there is otherwise limited connectivity to the rest of the supply area, yet there may be surpluses in other WRZs. That is, the surplus/deficit at area level is not always reflective of the driver behind the need for some options being selected.

Nevertheless, these 'waterfall' plots provide a useful way of presenting the deficits at key points in time and the composition of the solution to address those deficits.

Figure 5 Deficits and solutions plot for Central area at the end of AMP8 (severe drought MDO)

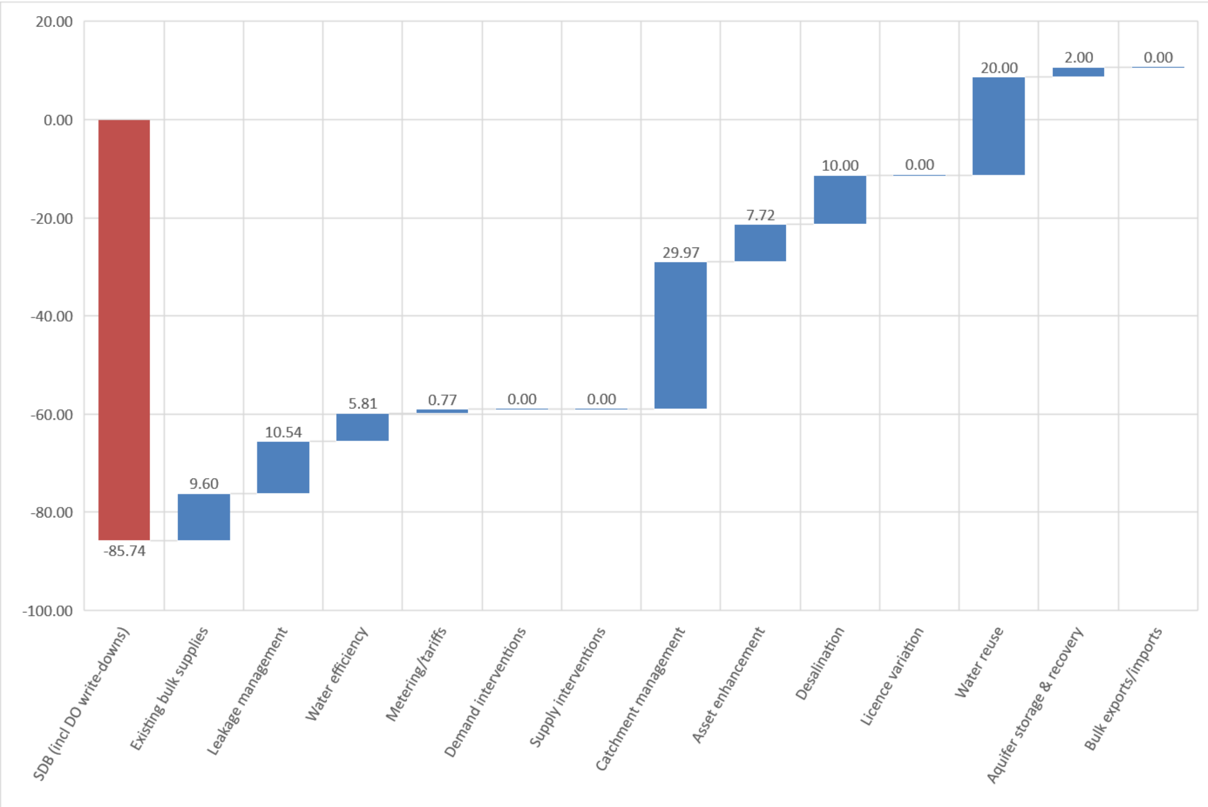
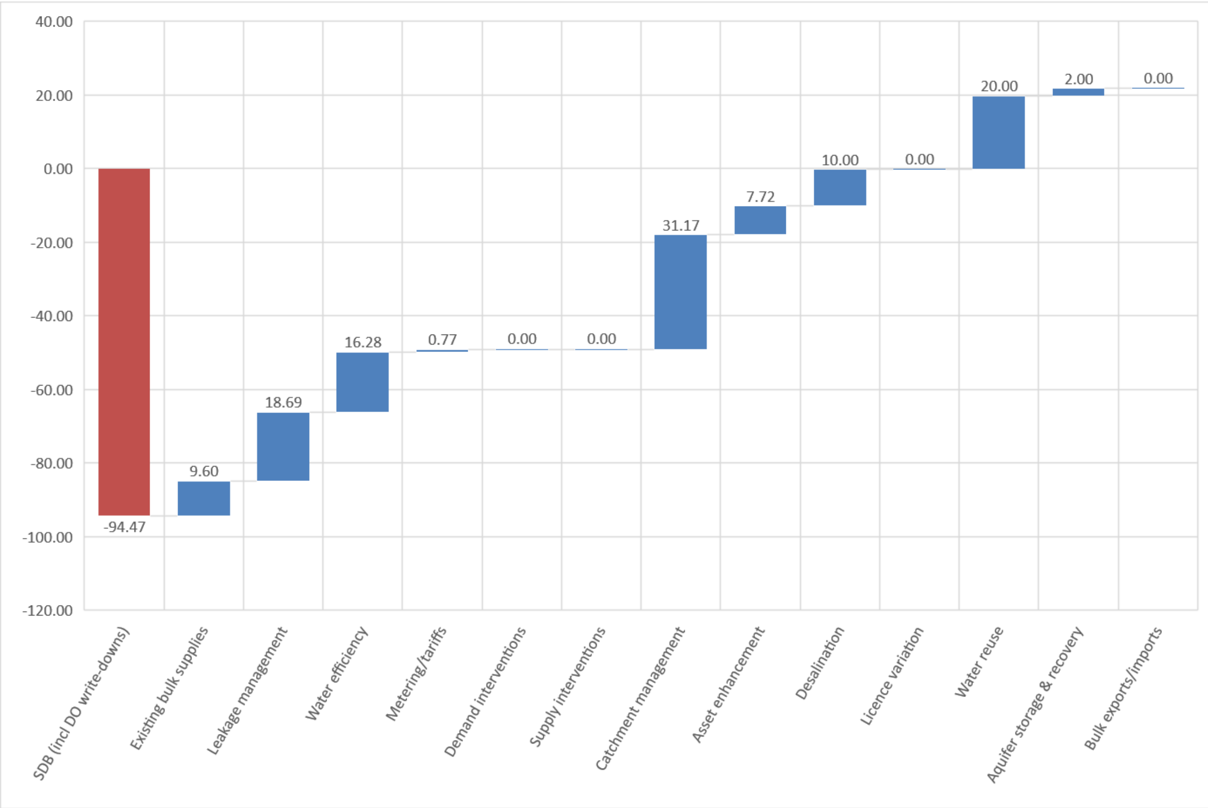


Figure 6 Deficits and solutions plot for Central area at the end of the planning period (2069-70) (severe MDO)

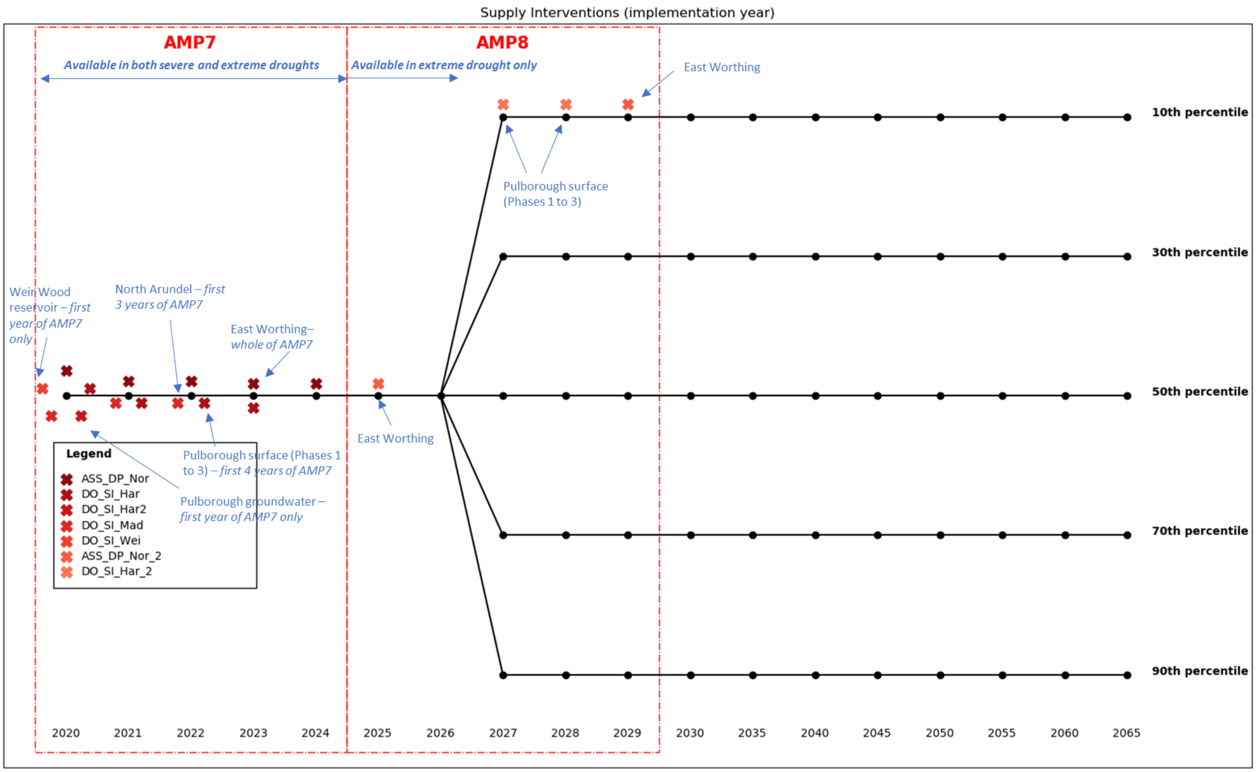


4.1.3 Drought Permits and Orders

As discussed previously we have taken a policy decision that drought Permits / Orders will only be used in the extreme drought states of the world. However, in AMP7, there are insufficient resources available to be developed in the short term to solve the initial deficits in the severe drought conditions, without recourse to drought Permits / Orders. Therefore, we have allowed for an interim period where drought Permits / Orders would be used in both severe and extreme drought conditions. For the Central area this interim period was until the end of AMP7. After that interim period, drought Permits / Orders would only be available for selection under the extreme droughts. This compromise ensures that the target Level of Service is met and that we continue to work to improve our resilience to drought. The model was therefore allowed to select drought permits and orders on this basis.

Drought permits / orders are therefore allowed in both severe and extreme droughts for the period 2020-24 (AMP7), but from 2025 onwards, Drought Permits / Orders will only be allowed under the extreme drought states of the world. The way in which drought permit/order options are selected in the strategy is summarised in Figure 7.

Figure 7 Summary of Drought Permits / Orders by branch



4.1.4 Demand management

A number of demand management options have been selected in the preferred plan and are assumed to commence at the start of AMP7, but run over a number of AMP periods delivering longer term demand savings.

- Extension of the UMP to provide coverage to around 92% of customers – this was included as a policy decision to maximise demand management, in light of the fact that major resource developments (including desalination) may be required in this area (as discussed in section 3.3)
- Implementation of the 'Target 100' policy, to reduce average per capita consumption in years of normal weather conditions to 100 litres per day. This policy decision was described in section 3.1

The programme of metering which has been selected as part of our Central area strategy is set out below, with greater detail on the options provided in Annex 6.

Extension of UMP

This is an extension of our UMP that involves installation of AMR meters at unmetered properties and moving them over to a metered charging regime. This option aims to increase domestic meter penetration from current levels (88%) up to 92% in each WRZ by the end of AMP7.

Consistent with our findings from implementing the original UMP, we have made an assumption that extending our metering campaign will also generate a small number of optant requests, which have been incorporated in the overall meter penetration target of option MAMR1 (92%). This is in recognition of our statutory obligation to continue to provide optant meters to customers when requested.

The total numbers of meters to be installed in each WRZ as part of this option are summarised in Table 4. At this strategic stage of the planning process, for the purposes of estimating costs and benefits of the option (as detailed in annex 6), a linear installation programme has been assumed across AMP7, with an equal number of meters being installed in each of the 5 years of AMP7 across each of the WRZs in the relevant areas. There are currently no priority areas which have been identified to be targeted first. As we move towards more detailed planning of the scheme, it is likely we will draw upon our experiences in designing and implementing our UMP. However, because there are relatively few meters being installed compared to our UMP, we will need to undertake geospatial analysis of where these customers are located, and design the implementation strategy accordingly, initiating customer contact in a systematic way.

Table 4 New meter installations under the preferred plan

Area	WRZ	Total number of meters to be installed during AMP7	Total installation cost (£k)[1]	Total cost of operation of meters (£k/yr)
Central area	Sussex Brighton	19,542	7,212	137
	Sussex Worthing	1,000	369	7
	Sussex North	6,795	2,508	48
Central area total		*27,337*	*10,089*	*191*
Company total [2]		33,864	12,497	237

[1] Note that these costs are all classified as operational for consistency with Business Plan classifications.
[2] Other activity to extend compulsory metering will be targeted in the Western area.

Target 100
As well as additional metering in our Western and Central areas, our preferred plan also includes implementation of our Target 100 option across all three of our supply areas. Whilst this option does not include installation of new meters at previously unmetered households, it does include, but may not be limited to, the following metering-related enhancement activities (more details are provided in annex 6):

- During AMP7: Increasing the meter reading frequency from six-monthly to monthly in all supply areas (including replacing the 45,500 visual meter reading (VMR) meters that are expected to remain after the end of AMP6 across the company) (detailed in Table 5)
- During AMP8: Company-wide smart metering roll-out, involving replacing 780,000 existing meters (those already in place at the start of AMP7) with smart meters and installation of the associated technology (detailed in Table 6)
- During AMP9: Completion of company-wide smart metering roll-out, installing 320,000 smart meters company-wide at existing metered households by 2032 (detailed in Table 6)

These activities, and the numbers of households that will be included in each activity, are summarised in the tables below.

Table 5 Number and cost of VMR meters that will be replaced with AMR meters during AMP7, and cost of increasing meter reading frequency, both part of Target 100

Area	WRZ	VMR meter replacements during AMP7*	Total installation cost of VMR meters (£k)	Total operational cost of increasing meter reading frequency from 6-monthly to monthly over 25-year planning period (£k)
Central area	Sussex Brighton	5,816	431	576
	Sussex Worthing	3,415	253	382
	Sussex North	4,501	333	486
Central area total		*13,732*	*1,017*	*1,443*
Company total		45,333	3,357	4,746

** An equal number of replacements has been assumed in each year of AMP7 within each WRZ.*

Table 6 Number of smart meters that will be installed over AMP8 and AMP9 as part of Target 100

Area	WRZ	Number of smart meters installed each year of AMP8 (2025-26-2029-30)	Number of smart meters installed each year for the first 3 years of AMP9 (2030-31-2032-33)	Total installation cost of smart meters (£k)
Central area	Sussex Brighton	22,660	15,494	25,975
	Sussex Worthing	12,307	8,415	14,108
	Sussex North	16,081	10,996	18,434
Central area total		*51,048*	*34,905*	*58,516*
Company total		156,000	106,667	178,821

Meters installed at new properties

It is important to recognise that new household properties will also contribute to the levels of household meter penetration achieved as part of our WRMP strategies, because all new properties are metered. Table 7 below summarises the forecast number of new properties in each WRZ across each 5-year period (AMP) over the planning period, estimated as part of our WRMP demand forecast (details of which are provided in annex 2).

Table 7 New household meters installed over the 25-year planning period

Area	WRZ	Total number of new properties				
		AMP7	AMP8	AMP9	AMP10	AMP11
Central area	Sussex Brighton	6,009	5,109	5,288	5,282	5,262
	Sussex Worthing	4,249	2,684	2,045	2,056	2,086
	Sussex North	6,422	3,336	3,656	3,410	3,425
Central area total		*16,680*	*11,129*	*10,989*	*10,749*	*10,773*
Company total		61,589	49,774	44,581	46,347	46,233

Cost information

The cost of installing meters at new properties forms part of our base expenditure, rather than enhancement, so these costs are not presented in the WRMP. All meter installations and ongoing operation of these meters are classified in our Business Plan as operational (opex) costs, therefore are treated as such in our WRMP (i.e. total costs are included in WRP Table 5 as variable opex).

4.1.5 Leakage reduction

In this plan we have committed to meet Ofwat's leakage reduction target of 15% (from current levels) by the end of the next AMP. We have also increased this commitment over the longer term to achieve a 50% reduction in leakage from current levels by 2050, which aligns with recommendations in the recently published National Infrastructure Commission report.

The leakage reduction activity proposed to achieve these profiles of reductions are described more fully in Appendix C of Annex 6.

4.1.6 Resource developments

A **key part of the Central area strategy is the need for both water reuse and desalination schemes in 2027, primarily to address some large and uncertain sustainability reductions**.

