Draft Water Resources Management Plan 2024

Section 10 – Programme Appraisal and Scenario Testing

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Introduction and Background

What's in this section?

Programme Appraisal for this draft WRMP24 was undertaken at regional level. The processes, plans and pathways described in this section are consistent with the Draft Regional Plan for Water Resources, as published by Water Resources in the South East (WRSE). We support the regional modelling approach and our Board endorses the proposed overall best value plan at regional level and the company-level breakdown of activity.

In this section we:

- Explain the process used to bring together the input data on the baseline supply demand situation (from section 6) and the options available to solve any deficits (from sections 7-9) and model potential solutions
- Explain the approach to best value, adaptive planning and the decisions made in the identification of the Overall Best Value Plan and testing of alternatives
- Take the regional work and break it down to company and water resource zone level, summarising the best value outcomes (and alternatives) proposed, for the benefit of our customers and the environment

We have followed the Water Resources Planning Guideline (WRPG) and other technical guidance and reports in checking and approving the programme appraisal. At the outset, a problem characterisation was carried out in order to select a programme appraisal method that was appropriate to the risks faced.

We have shared our approach and briefed the public, stakeholders and regulators as the work has progressed, explaining the approach and considered their comments and feedback.

The future is uncertain and in order to provide a secure and reliable supply of water whilst at the same time providing best value for our customers and the environment we have developed an adaptive, best value plan that is robust to a variety of potential futures.

We have also considered a wide range of alternative plans and satisfied ourselves that the regional solution also provides the best solution for our customers.

The overall best value plan allows for an increase in system resilience to a 1 in 500-year drought (by 2040) and enables inter-company transfers to neighbouring companies in the south east of England.

Building on our WRMP19, the plan continues to be demand management focussed in the short-term, with an integrated package containing significant reductions in leakage, the metering of all connections and an enhanced water efficiency programme.

Demand management programmes, including Government-led initiatives, are not able however to resolve the supply demand deficits on their own. We have planned accordingly for large-scale water resource developments in the 2030s, 2040s and beyond, notably Teddington DRA, SESRO and the Severn-Thames Transfer.

10.1 Programme appraisal is the process by which we seek to address and resolve the supply and demand problems identified in Section 6, by appraising combinations of water management options detailed in Sections 7-9.

10.2 We have followed a structured programme appraisal process to select our preferred programme, which for this planning cycle has been carried out at regional level. We discuss this and other significant changes since WRMP19 in the sub-sections below.

Changes since WRMP19

Regional context

10.3 As discussed in Section 1, the water resources planning landscape has changed significantly since WRMP19 with the publication of the National Infrastructure Commission's '*Preparing for a Drier Future*'[1] review in 2018. This has shaped government (and thus regulator) policy and expectations.

10.4 In particular it led to increased national and regional assessment of water resource availability, to the point where now Regional Plans for water resources lead the water resources planning effort, and WRMPs are expected to reflect regional planning outputs.

10.5 In the South East we have a well-established regional planning group (WRSE) and in this planning cycle they have led regional water resource plan development.

10.6 With regard specifically to programme appraisal, WRSE member companies have jointly focussed on developing the regional modelling and assessment capabilities. Therefore, for the first time, we have been able to conduct a full programme appraisal at the regional level.

10.7 We have been embedded in WRSE activity at practitioner to director level and we are confident that the approach used and the overall best value plan that has resulted from this work is suitable for our statutory dWRMP24.

Policy changes

10.8 As well as support for regional planning, *Preparing for a Drier Future* and the Environment Agency's subsequent (2020) *National Framework for Water Resources*[2] set out other expectations for regional plans and company WRMPs. These include:

- **Build resilience to drought** – Plans should be based on achieving a level of drought resilience so that emergency drought order restrictions, such as rota cuts and standpipes, are expected to be implemented no more than once in 500 years on average. This increased level of public water supply drought resilience translates into an annual chance of not more than 0.2%, or a 5% chance of these restrictions being used over a 25-year period. Plans should set a date by which this level of drought resilience can be achieved by, although this should be in the 2030s
- **Greater environmental focus** - The Framework also seeks to deliver a shared ambition for the environment. It highlights the shared goal of the Government, regulators and regional groups to improve the environment and address unsustainable abstraction of water from it. Whilst company WRMPs already account for replacing a significant amount of water from unsustainable sources, in particular the unique and highly valued chalk streams, the Framework indicates that eventual reductions in abstraction may be

[1] National Infrastructure Commission (2018) Preparing for a Drier Future
[2] Environment Agency (2020) National Framework for Water Resources

even higher. The Framework calls for a shared 'environmental destination' with agreed steps for getting there covering short, medium and long-term changes, recognising that developing alternative supplies of water takes time and will need significant changes to how water is managed

- Managing uncertainty - The Framework recognises that these changes are ambitious and it will be necessary to manage uncertainty and risks associated with them. It promotes an adaptive planning approach with the need to carefully track progress of factors such as water demand, population, climate change and environmental improvements, and identify clear decision points where alternative approaches may need to be brought in. These decision points are to make sure there is enough time for alternative approaches to be adopted should demand reductions not follow the expected track

10.9 Each of these have had an important impact on the WRPG[3] we must comply with and therefore both our planning approach and also the extent of the challenges we face. We return to each of these points later in this section.

10.10 Overall, we understand and accept the call to be ambitious and for step changes.

Our approach

10.11 Our approach to programme appraisal for dWRMP24 builds on the approach developed for WRMP19. Readers of our WRMP19 will already be familiar with a number of the key processes and analyses discussed in this section, and there are also good similarities in the final plan outputs, despite the step changes in policy.

10.12 Both plans use a risk-based approach and both use a step-wise, multi-metric optimisation method to establish a) a least cost plan and b) alternatives based on a wider range of metrics. The method then goes on to examine trade-offs and select and justify an adaptive, overall best value plan.

10.13 The main change is to bring analysis of alternative futures and adaptability, which were sensitivity tests for WRMP19, forward into the baseline for dWRMP24. This allows for plans to be expressed as a range of pathways across the range of potential futures which are developed with adaptability built-in.

10.14 Optimisation can now be carried out over a range of futures at once, and in consideration of each other, which has enhanced our ability to produce adaptive plans and ensure that investment decisions made early in the planning period are able to be made in the context of a range of potential futures.

10.15 In summary, a plan no longer just covers a single pathway, it now provides a solution that can adaptively meet a range of potential future pathways. We are still required by Guidance to identify a preferred (single) pathway for reporting purposes. These pathways are different depending on the Regulators' approach to adaptive planning.

10.16 We will return to these points over the course of this section.

[3] Environment Agency, Ofwat and Natural Resources Wales, Final Water Resources Planning Guideline: April 2022.

Section structure

10.17 The rest of this section covers appraisal method, Decision Support Tools (DSTs), results and conclusions and is structured as follows:

- Understanding the planning problem – describes the planning period used and problem characterisation, which is how we ensure that the methods and tools we use are commensurate with the scale and complexity of the problems and potential solutions
- The Best Value Planning approach – describes the best value, adaptive planning approach we have used and the tools developed to undertake it
- Best Value Planning process – describes the step-by-step process we have used to produce solutions to the planning problems
- Stage 1: Data validation – describes how supply demand and option information is brought together and validated before programmes of options are developed
- Stage 2: Decision Making Framework– describes the objectives and policy constraints on the plan and the criteria and metrics used to judge programme performance
- Stage 3: Baselining and solution development – describes the establishment of the baseline planning problem and how solutions are developed
- Stage 4: Assess solutions – describes how we have developed our Least Cost plan, Best Environmental and Society plan and other potential alternative plans
- Stage 5: Sensitivity testing – describes how solutions could change under alternative policy and option assumptions
- Stage 6: Select the Overall Best Value Plan – explains how the preferred programme was chosen and sets out the key decision points over the planning period

10.18 The seventh stage of the best value planning process is the publication for Stage 7: Consultation of the plan. We strongly value your continued input, which has been critical in forming this draft plan. For how to respond and timescales for doing so, please see the Non-Technical Summary.

10.19 This section also has two technical appendices. Further information on the technical methods used by WRSE to develop the plan can be found in Appendix W. Appendix X contains model outputs, in the form of run dossiers, for each of the model runs referred to during the course of our appraisal.

Understanding the planning problem

The planning period

10.20 The statutory minimum planning period for a WRMP is 25 years. However, in recognition of the longer-term pressures, and the time it takes to develop some infrastructure, Government has encouraged regions and water companies to adopt a longer planning period where this is considered to be appropriate.

10.21 A planning period well in excess of 25 years also aligns with that chosen by the Environment Agency when settling its strategy of flood protection for London. The economic and social consequences of water supply failure in London would be equally as catastrophic as those associated with flood inundation and, as such, it is appropriate to work to an extended planning period when deriving the strategy for future water supply.

10.22 In co-ordination with WRSE a planning period of 50 years (2025-2075) has been chosen for this plan. This respects the long-term pressures and potential solutions and balances it with the practical need to limit model run times.

10.23 The impact of extending the planning period to 2100, which was the initial intention before modelling began, is that more resource development schemes would be required in the longer-term, but the schemes selected earlier in the period do not change.

10.24 It should also be noted that the iterative nature of the WRMP planning process is also relevant here. This allows us to refine our understanding of the future and make regular adjustment to track and review plans as appropriate. The flexibility of our potential programmes over time is also investigated through the use of adaptive assessment in the programme appraisal.

Problem characterisation

10.25 Problem characterisation is carried out to guide water resource planners towards the most appropriate method of assessment for the size and complexity of their supply demand planning problem.

10.26 UKWIR's WRMP 2019 Methods – Decision Making Process: Guidance[4] provides a decision-making framework for both defining the water resources planning problem and selecting the best method to address it using the full array of feasible techniques. We have followed this approach in drafting our plan.

10.27 For each WRZ, the UKWIR Guidance requires planners to address a set of questions that can be used to define the risk in each WRZ. Scores are assigned for strategic need, demand complexity, supply complexity and investment complexity, which are then put in a matrix to define an overall high, moderate and low level of concern.

10.28 Further information on our scoring is provided in Appendix W.

10.29 The summary problem characterisation matrices from the analysis we undertook for WRMP19 and this draft WRMP24 are shown in Table 10-1.

[4] UK Water Industry Research WRMP 2019 Methods – Decision Making Process: Guidance Report Ref. No. 16/WR/02/10

Table 10 - 1: Problem characterisation summary matrix

Draft WRMP24		Strategic risk score			
		0-1	2-3	4-5	6
Complexity factors score	Low <7	Henley			
	Med 7-11			Guildford Kennet Valley	
	High (11+)			SWA SWOX	London

WRMP19		Strategic risk score			
		0-1	2-3	4-5	6
Complexity factors score	Low <7	Henley Kennet V	Guildford		
	Med 7-11			SWA	
	High (11+)			SWOX	London

10.30 We can see that the strategic risks and complexity factors have generally increased since WRMP19. This was expected given changes in Government policy for the level of drought risk our supply systems should be resilient to. It also reflects an increased ambition to increase water availability for the environment.

10.31 While problem characterisation is carried out at WRZ level, with increasingly interconnected systems the problems apparent, or solutions available, in one zone may well be transferred to another. Accordingly, the planning methods for connected or potentially connected neighbouring zones should be as closely aligned as possible to enable best analysis of inter-zonal transfer capabilities and shared water resource planning where a management problem is significant and widespread.

10.32 Given that all our WRZs form part of the catchment of the River Thames, we consider that our supply system can be characterised as high-risk.

10.33 To understand the regional context, we provided our assessment to WRSE who collated the assessments of all the companies in the region to guide the methods and tools used for regional planning.

10.34 Their combined assessment was that the WRSE area as a whole is also high-risk and that therefore complex planning methods and tools are appropriate to develop solutions (see Models).

10.35 These methods and tools are brought together under an approach known as *best value planning.*

The Best Value Planning approach

What is Best Value Planning?

10.36 When water resources planning was in its infancy, cost was the primary factor advocated by regulators in devising WRMPs. The preferred programme was the cheapest practicable solution to the planning problem. There is now wide support from regulators, stakeholders and our customers, to develop best value plans which take account of a wider range of factors over the longer-term. These factors include the environmental impacts of programmes, resilience to drought and other outage events, the needs of other water users and future generations, and customer water management preferences, in addition to cost.

10.37 Also, a best value plan seeks a solution that not only secures supplies for customers, but also increases the overall benefit to customers, the wider environment and society as a whole.

10.38 We recognise that best value can mean different things to different people. Importantly the approach allows all those perspectives to be brought together and considered in deriving a preferred, overall best value plan.

10.39 We applied a best value approach at WRMP19 and we have worked with other water companies and industry regulators to develop the approach for application at a regional level through WRSE.

Adaptive planning

10.40 The future is inherently uncertain, so we have adopted an adaptive planning approach to our best value planning. We have done this in two ways:

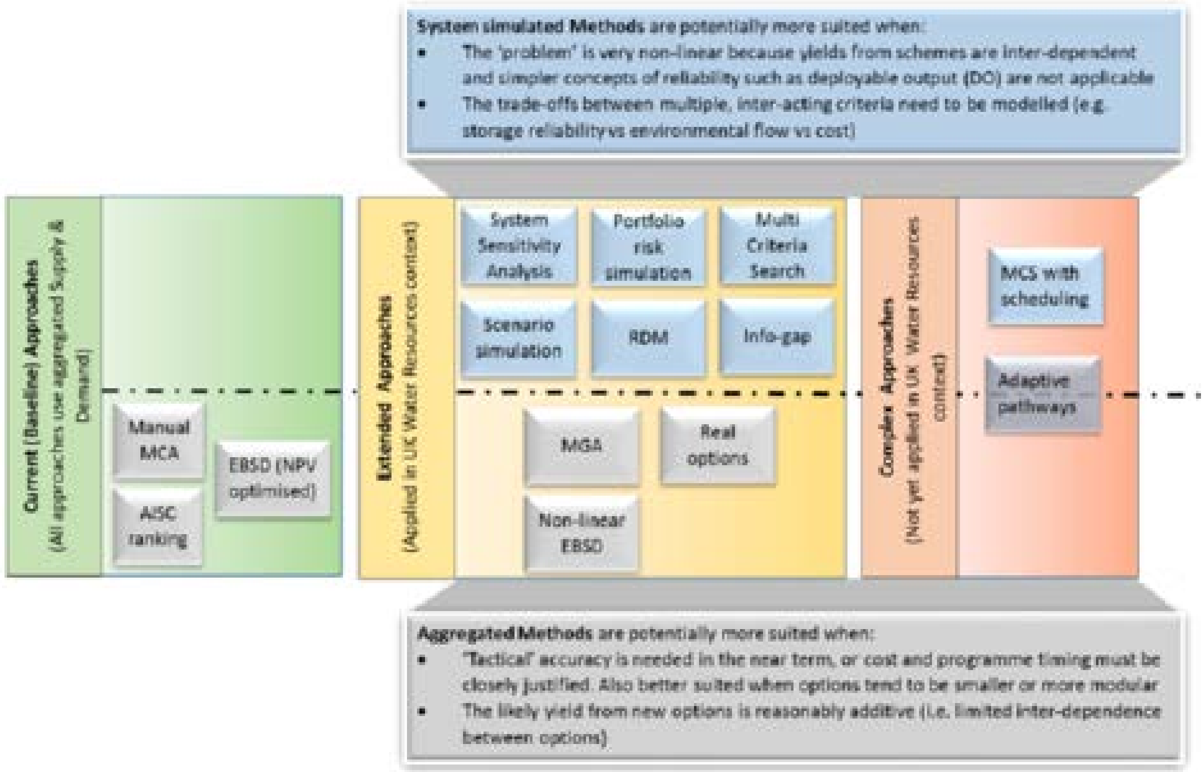
- Developing models that can find optimal solutions across multiple futures at the same time
- Using adaptive pathways to identify branching and decision points over the planning period. That is to say the dates when key policies need to be met and thus when decisions are needed in advance of those points in order to achieve them

Models

10.41 There are a wide range of DSTs available to facilitate programme appraisal, from simple to more advanced.

10.42 The size of the supply demand imbalance and so the size, cost and overall value of some of the solutions available mean that least cost optimisation alone is no longer appropriate. In these circumstances, the UKWIR Guidance recommends the use of extended or complex risk-based techniques to enable a thorough analysis of the planning problem, as can be seen in Figure 10-1, which is colour coded to match the problem characterisation matrix.

Figure 10 - 1: Decision making methods and tools for problems of different complexity



Source: UKWIR WRMP 2019 Methods

10.43 We have developed a DST, the Investment Model (IVM), that uses aggregated methods to develop a range of potential solutions to the planning problem using a variety of techniques that fit within the general, extended and complex approaches (see Table 10 - 2 below).

Table 10 - 2: Our DSTs and modelling approaches

Model		Method		Approach	Used for
IVM	EBSD	Current	Aggregated	NPV[5] optimised – single future	Baseline scenarios
	Adaptive	Extended		NPV optimised – multi-future	Baseline scenarios; Least Cost and sensitivity testing
	Pareto	Complex		Multi-metric–multi-future	Best Value Planning

[5] NPV – Net Present Value

10.44 There has been a continuum of model development over recent WRMP planning cycles as computing capabilities have grown and we have needed to solve greater planning challenges:

- WRMP14 – A least cost EBSD model, single future
- WRMP19 – A multi-metric EBSD+ model, allowing analysis and optimisation using additional parameters besides cost. Performance tested using a system simulation model
- WRMP24 – Integrated multi-metric and multi-future investment regional model, with regional supply capability assessed using a regional system-simulation model

10.45 The primary purpose of the IVM is to identify and schedule programmes of options to meet the supply demand challenges passed to it. It is able to:

- Conjunctively optimise for four planning scenarios across all WRZs at the same time
- Ensure the supply demand balance remains in surplus each year of the planning period, for all planning scenarios, in all WRZs, while minimising or maximising the value of a single objective function (e.g. cost), or multiple objective functions (e.g. a cost and an environmental or resilience function)
- Optimise against a single future situation or multiple futures, defined in a situation tree

10.46 The IVM model has three modes:

- The EBSD mode can only consider a single future situation at a time. We use a series of EBSD mode runs at regional level, for initial investigation of the potential range of futures and to carry out what-if type analysis, where we are interested in identifying a broad indication of changes between programmes. As this is an investigative mode, we optimise on least cost considerations only at this point, consistent with guidance
- The Adaptive mode optimises across all the branches of a situation tree, rather than a single branch. We use this mode to investigate adaptive planning decisions, optimising on cost only. It is used to identify the Least Cost Plan and also other alternative plans when improved performance in individual or groups of wider BVP metrics are added as constraints
- The Pareto mode, like the adaptive mode optimises across all branches of a situation tree. We use this mode to produce programmes using objective functions other than just cost

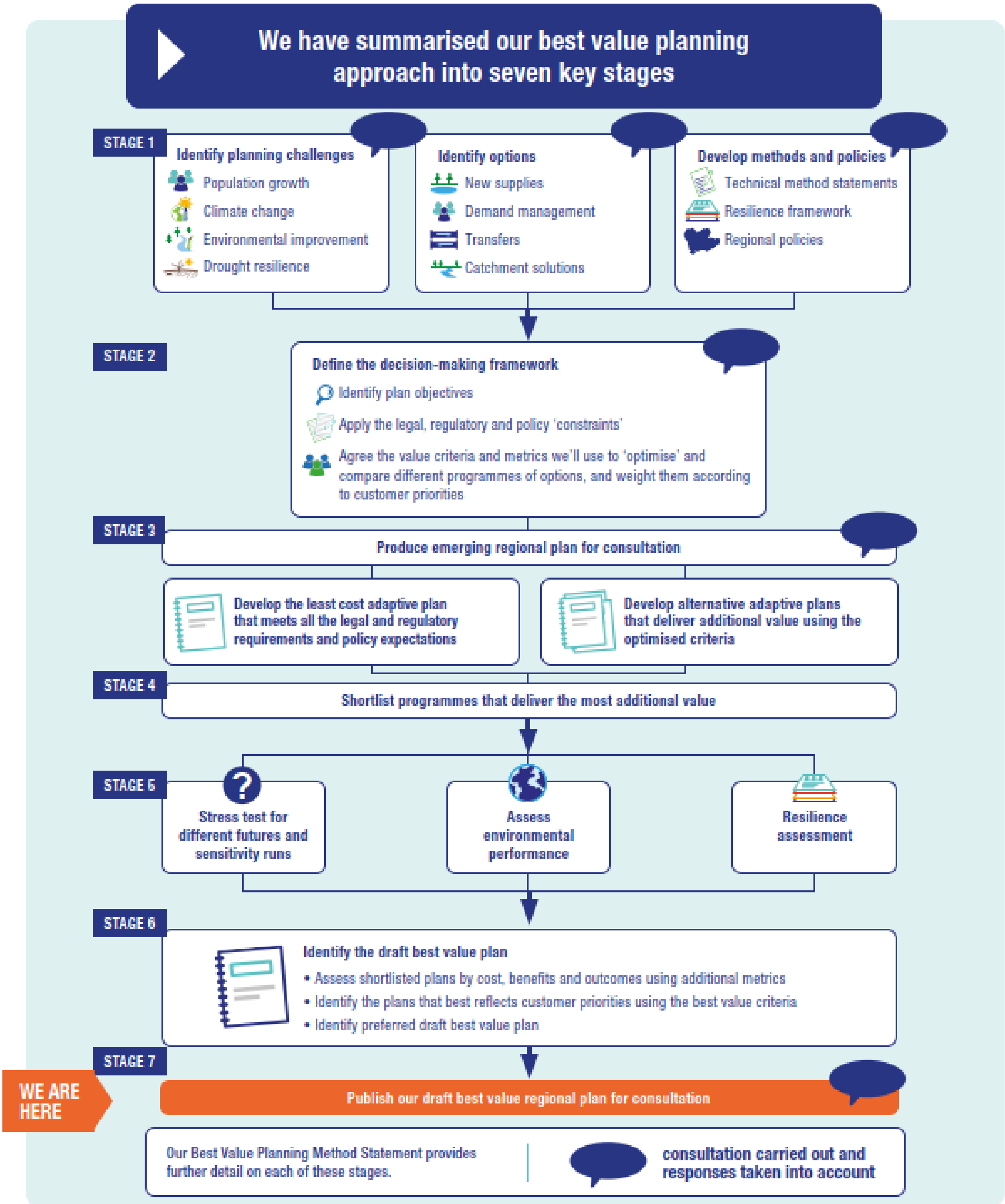
10.47 In all cases, it should be appreciated that the techniques detailed in the UKWIR WRMP 2019 Methods guidance are Decision ***Support*** Tools (as opposed to Decision ***Making*** Tools) and that they are used as such. The outputs need to be carefully appraised by knowledgeable experts and the information used to help inform the decision-making process to select a best value investment programme.

Best Value Planning process

Stages

10.48 Our process for generating, testing and presenting the best value plan can be summarised into seven key stages, as shown in Figure 10 - 2.

Figure 10 - 2: Best Value Planning Stages



Source: WRSE

Stage 1: Data validation

10.49 In the data validation stage, the WRSE data landing platform (DLP) tool is used to collate and check the input data required to feed the risk and investment models, to ensure consistency across the different data sources. In the main this data falls into two categories:

- Information used to identify the planning challenges (i.e. data that enables us to identify the problem)
- Information on potential options that could be used to meet the planning challenges [i.e. data on our options to solve the problem)

Stage 2: Decision Making Framework

10.50 In order to develop a Best Value plan, we first need to set its objectives – these are the specific goals that our regional plan must aim to deliver relating to 'Best Value'. We've used insight from water company customers and stakeholders across the South East to help us understand their priorities, so our objectives are representative of what matters most to them.

10.51 Each objective will be represented by a set of value criteria (i.e. categories against which the objective can be tested) which, in turn, will each have an associated metric that will measure the additional value it delivers. We will use the criteria and metrics to assess the different water resource programmes that are produced through our investment modelling.

10.52 In this stage we will set out our objectives, criteria and metrics, making it clear what things our plan must do (constraints), should do (a combination of both constraints and decisions), and could do, which we can make decisions on to produce a balanced best value plan that meets those objectives.

Stage 3: Baselining and solution development

10.53 In this stage we explain the range of modelled potential alternative future scenarios and how we have established a baseline position. We also describe how we develop programmes of options to meet those futures.

Stage 4: Assess solutions

10.54 In Stage 4 we explain how we've used a visualisation tool to help us display, filter and identify alternative solutions for further investigation, potentially trading-off performance against each of the value criteria in order to identify a set of high performing alternative plans.

Stage 5: Sensitivity testing

10.55 In Stage 5 the alternative plans will be examined in more detail to see how they perform and how robust they are. Specifically, we will undertake:

- Stress testing (i.e. how would the solution change key options were no longer available or if we make different policy assumptions)
- Environmental review (i.e. examining in-combination effects of the options selected in certain programmes)
- Resilience review (i.e. examining the sub-metrics and wider hot-spots)

10.56 Every programme will demonstrate additional value and could therefore constitute a best value plan. Stakeholders have the opportunity through this draft plan to consider these alternative 'best value plans', including how they would trade-off between value criteria, and confirm their priorities.

Stage 6: Select the Overall Best Value Plan

10.57 In Stage 6 we select a single overall best value programme, considering our technical work, outcomes of engagement with stakeholders, and all associated environmental and other pertinent information.

Stage 7: Consultation

10.58 Our preferred best value plan is an adaptive plan, showing how the proposals take account of different futures and when key decisions need to be made to manage uncertainty. We are undertaking a public consultation on our proposals and will take account of feedback in producing a Statement of Response and when finalising our plan.

Stage 1: Data validation

10.59 Inputs to programme appraisal have been set out in later sections of this plan. These datasets have come from a variety of sources and have been collated by WRSE. Whilst each provider has undertaken assurance on their own data, to control the data sharing, data management and quality assurance across the regional planning process a centralised DLP has been created. A complementary assurance process at regional level of the methods and data being used within WRSE has also been undertaken to ensure appropriate methods are being deployed by the companies.

10.60 This information is used to define the baseline planning problems and shared with the IVM in order to find solutions (programmes of supply and demand options).

The planning challenges

10.61 In the previous sections we have discussed the key datasets that set out the current supply demand balance and forecasts of those components over the planning period. These are available for a range of planning scenarios (e.g. NYAA, DYAA). The datasets can be combined with allowances for uncertainty, to define future supply demand challenges (see Stage 3: Baselining and solution development)

10.62 All this information is input to the DLP and checked for errors and consistency across datasets generated by individual companies and by WRSE.

The options

10.63 In the following sections we have set out the identification and screening of options and the datasets that define the costs and benefits of each option. This data is uploaded and held in the DLP and checked.

10.64 These include demand reduction strategies per WRZ, developed from combinations of available demand options, including Government-led measures, to meet different demand reduction targets.

10.65 New supply options and transfers can include elements (resource, treatment, conveyance), phases (modular increases in output) and stages (planning, development, construction and operation). They can also be grouped and linked due to mutual exclusivity (such as only one size of SESRO or STT per pathway), inclusivity (if an option must have certain treatment or conveyance elements) or by group constraints (e.g. options in the Thames Tideway group that are selected cannot exceed the Tideway DO limit to avoid in-combination environmental impacts).

10.66 The combination of the components of each option are held in the DLP and shared with the investment model. These are used by the model during optimisation to define when or if an option can be commissioned, its maximum DO contribution and its associated cost and wider benefit data, which the optimiser uses in comparison with the value and constraints of all other options to meet stated objectives while satisfying demand across all planning scenarios.

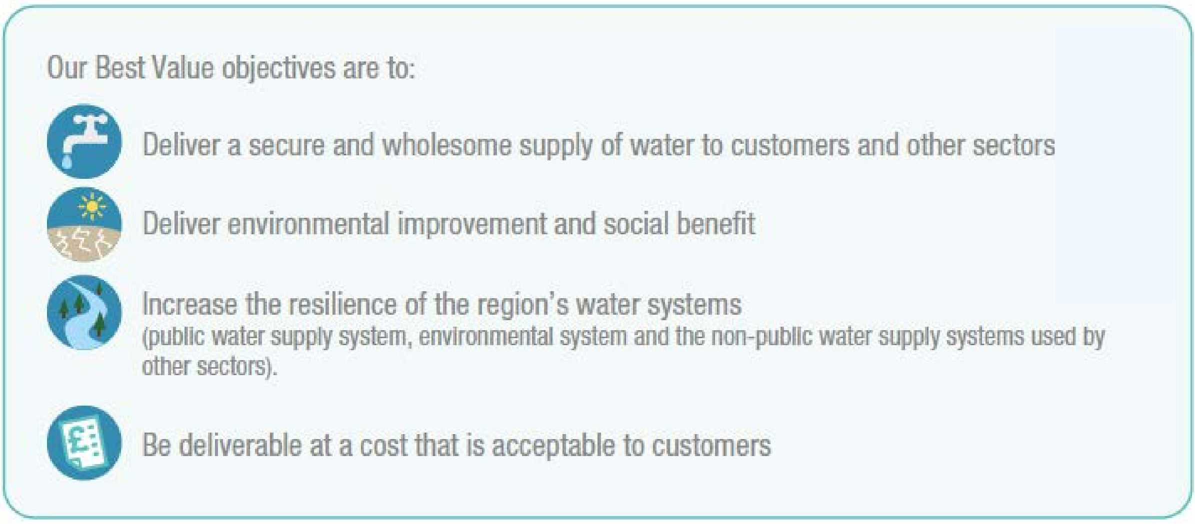
Stage 2: Decision-making framework

Objectives and criteria

10.67 As a minimum any plan must meet the legislative and regulatory requirements (including securing a supply of wholesome drinking water for customers) and other policy expectations in an efficient, affordable and deliverable way. A best value plan seeks a solution that not only secures supplies for customers, but also increases the overall benefit to customers, the wider environment and society as a whole.

10.68 Under our best value planning approach, we have identified and agreed at regional and company-level four objectives for our draft plan to achieve, building on consultation and engagement on best value as shown below.

Figure 10 - 3: Best Value Objectives



10.69 Based on our high-level best value objectives, we developed a range of measurable indices on which we can assess best value.

10.70 Each objective is represented by a set of value criteria which, in turn, will have an associated metric that measures the additional value it delivers.

10.71 There are 16 criteria as set out in the figure below. Some of the criteria identified are things that we 'must do', including the legal and regulatory requirements that our regional plan must meet to ensure that companies' WRMPs are compliant. Others are topics or policy areas (things we "should do") where there is a strong policy expectation that they will be achieved or where we have made commitments regarding their incorporation.

10.72 These are described as constraints and include:

- Meeting the supply-demand balance in all years and scenarios
- Halving leakage by 2050 and reducing it further beyond 2050
- Achieving levels of abstraction reduction
- Increasing resilience to a one in 500-year drought event by 2039/40

10.73 The remaining criteria are used to help us compare how different water resource programmes perform so we can identify the one that delivers 'best value' to the region.

Figure 10 - 4: Best Value Objectives and Criteria

Our best value objectives and criteria

Objective	Criteria
Deliver a secure and wholesome supply of water to customers and other sectors to 2100	Meet the supply demand balance – provide enough water for public water supply and other sectors by 2100
	Halve leakage by 2050 and reduce it further beyond 2050
	Reduce how much water is put into supply by water companies
	Options that customers prefer (using customer preference score from customer insight)
Deliver environmental improvement and social benefit	Reduce how much water is abstracted from identified sites and by when
	Environmental disbenefits of the programme (assessed by the Strategic Environmental Assessment)
	Environmental benefits of the programme (assessed by the Strategic Environmental Assessment)
	Enhance natural capital
	Improve biodiversity (biodiversity net-gain score)
	The cost associated with offsetting carbon emissions
Increase the resilience of the region's water systems	Achieve 1 in 500-year drought resilience (date achieved)
	Reliability - how well the water system can cope with short-term shocks without changing how it performs
	Adaptability - how well the water system can adapt so it can accommodate short-term shocks
	Evolvability - how well the system can be modified to cope with long term trends
Deliverable at a cost that is acceptable to customers	Total cost of the programme (using the Social Time Preference Rate)
	Spread the total cost of the programme across present and future generations (Using the Long Term Discount Rate)

Modelled metrics

10.74 Modelled metrics are those which are generated by the IVM model for each potential programme and can be used to compare and trade-off to identify a preferred, overall best value programme.

10.75 Most of the optimised metrics used in best value appraisal are calculated using information that is evaluated at option-level. The IVM takes the option-level information and combines it to make programme-level assessments.

10.76 Combining option-level information to make a programme-level assessment can be as simple as adding option-level values together for each year from the time each option is selected. In other cases, further calculations are made e.g. the cost metrics, where each of the schemes have to be scheduled over the planning period and costs discounted over time.

10.77 The modelled metrics are shown in in Table 10 - 3 below. They are discussed further in Appendix W and the relevant WRSE method statement. The four environmental metrics (SEA+/-, Natural Capital and Biodiversity Net Gain) are also described further in Section 9 and WRSE's draft Regional Plan Environmental Report.

Table 10 - 3: BVP Modelled metrics

Metric	Unit	WRSE Method Statement	Programme-Level Calculation
Cost	£m	Options appraisal	Options scheduled, capital cost annuitized and operating costs minimised, cost profiles generated including carbon, discounted and summed
Carbon	tCO_2e		Sum of total emissions
Natural capital	£	Environment Report	Cumulative sum of selected option costs per year
Biodiversity net gain	Score		Cumulative sum of selected option impact score per year
SEA Environmental benefit	Score		

Metric	Unit	WRSE Method Statement	Programme-Level Calculation
SEA Environmental dis-benefit	Score		Cumulative sum of selected option scores per year
Customer preference for option type	Value	Customer Engagement	Cumulative sum of selected option values per year
Reliability	Value	Resilience Framework	Sum of combined, weighted sub-metric values
Adaptability	Value		
Evolvability	Value		

10.78 We recognise there is a risk of double counting or double consideration of the benefits and dis-benefits of some of the metrics, in particular between each of the environmental metrics and between the resilience metrics. Additionally, carbon is monetised in the cost metric but has emissions (tonnes CO_2e) shown separately.

10.79 We have kept them as they highlight a particular element of interest and can be used to differentiate potential solutions. We have considered this in our decision-making process when we are assessing potential programmes.

Stage 3: Baseline position & solution development

Establishing a Baseline position

10.80 In Section 6 we set out a baseline situation tree comprising nine different futures. This tree and the nine supply demand challenges described by each pathway, forms our baseline position for programme appraisal. In this sub-section we discuss how we arrived at that tree and the drivers for it.

10.81 Water resource plans have traditionally always considered a range of potential futures, but identified a single forecast future which formed the basis for identifying the proposals necessary to balance customer demand and available supplies. This 'central forecast' included 'headroom' (an allowance for uncertainty and risk).

10.82 We have chosen to develop an adaptive plan, which means options that are ultimately chosen will be the ones that best meet a wide range of possible futures. The options identified for development in the early part of the plan (to 2040) need to be capable of meeting the full range of potential futures in the longer term.

10.83 We develop the futures using a 4-step process:

- Step 1 – Define possible futures – population growth, environmental destination, climate change
- Step 2 – Generate futures – combining the scenarios and creating a spread of possible future supply-demand balances
- Step 3 – Choose single pathways for the investment model
- Step 4 – Choose branched pathways or 'situation-trees' that enable the plan to adapt at pre-determined points

Defining futures

10.84 Sections 3-6 of this plan have set out the range of information on a wide range of factors affecting future supplies and resource demands, including population growth, climate change and environmental policies and aspirations.

10.85 From the information gathering and data generation we have undertaken, we have derived:

- Five different population growth scenarios
- 28 (+ median) climate change scenarios
- Four different environmental scenarios

10.86 Clearly, we do not know how these different scenarios may combine in the future, and there is therefore considerable uncertainty and a wide range of potential future challenges that we need to plan for. We will continue to monitor and update these scenarios over future iterations of the plan, but we need to plan now for the full range of potential futures we face.