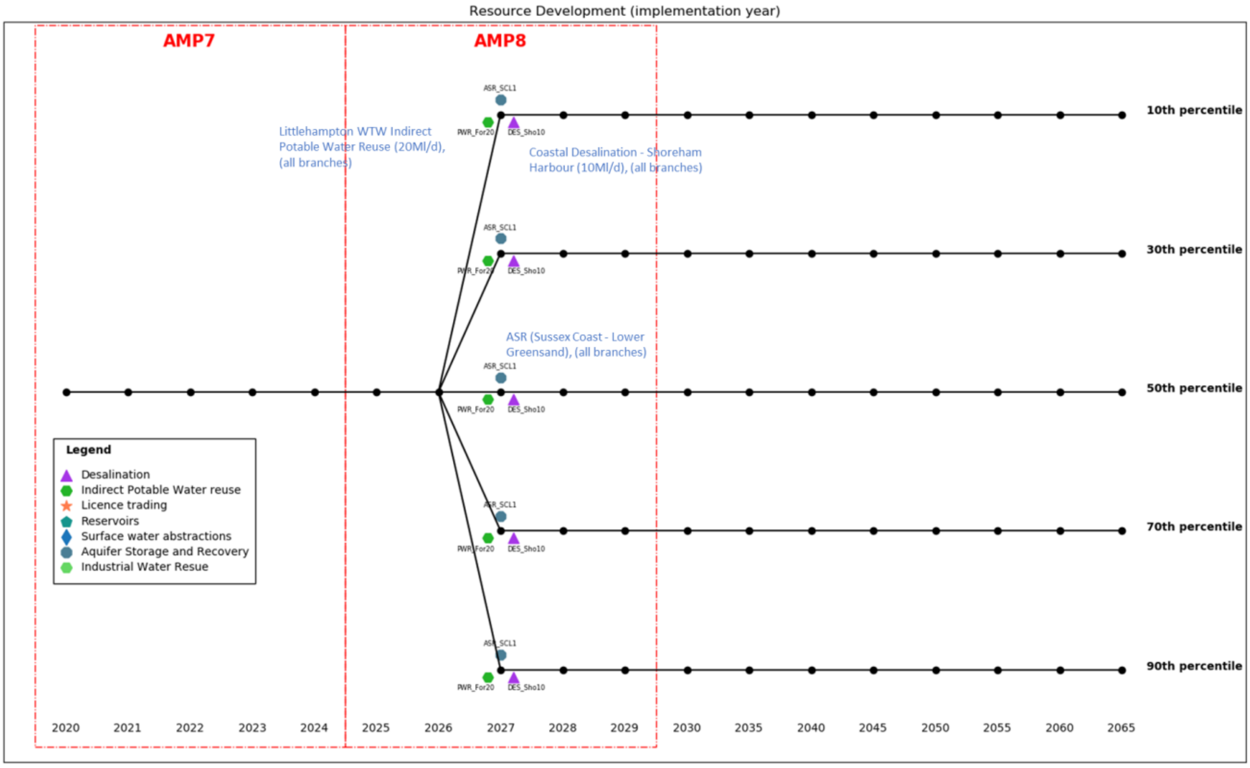
The Littlehampton WTW indirect potable water reuse scheme in SN WRZ is selected from 2027 onwards. In the severe and extreme drought states of the world it is generally fully utilised in the 10th and 30th percentile branches either through the plan (in the 10th) or until the late 2030s (in the 30th), when it is typically used more at 50% of capacity. It is also used in AMP8 in the drought MDO condition.

The 10Ml/d Shoreham coastal desalination scheme is used in the SB WRZ from 2027. It is generally fully used in the 10th and 30th percentile (higher deficit) branches in the severe and extreme drought MDO states of the world, but only in AMP8 / and AMP9. Otherwise its use tends to rarely exceed its minimum 'sweetening flow' of a quarter of capacity. This suggests that the final size of the desalination scheme could be optimised to be more appropriate, although there would be a risk of a shortfall in the medium term, unless allowance was made for modular components up to 10Ml/d.

The Sussex coastal aquifer storage and recovery (ASR) scheme was brought in to the strategy in 2027, as discussed in section 3.2.3. It is utilised in the severe and extreme drought states, where it is used extensively in the 10th and 30th percentile branches.

Figure 8 provides a summary of the resource development options selected under each branch and their timing.

Figure 8 Summary of resource development options selected by branch



4.1.7 Bulk supplies

Imports

There is an existing import from Portsmouth Water to Pulborough in the SN WRZ. The transfer capacity is 15Ml/d, although there may be some uncertainty around whether Portsmouth Water could supply this quantity of water in an extreme drought. This may pose a risk if an extreme drought event were to occur in the short term (e.g. in AMP7).

No additional bulk import options were identified.

Exports

There is one existing export from Weir Wood reservoir to South East Water. This has been assumed to continue at current volumetric rates for the duration of the plan.

No additional bulk exports were requested or identified.

4.1.8 Enabling transfers (inter-zonal transfers)

There are some existing inter-zonal transfers in the Central area:

- A reversible connection between SN and SW WRZs. In general, the SW WRZ is used to support the SN WRZ in the period up to 2027 in all branches, and after 2027 in the lower deficit (70th and 90th percentile) branches; whereas post-2027, SN supports SW in the higher deficit branches
- A main from SW WRZ to SB WRZ, which is used intermittently across the states of the world

One new enabling transfer option is included in the plan; this scheme is to **develop the infrastructure to allow the existing link from SW WRZ to SB WRZ to be reversed**, so that Brighton can support the Worthing zone instead if needed. This option is already planned for delivery in 2026, due to the system resilience benefits it would have.

In general terms, in the higher deficit branches (10th and 30th) SW supports SB, but in the lower deficit branches (70th and 90th) SB support SW.

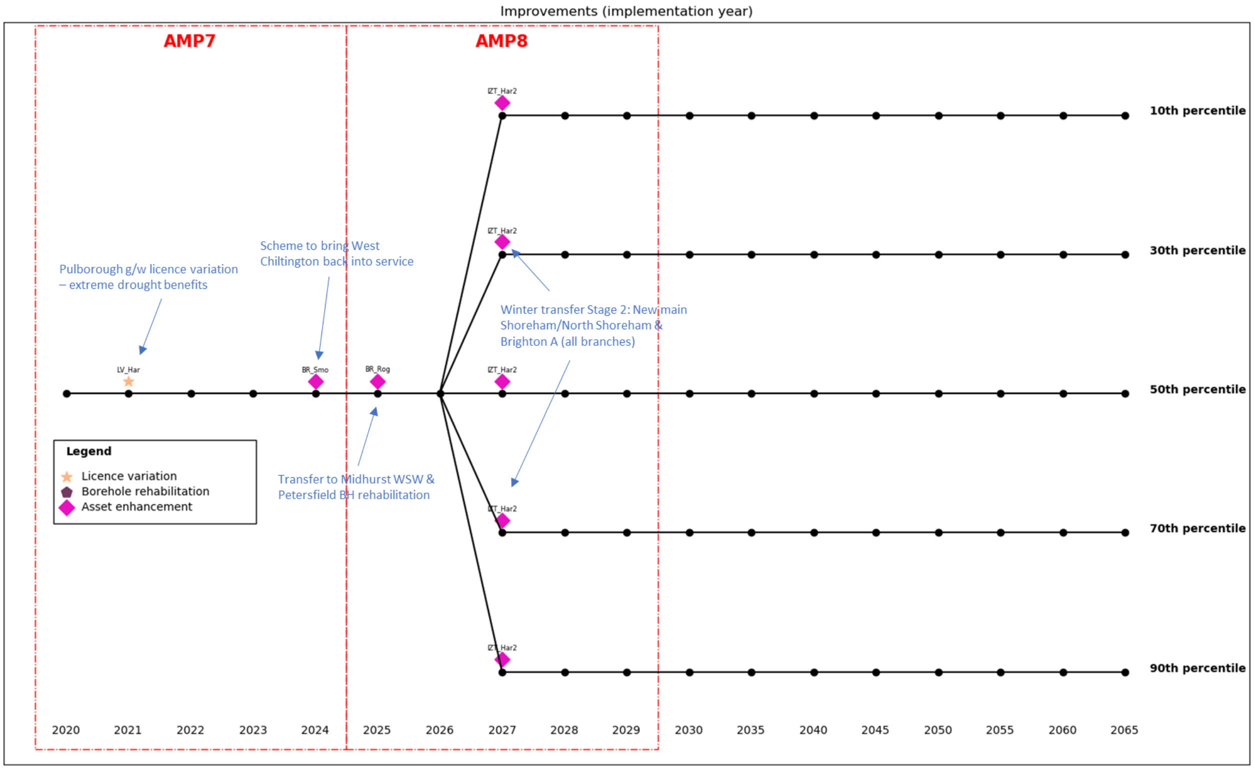
4.1.9 Asset enhancements

Several asset enhancement schemes are selected over the planning period.

- Pulborough groundwater licence variation in SN WRZ is selected in 2021, providing benefit in the extreme states of the world only. The Pulborough groundwater source is dependent on long term recharge to a confined aquifer and does not affect flows in the River Rother. This scheme proposes to decouple the groundwater licence from the Hands off Flow condition on the River Rother such that it is less sensitive to the Hands off Flow being reached in extreme droughts. It is used extensively in the extreme MDO condition in all branches, but in the extreme PDO state, it is not needed as much in the lower deficit branches
- Transfer to Midhurst WSW and Petersfield BH rehabilitation in SN WRZ from 2025. This is used across all branches in the extreme MDO drought condition, but only in the higher deficit branches in the others states of the world (extreme PDO, and both MDO and PDO in the severe and drought conditions)
- Scheme to bring West Chiltington back into service in SN WRZ from 2024. This is used in the drought, severe, and extreme states of the world (MDO and PDO) in the higher deficit branches
- Pulborough winter transfer: Stage 2 - New main between Shoreham WSW/North Shoreham WSW and Brighton A in SB WRZ from 2027. This is used in drought, severe drought and extreme drought conditions in the higher deficit branches

Figure 9 below provides a summary of the asset enhancement options selected under each branch and their timing.

Figure 9 Summary of asset enhancements selected by branch



4.1.10 Catchment management options

There are two sets of water quality-driven catchment management options in the Central area. The first are options to address water quality issues associated with nitrates; while the second set address water quality issues associated with pesticides. There is also an option for in-stream catchment management.

The pesticide options are not assumed to provide a DO benefit, but instead provide resilience in the event of a pesticide issue.

However, the nitrate water quality issues are assumed to effect sources resulting in a deployable output (DO) write-down, with a catchment management and treatment option that can recover that lost DO (where it is economic to do so). Table 8 provides a summary of the sources at which there has been a DO write-down to account for water quality risks from nitrates, and the year in which a scheme is implemented to recover that lost DO by installing treatment alongside catchment management activity.

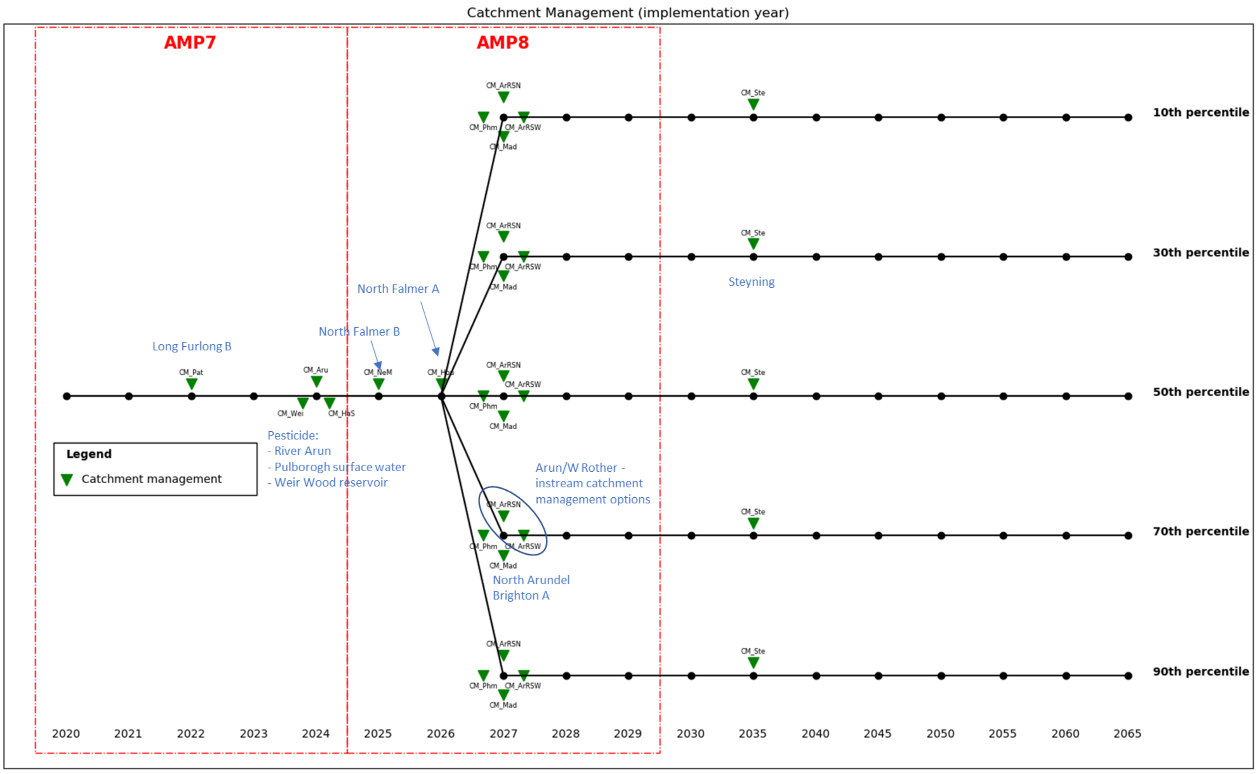
Table 8 Summary of nitrate catchment management options

Source	WRZ	DO write-down (year)	Scheme to recover DO (year selected)
Nitrate catchment management / treatment – North Falmer A	SB	2025	2026
Nitrate catchment management / treatment – North Arundel	SW	2027	2027
Nitrate catchment management / treatment – North Falmer B	SB	2025	2025
Nitrate catchment management / treatment – Long Furlong B	SW	2022	2022
Nitrate catchment management / treatment – Brighton A	SB	2027	2027
Nitrate catchment management – Steyning	SN	2034	2035-39

Figure 10 provides a summary of all the catchment management options selected under each branch and their timing.

Southern Water

Figure 10 Summary of catchment management options selected by branch



4.2 Changes from the draft strategy

The draft strategy was published on 5 March 2018 and consulted on over the period 5 March to 28 May 2018.

This final plan differs from the draft strategy in the following ways:

- The approach to leakage has changed significantly with a new profile being applied for the final WRMP
- The incorporation of the Target 100 policy has been applied explicitly rather than as part of the baseline demand forecast
- There is no selection of metering to 100% in SN WRZ in the plan
- The 10Ml/d Tidal River Arun desalination scheme was selected in addition to 10Ml/d Shoreham desalination scheme in the draft WRMP; whereas for this final plan, only one of these is required, and the preference is for that desalination to be at Shoreham rather than on the River Arun
- The Brighton WTW water reuse scheme (jointly developed with South East Water) was not needed by either company
- There is a new option for a licence variation at Pulborough groundwater that was not available for the draft plan
- Minor changes to the start year of the asset enhancement schemes
- There is a new option for an in-stream solution on the Arun / Western Rother that was not available for the draft plan
- There are fewer nitrate catchment management schemes than in the draft plan

What is driving the changes from the draft WRMP?

The changes to the supply demand balance inputs in this final plan, compared to the supply demand balance from the draft plan are presented and discussed in detail in Annex 5. The key changes to note are:

- SN WRZ has a higher relative supply-demand balance (SDB) in the final plan compared to the draft, driven by a lower outage forecast by the end of AMP7, and a less severe dry climate change
- SB WRZ has a higher relative SDB in the final plan compared to the draft, driven by a lower outage forecast by the end of AMP7, and a larger baseline DO due to changed climate change assumptions
- SW WRZ has a slightly higher SDB in the final plan compared to the draft (from 2021 onwards), driven by a larger baseline DO due to changed climate change assumptions, and a lower demand forecast

Note that a higher relative SDB means that the SDB is greater in the final plan when compared to the draft plan, not that the revised plan is itself in surplus. Or expressed another way, a higher relative SDB means that the deficit faced is lower compared to the draft plan. These changes, alongside revised assumptions following the consultation on the draft, have driven the relatively limited changes from the draft plan outlined above.

4.3 Climate change assessment of the preferred plan

A quantitative assessment of the impacts of climate change on the DOs or demand savings expected to be obtained from each of our identified supply and demand measures has been undertaken in accordance with section 37A(3)(b) of the Water Industry Act, 1991. The results of this assessment are presented in the table below.