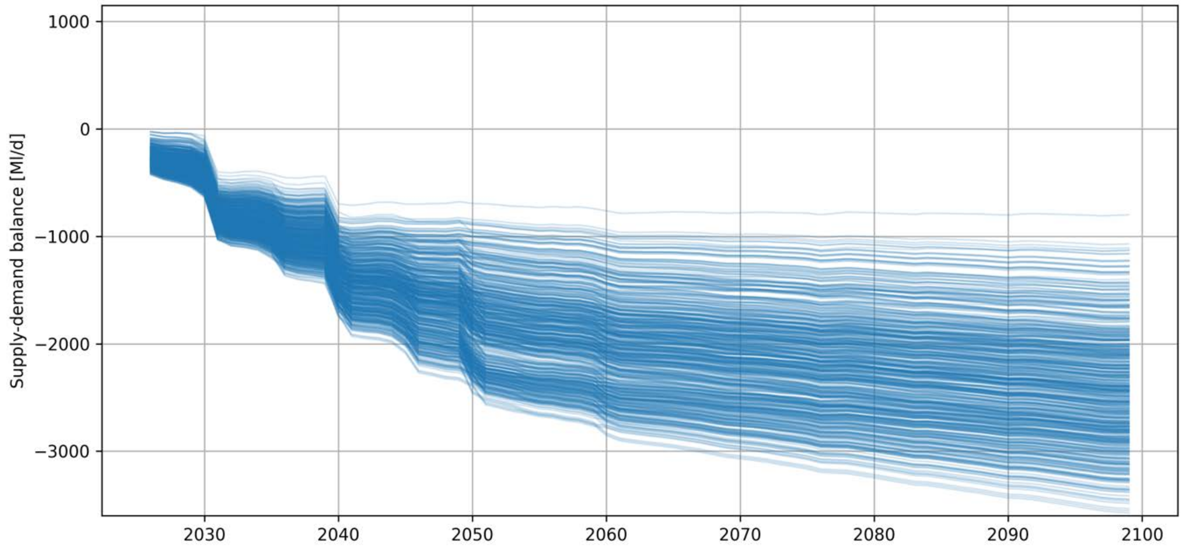
10.87 This will enable us to ensure that we maintain sufficiently resilient public water supplies for customers in an environmentally acceptable and responsible way.

Generating futures

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

10.89 This results in a significant number of different potential future water need pathways, covering the full range of challenges that we face, for each of the planning scenarios (NYAA, DYAA, DYCP) and the drought resilience requirements (1:100, 1:200 and 1:500).

Figure 10 - 5: Range of future forecast supply demand balances (WRSE, DYAA)



10.90 We can see that in the early part of the planning period the lines are relatively closely grouped, as there is less variability in the forecasts in the short term. However, by the middle of the planning period the spread between the lines increases, as the range of potential futures, and the corresponding impacts on the supply demand balance increases. By the end of the planning period the range between the most challenging and least challenging future is very significant.

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

Single pathways

10.92 We initially run single futures (or situations) through the investment model, sampling across the range. The model (run in EBSD mode) selects the optimal least cost programme of options for each of the sampled situations.

10.93 We use this information to validate the model and ensure it is working correctly, we also observe the types of option selected and how the selection changes over time, according to the scale of the challenges that it is being asked to solve.

10.94 Understandably, the greater the challenge, the greater the level of demand management and new resource development the model must select as a result. Through WRSE, several hundred single situation investment model runs have been completed and have been used to inform internal and external discussions regarding core solutions, the impacts of different drivers and policies.

10.95 From this work, we have been able to assess the scale of supply demand balance deficits arising from some of the more challenging climate change, population growth and environmental destination scenarios.

10.96 For example, we have noted the significant impact of the environmental destination scenarios and that for the more extreme scenarios, we are (as a region) having to use most of our options sets to overcome supply demand deficits. This has led to discussion on whether some options that are considered to be potentially environmentally damaging, have to be selected in order to meet the scale of deficit forecast.

10.97 Whilst single situation runs are helpful to give an early view of how the investment model behaves, they do not generate efficient plans across a wide range of challenges. Typically, they produce efficient plans for the situation that is being tested, but soon become inefficient or inadequate when considering a wider set of challenges; hence the need to use adaptive plans for situations which are quite diverse in their nature.

Branched pathways (situation trees)

10.98 To assess efficient plans across the range of future supply demand challenges, WRSE has developed branched pathways through the range of future forecasts. These branched pathways form 'situation trees', like the one chosen as the baseline tree, as discussed in Section 6 of this plan.

10.99 Branch points are identified based on:

- Risk-based triggers – using the analysis of single pathways, to determine what is the point at which future uncertainties risk bringing the region into supply demand deficit
- Policy-based triggers – When do key policies need to be delivered and when do decisions need to be made in order to deliver them?
- Aligning with the 5-year business planning and investment cycles

10.100 WRSE has undertaken investment model runs on various iterations of branches and trees, to determine what it considers to be the most appropriate to select as the basis for the regional plan that then informs dWRMP24.

10.101 These have been tested and reviewed, in a similar way to the single pathways, enabling the impacts on investment model option selection to be understood at each stage of the process.

10.102 Arising from this work, initially (for the WRSE Emerging Regional Plan[6], consulted on early in 2022) a tree was chosen with branch points at 2040, to coincide with the latest date companies have been asked to achieve 1:500 resilience to drought, and at 2060, for when environmental destinations could be achieved.

10.103 Feedback from the consultation suggested we should branch earlier to better understand variability before 2040.

10.104 A tree has now been chosen with branch points at 2035 and 2040 and decision points five years earlier in 2030 and 2035 respectively. These timings allow focus initially on the variability caused by different growth forecasts and then on resilience, environmental destination and climate change.

[6] WRSE Emerging Regional Plan, January 2022

10.105 Alternative timings for branch points are included as sensitivity tests, as discussed in later sections.

10.106 The root branch (Stage 1) has been selected to be in line with guidance. It includes growth based on Housing Plans developed by Local Authorities, licence reductions that would be required to comply with currently known legal requirements (including the potential impact of licence capping) and median climate change impacts.

10.107 The split to three branches (Stage 2) occurs in 2035 after a decision point in 2030. We have chosen this point as it aligns well with the Business Plan cycle and guidance that after this point growth forecasts beyond Local Authority housing plan should be considered. Therefore, we have included an allowance for the Oxford Cambridge Arc in the upper branch and used a trend based ONS18 (principal) projection for the lower branch. Section 3 of this draft WRMP sets out the details of the differences between the different demand forecasts. Environmental destination and climate change forecasts remain as those used for Stage 1.

10.108 The split to nine branches (Stage 3) occurs in 2040 after a decision point in 2035. Growth projections are kept as per Stage 2 except for situations 1 and 9, where the maximum and minimum growth projections are used. For Environmental destination and climate change in Stage 3, we use a high projection in the upper branches of each set, medium (median, for climate change) in the middle branches and low in the lower branches.

10.109 Each tree can be described by:

- A schematic of the combination of the population growth, environmental destination and climate change scenarios on which each of the nine pathways are based
- The supply demand balance deficit resulting from that combination of scenarios for each pathway

10.110 Both the schematic and the supply demand deficits are shown in detail in Section 6, are shown below again for ease of reference.

10.111 It is important to recognise that the adaptive planning approach that is being used means that the regional plan optimises across all pathways equally. No weightings are applied to the pathways to suggest one is more likely than another.

10.112 Additionally, the investment identified by the model in the root branch ensures that any of the subsequent pathways are able to be met in the future. In other words, the model only includes investment in the 2025-2030 period if it makes economic sense in consideration of all the future pathways to 2075. This ensures that we propose low regrets investment where the modelling analysis indicates it is ‘best value’ to do so.

10.113 Although the modelling encompasses all pathways, we are required to identify certain pathways within the situation tree for reporting purposes, particularly within the WRMP Tables. These include a ‘preferred pathway’, which represents the current best view based on company and regulator expectations, and also a ‘core pathway’ that Ofwat will use as a guide for minimum future investment.

Figure 10 - 6: What's included in each of the nine pathways

Stage 1 2025 to 2030/35	Stage 2 2030/35 to 2035/40	Stage 3 2035/40 to 2075	Pathway
		Growth: Maximum, Env. destination: High Climate change: High	1
	Growth: HP + Oxcam Env.destination: Low Climate change: Median	Growth: HP + Oxcam Env. destination: Medium Climate change: Median	2
		Growth: HP + Oxcam Env. destination: Low Climate change: Low	3
		Growth: Housing Plan Env. destination: High Climate change: High	4
Growth: Housing Plan Env.destination: Low Climate change: Median	Growth: Housing Plan Env. destination: Low Climate change: Median	Growth: Housing Plan Env. destination: Medium Climate change: Median	5
		Growth: Housing Plan Env. destination: Low Climate change: Low	6
		Growth: ONS18 (principal) Env. destination: High Climate change: High	7
	Growth: ONS18 (principal) Env. destination: Low, Climate change: Median	Growth: ONS18 (principal) Env. destination: Medium Climate change: Median	8
		Growth: Minimum, Env. destination: Low Climate change: Low	9

10.114 We have selected 'situation 4' (shaded green) as the preferred pathway. This is primarily because it aligns with the expectations within the WRPG:

- It uses Local Authority housing plan-based forecasts
- It includes 'High' environmental destination, to be compliant with the Water Framework Directive

10.115 For our PR24 business plan, Ofwat has set out its expectations in relation to long-term management of assets through its 'long-term delivery strategy' (LTDS) guidance. This requires that long-term plans consider a core scenario, movements from which should represent best value.

10.116 We have identified 'situation 8' (shaded tan) as being the 'core pathway' for Ofwat reporting purposes, because it includes ONS18 mid-range growth in the medium to long-term, likely statutory minimum environmental destination and median climate change.

Figure 10 - 7: Range of future forecast supply demand balances by pathway (Thames Water, DYAA)

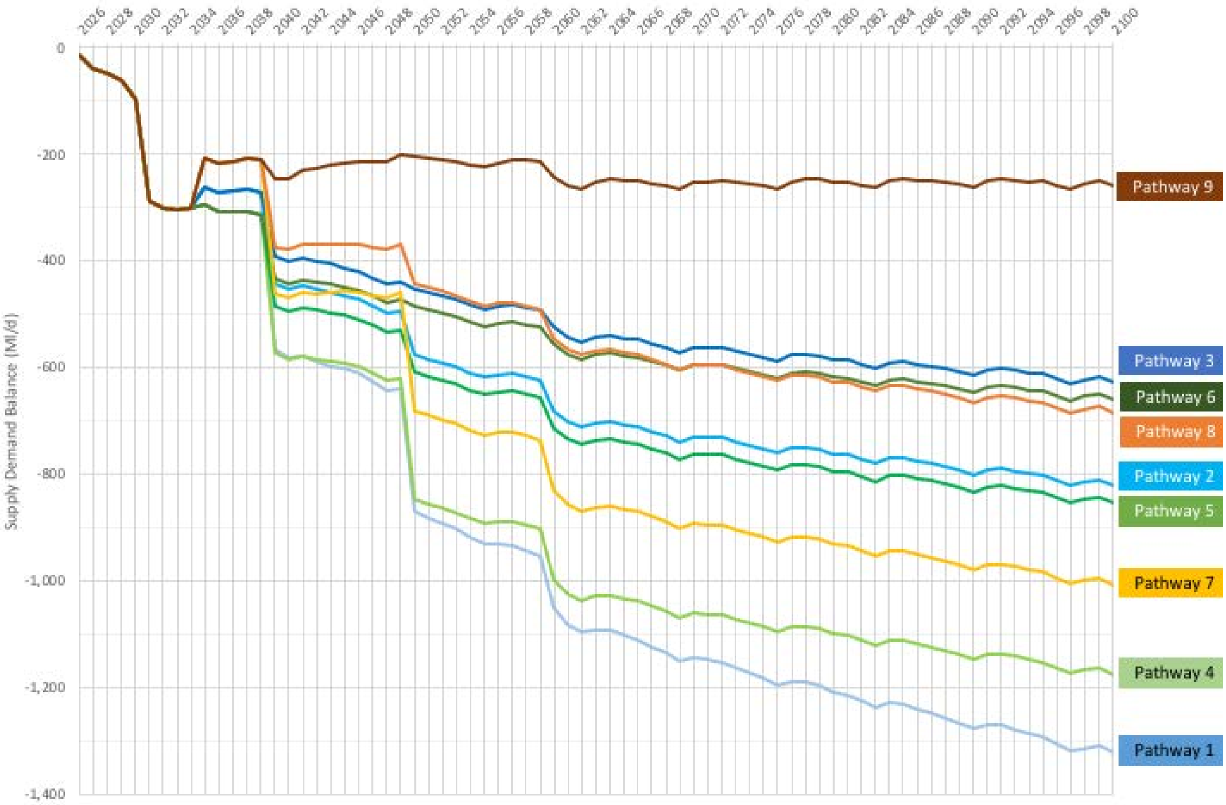


Table 10 - 4: Company-level baseline supply demand balances

Pathway	Baseline Supply Demand Balance (DYAA, Ml/d)							
	2030	2040	2050	2060	2070	2080	2090	2100
1	-116	-566	-868	-1,051	-1,142	-1,207	-1,276	-1,322
2	-116	-441	-576	-681	-729	-761	-800	-822
3	-116	-392	-453	-524	-562	-585	-615	-627
4	-116	-573	-846	-997	-1,059	-1,099	-1,146	-1,176
5	-116	-483	-608	-714	-761	-793	-833	-854
6	-116	-434	-485	-557	-595	-617	-647	-659
7	-116	-464	-681	-830	-891	-931	-978	-1,007
8	-116	-374	-442	-547	-593	-625	-665	-685
9	-116	-245	-203	-243	-253	-253	-263	-260

Stage 4: Assess solutions

The Investment Model

10.117 The investment model includes all the WRZs across the region and existing links between them. It evaluates the available options to generate solutions for solving supply demand deficits across the 50-year planning horizon. These options include demand management strategies, existing and potential new transfers between WRZs and resource development.

10.118 Further information can be found in WRSE Method Statements and Appendix W.

10.119 To support a robust evaluation of potential programmes of solutions, the investment model was run multiple times in its various modes. This allowed us to examine how the investment plan would change depending on which metric or group of metrics were focussed on, or if changes were made to the option sets and planning challenges given to the model.

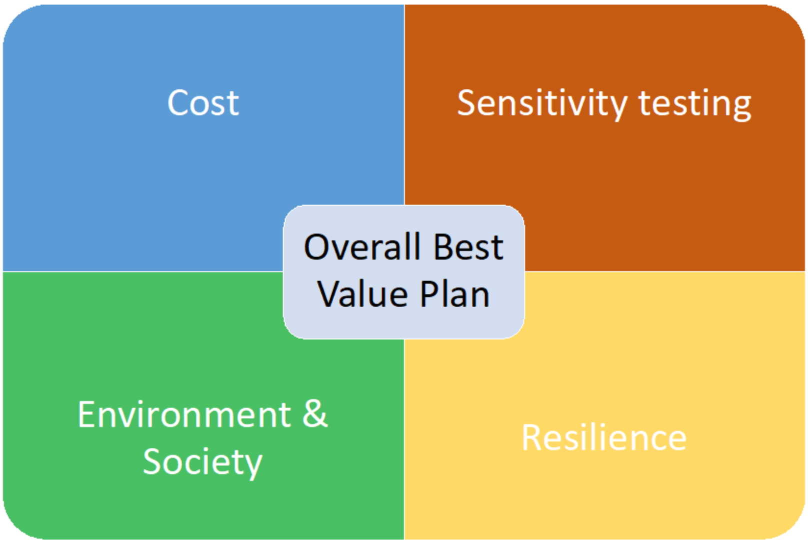
10.120 These included:

- Cost-focussed runs – those used to identify the least cost solutions. This includes sensitivity to key economic inputs such as discount factors, which impact how the cost of investment is spread over the generations
- Best Value runs – the trade-off between increasing cost and better performance against the optimisable Best Value metrics was investigated using 'pareto runs' to determine how investment plans changed as the environmental and society and resilience metrics improved
- Sensitivity tests:
  - Specific sensitivity assessments – e.g., certain large schemes removed, or costs altered for particular options
  - Policy and global sensitivity assessments – this involved testing the implications of timings around policies such as drought resilience and environmental destination, as well as the success and government support of demand management being a key uncertainty that has been tested

10.121 Although the IVM can produce programmes on all the individual metrics, for simplicity there are three principal 'lenses': Cost, environment and society (E&S) and Resilience, through which programmes can be created.

10.122 The programmes produced when focusing on Cost, E&S and Resilience are described in the following sub-sections. The Sensitivity tests are described in Stage 5. The Overall BVP is discussed in Stage 6.

Figure 10 - 8: The inputs to the overall BVP



10.123 The outputs from these runs are complex and visualisation tools were developed to support the evaluation of alternatives.

Output Visualisation

10.124 We assess investment model run outputs using a Visualisation Tool (VT). This tool enables the complex and lengthy sets of data generated by the model to be more easily understood and interpreted. It presents each run in a uniform way and offers fixed and interactive visualisations.

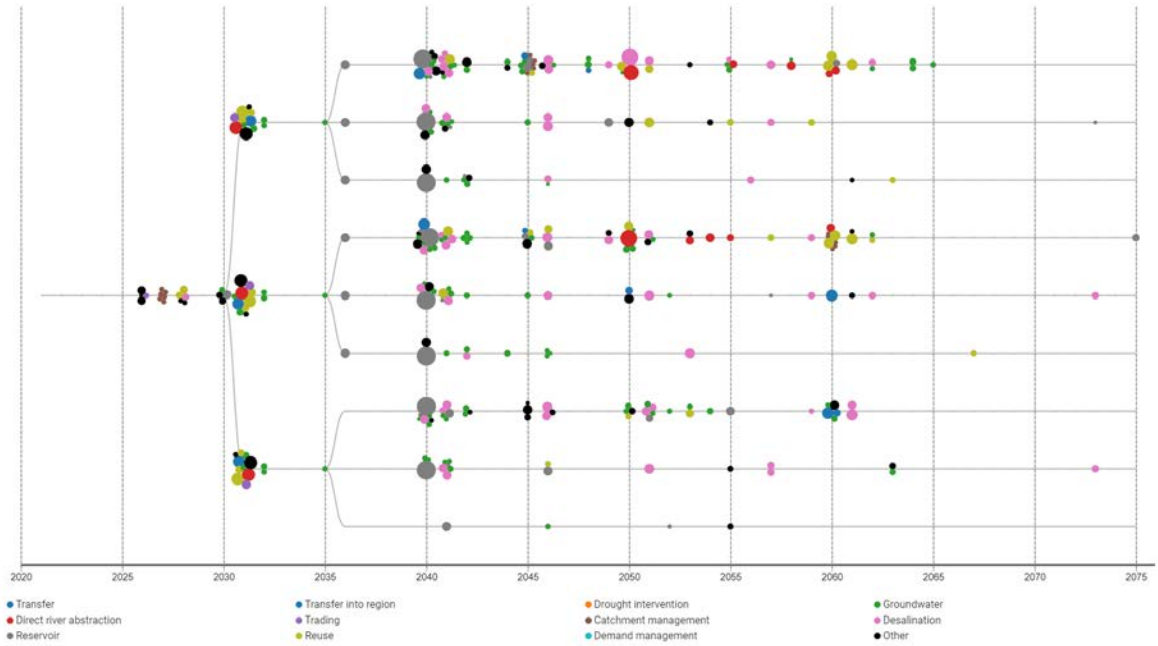
10.125 Through using the VT, WRSE and the individual companies are able to interrogate and understand the model runs in selecting the most appropriate basis for the emerging regional plan and each individual WRMP.

10.126 We introduce the main plots below. In all cases the plots are representative and do not illustrate the final model outputs.

10.127 Option selection plots are schematics of the planned pathways populated with the options selected by the investment model. These plots identify the individual options selected in each year of the planning period as coloured dots (coloured by option type) and are sized according to the option's benefit.

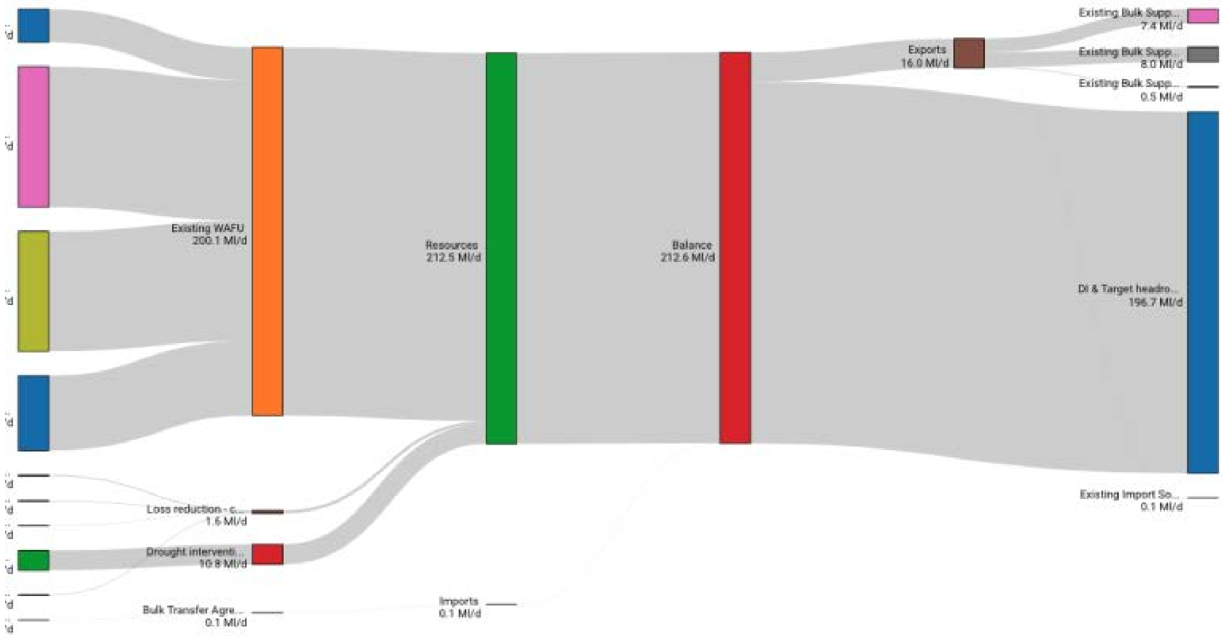
10.128 Plots can be produced for each WRZ, by Company and for the South East region as a whole, for each of the NYAA, DYCP and DYAA planning scenarios. The plots can also be filtered to highlight when or if specific options are selected or utilised. An example plot is shown below.

Figure 10 - 9: Example Option selection plot



10.129 The VT includes "Sankey plots' which provide an illustration for how the supply demand balance for the region as a whole, individual company or WRZ will change during the planning period. The plot shows the amount of water available for use (WAFU) at the start of the planning period and then can be used to layer on the contribution of water from the individual options selected by the investment model year by year through the planning period.

Figure 10 - 10: Example Sankey plot

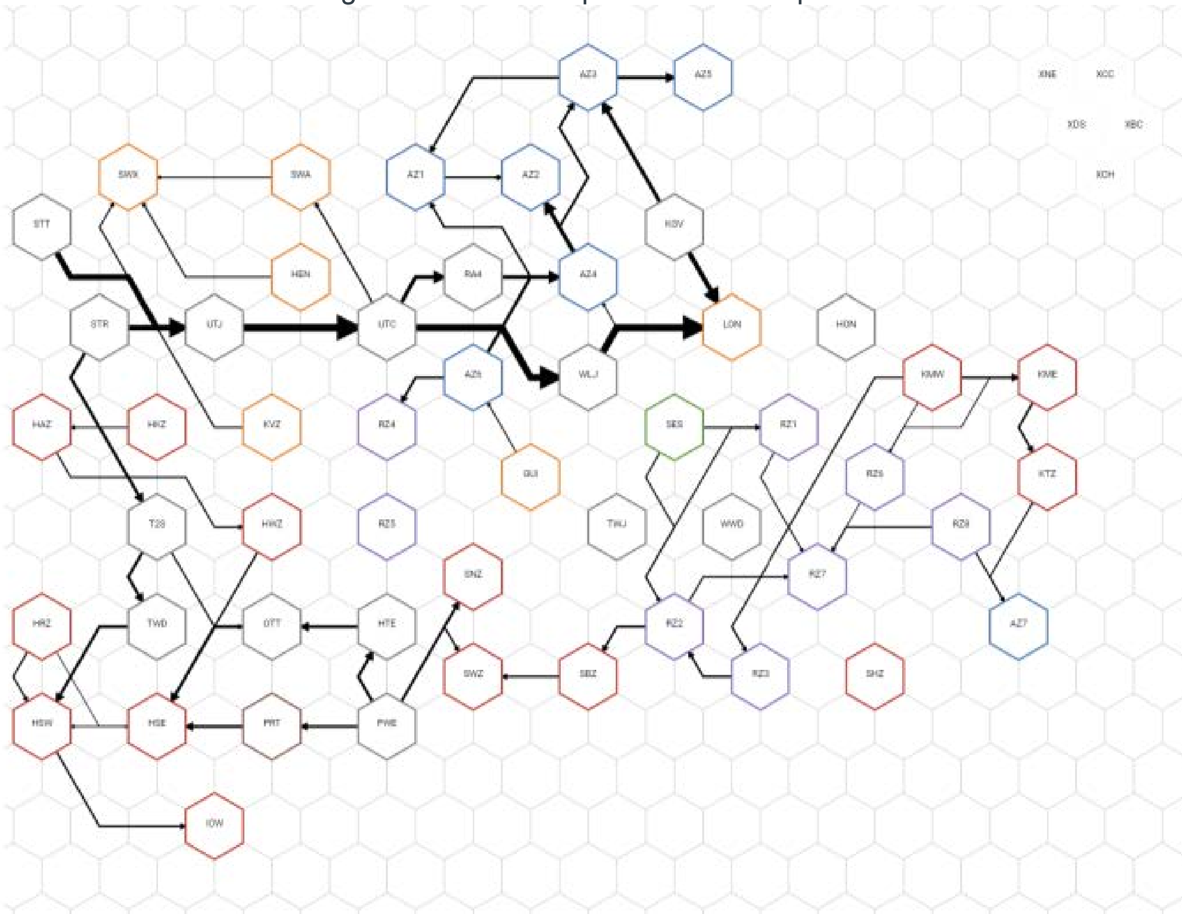


10.130 To visualise transfers 'hex plots' (see example below) are used highlighting how the number and type of transfers selected within the region change over time. These diagrams help us to see how connectivity changes over time across the region under different model runs.

10.131 Each coloured hexagon represents a WRZ or a junction node. Transfers (via river or pipeline) are shown as black lines, the thickness of lines increasing with the size of the transfer.

10.132 Junction nodes help us where water can either be combined from different options and transfers, shared downstream between different zones, or to allow untreated water to be coupled to a WRZ via a treatment works. For example, the river Thames is represented as a series of junctions to enable water to be input and abstracted by all relevant parties along its catchment: Severn-Thames Transfer (STT); Strategic Thames Reservoir (STR); Upper Thames Junction (UTJ); Upper Thames Constrained (UTC); West London Junction (WLJ); West London WTWs (KEM) and London (LON).

Figure 10 - 11: Example 'hex' transfer plot



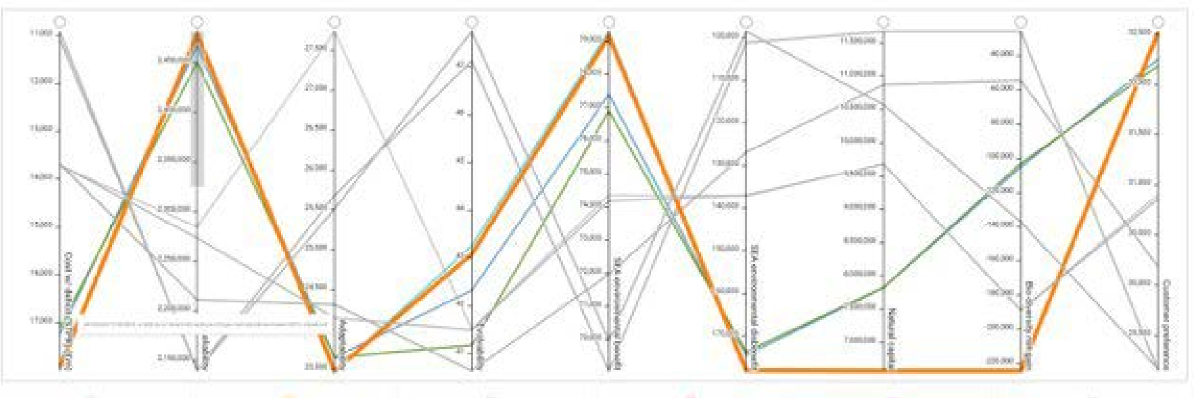
10.133 The visualisation tool also provides tabular data for each model run, including the BVP metric scores and option selection date, which we will see in the forthcoming sections.

10.134 All of the above plots are available within run dossiers that are available in Appendix X.

10.135 Run comparison tools are also available in the VT, to help us distinguish differences in performance and trade-offs between metrics.

10.136 In the WRMP19 we used a parallel plot, such as the one below to show the metrics outputs for many runs together.

Figure 10 - 12: Example Parallel plot



10.137 For WRMP24, given the number of runs being produced, we are using an alternative scatter plot summarising run best value and cost performance, as shown in the figure below.

Figure 10 - 13: Example Cost vs Metric scatter plot

10.138 Each model run appears as a single dot on this plot. The cost is the average annuitized NPV cost across the nine pathways, the BVP aggregate metric represents relative performance of the run against other runs for the wider BVP metrics. Therefore, the best plans would appear towards the top left of the chart.

10.139 The aggregate BVP metric is calculated by comparing the ranked performance of each run for eight BVP metrics and expressing that performance as a percentage. So, 100% would mean the run performed best in all the metrics across all of the runs.

10.140 We will use this plot throughout this section, building up the number of dots as we step through the BVP process.

Cost-based plans

Derivation

10.141 We begin by using the IVM to generate cost-focused plans. The objective for cost-focused optimisation is to ensure there is sufficient supply to meet demand plus target headroom in all years whilst minimising the cost to customers, society and the environment of the plan selected.

10.142 When optimising, the model will select a feasible schedule of options for each pathway, i.e. considering earliest delivery date, dependence, precedence and mutual exclusivity with other options. Where there are no feasible options available to maintain the supply-demand balance the model will indicate there is a remaining deficit.

10.143 This cost is assessed as the average 50-year NPV (2025-75) of whole life costs over each of the nine pathways in the situation tree.

10.144 All costs incurred over this span (capital costs are annuitised) were converted into present values by applying the Social Time Preference Rate (STPR, a 'discount' rate) of 3.5% per annum and reducing to 3% after 30 years as specified in the Treasury Green Book.

10.145 As suggested in the Treasury Green Book for investments of this type and lifespan, we have also run the model using alternative discount rates, to see if they impact the plan. We have used the Long-term Discount Rate (LTDR) rate of 3% per annum reducing to 2.6% after 30 years, and also an Intergenerational Equity (IGEQ) rate of 1.5% per annum, reducing to 1% after 30 years.

10.146 In the WRMP19 we discussed whether using a lower discount rate to provide a more equitable share of cost across the generations was preferable. This was received well at the time, but this may no longer be the case given the current pressures on household bills. As such we have kept to the STPR for the programme appraisal.

10.147 The impact of changing the discount rate on the least cost plan costs as shown in the table below,

Table 10 - 5: Least cost plan cost by discount rate

Discount rate	Average Cost (£bn NPV)
STPR	12.98
LTDR	14.35
IGEQ	20.14

10.148 The whole life cost of the programme includes not just the capital cost to build the options selected, but also to operate and maintain them to continue to supply water until they reach the end of their useful life and need to be replaced.

10.149 Operating costs are not incurred just by virtue of delivering an option but are also incurred in proportion to how much the option is utilised. For example, in constructing a new borehole to abstract water we must purchase the abstraction licence and employ a member of staff to operate and maintain the site; these costs are fixed and incurred regardless of how often or how much the borehole is used. When we need to produce water from this new borehole we must also pay for the power to operate the abstraction pump and the chemicals to disinfect the raw water produced; these costs vary in direct proportion to how much water the option is used to produce.

10.150 The volume of water produced (or saved) by each option is calculated in each year to satisfy two rules which ensure the total variable cost is minimised:

- The total volume of water produced must equal the weighted average distribution input
- Options are utilised in ascending order of total unit variable cost

10.151 For new sources of water such as third party and/or other water company options, we treat the scheme charges as operational costs (fixed and variable elements) and these would be compared with the operational costs (plus any maintenance capex element) of our schemes that we have developed. If the third-party scheme requires a pipeline, or other infrastructure to be constructed which we would own and operate, these costs would be our capex and would be included within the overall cost comparison.

10.152 The cost of an option, and therefore the programme, is assessed not just as the direct financial cost but also by reference to the impact on the environment. This includes costs for impacts such as carbon emissions. The Government has provided guidance on the methodology for valuing carbon emissions and UKWIR has provided additional guidance on the estimation of emissions from construction. The Government has also provided guidance on the environmental impact of greenhouse gas emissions and forecasts of the costs of:

- Energy from the National Grid
- The value to society of the emission of greenhouse gases

10.153 We have followed Government and industry guidance for assessing the amount of greenhouse gases emitted by each feasible option. We have followed Government guidance in the valuation of energy use and carbon emissions.

10.154 Natural capital, that is, the loss and gain in natural assets (stocks) providing different ecosystem services, has been assessed at option level. Expected changes in natural capital stocks were assessed for each option, along with implications for four ecosystem services outlined in the WRPG supplementary guidance note 'Environment and Society in decision-making' – biodiversity and habitat, climate regulation, natural hazard regulation, and water purification, as well as air pollutant removal, recreation and amenity value and food production. Water regulation has not been included for assessment to avoid the potential double accounting of benefits with capacity-based and financial assessment. The gains and losses in provision of these ecosystem services has been quantified for each option as relevant and has been monetised by applying rates from standard tools and datasets recommended in the WRPG. This monetised NC value for each option has been used as the NC metric by the investment model in appraising our plans.

10.155 Other environmental and social costs have not been monetised (and are not readily capable of monetisation). These have been evaluated on a qualitative basis in our options assessment, as discussed in Section 9: Environmental appraisal.

Outputs (all pathways)

10.156 The metric outputs of the Least Cost plan (cost-based run using the STPR discount rate) are described below. The preferred pathway is shaded green and the Ofwat Core pathway shown in tan.

Table 10 - 6: Least Cost Plan – regional-level metric outputs

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	16.24	13.06	11.77	15.37	13.06	11.71	13.40	11.57	10.61	12.98
Carbon	6,141,159	4,112,843	3,513,785	5,610,401	4,071,788	3,488,548	4,380,187	3,349,718	2,933,685	4,178,013
NC	7,278,533	7,887,031	8,533,579	7,494,195	8,557,242	8,544,440	11,380,569	14,765,374	16,048,010	10,054
BNG	-262,703	-143,687	-132,152	-258,496	-144,728	-129,938	-202,457	-167,965	-145,901	-176,447
Env +	86,220	79,709	78,217	84,475	79,727	78,071	81,584	77,143	75,842	80,110
Env -	124,026	91,292	82,358	115,629	91,160	83,196	103,105	80,300	71,530	93,622
Cust_p	32,870	30,760	30,204	32,452	30,876	30,268	31,729	29,968	29,372	30,944
Reliab	38	40	42	38	40	42	38	39	45	40
Adapt	19	21	23	19	21	22	20	22	25	21
Evolv	27	28	29	27	28	29	27	29	33	29

10.157 The metric table provides a basis for comparison with the metric tables of alternative plan runs as we move through the programme appraisal process.