This table sets out the specific assumptions we have made when assessing the climate change impact of each of the schemes in our preferred plan. We have also applied the following general assumptions to all estimated climate change impacts:

- We have excluded our “Strategic Alternative” options from this assessment after receiving clarification from the EA that only the preferred schemes needed to be included.
- We have assumed and stated the full impacts of climate change to 2085 consistent with our modelling assumptions in annex 3
- We have applied the same dry, medium and wet possible future climate change scenarios used in our annex 3 modelling of climate change impacts for our baseline supply forecast.
- The climate change impacts on schemes are stated in a consistent manner with our baseline supply forecast for a severe drought (1:200) unless the option specifically states benefits under extreme droughts (1:500) or drought conditions (1:20)
- Unless otherwise stated, the climate change impacts are the same for both our critical period (PDO) and minimum or average period (MDO/ADO) states of the world. Generally, this means that where there are no forecast impacts, a single figure of 0Ml/d is reported and applies to all states of the world

Table 9 Assessment of the impacts of climate change on the strategy

Strategic Schemes	Climate Change Impact (Ml/d)			
	Dry Scenario	Mid Scenario	Wet Scenario	Climate change impact assessment assumptions
Demand management				
Target 100 water efficiency activity	0Ml/d	0Ml/d	0Ml/d	We have assumed that the benefits of demand management are not sensitive to impacts from climate change as they are dominantly controlled by behavioural or infrastructure change. The impacts of our water efficiency activities within our demand forecasts already reflect the impacts of hot, dry weather, so any additional effects of climate change are expected to be small. Therefore, in our WRMP we assume that climate change has no impact on water efficiency measures
Leakage reduction (15% reduction by 2025; 50% by 2050)	0Ml/d	0Ml/d	0Ml/d	
Installation of AMR meters to take HH meter penetration from 88% to 92%	0Ml/d	0Ml/d	0Ml/d	
TUBs and NEU ban	-2.8Ml/d at MDO -2.7Ml/d at PDO	0Ml/d	0Ml/d	We have quantified the DO benefits of TUBs and NEU bans as a percentage of baseline DO. To determine the impacts of climate change on these DO benefits for the Dry scenario we have assumed the same percentage factors and applied those to the total area DO. For the Mid and Wet Scenarios the impacts of climate change have minor water resource benefits and so we have assumed there would be no change in the DO benefit of demand restrictions.
Resource development and bulk supplies				
Coastal desalination - Shoreham Harbour (10Ml/d)	0Ml/d	0Ml/d	0Ml/d	We have assumed that the DO benefits of desalination are not sensitive to climate change as dependency is on seawater availability. We have assumed there will be no change in water quality or environmental standards due to climate change that may affect our desalination options
Winter transfer Stage 2: New main Shoreham/North Shoreham and Brighton A	-3Ml/d at MDO -3Ml/d at PDO	0Ml/d	0Ml/d	This is dominantly an infrastructure scheme and consequently there are no climate change impacts under a medium or wet climate change scenario. Climate change sensitivity has been addressed in our baseline climate change assessments of contributing sources. This has indicated that under a dry climate change scenario flows in the Western Rother may be reduced

Strategic Schemes	Climate Change Impact (Ml/d)			
	Dry Scenario	Mid Scenario	Wet Scenario	Climate change impact assessment assumptions
				and consequently we have assumed that the scheme will deliver no DO benefit in the winter.
Littlehampton WTW Indirect Potable Water Reuse (20Ml/d)	0Ml/d	0Ml/d	0Ml/d	We have assumed that the DO benefits of water reuse are not sensitive to climate change as dependency is on wastewater availability. We have assumed there will be no change in water quality or environmental standards due to climate change that may affect our water reuse options.
Pulborough groundwater licence variation	0Ml/d	0Ml/d	0Ml/d	The DO of the Pulborough groundwater sources is dependent on long term recharge to a confined aquifer. By decoupling the groundwater licence from the River Hands off Flow condition we consider that this option and source become less sensitive to climate change under extreme droughts.
Transfer to Midhurst WSW and Petersfield BH rehabilitation	0Ml/d	0Ml/d	0Ml/d	We have assumed the rehabilitation and transfer scheme removes the existing demand, infrastructure and water quality constraints. We have assumed that the yield of rehabilitated boreholes can unlock licenced rates. Extrapolation of drought curve using SB WRZ Indicator borehole (as per AMP3 analysis) suggests yield will be constrained by the abstraction licence under all climate change scenarios.
Scheme to bring West Chiltington back into service	-0.3Ml/d at MDO 0Ml/d at PDO	+0.3Ml/d at MDO 0Ml/d at PDO	+0.8Ml/d at MDO 0Ml/d at PDO	We have assumed the rehabilitation and transfer scheme restores DO to yield and removes treatment constraints. We have assumed that the yield of rehabilitated boreholes can unlock licenced rates. Extrapolation of drought curve using SB WRZ Indicator borehole (as per AMP3 analysis) suggests yield will be constrained by the abstraction licence under all climate change scenarios.
ASR (Sussex Coast - Lower Greensand)	0Ml/d	0Ml/d	0Ml/d	The scheme utilises a deep confined aquifer as a storage reservoir. Recharge water will be sourced during wetter periods and stored for drought use. Consequently, the scheme is not expected to be vulnerable to drought or climate change.
Catchment management				
Nitrate catchment management / treatment – North Falmer A	-0.03Ml/d at MDO -0.04Ml/d at PDO	0.05Ml/d at MDO 0.04Ml/d at PDO	0.1Ml/d at MDO 0.1Ml/d at PDO	Our Catchment Management and Nitrate schemes provide an equal DO benefit to that lost as a consequence of Water Quality impacts. The impacts of climate change on the DO from

Strategic Schemes	Climate Change Impact (Ml/d)			
	Dry Scenario	Mid Scenario	Wet Scenario	Climate change impact assessment assumptions
Nitrate catchment management / treatment – North Falmer B	-2.8Ml/d at MDO 0Ml/d at PDO	+1.4Ml/d at MDO +1.4Ml/d at PDO	+3.2Ml/d at MDO +3.1Ml/d at PDO	individual schemes has therefore been assessed as the same as the climate change impacts on baseline DO of each source. Some measures do not have DO benefits and are for resilience purposes only. We have assumed there will be no climate change impacts on these measures. Agricultural practices may change in response to climate change and there could be shifts in the patterns of nitrate / pesticide usage. Catchment management schemes would still be required, and the schemes would need to dynamically respond to such changes in practices. For our in-stream catchment management options our modelling has shown that surface water flows may be significantly lower than present. Consequently, we have assumed that for a dry climate change future these schemes, which will partially offset future sustainability reductions, will not deliver any DO benefits.
Nitrate catchment management / treatment – Brighton A	0Ml/d	0Ml/d	0Ml/d	
Pesticide catchment management / treatment – River Arun	0Ml/d	0Ml/d	0Ml/d	
Pesticide catchment management / treatment – Pulborough Surface	0Ml/d	0Ml/d	0Ml/d	
Pesticide catchment management / treatment – Weir Wood Reservoir	0Ml/d	0Ml/d	0Ml/d	
Nitrate catchment management – Steyning	0Ml/d	0Ml/d	0Ml/d	
Arun/W Rother - instream catchment management options	-1.5Ml/d at MDO -1.8Ml/d at PDO	0Ml/d	0Ml/d	
Nitrate catchment management / treatment – North Arundel	0Ml/d	0Ml/d	0Ml/d	
Nitrate catchment management / treatment – Long Furlong B	-0.2Ml/d at MDO -0.2Ml/d at PDO	+0.2Ml/d at MDO +0.2Ml/d at PDO	+0.5Ml/d at MDO +0.5Ml/d at PDO	

Strategic Schemes	Climate Change Impact (Ml/d)			
	Dry Scenario	Mid Scenario	Wet Scenario	Climate change impact assessment assumptions
Drought Permits / Orders in severe and extreme droughts				
Pulborough surface (Phases 1 to 3) Drought Permit/Order (2020-25)	-8.3Ml/d at MDO -16.8Ml/d at PDO	0Ml/d at MDO -16.8Ml/d at PDO	0Ml/d at MDO -16.8Ml/d at PDO	Our climate change modelling has shown that surface water flows in the River Rother may be lower than present under some climate change scenarios. Consequently, we have assumed that where flows are reduced the scheme will not deliver any DO benefits.
Pulborough groundwater Drought Order (2020 onwards)	0Ml/d	0Ml/d	0Ml/d	The DO of the Pulborough groundwater sources is dependent on long term recharge to a confined aquifer. By decoupling the groundwater licence from the River Hands off Flow condition via a drought order we consider that this option and source become less sensitive to climate change under extreme droughts.
Weir Wood reservoir Drought Permit/Order (2020-25)	-3.6Ml/d at ADO -5.4Ml/d at PDO	0Ml/d at ADO -5.4Ml/d at PDO	0Ml/d at ADO -5.4Ml/d at PDO	Our climate change modelling has shown that surface water flows to the reservoir may be lower than present under some climate change scenarios. Consequently, we have assumed that where flows are reduced the scheme will not deliver any DO benefits.
East Worthing Drought Permit/Order (2020-25)	0Ml/d	0.l/d	0Ml/d	Yields from this source are licence constrained and will remain, licence/infrastructure constrained under all climate scenarios. We therefore consider that yield of this scheme will not be drought sensitive and there will be no impact from climate change.
North Arundel Drought Permit/Order (2020-25)	0Ml/d	0Ml/d	0Ml/d	Yields from this source are licence constrained and will remain, licence/infrastructure constrained under all climate scenarios. We therefore consider that yield of this scheme will not be drought sensitive and there will be no impact from climate change.
Drought Permits / Orders in extreme droughts only				
Pulborough surface (Phases 1 to 3) Drought Permit/Order (2025 onwards)	-5.6Ml/d at ADO -23Ml/d at PDO	0Ml/d at ADO -23Ml/d at PDO	0Ml/d at ADO -23Ml/d at PDO	Our modelling has shown that surface water flows may be lower than present climate change scenario. Consequently, we have assumed that where flows are reduced the scheme will not deliver any DO benefits.

Strategic Schemes	Climate Change Impact (Ml/d)			
	Dry Scenario	Mid Scenario	Wet Scenario	Climate change impact assessment assumptions
East Worthing Drought Permit/Order (2025 onwards)	0Ml/d	0Ml/d	0Ml/d	Yields from this source are licence constrained and will remain, licence/infrastructure constrained under all climate scenarios. We therefore consider that yield of this scheme will not be drought sensitive and there will be no impact from climate change.

4.4 Greenhouse gas emissions

The impact of the strategy on potential greenhouse gas emissions has been assessed for this plan. The SEA (Annex 14) considers this specifically as one of the SEA objectives, as part of the overall environmental assessment of the feasible options.

Table 10 presents a summary of the carbon equivalent emissions expected from the strategy. The emission of greenhouse gases from usage of our existing sources is presented in our business plan return to Ofwat (table WS18). For the base year (2017-18) this was 65 ktCO2e.

Table 10 Summary of carbon emissions associated with strategy for this plan

Schemes	Embodied carbon (KgCO2e)	Operational Carbon (KgCO2e/a)
Demand management		
Target 100 water efficiency activity	*Negligible*	*Negligible*
Leakage reduction (15% reduction by 2025; 50% by 2050)	*Negligible*	*Negligible*
Installation of AMR meters to take HH meter penetration from 88% to 92%	*Negligible*	*Negligible*
TUBS and NEU Ban	*Negligible*	*Negligible*
Resource development and bulk supplies		
Littlehampton WTW Indirect Potable Water Reuse (20Ml/d)	7,746,000	4,558,000
Coastal desalination - Shoreham Harbour (10Ml/d)	3,441,000	4,712,000
Pulborough groundwater licence variation	-	3,334,000
ASR (Sussex Coast - Lower Greensand)	1,657,000	1,404,000
Transfer to Midhurst WSW and Petersfield BH rehabilitation	1,179,000	203,000
Scheme to bring West Chiltington back into service	1,383,000	512,000
Winter transfer Stage 2: New main Shoreham/North Shoreham and Brighton A	1,894,000	676,000
Catchment management		
Arun/W Rother - instream catchment management options	*Negligible*	*Negligible*
Pesticide catchment management / treatment – River Arun	1,033,000	4,321,000
Pesticide catchment management / treatment – Pulborough Surface	1,033,000	1,380,000
Pesticide catchment management / treatment – Weir Wood Reservoir	178,000	377,000
Nitrate catchment management / treatment – North Falmer A	408,000	138,000
Nitrate catchment management / treatment – North Arundel	436,000	96,000
Nitrate catchment management / treatment – North Falmer B	412,000	335,000
Nitrate catchment management / treatment – Long Furlong B	396,000	83,000
Nitrate catchment management / treatment – Brighton A	436,000	186,000
Nitrate catchment management – Steyning	-	27,000
Drought Permits / Orders in severe and extreme droughts		
East Worthing Drought Permit/Order (2020-25)	-	-
Pulborough surface (Phases 1 to 3) Drought Permit/Order (2020-25)	-	-
Pulborough groundwater Drought Order (2020 onwards)	-	-
North Arundel Drought Permit/Order (2020-25)	-	-
Weir Wood reservoir Drought Permit/Order (2020-25)	-	-
Drought Permits / Orders in extreme droughts only		
East Worthing Drought Permit/Order (2025 onwards)	-	-
Pulborough surface (Phases 1 to 3) Drought Permit/Order (2025 onwards)	-	-

5. Sensitivity testing of the strategy

Having developed the strategy for this WRMP, as described above, we then carried out sensitivity testing of the strategy.

A Real Options modelling approach already incorporates uncertainty around how different futures may evolve and thus trigger the selection of different options. Our approach therefore already provides some evaluation of alternatives in the strategy and therefore reduces the requirement of sensitivity analysis to some degree (UKWIR 2016).

Nevertheless, sensitivity testing was performed on the plan. The purpose of sensitivity testing is two-fold:

- To ensure the plan is as robust as possible in the face of uncertainties. This provides confidence in the portfolio of schemes selected, and also addresses key queries raised in consultation responses on the draft WRMP
- To understand the range of potential alternative options if the preferred options cannot be delivered/implemented for whatever reason. These alternative options may require feasibility studies, investigations or planning activity to be carried out in parallel to the main portfolio of options in the strategy, particularly where they may be needed in the next 5-10 years

We developed a range of sensitivity testing model runs to compare against the strategy. The rationale for the sensitivity tests, and the key outputs from the modelling runs, are presented below in section 5.1. We provide additional commentary on the key findings from sensitivity testing in section 5.2. We also provide a comparison of the preferred strategy with a conventional Economics of Balancing Supply and Demand (EBSD) approach (section 5.3) and with our previous WRMP (published in 2014) (section 5.4).

5.1 Results of sensitivity testing

We have run a wide range of scenario and sensitivity tests in order to help formulate the preferred plan for the WRMP, to test the robustness of that plan, and to identify key strategic alternatives. Table 11 provides a description of the scenario and sensitivity tests undertaken and the rationale for these.

Table 11 Summary of scenario and sensitivity tests performed

Phase	Scenario	Scenario description
Formulation of the strategy for the WRMP	Least cost run	An initial run to establish, with no constraints, what the least cost plan would be. This assumes that Drought Permits / Orders are only available in extreme drought conditions (not severe ones), to test whether an interim position is needed.
	Target 100	Incorporates the policy decision to implement the Target 100 water efficiency measures throughout the supply area commencing in 2020. Maintains the assumption that Drought Permits / Orders are only available in extreme drought conditions (not severe ones), to test whether an interim position is needed.
	Target 100 and leakage profile included	As above, but in addition, it also incorporates the policy decision to implement a leakage profile which achieves 15% reduction from current leakage levels by the end of AMP7, and a reduction of 50% from current levels by 2050.
	Constrained least cost plan	Initial constrained plan with the Target 100 and leakage reduction policies applied. Also includes the interim drought permit/order position, whereby Permits / Orders are allowed in both the severe and extreme drought conditions through AMP7, but from 2025 onwards, only in the extreme drought conditions

Phase	Scenario	Scenario description
	Disable Arun desalination	An iteration of the constrained least cost plan, where the Tidal River Arun desalination scheme was excluded on environmental and planning risk grounds to examine what would get selected in its place.
	Increase meter penetration and include resilience	Another iteration of the constrained least cost plan, where the Tidal River Arun desalination scheme was still excluded, and in addition: A policy decision to include the extension to the UMP to provide coverage to around 92% of customers, on the grounds that desalination was being selected and as such, there was a clear driver to maximise demand management. An asset enhancement scheme was also included to provide greater resilience in the SN WRZ (Transfer to Midhurst WSW and Petersfield BH rehabilitation)
	Preferred plan	A further iteration of the above constrained least cost plan, in which a decision to include the ASR scheme was also made. A further resilience decision was made to use the Steyning nitrate catchment management option to ensure the source would be maintained in the future. **This constrained plan, when reviewed against all the testing criteria, was considered to represent the Preferred Plan.**
Sensitivity testing of the preferred plan: **Testing plan robustness and strategic alternatives**	Brighton WTW water reuse	Potential regional solution implemented in 2045-49, which was one potential date that South East Water felt they may need the scheme from initial discussions during consultation. The purpose of this run is to understand what this would mean for utilisation and cost of strategy.
	No desal at all	A test of the preferred plan to understand what would be selected if there was no desalination schemes available / deliverable in the supply area
	ASR uncertainty	A test of the preferred plan to understand what would be selected if the ASR scheme could not be delivered
	No Littlehampton WTW water reuse	A test of the preferred plan to understand what would be selected if the Littlehampton WTW water reuse scheme could not be delivered
	No Pulborough groundwater licence variation	A test of the preferred plan to understand what would be selected if the Pulborough groundwater licence variation scheme could not be delivered
	Pulborough wellfield not achieving DO	A test of the preferred plan to understand what would be selected if the assumed Pulborough wellfield reconfiguration that has been included in the baseline supply forecast cannot achieve the expected DO benefit
	No ASR and no Pulborough groundwater licence variation	A test of the preferred plan to understand what would be selected if both the ASR and the Pulborough groundwater licence variation could not be delivered
	No ASR and no Pulborough groundwater licence variation and no DO improvement from Pulborough wellfield	A test of the preferred plan to understand what would be selected if both the ASR and the Pulborough groundwater licence variation could not be delivered, in combination with the Pulborough wellfield reconfiguration not achieving the expected DO benefit.
	1:500 without drought orders (NIC run)	A test of what would happen if there were no drought Permits / Orders available in extreme drought conditions after 2025, which represents an attempt to understand the additional investments this extra drought resilience would drive, building on the recent NIC report.
	Accepted deficits - through to 2029	Hypothetical sensitivity test where we accept deficits for the initial part of the plan to confirm that the options selected in the strategy are not driven purely by them being available for delivery before other options - i.e. it is a test of whether the plan remains optimal. This scenario will be cheaper than the preferred plan, as the model does not need to introduce any solutions until 2029. It would also present a risk in terms of supply failures to customers, which are, in reality, unacceptable.