10.158 The Least Cost plan, when optimised regionally, has an average NPV cost of £13 billion with a maximum of £16.2 billion and minimum of £10.6 billion.

10.159 We can observe general patterns in the metric outputs within pathways 1-3 (highest population growth), 4-6 (LA Housing plan growth) and 7-9 (Trend based growth).

- Reducing cost, emissions
- Improved Natural capital and Biodiversity Net Gain performance
- Improved resilience metrics
- Less environment dis-benefit (and also benefit)

10.160 Similar patterns can also be seen between the pathways with the highest (1, 4 and 7), medium (2, 5 and 8) and lowest impacts (3, 5 and 9) from all the future growth drivers.

10.161 These are to be expected and are linked to the level of supply and demand deficit being resolved, but it is comforting to see it play out in the metrics.

10.162 Other observations on metrics:

- All pathways cause a reduction in BNG (prior to mitigation), the total BNG score is always negative. This is because it is very difficult to achieve an overall biodiversity net gain for hard infrastructure options with a ‘land footprint’ just by implementing onsite mitigation measures such as enhancing existing habitat. Post-mitigation, using both onsite and offsite mitigation either at scheme or programme level, we will ensure that 10% Net Gain is achieved. This metric gives a relative idea of the amount of ‘credits’ that will need to be gained in each pathway to achieve this gain
- Env- is always higher than Env+ - This is because the scoring focuses on the SEA impact of building and operating the new infrastructure required which is often negative. However, this too can be mitigated and also does not take into account the benefit of the actions that are contributing to the need to develop the options in the first place, such as sustainability reductions at existing sites

10.163 With respect to the options selected in each of the Least Cost Plan pathways, a table of the selected resource and transfer elements (for Thames Water only) are shown in the table below by the date the option is first utilised. The key Strategic Regional Options are in **bold**.

Table 10 - 7: Least Cost Plan – Thames Water options selected

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Media Campaigns	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Temporary use bans	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Non-essential use bans	ALL		2031	2031	2031	2031	2031	2031	2031	2031	2031
TW Integrated Demand Management (Deliverable)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government Led Demand Management (Hybrid B)	ALL		2046	2046	2046	2046	2046	2046	2046	2046	2046
Teddington DRA	**LON**	**67**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**
Didcot Raw Water Purchase	LON	23	2031	2031	2031	2031	2031	2031	2031	2031	2031
GW - Southfleet/Greenhithe	LON	9	2031	2031	2031	2031	2031	2031	2031	2031	2031
GW - Woods Farm	SWX	2	2031	2031	2031	2031	2031	2031	2031	2031	2031
GW - Addington	LON	3	2032	2032	2032	2032	2032	2032	2032	2032	2032
Reservoir Abingdon 150 Mm^3	**SWX**	**271**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**			
Reservoir Abingdon 100 Mm^3	**SWX**	**185**							**2042**	**2042**	
GW - Mortimer Recommission	KV	5	2050			2042	2042	2042	2040		
STT300: Unsupported pipeline + Netheridge	**SWX**	**104**				**2050**					
STT300: Vyrnwy release 1 (25 Ml/d bypass)	**SWX**	**14**				**2055**					
STT300: Minworth STW Phase 1	**SWX**	**35**				**2060**					
STT300: Minworth STW Phase 2	**SWX**	**35**				**2060**					
STT300: Vyrnwy release 2 (35 Ml/d bypass)	**SWX**	**20**				**2050**					
STT300: Vyrnwy release 4 (30 Ml/d bypass)	**SWX**	**17**				**2060**					
STT300: Vyrnwy release 3 (15 Ml/d bypass)	**SWX**	**9**				**-**					
STT500: Unsupported pipeline + Netheridge	**SWX**	**157**	**2050**								
STT500: Vyrnwy rrelease 1 (25 Ml/d bypass)	**SWX**	**14**	**2058**								
STT500: Minworth STW Phase 1	**SWX**	**35**	**2060**								
STT500: Minworth STW Phase 2	**SWX**	**35**	**2060**								
STT500: Vyrnwy release 2 (35 Ml/d bypass)	**SWX**	**20**	**2060**								
STT500: Vyrnwy release 4 (30 Ml/d bypass)	**SWX**	**17**	**2060**								
STT500: Vyrnwy release 3 (15 Ml/d bypass)	**SWX**	**9**	**2064**								
SES (Reigate) to Guildford	GUI	5							2050		
SEW (Hogsback) to Guildford	GUI	10	2050			2050					
Dapdune Licence disaggregation	GUI	2	2050			2050					
GW - Datchet	SWA	2	2050			2050					
Henley to SWA	SWA	5				2050					
Henley to SWA	SWA	2	2053								
ASR Horton Kirby	LON	5	2050			2053			2051		
SES to Thames Water (Merton)	LON	15				2054			2050		

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Wessex Water to SWOX (Flaxlands)	SWX	3	2050			2054					
GW - London Confined Chalk	LON	2	2051			2059			2053		
Deephams Reuse	LON	42	2061			2061			2061		
Medmenham WTW Phase 1	SWA	24	2048						2050		
Medmenham WTW Phase 2	SWA	24	2048								
ASR Thames Valley Central	LON	5	2051						2051		
Crossness Desalination Ph 1	LON	44	2054								
GW - Merton Recommissioning	LON	6	2057						2053		
AR Streatham (SLARS2)	LON	7							2040		
Oxford Canal - Cropredy	LON	10							2060		
AR Merton (SLARS3)	LON	5							2055		

10.164 In the Root plan to the early 2030s, in which we plan to increase drought resilience to 1:200 from 1:100, we can observe across all pathways that:

- Demand management continues to be the focus, as it was in WRMP19. The model outputs strongly suggest continuing with our key polices of leakage reduction, and encouraging usage reduction through metering and water efficiency. It also requires the Government to implement water labelling on appliances and encourage market transformation, which are built into our forecasts
- In line with our levels of service, we still require additional savings to be made during droughts in this period
- In order to deliver an increase in drought resilience to 1:200 from 1:100 in the early 2030s we also need some resource development, principally the Teddington DRA scheme, supported by a raw water purchase and some groundwater development
- The Teddington DRA scheme involves the re-routing of a part of treated effluent flow from Mogden STW, further treating it and then discharging it upstream of Teddington Weir. This would allow us to abstract water from the River Thames, through a new intake a short distance upstream of the discharge location, with the increased abstraction replaced by the re-routed Mogden flow
- In the period to 2030 the SESRO would also enter the planning process, given the long lead time for the scheme. Beckton re-use and the Severn-Thames Transfer options would continue to be progressed as back-up options for Teddington DRA and SESRO, respectively

10.165 In the period to 2040, in which we plan to further increase drought resilience to 1:500 and step up our work to improve river flows, we observe:

- Demand management work continues. At this point metering will be completed, with leakage reductions continuing towards the policy target of a 50% reduction from 2017-18 levels by 2050

- Reservoir development is required by the early 2040s, with the SESRO selected in all pathways, and utilised in all but the most optimistic pathway (9)
- The model selects the SESRO sized at 150Mm^3 in pathways 1-6 where population growth follows the local authority housing plans or higher, and SESRO sized at 100Mm^3 in pathways 7-9 where population growth follows the ONS18 principal forecast or lower
- SESRO is selected in preference to the Severn-Thames Transfer (STT), which is in turn selected in preference to Effluent Re-use and Desalination. This is in keeping with the findings of WRMP19
- The water from the reservoir is shared between Thames Water, Affinity and Southern Water

10.166 By 2050 we will have met our leakage reduction target and have delivered our environmental destination programme (irrespective of the eventual extent of the programme), we observe:

- Although we will be approaching the national level PCC target of 110 at a regional level by 2050, in all pathways we will need further government-led demand management efforts (supported by companies, housing developers and manufacturers), to continue to drive market transformation. Particular attention will be needed on tightening building standards and water regulations in order to reduce demand
- Continued investment in resource development is required in order to meet the high environmental destination and high climate change pathways (1, 4 and 7). On other pathways further company investment in resource development is not required
- In pathways 1 and 4 an inter-regional transfer would be required via the initial phases of the STT. This is in keeping with WRMP19
- Internal transfers are also selected in order to distribute the water from SESRO and STT more widely as environmental destination drives the re-distribution of abstraction. This was not envisaged at WRMP19 as the extent of the environmental programme was not known at that point

10.167 Beyond 2050 to the end of the planning period, we observe:

- Further support phases of the STT are required in pathways 1 and 4 into the early 2060s
- Re-use and desalination options also appear as further smaller internal and external transfers are also required and groundwater options
- Phased development of these options was predicted at WRMP19

Discussion (Preferred pathway)

10.168 There are strong similarities in the least cost plan preferred pathway (4) and our WRMP19 preferred plan.

10.169 We support the continued focus on demand management measures early in the planning period. The integrated programmes of demand management measures included for our supply area are ambitious and they allow us to follow at pace the course set out in WRMP19 to meet our leakage targets and to reduce usage by 2050 and beyond that to the end of the planning period.

10.170 The selection of the Teddington DRA as the main resource development measure, replacing Deephams re-use, is not a surprise. A larger Teddington DRA option (300 Ml/d) was first considered in our draft WRMP19, but concerns raised about the impact of an option of that size led us to replace it with Deephams re-use in the final WRMP19.

10.171 Since then we have further investigated both options and have shown that a smaller Teddington option is acceptable and is preferable to Deephams, which (as explained in Section 7) has in any case been deferred until the 2060s on the basis that the option would become available if compensatory flow improvements are implemented on the River Lee.

10.172 The least cost plan indicates that both strategic reservoir and large inter-regional transfers would be required over the planning period in order to increase resilience and to allow for proposed sustainability reductions to existing abstractions.

10.173 It also supports that the SESRO option should be developed first and then supported by increased flows into the region from the West, depending on the extent of the sustainability reductions.

10.174 We have explored this further within our sensitivity testing, to understand what would happen if SESRO was no longer be available.

10.175 Both the SESRO and STT would be truly regional options with the water shared by Thames, Affinity and Southern Water.

10.176 The model selects the 150Mm^3 option in pathway 4 (and all the medium and high growth pathways) rather than a smaller 100Mm^3 reservoir in the lower population growth pathways.

10.177 We understand that we will need to propose a specific option size when seeking a development consent order. As such, the question of reservoir size is a key decision that we will return to a number of times throughout this programme appraisal, as we consider other plans generated using wider best value metrics and also through sensitivity testing.

10.178 An intra and inter-plan cumulative effects assessment of pathway 4 of the Least Cost Plan, completed as part of the Strategic Environmental Assessment, is provided in Appendix B.

10.179 Note that the potential cumulative effects of development on the River Thames (from options such as the STT and SESRO) and also the Thames Tideway (from options including desalination and re-use) were studied at WRMP19 and the theoretical maximum development figures developed at that time for each area are now included as constraints in the investment modelling.

10.180 The Least Cost Plan includes a 5Ml/d Henley to SWA transfer and the Oxford Canal Transfer (Duke's Cut to Farmoor). There is the potential for low and localised in-combination construction effects on the Oxford Meadows SAC as part of the plan, based on the timing of options relative to one another. We will look into this further to better understand the magnitude of impacts and actions to avoid or mitigate these, as part of finalising our plan.

10.181 The Duke's Cut to Farmoor option presents a medium INNS risk in the absence of mitigation. An evaluation of suitable mitigation measures to mitigate this risk will be undertaken as options are progressed and the WRMP is finalised.

BVP metric-based plans

10.182 Having produced cost-based plans, we now look to improve wider value by extending the analysis to look at plans produced based on alternative metrics, as described in 10.6.2.

10.183 Essentially, by looking at the same dataset but using a different lens we can examine how much wider value we can generate in the plan at how much extra cost and also what it does to the combination of options selected in each of the pathways.

10.184 We have generated alternative plans based on wider BVP metrics using the following approach:

- Stepped increases in single metric score at lowest cost
- Stepped increases for all metrics in a category at lowest cost
- Stepped increase in all metrics at once at lowest cost

10.185 We found that the first type of model run, focussing on individual metrics, often led to unsuitable plans being produced. The model tended to over-select options just to increase the metric score. In other words, without being constrained by another factor, the model selected more options than were needed to balance supply and demand and large unnecessary surpluses were generated.

10.186 When conducting the first type of run, we found that the large options (Teddington DRA, SESRO, STT) largely appeared in the same branches, at the same points in the planning period. This tended to be the case no matter how high a metric threshold was used, and so this indicated to us that the model could not improve metric values by substituting large options which featured in the least cost plan, or by changing the scheduling of these options.

10.187 With the model not seeming to be able to improve metric values by changing which options were selected or when they were selected, in order to increase metric values, it therefore resorted to building additional capacity, This, along with comparison of metric values associated with individual options, gave us an indication that the key components of the least cost plan also performed well when assessed using other metrics.

10.188 Our view is that a WRMP in which additional options were built without a supply-demand balance driver would not be deemed an efficient plan, and so we sought to limit the degree to which the model built excess capacity.

10.189 When undertaking the second type of run, stepped increases for several metrics were undertaken at the same time. For environmental and social metrics (see An Environmental and society-focused plan) and all resilience metrics (see A Resilience-focused plan). With the model being asked to find a least-cost solution subject to achievement of supply-demand balance and achievement of minimum thresholds for several metrics, we found that some of the metrics acted as balances on one another. For example, SEA benefit and SEA dis-benefit. While in the first type of model run the model was able to select additional options to increase the SEA benefit metric, in the second type of run the model could not build additional options without also accruing SEA dis-benefit.

10.190 Having thresholds set on multiple metrics, with some metrics acting as balances to one another, forced the model to find solutions in which substitution of options, or changes in their scheduling, was the main finding, rather than solutions in which excess capacity was built.

10.191 We found that some environmental metrics were in opposition to one another, and that some resilience metrics were in opposition to one another. As such, in our best value planning we also considered a third type of model runs which introduced a general uplift (see Improvement across all the metrics (BVP)) across the environmental and social and resilience metrics at the same time.

10.192 We again found that the key components of the plan did not move significantly when we conducted these runs. We were initially surprised by the degree to which options did not change in these runs, but on further inspection at option-level we noted that:

- Teddington DRA is an option which neither scores notably well or notably poorly on any metric, but which is several hundred million pounds cheaper than other options with similar supply capability and relatively short lead times. As such, it is unsurprising that, given a short-term need for water, it is selected
- SESRO is the only one of our large options to have positive Biodiversity Net Gain and Natural Capital assessments (across all option size variants), meaning that optimising for a plan which benefits the environment would not alter our choice of the SESRO scheme
- The embedded carbon associated with building SESRO is around the same as the embedded carbon needed to build an STT scheme with a similar supply benefit, with STT having higher ongoing, operational carbon emissions, leading to SESRO being a lower whole-life carbon source of water over the planning period
- SESRO scores well on resilience metrics, compared to other large options

An Environmental and society-focused plan

Derivation

10.193 We have configured the model to find plans that increase the combined output of the five environment and society focused metrics: natural capital, biodiversity net gain, SEA benefits and dis-benefits and customer preference.

Outputs (across all pathways)

10.194 The metric outputs (at regional-level) of the Environmental and Society-focused plan are shown below. The metrics with greater than +/-5% change when compared to the LCP are shown in bold.

Table 10 - 8: Environment & Society focused plan – regional-level metric outputs

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	16.21	13.05	11.73	15.40	12.993	11.72	13.41	11.59	10.61	12.97
Carbon	6,055,200	4,066,690	3,488,169	5,577,068	4,059,562	3,463,063	4,399,008	3,310,006	2,933,147	4,150,213
NC	**8,404,628**	**9,447,628**	**12,042,430**	7,681,917	8,712,554	8,582,431	**12,054,448**	15,174,590	16,048,010	**10,905,404**
BNG	**-235,231**	-147,489	-131,154	**-240,648**	**-133,929**	-123,858	**-223,096**	-169,691	-145,901	-172,333
Env +	**85,993**	78,561	79,222	**84,103**	**80,114**	**78,593**	81,403	76,981	76,668	80,182
Env -	122,594	87,922	83,482	115,980	89,745	81,152	102,862	78,112	70,090	92,438
Cust_p	**35,831**	**33,445**	**33,423**	**35,365**	**33,774**	**33,217**	**34,662**	**32,843**	**32,445**	**33,889**
Reliab	**41**	**44**	**47**	**42**	**44**	**47**	**42**	**44**	**51**	**45**
Adapt	**20**	22	24	**20**	**22**	**24**	**21**	**23**	**27**	**22**
Evolv	**29**	**30**	**32**	**29**	**30**	**32**	**29**	**31**	**36**	**31**

10.195 The Environment and Society focused plan, when optimised regionally, has an average NPV cost of £13 billion with a maximum of £16.2 billion and minimum of £10.6 billion. This is very similar to the LCP, with pathway 4 at £30 million (NPV, STPR) more expensive while pathway 8 is £20 million (NPV, STPR) more expensive.

10.196 This run shows that despite no material change in cost, an improvement in environmental and society and (inadvertently) resilience performance is possible. However, there is very little material change in pathway 4 or pathway 8 and the changes are mainly brought about outside of the Thames Water area.

10.197 An analysis of the options selected in this run shows that there are no changes in the options selected in our supply area until after 2050. After this date there are minor rearrangements of the STT elements with the smaller groundwater and local transfer options. STT elements are brought forward, particularly in pathway 1, where the STT support options move forward by 5-6 years so that Crossness desalination is not required, which is the key environmental and social improvement across the pathways.

10.198 An intra and inter-plan cumulative effects assessment of pathway 4 of the Environment and Society-focused plan, completed as part of the Strategic Environmental Assessment is provided in Appendix B. Effects identified are identical to those for the Least Cost Plan, described above.

A Resilience-focused plan

Derivation

10.199 We have configured the model to find plans that increase the combined output of the three resilience metrics: reliability, adaptability and evolvability.