Phase	Scenario	Scenario description
	Outage scenario 1	A test of the preferred plan to understand what would be selected if the profile of outage was maintained at constant levels (rather than assuming activity to reduce outage over AMP7). The values are based on the draft WRMP outage assessment, rather than the revised assessment for the current plan.
	Cost uncertainty of options	A test of the preferred plan to understand whether alternative schemes would be selected if the costs of schemes for which we have less confidence (i.e. those for which the company has little previous experience of implementing) are scaled proportionally higher than those schemes that we have greater cost confidence in (e.g. which the company has successfully delivered in the past).
	1:1000 extreme drought	A hypothetical test of whether planning to a more extreme drought (of the order of 1:1000) with Drought Permits / Orders available would require significant additional investments. This is a run to help us begin to understand the implications of more extreme droughts.
	100% metering run	A test of the preferred plan to understand what would be selected if the further metering was implemented to aim to reach 100% of household customers (noting that the technical feasibility and the costs associated with this are uncertain).
	SELL run	A test of the preferred plan to understand what would be selected if the model were allowed to select the combination of leakage reduction options at least cost (i.e. representing an economic level of leakage), rather than a forced profile. Note that few constraints are placed on the leakage options in terms of the amount that can be delivered in any one year.
	No SR impacts	The purpose of this sensitivity run is to understand how the large uncertainty on timing and particularly scale associated with the possible sustainability reductions may affect the strategy
	EBSD 50th percentile	This run is to allow a comparison of our preferred plan against a conventional EBSD approach (assuming it is solving a supply-demand balance based on our 50th percentile)
	EBSD 10th percentile	This run is to allow a comparison of our preferred plan against a conventional EBSD approach (assuming it is solving a SDB based on our 10th percentile - i.e. higher deficit)
	EBSD 90th percentile	This run is to allow a comparison of our preferred plan against a conventional EBSD approach (assuming it is solving a SDB based on our 90th percentile – i.e. lower deficit)
	Branch weighting - weighted to central estimate	A test of the impact of the assumption in the real options process that all branches are equally probable, which affects the costing of plan. This one places greater emphasis on the central forecasts
	Branch weighting - weighted to lower impacts	A test of the impact of the assumption in the real options process that all branches are equally probable, which affects the costing of plan. This one places greater emphasis on the lower deficit forecasts
	Branch weighting - weighted to higher impacts	A test of the impact of the assumption in the real options process that all branches are equally probable, which affects the costing of plan. This one places greater emphasis on the higher deficit forecasts
	Remove 1:500 states of the world	A test of the impact of solving the severe and extreme drought states of the world. The run removes the 1:500 states of the world to allow us to examine the influence that the extreme drought condition has on the preferred plan
	Environmental forecasting output	A sensitivity run which assumes that there could be additional sustainability reductions in future (over and above those assumed in the baseline supply-demand-balances in the late 2020's), due to future environmental changes or policies

The results of the sensitivity testing are presented in the comparative table below. The cost increase or decrease of the sensitivity test is presented in comparison to the strategy for this plan (which was outlined in the previous section). Costs are expressed in net present value (NPV) terms (described more fully in annex 8). The year is the earliest year the scheme is implemented by, and a year in brackets denotes the implementation year but that the scheme is not needed in all branches. N/a means that a scheme is not available for selection because it has been removed from selection for that scenario.

One key thing to note is that the **options that get selected are reasonably stable in the face of the sensitivity tests**. The main changes relate to how the selected schemes are utilised, although there are some alternative schemes that are selected.

Section 7 provides the overarching summary of the strategy, key alternatives and investigations that we will need to focus on over the next two AMP periods.

Table 12 Summary of outputs from scenario and sensitivity testing

Scenario	Plan cost (NPV, £M)	Compare to constrained least cost (£M)	Compare to preferred (£M)	Deficit remaining?	T100 and leakage reduction policies	Extension of UMP to take HH meter penetration from 88% to 92%	Drought permits/orders available in severe drought to 2025	Littlehampton WTW Indirect Potable Water Reuse (20Ml/d)	Coastal Desalination - Shoreham Harbour (10Ml/d)	Pulborough groundwater licence variation (extreme drought benefit)	ASR (Sussex Coast - Lower Greensand)	Transfer to Midhurst WSW & Petersfield BH rehabilitation	Scheme to bring West Chiltington back into service	Winter transfer Stage 2: New main Shoreham/North Shoreham & Brighton A	Brighton WTW Indirect Potable Reuse (joint scheme with SEW)	Tidal River Arun Desalination	Turbidity/sludge handling process improvements at Pulborough	Notes
Least cost run	330	-	-	-	No	-	No	2027	-	2021	(2055)	(2035)	2024	(2035)	-	2027 (20Ml/d)	(2030)	
Target 100	347	-	-	-	T100 only	-	No	2027	-	2021	-	2027	2024	(2035)	-	2027 (10Ml/d)	2027	
Target 100 and leakage profile included	477	-	-	Yes	Yes - 2020	-	No	2027	-	2021	2027	-	2024	2027	-	2027 (10Ml/d)	2027	Unsolvable deficit in SN in 2020 only (<3Ml/d)
Constrained least cost plan	478	-	-	-	Yes - 2020	-	Yes	2027	-	2021	2027	-	2024	2027	-	2027 (10Ml/d)	2027	Drought permits/orders with interim LoS reduction
Disable Arun desalination	490	12	-	-	Yes - 2020	-	Yes	2027	2027	2021	2027	-	2024	2027	-	n/a	2027	
Increase meter penetration & include resilience	492	14	-	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	-	2025 (forced)	2024	2027	-	n/a	2027	Metering to 92% forced in
PREFERRED PLAN	501	23	-	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	n/a	-	ASR forced in. Metering to 92% forced in
Brighton WTW water reuse	542	64	41	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	2045 (10Ml/d)	n/a	-	Brighton WTW in 2045-49 to align with SEW poss.
No desal at all	510	32	9	-	Yes - 2020	2020 (forced)	Yes	2027	n/a	2021	2027 (forced)	2025 (forced)	2024	2027	2027 (10Ml/d)	n/a	-	
ASR uncertainty	493	15	-8	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	n/a	2025 (forced)	2024	2027	-	n/a	2027	
No Littlehampton WTW water reuse	554	76	53	-	Yes - 2020	2020 (forced)	Yes	n/a	2027 (30Ml/d)	2021	2027 (forced)	2025 (forced)	2024	2027	-	n/a	-	
No Pulborough groundwater licence variation	505	27	4	-	Yes - 2020	2020 (forced)	Yes	2027	2027	n/a	2027 (forced)	2025 (forced)	2024	2027	-	n/a	-	Changes in extreme states only
Pulborough wellfield not achieving DO	552	74	51	Yes	Yes - 2020	2020 (forced) + to 100%	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	-	-	n/a	2023	Unsolvable deficit in SN in 2020 only (10Ml/d). Also does Lewes Road asset enhancement scheme in 2027
No ASR and no Pulborough groundwater licence variation	497	19	-4	-	Yes - 2020	2020 (forced)	Yes	2027	2027	n/a	n/a	2025 (forced)	2024	2027	-	n/a	2027	
No ASR and no Pulborough groundwater licence variation and no DO improvement from Pulborough wellfield	550	72	49	Yes	Yes - 2020	2020 (forced) + to 100%	Yes	2027	2027 (20Ml/d)	n/a	n/a	2025 (forced)	2024	-	-	n/a	-	Unsolvable deficit in SN in 2020 only (10Ml/d)
1:500 without drought orders (NIC run)	506	28	5	(Yes)	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	n/a	-	No drought permits/orders in extreme after 2025 - fails in 1 branch
Accepted deficits - through to 2029	410	-68	-91	-	Yes - 2020	2020 (forced)	Yes	-	2029 (30Ml/d)	2029	2027 (forced)	2025 (forced)	2029	-	-	n/a	-	Selects up to 30Ml/d - 10Ml/d in all branches, and greater volumes in fewer branches. Costs not directly comparable
Outage scenario 1	565	87	64	-	Yes - 2020	2020 (forced)	Yes	2027	2027 (20Ml/d)	2021	2027 (forced)	2025 (forced)	2024	2027	-	n/a	2023	
Cost uncertainty of options	561	83	60	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	n/a	-	
1:1000 extreme drought	503	25	2	(Yes)	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	n/a	-	Fails in 2020 only in 1:1000. Costs will not be directly comparable
100% metering run	519	41	18	-	Yes - 2020	2020 (forced to 100%)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	-	-	n/a	2027	100% metering forced in
SELL run	358	-120	-143	-	Yes - 2020	2020 (forced)	Yes	2027	-	2021	2027 (forced)	2025 (forced)	2024	2027	-	n/a	2023	Also does Lewes Road asset enhancement scheme. No particular constraints on leakage reductions per year/AMP - lots done in 2027
No SR impacts	335	-143	-166	-	Yes - 2020	2020 (forced)	Yes	-	-	2021	2027 (forced)	2025 (forced)	(2065)	-	-	n/a	-	Does not need to do as much catchment mgmt

Scenario	Plan cost (NPV, £M)	Compare to constrained least cost (£M)	Compare to preferred (£M)	Deficit remaining?	T100 and leakage reduction policies	Extension of UMP to take HH meter penetration from 88% to 92%	Drought permits/orders available in severe drought to 2025	Littlehampton WTW Indirect Potable Water Reuse (20Ml/d)	Coastal Desalination - Shoreham Harbour (10Ml/d)	Pulborough groundwater licence variation (extreme drought benefit)	ASR (Sussex Coast - Lower Greensand)	Transfer to Midhurst WSW & Petersfield BH rehabilitation	Scheme to bring West Chiltington back into service	Winter transfer Stage 2: New main Shoreham/North Shoreham & Brighton A	*Brighton WTW Indirect Potable Reuse (joint scheme with SEW)*	*Tidal River Arun Desalination*	*Turbidity/sludge handling process improvements at Pulborough*	Notes
EBSD 50th percentile	351	-127	-150	-	Yes - 2020	2020 (forced)	Yes	-	-	2021	2027 (forced)	2025 (forced)	2024	-	-	*n/a*	-	
EBSD 10th percentile	519	41	18	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	*n/a*	-	
EBSD 90th percentile	323	-155	-178	-	Yes - 2020	2020 (forced)	Yes	-	-	2021	2027 (forced)	2025 (forced)	-	-	-	*n/a*	-	Also does not require most catchment mgmt or asset options
Branch weighting - weighted to central estimate	499	21	-2	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	*n/a*	-	No change from preferred plan
Branch weighting - weighted to lower impacts	498	20	-3	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	*n/a*	-	No change from preferred plan
Branch weighting - weighted to higher impacts	503	25	2	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	-	*n/a*	-	No change from preferred plan
Remove 1:500 states of the world	478	0	-23	-	Yes - 2020	2020 (forced)	Yes	2027	2027	-	2027 (forced)	2025 (forced)	2027	2027	-	*n/a*	-	Need for drought permits/orders is significantly reduced, as these are driven by extreme branches, post 2025
Environmental forecasting output	511	33	10	-	Yes - 2020	2020 (forced)	Yes	2027	2027	2021	2027 (forced)	2025 (forced)	2024	2027	*(2055) (10Ml/d)*	*n/a*	*(2040)*	Also does Lewes Road asset enhancement scheme in 2045 in 1 branch

Southern Water

5.2 Commentary on key findings from sensitivity testing

We have selected a few key sensitivity tests from the table above to comment on. The first set involve scenarios where we exclude key strategic schemes in turn to understand what alternative schemes would be selected instead. The second set are more concerned with the robustness of the preferred plan.

5.2.1 Alternatives if there are no desalination schemes

When neither the Shoreham (nor the River Arun) desalination schemes could be implemented, the alternative scheme selected was the Brighton WTW water reuse scheme (providing 10Ml/d benefit to SWS).

The difference in costs, in NPV terms, was relatively small suggesting that this could be a feasible alternative in terms of costs. Although there are environmental and planning risks associated with this scheme that are similar to those for the desalination schemes.

Nevertheless, this suggests that the company should continue to investigate and explore the Brighton WTW water reuse scheme, working with South East Water, as a potential future option. This could entail a different operational design – for example, consideration of using the water in a way similar to an aquifer storage and recovery (this has not been investigated to date, but provides a potential alternative operational model).

5.2.2 Alternatives if Littlehampton WTW water reuse scheme cannot be delivered

Without the 20Ml/d Littlehampton WTW water reuse scheme being implemented in 2027, the model needs a larger desalination scheme, so uses the extra modules available with the Shoreham desalination scheme to increase the capacity of that desalination scheme to 30Ml/d. The difference in costs, in NPV terms, was relatively significant – larger by around £53M in NPV terms.

5.2.3 Alternatives if Pulborough groundwater licence variation cannot be delivered

The Pulborough groundwater licence scheme is selected early in AMP7, which may pose a risk in terms of deliverability. It provides benefits in the extreme drought conditions only. There is little difference in terms of the main schemes selected, nor the cost (only marginally larger in NPV terms compared to the preferred plan).

The key difference relates to the use of drought Permits / Orders and utilisation in the extreme states only. Without the Pulborough groundwater licence variation option, the Pulborough g/w drought order needs to be used throughout the planning period in 10th and 30th percentile branches.

5.2.4 Alternatives if the ASR scheme cannot be implemented

The ASR scheme was forced to be selected in the preferred plan in AMP8, due to strong preferences for this type of option from our customers. However, if it were not possible to deliver this scheme, then the key alternative would be the implementation of the turbidity/sludge handling process improvements at Pulborough. The difference in costs is small, but marginally cheaper than the preferred plan, as the ASR scheme was included on the basis of customer preferences, rather than purely on a least cost basis.

5.2.5 Alternatives if the planned Pulborough wellfield reconfiguration cannot achieve its DO

The baseline DO assessments assume a benefit from the planned Pulborough wellfield reconfiguration works of 4Ml/d during MDO periods. If this wellfield reconfiguration were not able to be delivered, or if the DO benefit could not be achieved in practice, then there would be a risk of an unsolvable deficit in the first year of AMP7 in SN WRZ in an extreme drought event (which could be mitigated if the Pulborough licence variation could be brought forward).

The scheme for turbidity/sludge handling process improvements at Pulborough would be introduced as soon as possible, in 2023, when there are little other options available that could be delivered. Extension of the universal metering to target 100% meter penetration would also be triggered to try to minimise the deficit early in AMP7. These changes drive a significantly higher cost in NPV terms.

The Lewes Road asset enhancement scheme would then be needed in 2027, but the winter transfer scheme to develop a new main between Shoreham/North Shoreham and Brighton A would then not be needed.

5.2.6 Alternatives if a combination of the above could not be implemented

This scenario assumed that the ASR and the Pulborough groundwater licence variation cannot be delivered, and in addition that there is no DO improvement from Pulborough wellfield reconfiguration. In this event, there then would be a risk of an unsolvable deficit in SN WRZ in an extreme drought event. Extension of the universal metering to target 100% meter penetration would also be triggered to try to minimise the deficit early in AMP7. These changes drive a significantly higher cost in NPV terms.

The key strategic alternative is that the Shoreham desalination scheme would need to be increased from 10Ml/d to 20Ml/d.

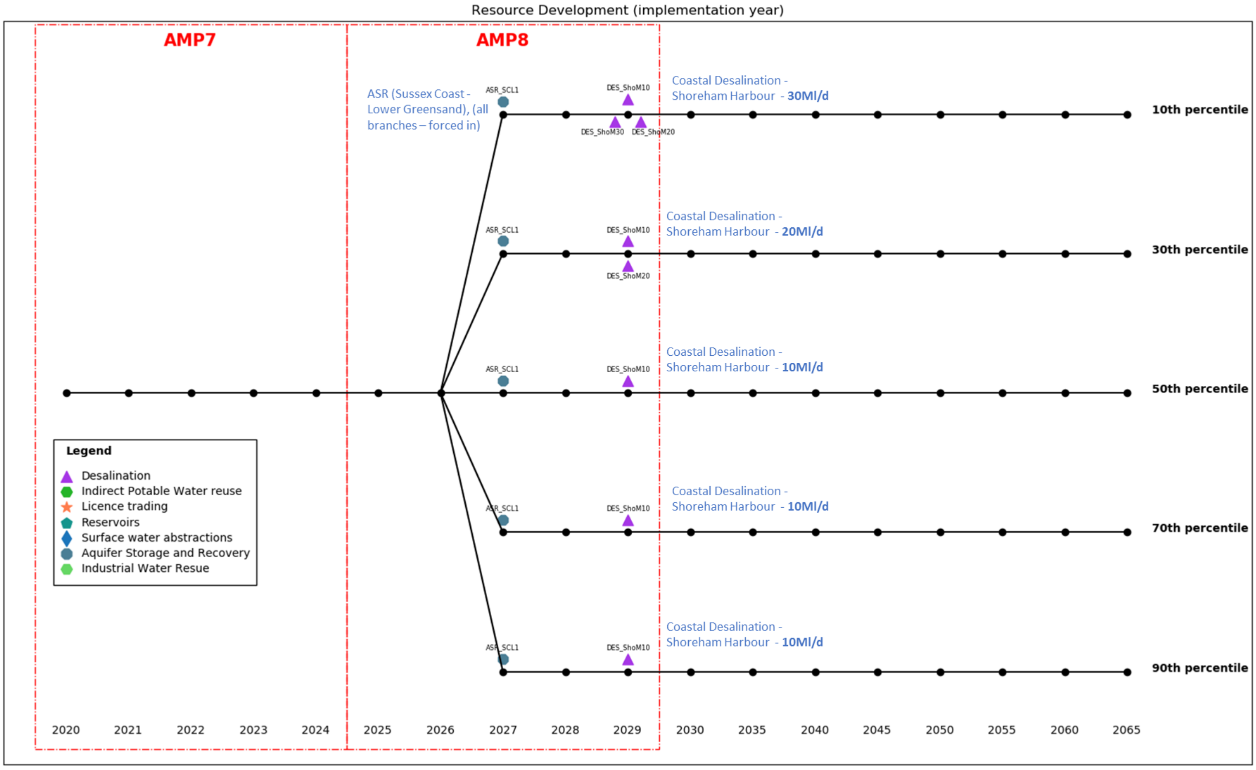
5.2.7 Allow deficits until 2029

A useful hypothetical sensitivity test is to accept deficits for the initial part of the plan to confirm that the options selected in the strategy are not driven purely by them being available for delivery before other options. If we do not force the model to solve any deficits until the end of AMP8 (i.e. until 2029), would the options selected in the strategy change and if so, is this optimal or is time a critical element to the strategy?

The results were as follows:

- The Littlehampton water reuse scheme is not selected; it is replaced by a larger Shoreham desalination scheme
- Different sized modules of desalination are needed in different branches – as illustrated in Figure 11 below

Figure 11 Selection of resource developments when accepting deficits to 2029



- The costs are not directly comparable to the preferred plan, as the model does not need to solve all deficits until 2029, which provides a saving in NPV terms.

5.2.8 No sustainability reduction scenario

The purpose of such a sensitivity run is **to understand how the large uncertainty on timing and particularly scale associated with the possible sustainability reductions in the Central area may affect the strategy**.

Each of the five branches could have some element of sustainability reduction included in them, as the uncertainties around the sustainability reductions are incorporated with other elements through the Monte Carlo modelling to generate the percentile distribution of SDBs (although it is likely that the 90th percentile is impacted only a little by the sustainability reduction components). This run allows the sustainability reductions to be stripped from the branches entirely to understand their impact on the strategy.

There is a very significant cost saving of £166M in NPV terms over the planning period.

The key strategic changes are that a number of the large developments needed in 2027 would not be required or would be delayed:

- Littlehampton WTW indirect potable water reuse – not required
- Coastal desalination Shoreham Harbour (10Ml/d) – not required
- A number of the nitrate catchment management schemes are not required, or are only needed later and only under 1 branch to recover DO lost due to nitrate issues. The in-stream catchment option is not needed

- The scheme to bring West Chiltington back into service is not needed until the end of the planning period (and then in one branch only), while the other asset enhancement, the winter transfer Stage 2: New main Shoreham/North Shoreham and Brighton A, is not required

This run also suggests that the **Pulborough licence variation scheme is still needed** to meet extreme drought conditions, even where the large uncertain sustainability reductions do not occur.

5.2.9 Regional outcomes

We have undertaken a sensitivity run where we have assumed that the Brighton WTW water reuse scheme would be developed as a joint scheme with South East Water. We have assumed that it would be implemented in the second half of the 2040's, which was a timeframe that came up during initial discussions with South East Water during consultation on the draft WRMP, but which they subsequently confirmed was not required. The scheme was not selected in our modelling either. Therefore, the purpose of this run was to examine whether the scheme would be utilised.

It tends only to be used at its minimum capacity. The cost of this plan is more expensive than the preferred, but that is expected, because other developments are still needed in the short to medium term before the Peacehaven scheme would be available to be developed.

5.2.10 'Sustainable Economic Level of Leakage' (SELL) run

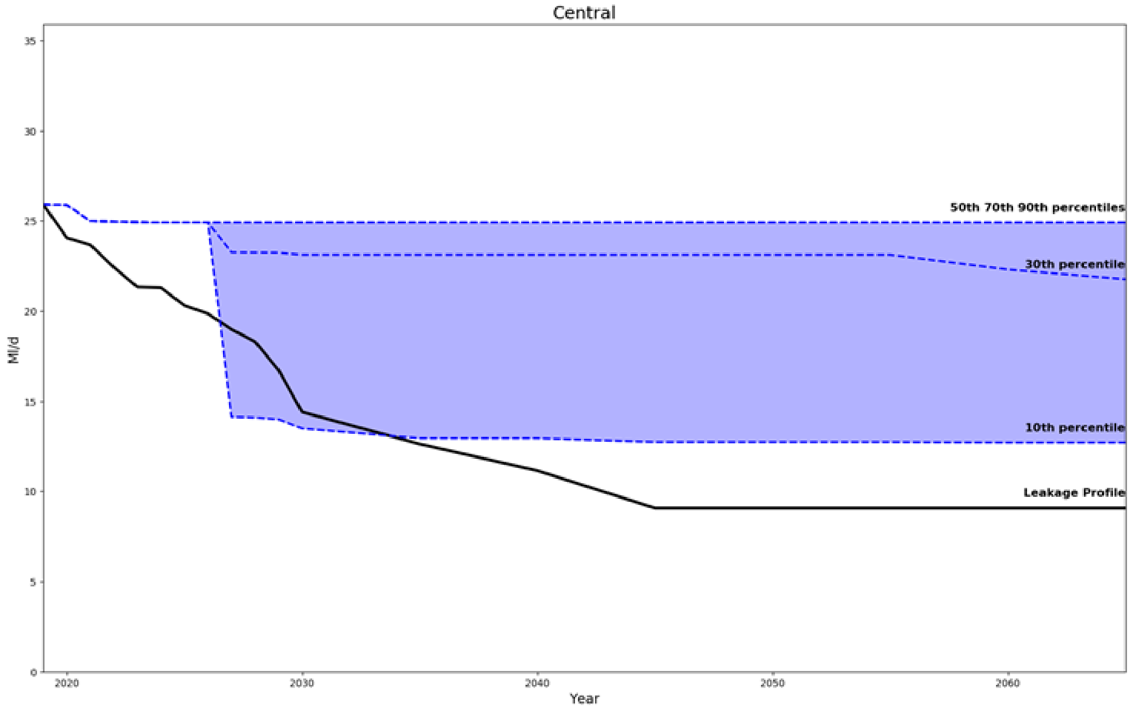
We have undertaken a sensitivity run in which we allowed the model to select the optimum amount and timing of leakage reduction activity – i.e. effectively the 'Sustainable Economic Level of Leakage' (SELL) run.

However, there are a number of important caveats to this:

- The costs are significantly cheaper than the preferred plan, suggesting that the costs of the leakage reduction policy are quite significant. This is in part because this approach allows the leakage profile to be optimised for the deficits faced in each branch
- The chief differences in terms of options was that the 10Ml/d Shoreham desalination scheme was not required; instead the scheme for turbidity / sludge handling improvements at Pulborough surface water was selected in 2023
- Very little leakage reduction was needed in AMP7
- There was a lot of leakage reduction in 2027 – the point at which the branches diverge, because that was when there was a step change in the supply demand balance (relating in large part to uncertain sustainability reductions), which the application of leakage reduction helped to solve. However, undertaking lots of leakage reduction activity in only one year does not necessarily reflect a technical or practicably feasible approach to leakage reduction

The comparison of our preferred plan leakage reduction profile to an unconstrained leakage profile is shown in Figure 12.

Figure 12 Comparison of leakage profile against range of SELL reductions



5.2.11 Removing the extreme drought states of the world

The purpose of this sensitivity test is to help understand the influence that the extreme drought states of the world have on the investment needed. This will depend on the balance between deficits faced in extreme droughts, the drought intervention options that are available, and the ability to transfer water between WRZs to minimise deficits.

This scenario is cheaper than the preferred plan which needs to solve the extreme drought states of the world too. The main difference is that the Pulborough licence variation scheme, which provides benefits only in the extreme drought, would not be selected.

5.2.12 What if there were future environmental effects?

This sensitivity run assumes that there could be additional sustainability reductions in future, over and above those assumed in our baseline SDBs in the late 2020's – i.e. what if there were further reductions to water available for abstraction due to future environmental changes or policies?

We have developed a possible future environmental forecast (see Annex 4) which has been used to estimate a future where there are further DO reductions. This to identify how this would change the strategy and whether it would trigger significantly different options or highlight that there would not be sufficient options available at present to solve additional possible sustainability reductions later in the planning period.

The results suggest the need for a number of additional schemes, but in the largest deficit branch only. The turbidity / sludge handling process improvements at Pulborough and the Lewes Road asset enhancement scheme would be needed in 2040 and 2045 respectively, and in addition the 10Ml/d Brighton WTW indirect potable reuse (joint scheme with South East Water) would be needed from 2055.

5.3 Comparison of strategies with conventional EBSD approach

Following best practice, as outlined in the UKWIR decision making process guidance (2016), we have undertaken traditional EBSD runs to compare against the strategy resulting from a Real Options approach. This provides a useful benchmark against the more advanced Real Options decision making approach. By EBSD we mean the traditional way of solving a single SDB through the planning period, as described originally in the *Economics of balancing supply and demand* guidance from UKWIR.

The EBSD run involves using the Real Options model but with only one branch. The 50th percentile branch has been run as this is the SDB that is used up to the ‘pre-branching point’ in 2027. We have also run the 10th and 90th percentile branches to show how the EBSD approach of scenario testing of high and low forecasts might also be applied and compared to the Real Options approach.

Table 12 (in section 5.1 above) presents the comparison of the real options model to the EBSD approach for the 50th and for the upper 10th and lower 90th percentile branches.

In order to meet the uncertainties with different plausible futures, our plan has had to select a wider range of options that need to be investigated and promoted, in order to meet the 22 December 2027 deadline relating particularly to the Water Framework Directive (WFD) requirements, specified by the EA. With a smaller range of more certain futures, the array of options could be reduced. This is shown by the EBSD 50th percentile sensitivity test, and also the 90th percentile (lowest deficit branch). However, if the uncertain sustainability reductions were to materialise, and we were to have planned only on the basis of the conventional EBSD approach, we would not have a plausible plan to meet and deliver those sustainability reductions within the timescale required, given that confirmation of the sustainability reductions with the EA is unlikely until the middle of AMP7 at the earliest.

5.4 Comparison of strategies with WRMP14

It can be instructive to compare the results with the last plan that was developed in AMP5 and published in 2014 (referred to as WRMP14).

For the current plan, we have developed a Real Options approach – so rather than considering one future only, with some testing around uncertainties of some forecast components, this time we solve a wide range of futures simultaneously through the use of the branches.

We are also solving for a wider range of states of the world: previously we solved for the normal year and a level of around 1 in 200 drought return period. This time, we are also solving for drought, severe drought and extreme drought conditions, which equate approximately to 1 in 20, 1 in 200 and 1 in 500 year drought events, although we do allow drought Permits / Orders for the extreme droughts, which were not available to the WRMP14 plan for use in the severe drought.

The strategy for WRMP14 incorporated the following elements, with commentary of similarities with this plan based on the real options approach of solving 5 possible futures simultaneously is presented in Table 13.

Table 13 Comparison of WRMP14 strategy with the current preferred strategy

Scheme	WRMP14	WRMP19
Pulborough winter transfer stage 1	In AMP6	*Has already been implemented*
Pulborough groundwater well field reconfiguration	In AMP6	*Is already being implemented*
Reduction of Portsmouth Water bulk supply to Pulborough to 10Ml/d (allowing more water to Hampshire)	In AMP7	*15Ml/d supply agreed alongside additional bulk supply options for Hampshire*
Aquifer storage and recovery scheme	In AMP7	Delivery in AMP8
Littlehampton WTW water reuse scheme	In AMP8	Also selected in AMP8, but larger 20Ml/d scheme needed
Lewes Road asset enhancement	In AMP9	Not selected
Pulborough winter transfer stage 2 and 3	In AMP10	The new main is selected in AMP8
Demand management – focused on leakage activity (active leakage control) Enhanced water efficiency activity	Various	Much greater water efficiency through implementation of the 'Target 100'. Significantly greater leakage reduction applied through policy of achieving 50% reduction from current levels by 2050 Also implementing extension of metering to 92% of households.
Conventional and catchment management schemes to address nitrate issues	AMP6 and AMP7	Similar approach, although variation in list of sources suitable for catchment management and treatment – AMP7-AMP9. Addition of catchment management for pesticide issues, and in-stream restoration measures
Not selected in WRMP14	n/a	Coastal desalination at Shoreham in AMP8. Pulborough groundwater licence variation (only provides benefit in extreme drought, so not directly comparable with WRMP14 which did not consider 1:500 drought). Infrastructure to reverse the Worthing-Brighton main (AMP7/8). Additional asset enhancement schemes: rehabilitation of Petersfield BH; bring West Chiltington back into service.

6. Summary WFD, HRA and SEA assessment

6.1 Environmental cumulative impact assessment and programme appraisal

A detailed environmental assessment, covering SEA, Habitats Regulations Assessment (HRA) and WFD assessment, was carried out for a wide range of feasible options considered for inclusion in the Central area strategy to help inform decision making on the final strategy and inform development of WRMP19. In particular, the findings of the feasible option assessments were used to evaluate the environmental and social performance of a range of alternative strategies for maintaining a SDB in the Central area, with each alternative strategy comprising a different mix of options and option types.

For each alternative strategy, the likely scale of adverse and beneficial environmental and social effects for each option was considered, both on its own but also in combination with the other options included in that strategy. The potential effects in combination with any other relevant projects, plans or programmes (for example, any planned major infrastructure schemes that may be constructed and/or operated at the same time and affecting the same environment and/or communities) was also assessed. This appraisal of each alternative strategy also included consideration of the potential for any regulatory compliance risks associated with the HRA and WFD.

The environmental and social performance of each alternative strategy was used to help make decisions on which strategies to explore further through the programme appraisal modelling process and to finally determine the appropriate strategy for inclusion in this plan. Several modifications to the potential strategy were made as part of this process where environmental and social effects were considered challenging. Due to the scale of the forecast supply deficit in the Central area, it was not considered feasible to remove any option from consideration for the final strategy.

All options were therefore considered and the SEA findings (along with the HRA and WFD assessments) were actively used in reaching a decision on the WRMP strategy. A number of alternative options and option combinations were explored in developing the preferred strategy as well as a wide range of scenario testing model runs - the SEA, HRA and WFD assessments were used to compare the environmental performance of these alternative combination of options to inform and contribute to the decision-making process which also took into account other factors including cost, resilience and customer preference information. We also took account of the consultation responses on the draft WRMP19. This assessment and decision-making process led to the development of our preferred strategy for the Central area.

Our strategy includes development of a strategic Littlehampton WTW Indirect Potable Water Reuse scheme (20Ml/d) and a coastal desalination plant at Shoreham Harbour (10Ml/d). Additionally, there are a number of small groundwater schemes and an artificial groundwater storage and recovery (ASR) scheme for the Sussex Coast Lower Greensand aquifer. We will also maximise the use of remaining surplus water in winter when river flows are high from our Pulborough surface water source within the conditions of our existing abstraction licence.

We have also included nine catchment management schemes in our strategy to address nitrate and/or pesticide water quality issues at some of our water sources, securing existing supplies and in the majority of cases enabling more water to be made available for supply.
The ability to achieve our aim of restricting Drought Orders / Permits to extreme drought conditions only to reduce the risk of adverse environmental effects was examined as part of developing the strategy taking account of the costs, risks, feasibility and environmental effects of the measures required to deliver this objective. Delivery of this objective requires several new resource schemes

to be developed first, including the transfer to Midhurst WSW and Petersfield BH rehabilitation scheme and the scheme to bring the West Chiltington supply back into service, along with continuing activity to further reduce leakage and customer consumption through more metering and water efficiency measures. Consequently, until all of these schemes are delivered, drought Permits / Orders in the Central area would still be required in severe as well as extreme drought conditions in the period up to 2024.

As well as the adverse effects of options, we looked at the beneficial effects of options to decide whether any options should be prioritised in view of the environmental or social benefits they may bring. This led to our decision to preferentially include in our strategy the early implementation of further measures to reduce demand for water in the Central area.

- Reduce leakage by a further 15% by 2025 and by 50% by 2050
- Water efficiency activities to help our customers reduce their consumption to an average of 100 litres per head per day by 2040 (‘Target 100’ programme). This involves an intensive media and engagement campaign as part of an initial phase of the ‘Target 100’ programme, concentrated throughout the period 2020-2025, but helping to influence customers’ water use behaviour over the longer term.
- Metering of more household properties to increase meter penetration from 88% to 92% which will support the achievement of the ‘Target 100’ programme

Once the final strategy had been determined, environmental assessment (SEA, HRA and WFD assessment) was carried out to examine any cumulative effects from construction and/or operation.