Outputs (across all pathways)

10.200 The metric outputs (at regional-level) of the Resilience-focused plan are shown below. The metrics with greater than +/-5% change when compared to the LCP are shown in bold. Again, we could not increase all metric thresholds simultaneously to a large degree.

Table 10 - 9: Resilience-focused plan – regional-level metric outputs

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	16.24	13.09	11.77	15.34	13.09	11.75	13.41	11.57	10.62	12.98
Carbon	6,120,490	4,078,694	3,501,260	5,553,089	4,110,992	3,501,034	4,412,243	3,335,874	2,933,504	4,171,909
NC	7,374,783	**8,552,014**	8,535,203	7,475,041	8,701,388	8,547,747	11,385,609	14,765,548	16,048,010	10,153,927
BNG	**-245,866**	-145,895	-134,717	-246,876	-140,537	-125,981	**-213,670**	-166,624	-145,901	-174,007
Env +	87,311	81,256	80,017	85,768	80,980	79,677	83,410	78,832	77,586	81,649
Env -	124,203	91,311	84,591	115,339	90,240	81,225	104,531	80,520	71,956	93,768
Cust_p	34,423	**32,295**	**31,832**	33,868	32,234	31,668	**33,321**	**31,535**	**30,952**	32,459
Reliab	**42**	**46**	**48**	**43**	**45**	**48**	**43**	**46**	**53**	**46**
Adapt	**20**	**23**	**24**	**20**	**23**	**24**	**22**	**23**	**27**	**23**
Evolv	**29**	**31**	**33**	**29**	**31**	**33**	**30**	**32**	**37**	**32**

10.201 The Resilience-based plan, when optimised regionally, has an average NPV cost of £13 billion with a maximum of £16.2 billion and minimum of £10.6 billion. Again, this is very similar to the LCP and the Environment and Society-focused plan. Pathway 4 is £30 million (NPV, STPR) less expensive than the LCP, while pathway 8 is the same cost as the LCP.

10.202 A greater overall increase in the resilience metrics are achieved in this run, but with a lesser incidental improvement in the environmental and society metric group.

10.203 To achieve greater resilience in our area, there is more frequent and earlier use of drought permits and NEUBs, which would be undesirable. Teddington DRA and SESRO are selected and are unchanged versus the least cost plan in terms of size. STT is selected in 2050 as before but not all elements are utilised, although the ones that are selected are utilised earlier. The Deephams reuse plant is no longer required in pathway 4 in favour of groundwater options, but is still chosen in pathways 1 and 7. The Crossness desalination (50 Ml/d) option that was selected in pathway 1 of the LCP is replaced by a later but larger desalination plant at Beckton (150 Ml/d) in 2060.

Improvement across all the metrics (BVP)

Derivation

10.204 We have configured the model to find plans that increase the combined output of both the environment and society and the resilience metrics.

Outputs (across all pathways)

10.205 The metric outputs (at regional-level) of the BVP uplift run are shown below. The metrics with greater than +/-5% change when compared to the LCP are shown in bold.

Table 10 - 10: General BVP uplift plan – regional-level metric outputs

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	16.27	12.96	11.73	15.39	13.10	11.72	13.46	11.66	10.69	13.00
Carbon	6,113,684	4,031,736	3,499,205	5,620,656	4,090,481	3,493,506	4,421,503	3,361,514	2,965,794	4,177,564
NC	**7,674,162**	**8,691,428**	8,529,239	7,487,611	8,664,884	8,504,623	**7,525,981**	**9,518,472**	**12,295,818**	**8,765,802**
BNG	**-229,669**	-144,981	-132,069	-249,703	**-137,272**	-127,908	**-214,655**	-161,101	-146,380	-171,526
Env +	84,106	79,041	78,472	83,304	79,407	78,110	81,615	77,258	76,604	79,769
Env -	122,774	91,237	83,333	114,314	91,319	82,012	104,042	80,761	71,340	93,459
Cust_p	**36,288**	**34,296**	**33,904**	**35,764**	**34,300**	**33,770**	**35,378**	**33,553**	**33,137**	**34,488**
Reliab	**42**	**45**	**48**	**43**	**45**	**48**	**44**	**47**	**54**	**46**
Adapt	**20**	**22**	**24**	**20**	**23**	**24**	**22**	**24**	**28**	**23**
Evolv	**29**	**30**	**33**	**29**	**31**	**33**	**30**	**32**	**37**	**32**

10.206 The General BVP uplift plan, when optimised regionally, has an average NPV cost of £13 billion with a maximum of £16.3 billion and minimum of £10.9 billion. Again, this is very similar to the LCP and the Environment and Society-focused plan. Pathway 4 is £20 million (NPV, STPR) more expensive than the LCP, while pathway 8 is £90 million more expensive.

10.207 This run manages to improve the metric scores for both environment and society and resilience metrics. The advantage is that it this has removed some of the undesirable aspects of the resilience focused plan (the earlier and more frequent use of drought permits and restrictions), however overall, the impacts in metric terms remains fairly marginal.

10.208 There are fewer changes in the composition of the options in the pathways than seen in the resilience-focused BVP runs, but there are more changes to SROs. In particular:

- A larger reservoir is chosen in pathways 7 and 8: 125Mm^3 instead of 100Mm^3
- A smaller STT transfer is selected in pathway 1: 400 Ml/d capacity instead of 500 Ml/d.
- The STT elements post-2050 are developed more quickly, but fewer elements are utilised in favour of additional groundwater options
- A larger desalination plant (150 Ml/d) is favoured as the solution in pathway 1 in the longer-term once the smaller capacity STT is fully utilised

10.209 What this all means for our plan preferences is discussed below.

Overall observations on BVP metric analysis

10.210 The assessment of wider BVP metrics (across all pathways) has not generated as many stand-out alternative plans as we had anticipated. We've not been able to create trade-off curves that would allow us to fully debate how much additional improvement in a wider BVP can be gained for additional cost.

10.211 Nevertheless, we have been able to show that BVP metrics can be improved for minimal changes in cost and therefore that a BVP-based solution is preferable to a cost-based only solution.

10.212 We can see the relative performance of the four main runs described above using the Cost vs BVP Metric plot. We can see that all four alternative plans have similar average costs. Despite relatively small movements in the raw BVP metric values, when compared and ranked against the full database of model runs the aggregate BVP metric performance can be improved versus least cost.

10.213 We can also see that the general uplift BVP run performs marginally better than the Environmental and Society and Resilience focused BVP runs.

Figure 10 - 14: Cost vs BVP metric (v1, LCP and grouped BVP metrics)

10.214 At an individual BVP metric level, Natural Capital appears to be showing the greatest variability.

10.215 In terms of the options selected in each of the programmes, we note that:

- The demand management and resource development options selected in the root plan to the early 2030s are consistent. The 'deliverable' DM programme is always chosen ahead of High or High+ programmes, likely due to the increasing incremental cost of doing more mains rehabilitation in those runs
- SESRO in 2040 is chosen in all but the least challenging future

- In pathways 1 to 6 the 150Mm^3 is always chosen, with either the 125Mm^3 or 100Mm^3 chosen in pathways 7 and 8
- STT is chosen in 2050 in pathways 1 and 4
- The capacity of the transfer (300, 400 or 500 Ml/d) and how many elements are built between 2050 and 2060 remains uncertain and is in competition with desalination, reuse and local groundwater and transfers options

10.216 With these observations in mind we move forward to sensitivity testing, i.e. changing policy assumptions and/or options available to see whether this generates more alternatives.

Stage 5: Sensitivity testing

10.217 To this point we have examined various alternative plans by looking at the same dataset under different lenses. That is to say looking to optimise the solutions based on cost, environment and society, resilience and a general uplift to all BVP metrics.

10.218 In Stage 5, we look to produce alternative plans by changing the dataset (i.e. changes in option availability or capability) or by changing key policy assumptions (such as using alternative government-led demand management profiles and exploring changes to the date at which we achieve our drought resilience goals).

10.219 In total over 50 sensitivity tests were completed by WRSE, which can be explored in their draft Regional Plan. The model runs most relevant to our programme appraisal decisions are shown in the table below and discussed in the following sub-sections.

Table 10 - 11: List of sensitivity tests

Topic	Name	Change
Supply Options	No SESRO	All SESRO options excluded
	125Mm^3 SESRO only	Only 1 size of SESRO available for selection in the model. The others are excluded.
	100Mm^3 SESRO only	
	75Mm^3 SESRO only	
	No Teddington DRA	Teddington DRA excluded
	Force STT300 by 2040	The model must select a STT pipeline size by 2040 if required.
	Force STT400 by 2040	
	Force STT500 by 2040	
	Gateway capability - 50 Ml/d	Gateway desalination plant output reduced from 100 to 50 Ml/d
	Gateway capability - 50 Ml/d (100Mm^3 SESRO only)	As above, but with only 1 size of SESRO available for selection.
Drought Resilience Policy Delivery Date	1:500 by 2035	Moving the date for achieving 1:500 resilience from 2040 to an alternative.
	1:500 by 2045	
	1:500 by 2050	
	1:200 by 2034	Pushing back the date for achieving 1:200 resilience from 2030 to 2034.
Government-led Demand Management Policy	No Gov-led demand management	No Gov-led demand management included, or alternative Gov-led demand management delivery profiles and timings. See sub-section below for details.
	Gov-led hybrid A	
	Gov-led hybrid C	
	Gov-led hybrid D	
	Gov-led hybrid E	
	Gov-led hybrid F	
	Gov-led hybrid G	

10.220 Run dossiers with IVM model outputs for all pathways are available in Appendix X, however, for brevity, in the following sub-sections we have presented changes observed in pathway 4 only, as this is the preferred reporting pathway. In each case comparison is made to the Least Cost Plan as we have done for the wider BVP metric runs.

Changes in Option availability/capability

SESRO and Teddington DRA

10.221 In these sensitivity runs we have excluded SESRO or Teddington DRA or only allowed the model to select a certain size of SESRO.

Table 10 - 12: Sensitivity run outputs – option availability (SESRO and Teddington DRA)

Metric	Least Cost	No SESRO	SESRO 125 Only	SESRO 100 Only	SESRO 75 Only	No Teddington DRA
	Pathway 4					
Cost	15.37	15.94	15.45	15.44	15.67	15.82
Carbon	5,610,401	6,041,727	5,532,038	5,676,794	5,501,756	5,756,145
Natural Capital	7,494,195	6,477,558	6,094,152	10,847,786	9,678,647	7,736,003
Bio Net Gain	-258,496	-351,987	-294,132	-305,256	-296,398	-252,201
SEA Env +	84,475	85,359	85,461	85,385	84,836	83,795
SEA Env -	115,629	122,912	118,090	115,662	119,687	118,320
Cust_preference	32,452	32,894	32,472	32,457	32,532	32,225
Reliability	38	36	38	37	36	37
Adaptability	19	18	19	19	18	18
Evolvability	27	27	27	27	26	26
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)	Beckton Reuse 50 (2031)
	SESRO 150 (2040)	STT300 (2038-49)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)	SESRO 150 (2040)
	STT300 (2050-60)	Desalination Beckton 150 (2050)	STT500 (2050-61)	STT500 (2050-60)	Desalination Beckton 150 (2040)	Desalination Beckton 150 (2050)
	Deephams (2061)	Re-use Beckton 150 (2060)		Deephams (2060)	STT300 (2050-61)	Beckton Reuse 100 (2058)
						STT300 (2060)

10.222 Excluding all SESRO options from selection forces the model to find an alternative and as expected given the order of selection of other SROs when SESRO is available, the STT is chosen first, slightly earlier in 2038 but not upsized. This is followed by large (150 Ml/d) desalination and reuse plants at Beckton in 2050 and 2060 respectively.

10.223 In metric terms the No SESRO solution is £570m NPV more expensive, provides lower natural capital and requires more money to offset carbon emissions and credits to ensure biodiversity net gain.

10.224 Of the alternative reservoir sizes, we note that cost increases as the size is reduced, but only marginally. The main BVP metric finding is the improved Natural Capital associated with the 100Mm^3 and 75Mm^3 sizes. This is due to the smaller footprint of the reservoir development.

10.225 In compensation for the c.100 Ml/d of deployable output from resizing the SESRO from 150Mm^3 to 100Mm^3, the model builds the largest capacity STT in 2050, which in turn defers the need for the Deephams reuse plant. If SESRO is resized to 75Mm^3, a desalination plant is required to be built at the same time before the STT 300 (Ml/d capacity) comes online as normal in phases over the 2050s.

10.226 The reduction does have knock-on, potentially undesirable effects elsewhere in the WRSE region, particularly on Southern and Portsmouth Water's plan and scale of recharge to Havant Thicket reservoir from an effluent reuse scheme in Hampshire.

10.227 If we were to exclude the Teddington DRA option, Beckton re-use is selected as its replacement in order to facilitate moving to a 1:200 level of drought resilience in the early 2030s. We can also note that in this run, after the construction of SESRO 150Mm^3 in 2040, the extension of re-use at Beckton and desalination at Beckton is chosen in the 2050s ahead of the STT, which is deferred to 2060 and only the unsupported and Netheridge elements are constructed.

10.228 The cost increases by £450 million NPV with marginally worse performance across the BVP metrics, when compared with the LCP.

Severn-Thames Transfer

10.229 In these sensitivity runs we have forced the model to choose the unsupported STT pipe of various sizes, before 2040. This is designed to see what would happen if STT was built first.

Table 10 - 13: Sensitivity run outputs – option availability (STT)

Metric	Least Cost	STT300 in 2040	STT400 in 2040	STT500 in 2040
	Pathway 4			
Cost	15.37	15.64	15.93	16.04
Carbon	5,610,401	5,731,952	5,810,849	5,842,753
Natural Capital	7,494,195	7,473,972	7,340,154	7,349,998
Bio Net Gain	-258,496	-252,253	-260,667	-264,743
SEA Env +	84,475	85,251	85,011	85,611
SEA Env -	115,629	114,815	119,684	119,211
Cust_preference	32,452	32,333	32,749	32,616
Reliability	38	38	38	38
Adaptability	19	19	19	19
Evolvability	27	27	27	28
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)
	SESRO 150 (2040)	SESRO 150 (2040)	STT400 (2040-61)	STT500 (2040-63)
	STT300 (2050-60)	STT300 (2050-65)	SESRO 150 (2045)	SESRO 150 (2045)
	Deephams (2061)			

10.230 Forcing unsupported STT pipes to be built before 2040 (if required) increases the overall cost in pathway 4 by between £270m-£670m NPV.

10.231 Whilst the impact on the BVP metrics is muted, there are interesting outcomes in terms of option selection:

- At the smallest pipe capacity, SESRO is not deferred at all. Although the model builds the pipeline it chooses not to utilise it until after the selection of SESRO in 2040
- At the medium and large pipe capacities, SESRO is deferred for five years, but it is chosen ahead of most of the STT supporting elements, despite the pipeline already being in place. Therefore, the delivery of STT components is spread over a much longer period of time, up to 22 years, rather than 10

- For this set of tests, the model was run including an additional 75 Ml/d of support from Vyrnwy, which is excluded the other tests as there is uncertainty whether West Country Water need this water for their own requirements. It was included in this test to give the model every chance to maximise the transfer. At all pipe sizes this extra river release was selected by the model, after SESRO construction, i.e. it was not used by the model to defer SESRO further. It has however removed the need for additional reuse or desalination development in the early 2060s

10.232 Overall, we can conclude that on pathway 4, plans without SESRO or where SESRO follows the STT are more expensive than ones where SESRO is developed first. We can also see that in each case SESRO is developed alongside the STT and is preferred to most of the STT support elements, even if the pipeline has already been constructed.

Existing Gateway Desalination Plant

10.233 In Section 4 we set out the contribution of the Gateway desalination plant (at Beckton) to baseline deployable output, outage and water available for use. We explained how we have reduced the contribution of the plant between 2022/23 and 2029/30 due to ongoing outage issues.

10.234 Whilst we expect the Gateway plant to return to its full WAFU contribution by the end of AMP8, these sensitivity runs test what the impact would be if the reduced contribution continued throughout the planning period.

10.235 In the first run, we extend the reduced capability of the plant beyond 2029/30 to 2074/75. In the second we do the same thing, but only make one size of SESRO available for selection by the model, 100Mm^3.

Table 10 - 14: Sensitivity run outputs – option capability (Gateway)

Metric	Least Cost	50Ml/d	50Ml/d (SESRO100 only)
	Pathway 4		
Cost	15.37	15.52	15.59
Carbon	5,610,401	5,383,903	5,762,861
Natural Capital	7,494,195	6,900,586	10,869,657
Bio Net Gain	-258,496	-223,260	-308,962
SEA Env +	84,475	86,160	85,726
SEA Env -	115,629	121,991	118,923
Cust_preference	32,452	32,954	32,842
Reliability	38	37	37
Adaptability	19	19	19
Evolvability	27	26	27
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)
	SESRO 150 (2040)	SESRO 150 (2040)	SESRO 100 (2040)
	STT300 (2050-60)	Beckton Desalination 150 (2050)	STT500 (2050-61)
	Deephams (2061)	Deephams (2061)	

10.236 We observe that when the reservoir size is not restricted, the model prefers to build a further large desalination plant at Beckton in 2050, rather than the STT. Given the reason for the sensitivity test relates to difficulties with desalination, it is unlikely a further large desalination plant would be a desirable solution. In this situation a STT would likely to be favoured under best value planning.

10.237 When only a 100Mm^3 SESRO option is available, the model selects a larger STT in 2050 and drops Deephams in 2060. It is also noted that in this scenario more of the SESRO output is sent to London, reducing the volume of the transfer to Southern Water. Southern Water replace this volume by increasing the capacity of re-use support in Hampshire to Havant Thicket reservoir.