6.2 Environmental assessment of the Central area strategy

The SEA assessment summary of the final strategy for the Central area is presented in Table 14. The table shows for each scheme the adverse and beneficial effects assessment in two separate rows. Each coloured box in the table indicates the significance of effect assessed against the relevant SEA objective linked to the SEA topic area shown in the top row (e.g. biodiversity, flora and fauna). The key below the table indicates the significance of effect scale.

Some SEA topics have more than one underlying SEA objective (for example, there are four objectives linked to the SEA ‘water’ topic. The table provides an overview of the scale of adverse and beneficial effects associated with each scheme and the strategy as a whole. Further details are provided in annex 14.

Table 14 SEA effects summary for the Central area strategy

Option name	Residual Effects Significance	SEA objective																
		Biodiversity, flora and fauna		Population and human health			Material assets and resource use		Water				Soil, geology and land use	Air and Climate			Archaeology and Cultural Heritage	Land-scape and Visual
		1.1	1.2	2.1	2.2	2.3	3.1	3.2	4.1	4.2	4.3	4.4	5.1	6.1	6.2	6.3	7.1	8.1
Littlehampton WTW Indirect Potable Water Reuse (20Ml/d)	Adverse																	
	Beneficial																	
Transfer to Midhurst WSW & Petersfield BH rehabilitation	Adverse																	
	Beneficial																	
Scheme to bring West Chiltington back into service	Adverse																	
	Beneficial																	
ASR (Sussex Coast - Lower Greensand)	Adverse																	
	Beneficial																	
Winter transfer Stage 2: New main Shoreham/North Shoreham and Brighton A	Adverse																	
	Beneficial																	
Coastal Desalination - Shoreham Harbour (10Ml/d)	Adverse																	
	Beneficial																	
Pulborough groundwater licence variation	Adverse																	
	Beneficial																	
Nitrate catchment management / treatment – North Falmer A	Adverse																	
	Beneficial																	
Nitrate catchment management / treatment – North Arundel	Adverse																	
	Beneficial																	
Nitrate catchment management / treatment – North Falmer B	Adverse																	
	Beneficial																	
Nitrate catchment management / treatment – Long Furlong B	Adverse																	
	Beneficial																	
Nitrate catchment management / treatment – Brighton A	Adverse																	
	Beneficial																	
Nitrate catchment management – Steyning	Adverse																	
	Beneficial																	
Pesticide catchment management / treatment – Weir Wood Reservoir	Adverse																	
	Beneficial																	
Pesticide catchment management / treatment – Pulborough Surface	Adverse																	
	Beneficial																	
Pesticide catchment management / treatment – River Arun	Adverse																	
	Beneficial																	
Leakage reduction (15% reduction by 2025; 50% by 2050)	Adverse																	
	Beneficial																	
Installation of AMR meters to take HH meter penetration from 88% to 92%	Adverse																	
	Beneficial																	
Target 100 water efficiency activity	Adverse																	
	Beneficial																	

Key:
- Major adverse
- Moderate adverse
- Minor adverse
- Negligible beneficial or adverse
- Minor beneficial
- Moderate beneficial
- Major beneficial

The strategy involves implementing nine catchment management options to improve nutrient management and land-use practices and three catchment management options designed to reduce the issues caused from pesticides entering surface waters. The SEA assessment findings for these options are very similar; the effects are beneficial in relation to many of the SEA objectives with negligible or no adverse effects, except for minor adverse effects associated with carbon emissions for the extra water treatment necessary for the additional water made available by these schemes.

These schemes also provide a beneficial effect in respect of WFD objectives to achieve good ecological status and wider environmental objectives for terrestrial ecosystems.

We have also included an in-stream river restoration works scheme for the River Arun and Western Rother to provide increased environmental resilience to the abstraction of water from the rivers in times of drought. This will complement the Pulborough source options and the Littlehampton WTW indirect potable reuse scheme included in the strategy. The effects of this option are assessed as beneficial in relation to many of the SEA objectives with only negligible adverse effects.

Demand management options form an important component of the strategy reflecting their environmental benefits and include: installation of Automated Meter Reads (AMR) meters as part of increasing household meter penetration from 88% to 92%, further leakage reduction (15% by 2025 and 50% by 2050); and the 'Target' 100 water efficiency activities to reduce average per capita consumption to 100 litres per head per day by 2040. The SEA identified that the effects are mainly beneficial but with some minor temporary adverse effects in respect of materials required for water leak repairs and metering, as well as the risk of temporary traffic disruption and associated carbon emission and air quality effects of street works for leak repair activities.

There are seven supply-side options in our strategy, including a strategic water reuse scheme and desalination scheme which both provide beneficial effects relating to the provision of additional reliable water supplies by reusing treated effluent and seawater, respectively, and thereby increasing resilience to the future effects of climate change. The SEA identified a number of adverse effects for these two schemes:

The **Littlehampton reuse option** would give rise to a small number of major adverse effects relating to some construction activity within proximity to the South Downs National Park, the significant use of materials for construction and operation, as well as requiring high energy usage with consequent greenhouse gas emissions.

Since the draft WRMP19, the pipeline route for this scheme has been reviewed and revised to avoid adverse effects on the nationally rare ecological communities of the Fairmile Bottom Site of Special Scientific Interest (SSSI) and minimise effects on other nearby sensitive habitats within the South Downs National Park. The pipeline will be installed such that there will be no direct habitat loss. Air quality impacts will need to be considered and an air quality assessment will be completed once details of the construction programme and methods have been finalised.

The WFD assessment identified that the discharge of highly treated effluent to the Western Rother would not lead to any material adverse effects.

Some moderate adverse effects have been identified in relation to the **10Ml/d Shoreham desalination plant** including energy use and carbon emissions. The WFD assessment identified that the discharge of brine waste would not lead to any material adverse effects to water quality or ecology in the marine environment. The option will also make use of the existing long-sea outfall from Shoreham power station, and therefore at sufficient distance from the Adur Estuary SSSI.

The **Pulborough winter transfer scheme (Stage 2)** and the **Sussex Coast - Lower Greensand ASR** may result in some temporary moderate adverse effects as a consequence of pipeline construction; including in proximity to the South Downs National Park. The Pulborough scheme pipeline has been routed to minimise impacts to the South Downs National Park but some small sections of pipeline will be required within the South Downs National Park as existing water supply infrastructure are located within the Park and the pipeline needs to connect to these assets. Further route optimisation will be required at the detailed planning stage to minimise impacts to priority habitats including avoiding the lowland calcareous grassland and extensive loss of trees. The pipeline avoids the Adur Estuary SSSI.

Once operational, negligible adverse effects are anticipated for both of these schemes, with the exception of moderate adverse effects relating to energy use and carbon emissions

Both these schemes are beneficial for water supply sustainability and resilience, optimising existing water resources, During the summer, additional groundwater abstraction enabled by varying the existing abstraction licence condition for our Pulborough groundwater source (by not restricting groundwater abstraction when river flows are low) will help secure water supplies to the north Sussex area without adverse effects on the Western Rother.

The options to **rehabilitate the West Chiltington** and **Petersfield groundwater sources** have limited construction- related requirements and so no adverse construction effects are likely. However, for the West Chiltington option only, the WFD assessment has identified some uncertainty regarding the potential effects to surface waters (River Chilt) and a potential risk to wetland habitats (Hurston Warren SSSI) as a result of the groundwater abstraction Although historically the source was operated without any known effects on the water environment, further assessment of the hydrogeological connectivity between the groundwater source and these dependant ecosystems is required in order to confirm the magnitude of any potential impact during operation. These investigations will take place as part of the WINEP3 WFD no-deterioration investigations already agreed with the EA and scheduled for completion by 2022. We will work with the EA and Natural England over the coming months to agree the precise scope of these investigations. These investigations will support the development of any mitigation measures that may be required in the event that WFD status deterioration and/or adverse effects on the GWDTE SSSI site are identified.

Cumulative effects of the Central area strategy have been identified in relation to:

- Potential cumulative effects to the Sussex Coastal WFD water body due to the concurrent operation of the coastal desalination plants at Shoreham were assessed as negligible
- Potential cumulative effects to the Lower Greensand Arun and Western Streams WFD water body due to the operation of the Petersfield and West Chiltington groundwater sources were assessed as negligible. Six water supply options would be located within or adjacent to the South Downs National Park: Pulborough winter transfer scheme Stage 1 and 2; Brighton WTW indirect potable reuse (if this alternative option is developed); Littlehampton water reuse scheme; Rehabilitate Petersfield boreholes; and Sussex coastal ASR scheme. Much of the development will take place at existing Southern Water operational sites and the risk of cumulative effects in respect of construction activities is considered low. Careful planning, design and mitigation will be needed in relation to the pipeline construction elements required for some of these options to minimise impacts to habitats, heritage features and landscape features that provide the basis for the National Park designation. Close consultation will be necessary with the South Downs National Park Planning Authority, Natural England and other interested stakeholders
- Cumulative major effects on energy use and carbon emissions during operation of several energy-intensive schemes (notably the desalination and water reuse schemes)

Overall, the environmental assessment has concluded that the strategy has predominately minor to moderate adverse effects and negligible to minor beneficial effects. The Littlehampton WTW water reuse scheme will present some potential major adverse effects, mostly during construction but also in respect of high energy use.

For several of the schemes, we have considered a range of mitigation measures to reduce the assessed effects on the environment and these will be further developed as part of the

detailed planning and design of the schemes. We are committed to continuing dialogue with regulators, statutory bodies and interested stakeholders in developing these schemes and as we carry out detailed environmental investigations to inform precise details of any required mitigation measures.

Four strategic alternative options are being considered for the Central area: a larger coastal desalination option at Shoreham (up to 30Ml/d), Tidal River Arun desalination (10Ml/d), Brighton WTW indirect potable reuse (10Ml/d) and the Pulborough Winter Transfer Stage 1 scheme. The SEA, HRA and WFD assessments concluded that:

- The larger coastal desalination option at Shoreham would have moderate adverse effects including energy use and carbon emissions. Being located adjacent to an existing industrial area, there are few sensitive receptors in close proximity. The discharge of brine waste is not considered to lead to any material adverse effects to water quality or ecology in the marine environment. As with the smaller variant, the option will make use of the existing long-sea outfall from Shoreham power station, and therefore at sufficient distance from the Adur Estuary SSSI. The breakwaters at the mouth of the estuary will also deflect the plume away from the mouth of the estuary
- The Tidal River Arun desalination (10Ml/d) requires a pipeline which crosses the River Arun and extends partly through the South Downs National Park. The section within the South Downs National Park cannot be avoided as Perry Hill WSR is located in the National Park, therefore mitigation will be required to minimise landscape impacts. The waste brine discharge will be mixed with effluent from the Littlehampton WwTW and be discharged from Littlehampton WwTW's existing outfall. The brine will be discharged into the coastal waters to allow for better dispersion. Climping beach SSSI is downstream of the abstraction point on the River Arun, and therefore reduced flows in the river could have adverse effects on the site. Timing of the abstractions to avoid low tide may help to mitigate these impacts but will need to be investigated further if this scheme is to be progressed. The SSSI also has a coastal frontage and therefore dispersion modelling of the brine discharge will be required to ensure no adverse impacts to the SSSI if this scheme is to be progressed
- Since the draft WRMP19 and representations made by Natural England, the treated water pipeline route for Brighton WTW indirect potable reuse option has been reviewed and completely re-routed to avoid impacting receptors including the Lewes Downs Special Area of Conservation (SAC), irreplaceable priority habitats, visual amenity of the South Downs National Park, Clayton to Offham Escarpment SSSI
  As a result of this significant change to the pipeline route, the identified environmental effects of the pipeline component of the scheme have substantially reduced although there is still some pipeline construction required further east within the South Downs National Park which we cannot avoid. However, the revised scheme will ensure there is only one construction corridor required within the South Downs National Park, thereby minimising impacts
  Additionally, there is some uncertainty surrounding the operational effect of increased flows on aquatic ecology in the water body receiving the highly treated effluent from the Brighton WwTW scheme, with the potential risk of WFD status deterioration. If this alternative scheme was required to be developed, further investigations would be required to assess these potential impacts in more detail, and if necessary develop appropriate mitigation measures if a WFD status deterioration risk was confirmed

  This Brighton scheme provides beneficial effects relating to the provision of additional reliable water supplies by reusing treated effluent, thereby increasing resilience to the future effects of climate change
- The Pulborough Winter Transfer Stage 1 scheme makes use of existing water resources and involves improving water treatment processes to enable 2Ml/d to be made available for supply. As such there are negligible effects from construction or operation of this scheme

except for some minor adverse effects associated with additional energy and chemical use during operation and the use of materials during the construction phase.

7. Summary of strategy and strategic alternatives

This section summarises the strategic options that need to be developed in the next 10-15 years, along with alternative options identified through the Real Options modelling and sensitivity testing. It summarises the feasibility investigations that are needed in the next few AMPs.

Southern Water is setting a bold and UK leading demand reduction target to reduce per capita consumption to 100 litres per person per day across our region by 2040. The South East of England is officially declared as 'water stressed' and with population growth and future climate scenarios suggesting lower water availability then balancing supply and demand will have an even greater focus. Having been a leader in water efficiency and successfully delivered an ambitious UMP we are in a unique position to carry on setting the standard in demand reduction. However, our Target 100 programme is not just about reducing water consumption; it is about shifting society to value water. Southern Water is aiming to be at the forefront of taking action to effectively manage water resources, to keep bills affordable, to drive innovation and to support our customers. Southern Water has therefore outlined four key areas of focus in its '*Let's Talk Water*' strategy, with Target 100 being fundamental to delivering against each of these themes.

7.1 Strategic options and investigations in next 10-15 years

Our strategy has been examined and tested against environmental assessments, the outcomes of regional planning exercises and customer preferences for different option types, as outlined in Section 3. As part of this plan:

- We have implemented the 'Target 100' water efficiency policy, which aligns with customers' preferences for helping them to use water more wisely. We are also planning to extend our universal metering program to cover 92% of households
- We have selected a substantial amount of leakage reduction over the planning period, which again aligns with customer preferences, and aims not only to meet Ofwat's ambition of reducing leakage by 15% (from current levels) by the end of AMP7, but also to reduce leakage by 50% by 2050. This and the water efficiency scheme are also well supported by the environmental assessments
- We aim to use Drought Permits / Orders only in more extreme droughts (after an interim period to allow sufficient time to develop appropriate options to avoid the risk of a shortfall in severe drought conditions).
- We have selected the aquifer storage and recovery scheme, which was the customers' preferred type of option in pre-draft consultation
- We have identified the need to undertake further investigations to establish the need for and optimal amount of desalination and water reuse options that are being driven in large part by uncertain future sustainability reductions
- A number of options will only be progressed once we have confirmed the changes required to our abstraction licences. Nevertheless, given the scale of potential sustainability reductions, and given that confirmation of the sustainability reductions with the EA is unlikely until the middle of AMP7 at the earliest, we must conduct feasibility investigations and planning and promotional activity through AMP7 so we have a plan which can adapt to the wide possible range of SDB possibilities

We have identified the key schemes that need to be implemented in AMP7/AMP8 and the main steps that we will need to undertake to deliver them. We have also identified through scenario and sensitivity testing, the alternative schemes that may be required if the main ones cannot be delivered in the timescales required. These **alternative options will therefore need to be investigated in parallel with the development of the main options** in AMP6, AMP7 (and AMP8).