10.238 Additional groundwater schemes are selected from 2031 in both cases.

Changes in Policy

Drought Resilience Policy Delivery Dates

Table 10 - 15: Sensitivity run outputs – Drought resilience delivery dates

Metric	Least Cost (1:200 in 2030 1:500 in 2040)	1:500 in 2035	1:500 in 2045	1:500 in 2050	1:200 in 2034
	Pathway 4				
Cost	15.37	15.40	14.96	14.47	15.16
Carbon	5,610,401	5,428,533	5,323,291	5,274,253	5,316,851
Natural Capital	7,494,195	7,416,757	6,638,086	7,366,676	7,599,741
Bio Net Gain	-258,496	-240,002	-233,651	-236,180	-246,110
SEA Env +	84,475	86,204	85,294	83,452	84,665
SEA Env -	115,629	121,563	116,252	116,330	119,260
Cust_preference	32,452	33,040	32,493	32,524	32,716
Reliability	38	38	38	36	37
Adaptability	19	19	19	18	19
Evolvability	27	27	27	25	26
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)	
	SESRO 150 (2040)	Trade with Affinity linked to GUC100 (2035)	SESRO 150 (2045)	SESRO 150 (2050)	SESRO 150 (2040)
	STT300 (2050-60)	SESRO 150 (2040)	STT300 (2050-61)	Beckton Reuse 50 (2053)	Desalination Beckton 150 (2050)
	Deephams (2061)	STT300 (2050-61)		Desalination Beckton 100 (2060)	Teddington (2053)
				Deephams (2061)	Deephams (2060)

10.239 Moving the delivery date of 1:500 drought resilience forward by five years to 2035, moves it before the earliest start date of the SESRO options. In response to this the model chooses to bring forward groundwater schemes in our area and increases the size of Affinity Water's Grand Union Canal transfer option from 50 to 100. This would enable Affinity Water to temporarily trade excess abstraction licence on the Lower Thames with us, in order to meet our need. The SESRO 150Mm^3 and subsequent STT300 delivery is unchanged.

10.240 The metric response to these changes are fairly muted however the interaction of the Teddington DRA and GUC schemes and West London abstraction and storage is complex with mutual support expected for any problems with the development of either of the schemes, so upsizing that risk may not be suitable, albeit that it would deliver resilience five years early.

10.241 Pushing back 1:500 resilience delivery by five years to 2045, reduces the cost in pathway 4 by £490m NPV and defers SESRO 150 for five years. Pushing back 1:500 resilience delivery by 10 years to 2050, reduces the cost by £900m NPV and defers the SESRO 150 for 10 years. Also, STT is replaced with a combination of reuse and desalination options. The impact on BVP metrics is marginal, but a five or 10-year deferral of resilience to an extreme drought is a considerable trade-off and increases the reliance of Government-led demand management measures between 2040 and 2050.

10.242 Deferring the delivery date of 1:200 drought resilience to 2034 reduces the cost in pathway 4 by £210 million NPV. There are marginal improvements in some of the environmental and social metrics, balanced with reductions in the resilience metrics. Interestingly, Teddington DRA is not immediately built in 2034 and is in fact deferred until the 2050s, after SESRO 150Mm^3 in 2040 and a large desalination plant at Beckton in 2050. No SROs are required in the 2030s, because of the ongoing progress with the demand management programme, supported by groundwater options which are brought forward. STT is deferred entirely.

10.243 As with the 1:500 to 2050 test, the deferral of 1:200 drought resilience has a potential trade-off with cost and resource development, but goes against the direction of travel in government and company policy. It also increases the reliance on the success of the company-led programme of demand management.

10.244 Our levels of service and the need for a gradual increasing of restrictions during drought have been a central planning assumption in WRMPs since their inception. We have seen the desire to increase resilience to the risk of emergency restrictions in an extreme drought, as is now built into this plan, but during the current drought we are seeing increasing dis-satisfaction with the need to have any demand restrictions in a drought at all.

10.245 Graduated restrictions in a drought benefits the supply demand balance by approximately 300 Ml/d regionally (DYAA) i.e. 300 Ml/d is the total benefit of the demand measures and temporary supply increases during a drought. In order to avoid any drought restrictions on demand we would need to find alternative supplies or reduce demand equivalent to that amount.

10.246 We are currently investigating ways to model the removal of drought restrictions on demand entirely, to examine the potential impact.

Alternative Government-led demand scenarios

10.247 In this section we show the results of exploring different government-led interventions and the impact they have on performance. We have used three levels of government-led demand management support in the development of our plan: Low, medium and high as set out below:

Table 10 - 16: Government-led activity levels

Gov-led activity level	Action	TW additional PCC saving
Low	Water Labelling (no minimum standards)	0 - impact already included in our Baseline assumptions
Medium	Water Labelling (with minimum standards) – reliable estimate	3 l/h/d after 10 years, 6 after 25 years
High	Full government support (optimistic for water labelling with minimum	6 l/h/d after 10 years, 18 after 25 years

Gov-led activity level	Action	TW additional PCC saving
	standards, plus enhanced support on new developments)	

10.248 These activity levels have been combined to form several Government-led scenarios, which are described below. These allow us to explore a range of potential delivery rates that allow us to understand how close as a region we come to the national PCC target of 110 l/h/d.

10.249 As explained earlier in the plan, we chose to select Government-led B as the default scenario in our appraisal. We have selected a range to show in the sensitivity run outputs table below.

Table 10 - 17: Government-led activity scenarios

Scenario	Profile	Regional saving by 2050 (Ml/d)	Regional NYAA PCC by 2050 (l/hd/d)
No Government-led	No additional savings included		
Government-led A	Low until 2040 and medium from 2060 (interim between 2040 to 2060)	157	114.6
Government-led B	Low until 2040 and medium from 2060 and high from 2080 (interim between 2040 to 2060 to 2080)	115	116.3
Government-led C	Low until 2040 and medium from 2050 and high from 2060 (interim between 2040 to 2050 to 2060)	303	108.7
Government-led D	Government interventions by transitioning from low to medium and then high to allow the target to be met (medium by 2040; high by 2075)	182	113.6
Government-led E	Government interventions by transitioning from low to medium and then high to allow the target to be met (medium by 2035; high by 2050)	437	103.0
Government-led F	Low government savings by 2030 and medium by 2040.	182	113.6
Government-led G	Low government savings by 2030 and high by 2040.	437	103.0

Table 10 - 18: Sensitivity run outputs – Government-led scenarios

Metric	Least Cost (Gov-led B)	No Gov-Led	Gov-led C	Gov-led E	Gov-led G
	Pathway 4				
Cost	15.37	15.96	14.32	14.02	13.48
Carbon	5,610,401	5,824,165	4,875,008	4,667,917	4,540,446
Natural Capital	7,494,195	6,483,273	7,611,017	7,442,070	8,122,172
Bio Net Gain	-258,496	-232,265	-218,513	-190,560	-172,608
SEA Env +	84,475	87,191	84,166	82,084	82,037
SEA Env -	115,629	121,199	111,190	107,531	108,846
Cust_preference	32,452	32,809	32,010	31,743	31,673

Metric	Least Cost (Gov-led B)	No Gov-Led	Gov-led C	Gov-led E	Gov-led G
	Pathway 4				
Reliability	38	38	38	37	38
Adaptability	19	19	19	19	19
Evolvability	27	26	27	27	28
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)	
	SESRO150 (2040)	SESRO150 (2040)	SESRO150 (2040)	SESRO150 (2040)	SESRO150 (2040)
	STT300 (2050-60)	Desalination Beckton 150 (2050)	Deephams (2060)	Deephams (2061)	Teddington (2060)
	Deephams (2061)	STT300 (2053-61)			Deephams (2060)
		Deephams (2068)			

10.250 Government-led demand management scenarios are shown to be an important influence on cost and BVP metric performance and in terms of the programmes of options selected.

10.251 With respect to cost, we can observe a range of +£590m NPV if government-led support is removed, to -£1890m NPV in the government-led G scenario which is one that implements the highest level of savings in the quickest time. It should be noted however, that the cost for delivering the government-led activity scenarios themselves are not included in the assessment. This cost is assumed not to be borne by customers through their bills. There could be significant implementation costs to the state to be recouped by other means.

10.252 Whilst there is no clear signal in the resilience metrics, the environmental metrics do react as would be expected if demand changes under the influence of government-led policy. In scenarios C, E and G we see progressive reductions in carbon emissions, increases in natural capital and improvement in biodiversity net gain.

10.253 In terms of how the scenarios influence the selection of key resource development options for our supply area versus the Least Cost Plan, pathway 4:

- With no government-led support, an additional large desalination plant would be required in 2050, which would defer the STT and Deephams reuse options by three and seven years respectively
- In scenarios C and E, the increased activity is sufficient to defer the need for the STT entirely
- In scenario G, which includes the same level of savings as E but delivers them more quickly, demand savings come early enough to defer Teddington DRA to 2060, alongside the Deephams reuse plant
- SESRO 150Mm3 is consistently selected throughout the scenarios, in 2040

10.254 Overall, there is a strong potential benefit of continued support from government to tighten regulations and standards and drive market transformation. However, this is outside of our control and until such time as alternative scenarios can be confirmed with government; these tests are for information only and scenario B will be taken forward as it provides a balanced approach for the pace of the interventions being introduced and the ability to counter any risks of under-delivery over the period of the plan, should it be necessary.

Summary of sensitivity testing

10.255 The sensitivity testing runs have generated more variety in the alternative plans beyond the early 2030s.

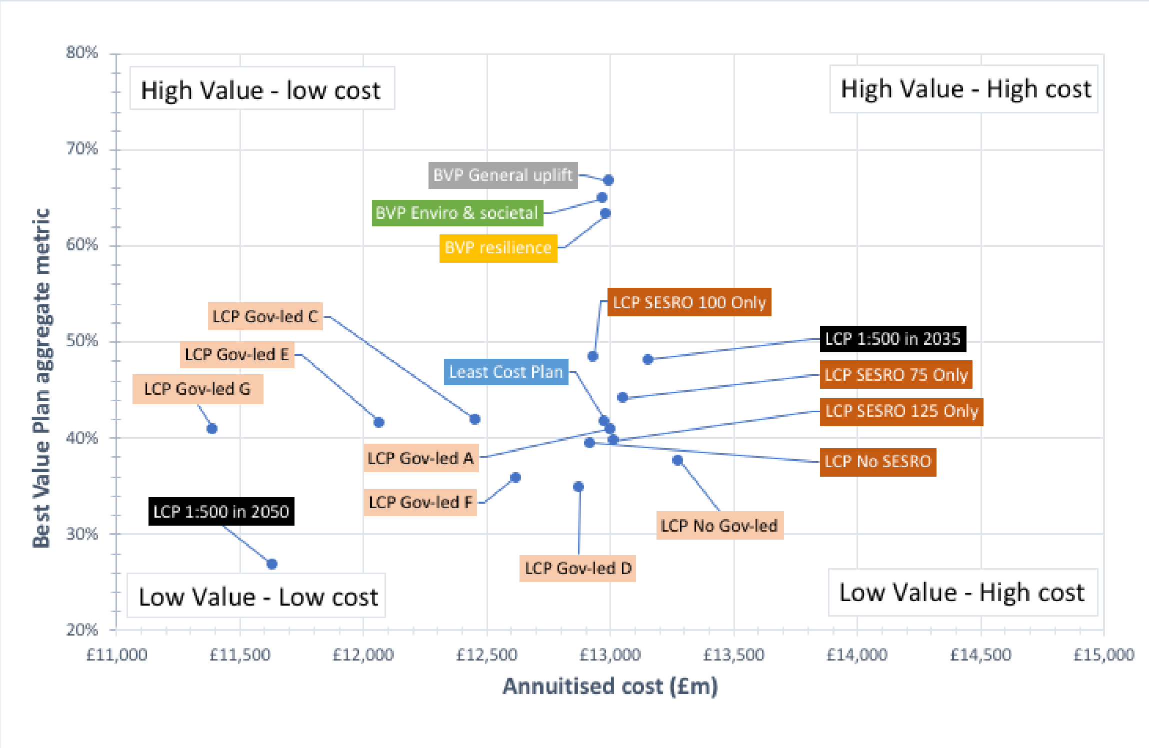
10.256 We have noted in particular when comparing the outputs for pathway 4 against the least cost plan that:

- If Teddington DRA is excluded, Beckton re-use is selected in its place at greater cost
- Removing SESRO brings forward the STT to replace it, but with a negative impact on cost and BVP metrics
- Natural capital performance is improved if SESRO 100 is selected, but reducing the size of the reservoir upsizes the STT, increases the region's reliance on transfers and increases recharge to Havant Thicket reservoir from an effluent reuse scheme in Hampshire
- Forcing the unsupported STT pipeline to be chosen, if required, before 2040 (and thus before or at the same time as SESRO), increases overall plan costs by between £270m-£670m NPV. At the larger pipe sizes, the SESRO 150Mm^3 option is deferred by five years, but is selected before most of the supporting elements of the STT scheme, reinforcing the overall preference for a SESRO option first
- If the capacity of the existing Gateway desalination plant remained reduced to the end of the planning period, the large options selected would remain unchanged although there could be some re-sizing of transfers involving Southern Water.
- If we pushed back reaching 1:200 drought resilience to 2034, Teddington DRA would be deferred until later in the planning period, reducing plan cost. However, deferral of drought resilience is against policy expectations and puts extra pressure on the need to deliver demand management measures to time and scale
- It is possible to bring forward 1:500 resilience to 2035 with a marginal impact on cost by building a larger Grand Union Canal transfer and trading between Affinity and Thames Water. However, the Grand Union Canal scheme, Teddington DRA and existing storage are already mutually supporting each other in case of problems in their development, so to upsize that risk may not be advisable in the near-term
- Pushing back the 1:500 resilience delivery date by five or 10 years to 2050 reduces overall plan cost and impacts by deferring schemes. However, this needs to viewed against the potential cost impact of reacting to a severe or extreme drought in the intervening period of time, which is likely to be much higher. Deferring by 10 years would mean that the STT would not need to be developed. However, it would lead to a very intensive period of alternative SRO development (desalination and reuse) between 2050 and 2061
- Progressive government-led demand management programmes are shown to be important to reduce demand and by doing so are a key influencer on cost and the timing of SRO development. However, the impact is outside of our control and including tighter controls would be high risk

10.257 Adding outcomes of the main sensitivity tests to the Cost vs BVP aggregated metric plot, demonstrates the spread in cost and relative BVP performance derived from these runs (across all the pathways)

10.258 Compared to the LCP (labelled in blue), we can observe an improved BVP metric performance if only a SESRO 100Mm^3 is available for selection. We can also see a similar improvement if we were to bring forward 1:500 resilience to 2035, but at extra cost and risk.

Figure 10 - 15: Cost vs BVP metric (v2, Sensitivity runs)



10.259 We can also extract from the runs completed the frequency of selection statistics for each import or resource development option, i.e. for the times an option is selected in a run and how many times it features in a pathway.

Table 10 - 19: Resource option frequency of selection (across all runs and pathways)

Type	Option	Runs selected in	Pathways selected in
DRA	Teddington	98%	96%
Reservoir	SESRO 150 Mm^3	62%	48%
	SESRO 125 Mm^3	18%	11%
	SESRO 100 Mm^3	27%	16%
	SESRO 75 Mm^3	13%	10%
	Phased development	0%	0%
STT*	STT 500 pipeline + Netheridge	63%	18%
	STT 400 pipeline + Netheridge	25%	6%
	STT 300 pipeline + Netheridge	50%	12%
Desalination	Beckton 150	80%	14%
	Crossness 100	12%	1%
	Beckton 100	8%	2%
	Crossness 50	8%	1%

Type	Option	Runs selected in	Pathways selected in
Reuse	Deephams	95%	20%
	Beckton 100	25%	4%
	Beckton 100 Phase 2	18%	2%
	Beckton 50	13%	3%
	Beckton 150	7%	1%
Groundwater	Woods Farm SWOX	100%	98%
	Southfleet LON	100%	95%
	Addington LON	100%	94%
	Mortimer KV	100%	52%
	ASR Horton Kirby LON	100%	52%
	Moulsford SWOX	100%	46%
	Confined Chalk LON	100%	35%
	Britwell SWOX	100%	32%
	Datchet SWA	100%	24%
	Merton LON	98%	29%
	AR Merton LON	97%	26%
	Dapdune GUI	93%	21%
	AR Streatham LON	92%	27%
	ASR Thames Valley LON	90%	23%
	AR Kidbrooke LON	90%	20%
	ASR Addington LON	68%	16%
	Dorney SWA	2%	0%
Other	Didcot licence transfer	100%	100%
	Catchment Man. - Colne	100%	44%
	Catchment Man. - Upper Lee	65%	19%
	Catchment Man. - Darent Cray	47%	12%
Imports	SEW to GUI	100%	23%
	SES to GUI	98%	11%
	WSX to SWOX	100%	25%
	Oxford Canal (SWOX)	97%	26%
	Oxford Canal (LON)	83%	14%

* STT support elements not included in table

10.260 It should be noted that these selection statistics are across all the LCP, BVP and sensitivity runs completed (n= 60).

10.261 Given that a large number of the runs are testing alternative sizes of SESRO and STT, the selection percentages for those option types are lower than would be the case if they were restricted to the only the runs when they were available to be selected.

10.262 We have done this for the SESRO options (see Table 10-18) and noted that the model always plans and develops a SESRO option when it has free choice to do so. Similarly, if the run excluding Teddington DRA is removed, then Teddington DRA is selected in all cases.