The **key strategic options and investigations in the next 10-15 years for the Central area** are:

- Plan for and implement an indirect 20Ml/d **water reuse scheme from Littlehampton WTW** by AMP8. Need to undertake more detailed feasibility investigations, undertake environmental surveys and monitoring, identify and implement suitable environmental mitigation measures (including opportunities for habitat creation where possible and feasible), prepare planning application documentation, secure land purchases, etc.
  - This scheme is critical to ensuring continuation of supplies under a wide range of drought conditions. It provides greater resilience to the supply system of the central area, as it allows existing groundwater sources to be rested, and provides resilience to other outage-type events
  - Its design and operation can be optimised during AMP7, as the uncertainties around sustainability reductions, in particular, become better understood
  - If the scale of sustainability reductions is low, then this option may not be needed. As the sustainability reductions still have to be investigated and confirmed with the EA then both the investigations and the feasibility/design of this potential solution to resolve deficits caused by the sustainability reductions needs to be undertaken at the same time
- Plan for implementation of a 10Ml/d **coastal desalination scheme at Shoreham** by AMP8. Need to undertake more detailed feasibility investigations, undertake detailed discharge modelling, undertake environmental surveys and monitoring, prepare planning application documentation, secure land purchases, etc.
  - Need to investigate for larger capacity of up to 30Ml/d, in case the Littlehampton WTW water reuse is needed but is not deliverable
  - This scheme, as with the water reuse scheme, provides greater resilience to the supply system of the central area, as it allows existing groundwater sources to be rested, and provides resilience to other outage-type events
  - Its design and operation can be optimised during AMP7, as the uncertainties around sustainability reductions, in particular, become better understood
  - If the scale of sustainability reductions is low, then this option may not be needed. As the sustainability reductions still have to be investigated and confirmed with the EA then both the investigations and the feasibility/design of this potential solution to resolve deficits caused by the sustainability reductions needs to be undertaken at the same time
- Further investigation of a 10Ml/d **desalination scheme on the tidal River Arun** as a possible alternative to the Shoreham desalination solution. Need to undertake more detailed feasibility investigations, undertake detailed discharge modelling, undertake environmental surveys and monitoring, etc.
  - This option should be investigated further as a possible alternative to the Shoreham desalination scheme, although investigations for this WRMP indicate it is a less optimal option, and there would be greater confidence in delivering the Littlehampton water reuse and Shoreham desalination schemes
- Plan for implementation of an indirect **water reuse scheme from Brighton WTW** by AMP8. Work with South East Water to jointly develop this scheme (our assumed share would be around 10Ml/d). Need to undertake more detailed feasibility investigations to optimise the potential operation of the scheme, undertake environmental surveys and monitoring, prepare planning application documentation, secure land purchases, etc.;
  - This option should be investigated further as a possible alternative to the Shoreham desalination and Littlehampton water reuse schemes if neither could be delivered; although investigations for this WRMP suggest it is a less optimal option, and there would be greater confidence in delivering the Littlehampton water reuse and Shoreham desalination schemes
  - Optimise the design of the scheme in association with South East Water (if selected by them as an alternative option). Pipeline routes to be reviewed and optimised and the scheme operation reviewed

- Scheme may be needed if desalination is not deliverable and/or if the Littlehampton water reuse scheme is not deliverable, provided the sustainability reductions are reasonably large

- Prepare for the **groundwater licence variation at Pulborough** in discussion with the EA, providing potentially large benefits in extreme drought events of 20Ml/d at MDO and 27Ml/d at PDO. This is partially linked to the ongoing discussions with regulators in relation to the planned Hardham wellfield reconfiguration.
- Continue feasibility studies, borehole drilling and test pumping, and secure consent from the EA to allow the **aquifer storage and recovery** to be operational in early AMP8
  - Dependent on outcome of testing programme, securing consents from the EA, and securing locations to allow construction of operational boreholes to be completed
- Implement planned infrastructure development to allow the **existing SW WRZ to SB WRZ main to be reversed –** which is already planned to be delivered in early AMP8 through AMP7 programme of works
- Develop additional **nitrate** treatment at identified sources and implement catchment management activity at these sources
  - Consider applicability of starting catchment management activity and monitoring in AMP6 and early AMP7
- Develop treatment for **pesticides** at surface water works potentially at risk and implement catchment management activity at these sources;
  - Consider applicability of starting catchment management activity and monitoring in AMP6 and early AMP7
- Develop programme of works, monitoring, engagement, etc to allow successful delivery of **in-stream catchment management measures in the Arun and Western Rother**, providing environmental resilience benefits
- Implement the '**Target 100' water efficiency campaign**. It should help to minimise the risk that the demand forecast could be higher than the central estimate
  - Significant engagement of customers and monitoring of success of the targeted PCC reduction profile will be critical through AMP7 (and AMP8) to minimise the risk that the target is not achieved and there is a subsequent potential supply shortfall
  - Associated with this is the need to develop appropriate trials of customer offerings or propositions to encourage efficient use of water during AMP7 to better understand how these could work and give greater confidence in the savings that could be achieved. This will include both incentives, and potentially alternative tariff structures
- Progress **leakage reduction activity** throughout AMP7 (to achieve 15% reduction from current levels) and AMP8 and beyond (to achieve reductions from current levels of 40% by 2040 and 50% by 2050), across all leakage options identified
- Undertake **extension of the universal metering programme** to achieve 92% metering of households
- **Undertake investigations of key uncertainties**, including:
  - Work with the EA to agree as early as possible in AMP7 the sources that are actually likely to require licence changes to delivery sustainability reductions. The scale of **uncertain sustainability reductions** is driving the selection of a number of schemes in AMP8. If the sources that are actually likely to require sustainability reductions can be formally agreed with the EA, we may be able to cease or limit the cost of feasibility investigations and planning preparation needed in AMP7
  - Work with Portsmouth Water to understand the **risks to the bulk import to Pulborough under an extreme drought**. There may be a short-term risk under extreme drought conditions if the bulk supply is not available at its full amount of 15Ml/d
  - Confirm that the **Pulborough wellfield redevelopment** does provide the assumed baseline DO, which we are confident that it does do. However, if the current work is shown not to have been successful, we would need to seek to cover up to 4Ml/d of assumed DO

benefits. This could require the turbidity/sludge handling process improvements at Pulborough in AMP7

7.2 Deliverability of the plan

As explained above, these strategic options were selected through a model which solves multiple states of the world, including a range of drought conditions, and five separate 'futures' representing a range of different potential SDBs. This model is sufficiently and appropriately robust for planning water resource management on this scale.

If the future turns out to have limited demand growth, limited climate change impacts and limited or no further sustainability reductions reflecting a future SDB more like those modelled in the 70th or 90th percentile branches – then a number of these options may not be required. For example, the company's 'Target 100' policy could reasonably limit the future uncertainty around demand growth and should (if customer water use savings are sustained) increase the likelihood that the company supply demand balances head more towards the lower 50th-90th percentile branches, rather than the 10th or 30th percentile branches (assuming that other drivers of uncertainty relating to climate change impacts and sustainability reductions do not push the company back towards the higher deficit branches).

As we prepare for our next plan, it may be possible to confirm that the implementation of some of the AMP8 options will not actually be required. However, the timescales are such that we will need to have done much of the feasibility and environmental investigations and the preparation of planning documentation in AMP7 (before it can be confirmed whether the schemes are not necessary) even if the scheme is not ultimately needed in AMP8.

For new resource developments, it will be necessary for detailed engineering and environmental assessments to be undertaken, for planning and other consents to be secured, and for the schemes to be constructed and commissioned. For transfers from other water companies there may be a need for asset enhancements, and/or for the development of new water resources within those companies in order to free up water to make the transfer available. The timings within this plan are our best estimates for delivery at this point in time.

Figure 13, Figure 14, and Figure 15 present some of these key decision points and uncertainties in general terms, and the impact that this can have on the plan.

Figure 13 Indicative timeline showing key decision points and external influences

Investigations, planning and promotion

- *Commence as soon as possible (end AMP6 / start of AMP7)*
- *Parallel investigations of preferred options and key alternatives*

Drought permits and orders

- *Available in severe droughts for an interim period, after which these are assumed to only be available in extreme drought events, as this aligns with customer preferences from WRMP14*
- *The interim period is needed to allow time to develop options to replace permits/orders in severe droughts to avoid the risk of a supply failure if a severe drought were to occur*

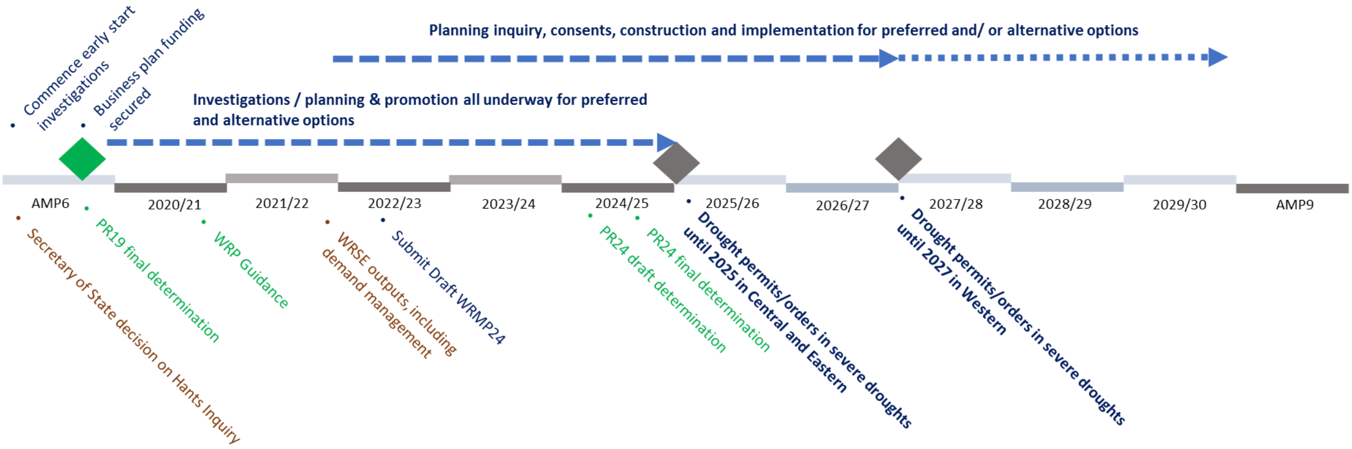
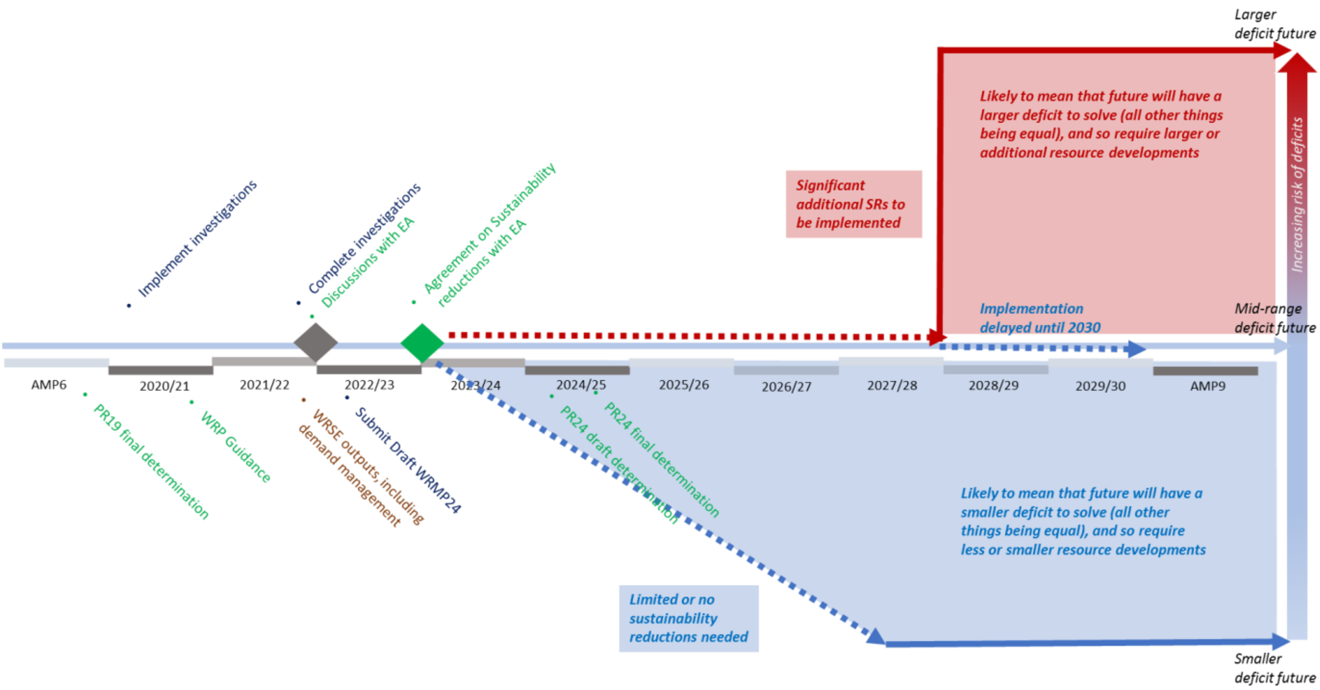
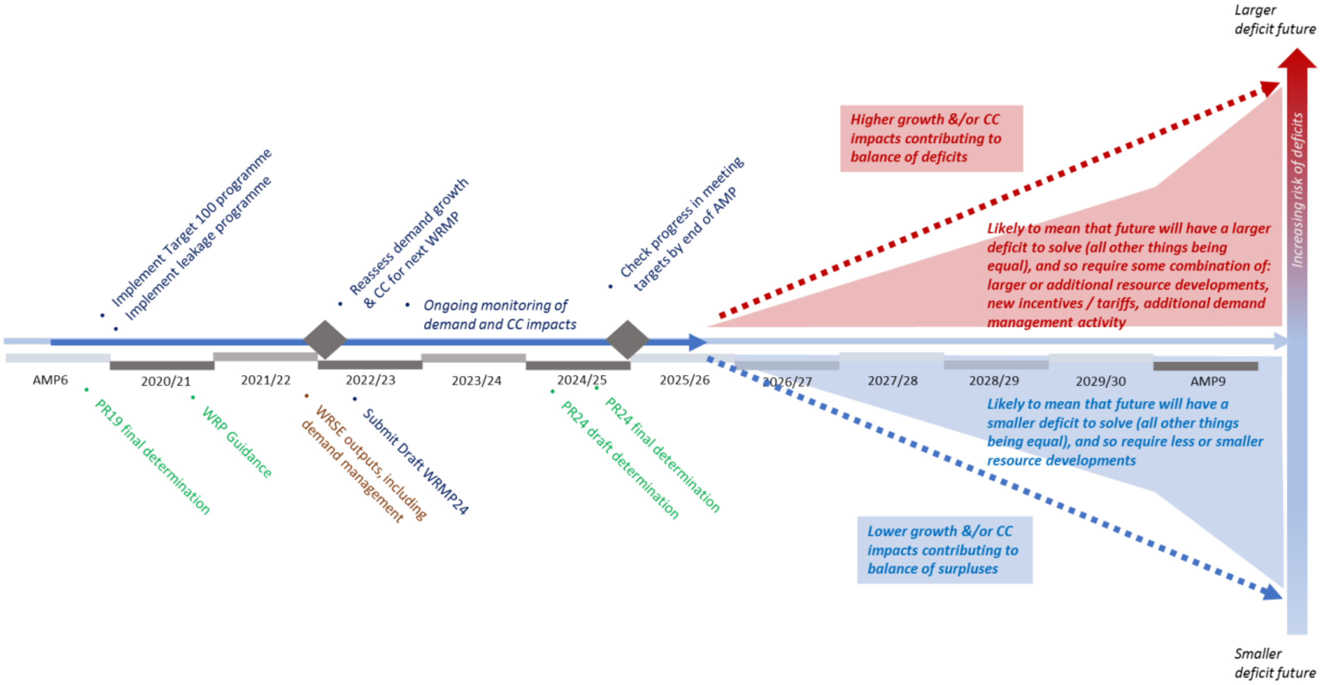


Figure 14 Indicative timeline showing the impact of the uncertainty of future sustainability reductions on the plan in the 2020s



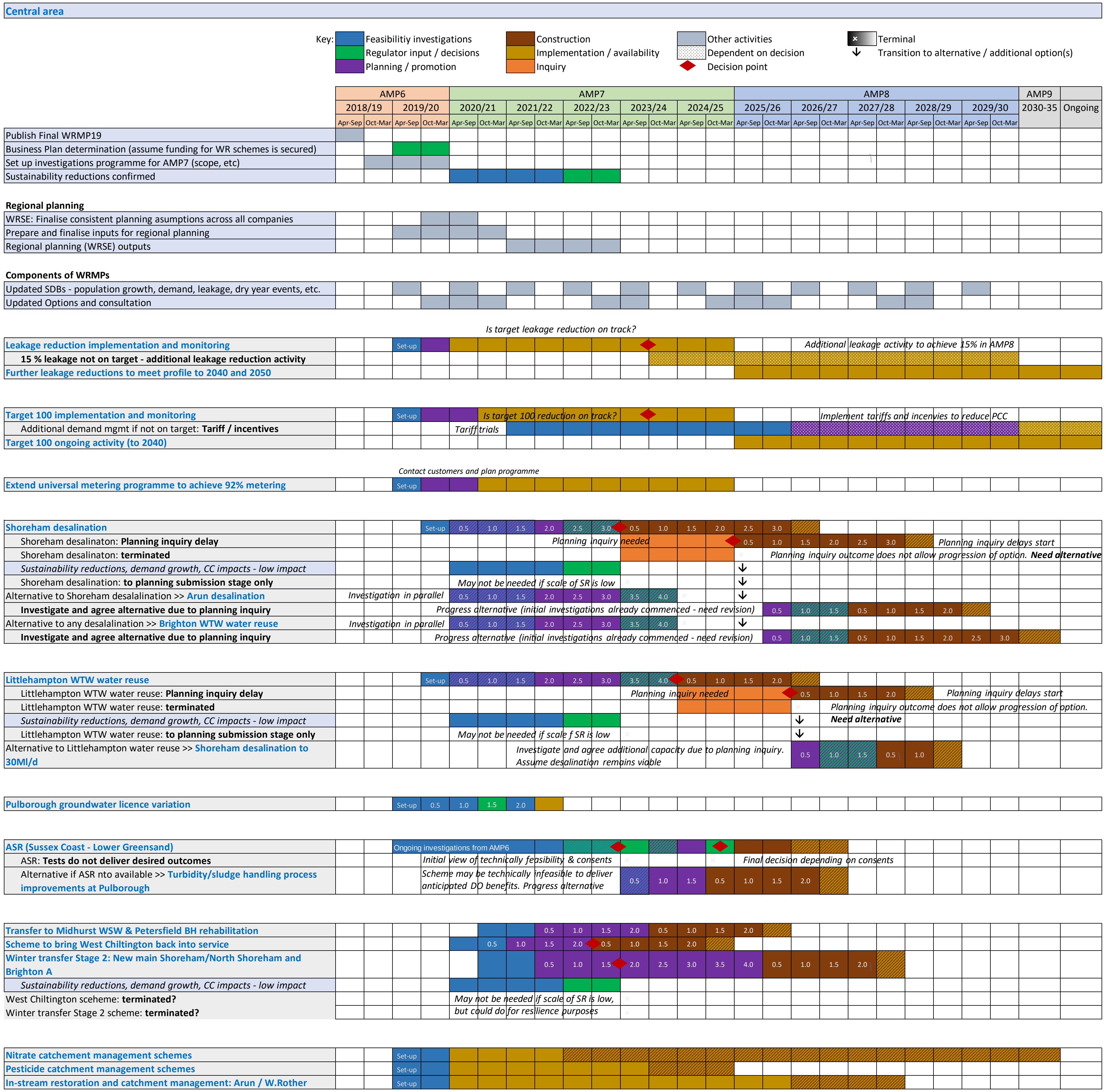
Southern Water

Figure 15 Indicative timeline showing the impact of the uncertainty of demand growth and climate change on the plan



The deliverability of the plan in the next two AMPs is shown below in Figure 16. This describes the main strategic schemes and key alternative schemes, and aims to present, at a simplified level, the potential impact that sustainability reduction uncertainty, planning inquiries, etc could have on the plan.

Figure 16 Indicative programme of proposed works for AMP7 and 8 to deliver the preferred plan and / or key strategic alternative



Southern Water

7.3 Regional strategy

Figure 17 presents a summary of the intra-zonal connections and the regional water trading options that comprise our strategy. There are two existing bulk supplies – one an import to SN WRZ, the other an export from the same WRZ. No additional water trading schemes were identified in our plan.

We did also include as an option in our feasible list, the Brighton WTW water reuse scheme, which was intended to be a jointly developed scheme with South East Water. However, they have advised that they do not require the scheme, and neither was it selected in our preferred plan. It was an option available for selection in the WRSE model, but was not one of the schemes that was selected in most scenarios. Nevertheless, it could conceivably be an alternative strategic scheme, and as such we have committed to further investigation of the scheme and its design, working with South East Water through AMP7.

Southern Water was the first company to chair the WRSE regional planning group in the mid-1990's. Since then it has played an active role in developing regional solutions for all customers in the south east. We have promoted and constructed a number of strategic transfers between companies, and this current plan continues to improve the connectivity in the south east. It is proposing new inter-regional transfers through AMP7 and 8.

Figure 18 shows an indicative grid system that could be developed for the south east region:

- Taking existing connections between the water companies
- Developing joint schemes or schemes that provide benefits to multiple companies
- Adding to the current network to provide an increased number of connections and to make these and existing connections bi-directional to allow water to flow in either direction
- Providing greater system resilience and redundancy which will help to reduce risks from outage and events such as extreme droughts, heatwaves, freeze-thaw, pollution or even terrorism, across the region as a whole

The company is committed to continuing to play a leading role in the development of a regional plan. In the future the remit of the WRSE is likely to be extended such that they would derive a regional plan that would then be provided to the Water Companies to incorporate into their business plan

Figure 17 Water trading in the plan

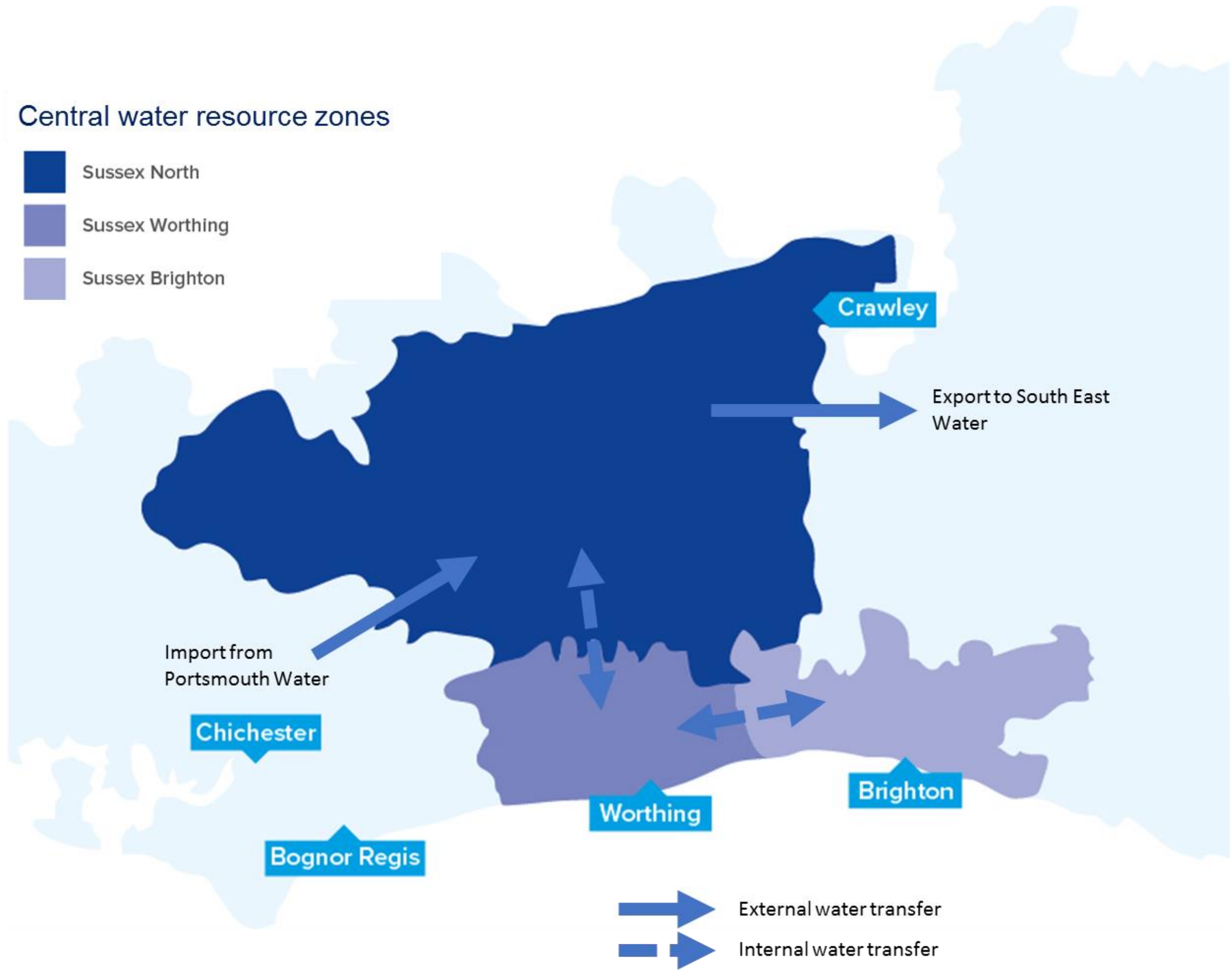


Figure 18 Indicative grid system for south east region by 2050s

8. Resilience

8.1 Resilience benefits our preferred plan

The EA's Water Resource Planning Guidelines instruct companies to consider options to increase resilience as part of the options appraisal, even when some options that provide resilience benefits may not necessarily provide readily identifiable water volumes. Ofwat also has a duty to further the long-term resilience of the water sector.

As a result, this section summarises the consideration we have given to aspects of resilience in this WRMP. The options detailed in Table 15 are likely to provide resilience benefits on top of any WRMP-driver, so may provide the company with greater flexibility to respond to a range of unforeseen events.

Table 15 Options providing resilience benefits

Source or scheme	Description	Resilience benefits
Reversing the SW-SB main to allow Brighton to support Worthing	Scheme is already being planned	Provides greater system resilience benefits, and reduces risks from outage and events such as extreme droughts, heatwaves, freeze-thaw, pollution or even terrorism
Desalination and water reuse schemes	A number of schemes selected in 2027	Allow resting of existing groundwater sources plus resilience to other outage-type events
Nitrate scheme	Catchment management scheme to reduce susceptibility to nitrate pollution	Increase resilience of source to nitrate pollution
Pesticide scheme	Catchment management scheme to reduce susceptibility to pesticide pollution	Not expected to provide DO benefit, but implemented in the WRMP plan to ensure resilience of surface water sources to these WQ events
In-stream catchment management on the Arun / W.Rother	Catchment management and in-stream restoration scheme	Allows increased environmental resilience and may limit the scale or need for sustainability reductions
Drought Permits / Orders	Mitigation measures included with Drought Permits / Orders	Aims to provide measures that will improve environmental resilience during periods of dry-weather related stresses in the environment, and optimise recovery from drought events

In addition, as discussed in Annex 8, our approach to planning whereby we solve for multiple drought events and inter-annual variability simultaneously, includes assessment of extreme drought conditions to ensure we have a plan that is resilient to drought events and minimises the potential for ‘level 4’ type restrictions such as standpipes and rota cuts. These can have significant impacts on society and the economy.

Our demand management activity, both in the last AMP and proposed as part of this current plan, will also contribute to our resilience to drought events, particularly periods of peak summer demand for water in hot, dry weather events. Our plan includes policy decisions to drive demand for water down through the Target 100 water efficiency programme and to reduce the water lost from our pipes through a policy of leakage reduction that is targeting a 50% reduction in leakage (from current levels) by 2050.

We have adopted a profile of outage for this WRMP which aims to minimise outage through activity identified in the business plan. This will increase system resilience to outages and water quality risks.

8.2 Non-drought resilience

8.2.1 Freeze-thaw analysis

Recent freeze-thaw events resulted in higher than usual demands between October and March in some of our supply areas. The aim of this section is to explore the prevalence and geographical distribution of freeze-thaw impacts across our supply area, and to understand the potential impact of freeze-thaw events on the resilience of our supply system, by examining a number of representative SDBs.

For the supply side of the SDB, we have used the data for the MDO scenario in the Western and Central areas, and the ADO scenario for the Eastern area (because it doesn’t have an MDO scenario). Whilst MDO represents potential available supplies in the autumn, rather than providing a view of the whole winter, we have analysed this because there is a possibility that freeze-thaw events could occur during this time period, therefore it constitutes a conservative or worst-case approach (in general, one might expect that the company could run their sources at a higher rate for a short period in the event of a freeze-thaw event).

Different freeze-thaw events are characterised by different demands, depending on the severity of the event. A particularly severe freeze-thaw event is likely to result in a higher demand for a short duration, and so we have considered the average day peak week (rolling 7-day peak week) during the winter period for each WRZ from 1997-98 to 2017-18. With a supply area the size of Southern Water’s, and with the discrete geographic nature of our three supply areas, there will likely be variation in the timing and severity of freeze-thaw events.

Our analysis showed that the peak week demands do not occur simultaneously in all WRZs: in many years, the peak week demand occurred in winter for some WRZs while occurring in summer for other WRZs in that year. This needs to be acknowledged when designing potential freeze-thaw SDBs – a situation where all WRZs experience their peak week demand simultaneously is likely to be a worst-case scenario, one that has not yet been experienced in our company area.

The plots below present our SDB analysis for two freeze-thaw years: 2010-11 and 2017-18 aggregated to the area-level.

Figure 19 Central area 2010-11 Oct-Mar peak demand plotted against MDO WAFU for Drought scenario

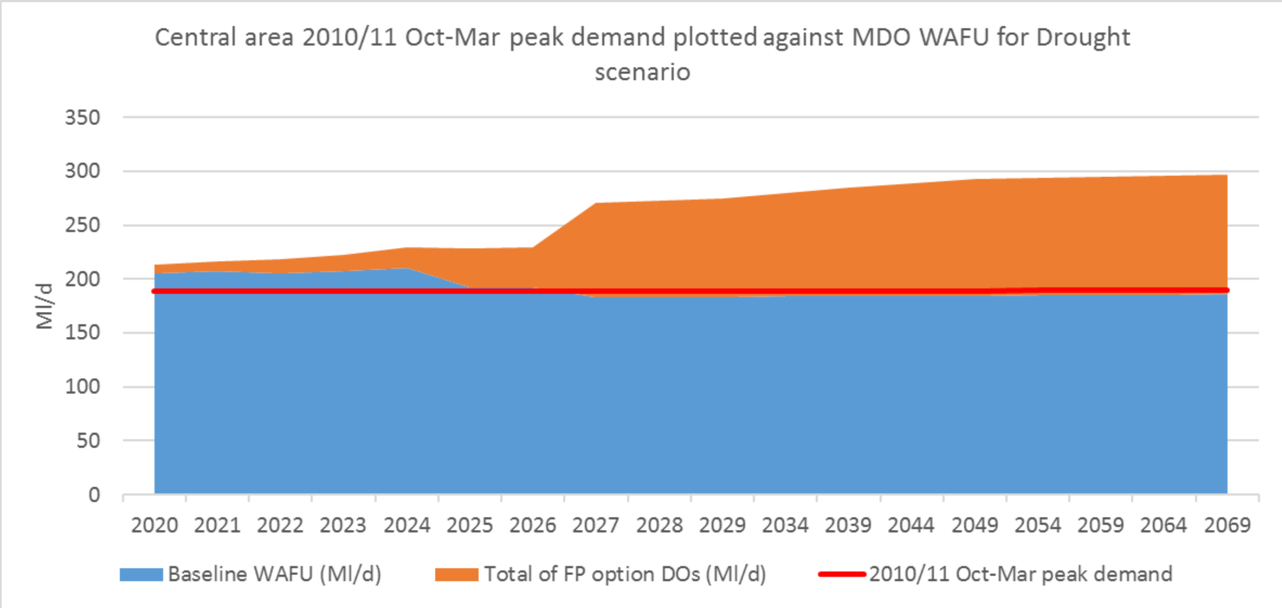
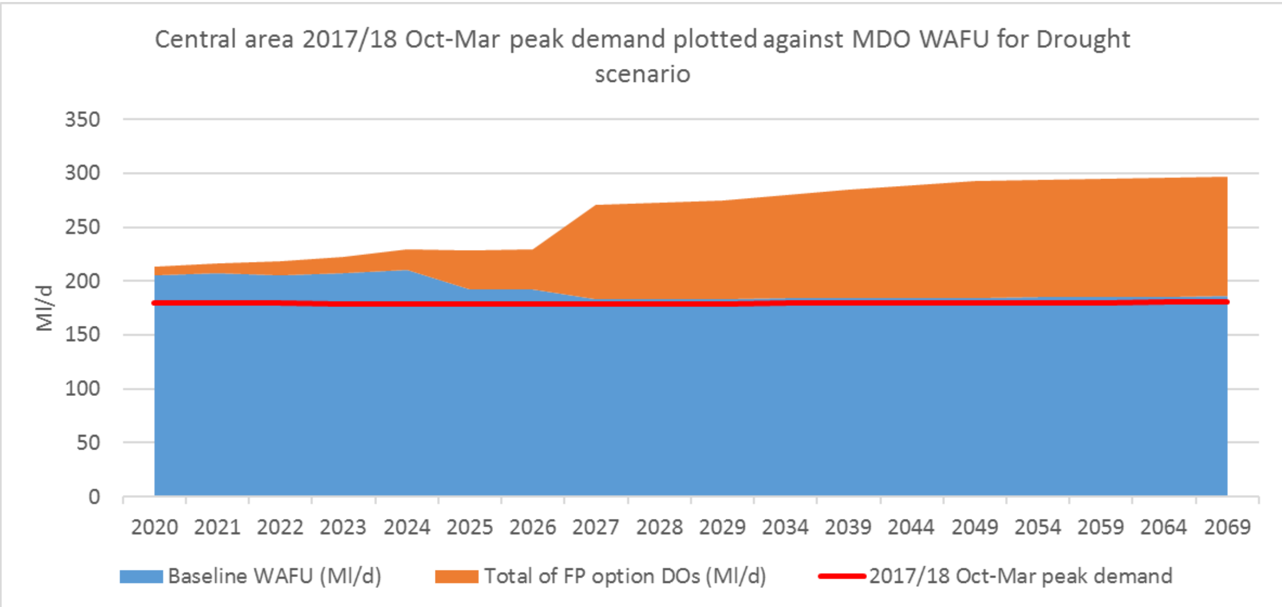


Figure 20 Central area 2017-18 Oct-Mar peak demand plotted against MDO WAFU for Drought scenario



From a SDB perspective, from 2020 onwards, the company can be considered largely resilient to the range of freeze-thaw events examined, in that there is sufficient water available at area level to meet potential winter demands in all areas.

Our preferred plan also provides solutions that deliver additional water available in the winter period, demonstrating that our preferred plan increases our resilience to freeze-thaw events from a water resources perspective.

Risks to supply from freeze-thaw events are not, however, limited to the overall availability of water, but also to the ability of the water supply system to convey water to where it is required. For example, if a demand centre is supplied by a single water main, which bursts during a freeze-thaw event, then water availability in the rest of the WRZ is unlikely to be relevant – the issue becomes one of network connectivity. Analysis of this nature is beyond the scope of what we have undertaken in this WRMP, which is primarily focused on drought events. However, we are keen to explore this aspect of resilience further ahead of the next plan for the 2020-25 period (WRMP24).

9. References

- UKWIR, 2016, “WRMP 2019 Methods – decision making process: guidance”, UKWIR Report Ref 16/WR/02/10.