10.263 Picking out some observations from the table above:

- There is a core set of options that are highly selected at both run and pathway level. These are the ones that are selected in the stable 'root' stage of the planning period through to 2030-35. This includes Teddington DRA, three groundwater schemes and a temporary licence trade
- All four of the strategic option types (Reservoir, STT, Desal and Reuse) are commonly chosen in runs, with a tendency towards the larger sizes, with the exception of reuse

- At pathway level SESRO 150Mm^3 is the most highly selected strategic option
- We see that there are high selection percentages for a number of the smaller volume option types (groundwater, catchment management and smaller scale transfers), which shows the importance of those options operating in tandem with the bigger schemes to provide flexibility in the higher demand pathways and in combination as solutions in lower demand pathways

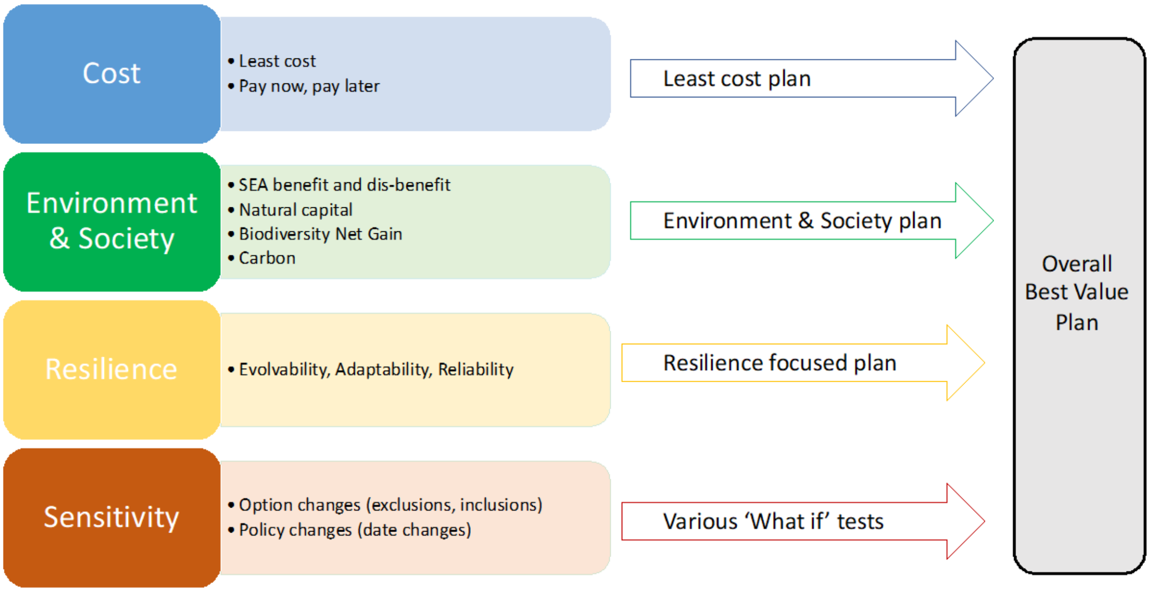
10.264 We can now use this information to inform the selection of our Overall Best Value Plan.

Stage 6: The preferred plan

Our Programme Appraisal journey

10.265 Our programme appraisal journey to identify the preferred plan is shown below.

Figure 10 - 16: The programme appraisal journey



10.266 It can be summarised in five steps:

- The least-cost plan to solve the range of baseline deficits
    - Average Regional Cost = £13 billion (50yr NPV)
    - Average relative Regional BVP score = 42%
    - Outcome: Solution meets the policy and regulatory requirements but it may be possible to deliver wider benefits for the environment and society or resilience in a trade-off with reasonable additional cost
    - Thames Water Options: The Least Cost Plan initially focuses on demand management and supplements this with clear resource development packages in 2031 (Teddington DRA), 2040 (SESRO), 2050 (STT) and 2060 (Reuse) SESRO and STT are shared resources supporting multiple companies via new and existing transfers. Across the different pathways, a range of reservoir and STT capacities are selected
- An environmental and society-focused plan
    - Average Regional Cost = £13 billion (50yr NPV)
    - Average relative Regional BVP score = 65%
    - Outcome: We are able to show that improvement in environmental metrics is possible with minimal increases to overall cost. However, the level of improvement is marginal and most of the impact is outside of our supply area

  - Thames Water Options: No change to 2050. Interplay between STT elements and smaller options and transfers beyond 2050 with a tendency to bring STT elements forward

- A resilience-focused plan
  - Average Regional Cost = £13 billion (50yr NPV)
  - Average relative Regional BVP score = 63%
  - Outcome: Improvements in resilience metrics are possible with minimal increases to overall cost. However, there is a tendency to bring forward drought measures and permits that are undesirable and the level of improvement is marginal
  - Thames Water Options: No change to 2050. Interplay between STT elements and smaller options and transfers beyond 2050 with a tendency to defer STT elements in favour of larger desalination and to include smaller options

- A general BVP uplift plan (across all Environmental and Social and Resilience metrics)
  - Average Regional Cost = £13 billion (50yr NPV)
  - Average relative Regional BVP score = 67%
  - Outcome: A balanced improvement to relative BVP metric performance
  - Thames Water Options: No change to 2050. Interplay between STT elements and smaller options and transfers and desalination. STT elements are brought in more quickly (like the E&S run) but not all used in favour of larger desalination in the more severe futures (like the resilience run)

- Sensitivity testing: Alternative option and policy decisions (vs the Least Cost Plan)
  - Average Regional Cost = Range of £11.4 - £13.9 billion (50yr NPV)
  - Average relative Regional BVP score = 27 - 48%
  - Outcome: No change to the early 2030s, but the runs with restricted option sets and alternative policy assumptions do generate greater variety of alternative plans with material difference to cost and performance
  - They help to confirm the general order of preference for scheme types in the model and are helpful to gain clarity on the SRO development decision in 2040
  - They also confirm the importance of government-led support in reducing demand in the medium to long-term
  - Lastly, they show the sensitivity of the cost and solutions to the plan of alternative dates for achieving drought resilience and changing levels of service

Selecting the Overall BVP

10.267 The process of selecting the overall BVP is undertaken at regional level and agreed with the member companies.

10.268 The regional technical work is reviewed by the Project Management Board and Oversight Group, before final sign-off by the Senior Leadership Team.

10.269 Final sign-off regarding translation of the regional plan into this company WRMP is carried out at Board Level. We have agreed our portion of the regional plan with no amendments.

10.270 All the alternative plans, unless specifically choosing not to as part of sensitivity testing, meet a number of key policy expectations:

- To increase drought resilience to 1:500 years across the region by 2040
- To reduce leakage by 50% by 2050 (from 2017-18 levels)
- To reduce usage and contribute towards meeting the national level ambition of 110 litres/person/day by 2050
- To prevent deterioration and to encourage improvements in the ecological status of the region's water bodies
- To achieve a minimum of 10% biodiversity net gain for all options involving an additional land take
- To share water resources and encourage cross-sectoral co-operation

10.271 Cost-based plans have provided a solid basis for planning and are providing a clear line of sight back to WRMP19, supporting the steps taken at that time. Despite step increases to the level of challenge put to WRMP through increased drought resilience and a greater than ever focus on environmental sustainability improvements, this draft WRMP24 is able to show a good level of continuity.

10.272 As we have modelled alternative plans, we have noted from the metric tables and cost vs BVP plots that average plan cost across all the future pathways does not vary significantly between runs, unless a) the government drives significant demand reductions, the cost of which we have assumed would not be borne by water bills or b) we change delivery dates for key policy assumptions.

10.273 We have also noted that many of the BVP metrics are not showing significant differences between runs either. However, we have been able to pull out a signal by aggregating and ranking scores for the runs.

10.274 Lastly, we have seen that despite the relatively marginal metric movements there is variety to be seen in the combination of options selected, especially beyond 2040.

10.275 We have noted that for the most part, the modelled outcome for actions to be taken within the next five to 10 years is stable. This stability is likely to be due to our adaptive planning approach and the need to be able to meet the wide range of potential future pathways.

10.276 In other words, the level of uncertainty as we move into the future is sufficiently large that there are certain options that we can consider as 'low-regrets'. Sensible building blocks of demand management and supply-side enhancements that will prepare us for the longer term.

10.277 We can also get a good idea of what studies need to continue in the next five years to inform future rounds of WRMPs.

10.278 This has led us to two important decisions:

- Selecting a base model run that represents best value
- Making changes to that run as a consequence of sensitivity testing and wider non-modellable factors

10.279 The decisions were made primarily on the Best Value criteria described previously, but also took into account 'risk and regret' factors when considering alternative plans with similar value outcomes.

10.280 We consider that the overall BVP should be a balanced plan, both in terms of the twin-track approach of demand management and resource development and also in the trade-offs between cost, environmental and societal improvement and water supply resilience.

10.281 As such we focused in on the General BVP uplift modelling run that provides a uniform uplift in BVP metrics whilst minimising cost (i.e. the BVP uplift run).

10.282 As discussed in the sensitivity section, unless told not to build SESRO, the model runs tended to select it over the Severn-Thames Transfer or effluent re-use and desalination.

10.283 We have advocated for SESRO for many years. We believe it remains the best choice as a regional hub-scheme because:

- It adds to the region's storage capability and storage is best way to respond to a flow regime that has surplus water available in winter and deficits in summer
- It is a true regional solution. It complements our existing storage capacity and provides Affinity Water and Southern Water with access to storage that can improve resilience and treatment and network control
- Regional deficits are not just at peak times but also under normal conditions. Baseload schemes with low operating costs such as reservoirs are preferable to meet this challenge rather than peak-lopping, intermittent usage options
- If in the future the supply demand situation turns out to be as bad, or worse than anticipated, having built SESRO offers least/low regrets (see below) versus other option types
- If in the future the supply demand situation turns out better, the reservoir by virtue of its location and low operating costs would not become a stranded asset
- SESRO captures water native to the catchment in the first instance and defers the risks associated with introducing raw water from outside of the region to the Thames Basin
- The STT when eventually required, having additional storage available and operating in tandem with SESRO can only add to the regional benefit
- It is the best large reservoir site (>75Mm^3) available in the South East of England
- Reservoirs are a well-established, well understood and safe option

10.284 In terms of reservoir size, the General BVP uplift run selects the 150Mm^3 SESRO in six future pathways and the 125Mm^3 size in two low demand futures.

10.285 The frequency of selection statistics for the reservoirs (for runs where there is a free choice of reservoir size) are shown in the table below.

Table 10 - 20: SESRO options – frequency of selection by pathway

SESRO Option	Pathways 1 & 4	Pathways 2 & 3	Pathways 5 & 6	Pathway 7	Pathways 8 & 9
Planning phase	100%	100%	100%	100%	100%

SESRO Option	Pathways 1 & 4	Pathways 2 & 3	Pathways 5 & 6	Pathway 7	Pathways 8 & 9
Development phase	100%	100%	96%	100%	96%
150 Mm^3	100%	96%	88%	20%	20%
125 Mm^3	0%	0%	0%	20%	16%
100 Mm^3	0%	0%	0%	36%	36%
75 Mm^3	0%	0%	0%	12%	12%
Phased development	0%	0%	0%	0%	0%

10.286 However, when the model only has one size of SESRO to select, we have seen from the sensitivity testing that it is the $100Mm^3$ that has marginally the better relative performance across the BVP metrics.

10.287 We summarise the competing advantages of the 100 and $150Mm^3$ SESRO sizes below.

Table 10 - 21: SESRO options – comparison of advantages

SESRO $100Mm^3$	SESRO $150Mm^3$
Is a balanced choice based on the current understanding of risk	Is the size chosen most regularly by the model
Performs better in terms of environmental and social metrics (Natural Capital and BNG)	Performs marginally better in terms of resilience
Performs relatively better on BVP metrics	Allows for a better management of future system and under-performance risk
Has lower regrets if the future is better than predicted	Has lower regrets if the future is worse than predicted
Smaller footprint provides for more opportunity for landscaping and mitigation of visual aspects of the scheme	Maximises the water resources potential of the site (c.100 Ml/d higher output)
Maximises inter-regional interconnectivity	Maximises intra-regional interconnectivity
Provides the opportunity to balance local and regional concerns	Provides additional headroom for changes in environmental policy requiring further abstraction reductions or improved levels of service.

10.288 We consider that the decision here is a close one and comes down to an opinion on the trade-off between environment and resilience and the mix of options chosen in each of the respective programmes.

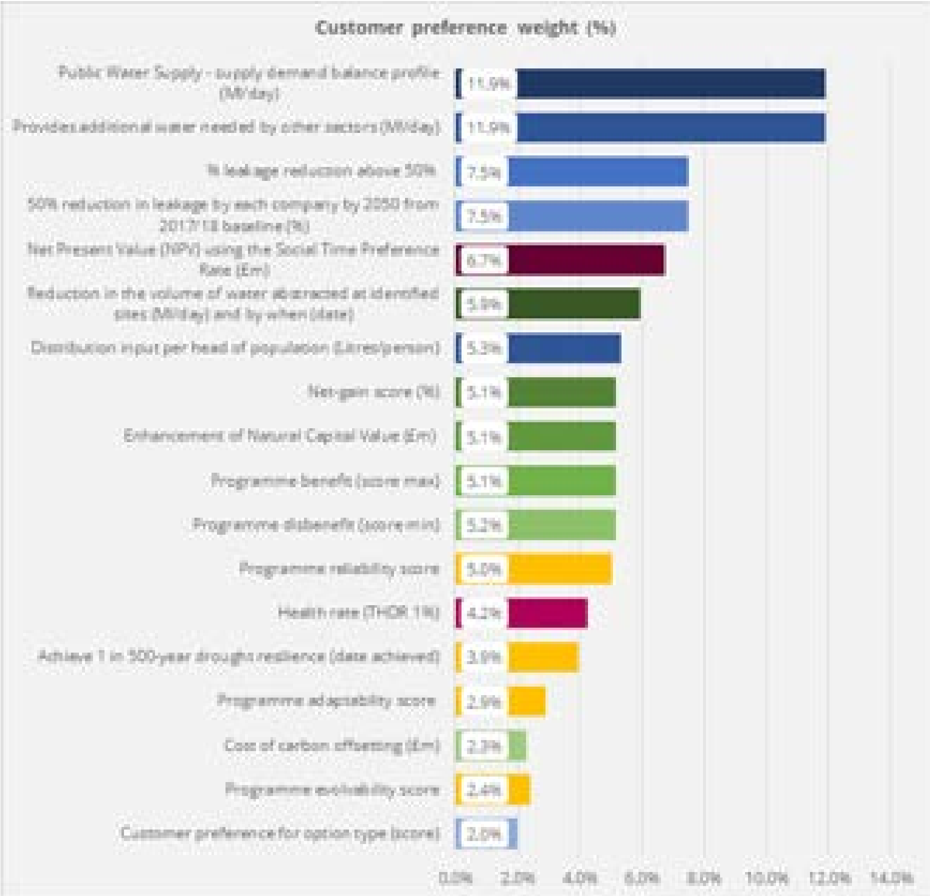
10.289 Recognising that the planning process requires us to decide which Strategic Regional Option to put forward for 2040 and at what size, we have considered the outcomes of the sensitivity analysis and concluded that the SESRO 100 Mm^3 offers the best value and least regrets choice for the region.

10.290 To test this against customer expectations we re-analysed the run outcomes weighted by customer preference instead of weighted equally. In 2021, WRSE undertook a survey[7] to see what customers thought a good plan should cover and how much weight they put behind certain

[7] Eftec (for WRSE) (May, 2021) Best Value Criteria – Customer Research

criteria. These criteria, as shown in the figure below with their weightings, link well to the supply demand and BVP criteria used in BVP assessment.

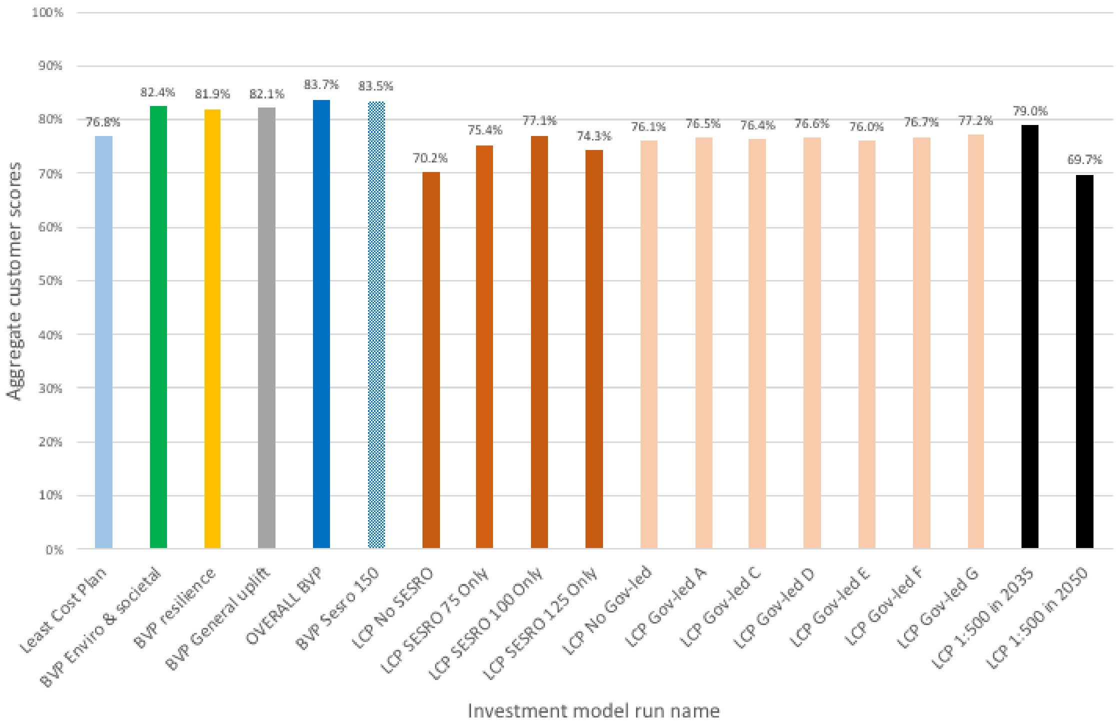
Figure 10 - 17: Customer preference weighting



10.291 By combining the output from the BVP metrics with the customer preferences we have been able to develop a customer weighted approach to appraising the regional plans.

10.292 The approach was to look at each of the criteria and score how well the plan performs against that criteria. Scores for each criterion are either assigned using a binary choice (you have either met that criteria or not) or on a performance-based approach based on the score obtained in the BVP metric. The provisional results are shown below and indicate that SESRO 100Mm^3 is marginally better than SESRO 150Mm^3.

Figure 10 - 18: Customer preference weighted model runs

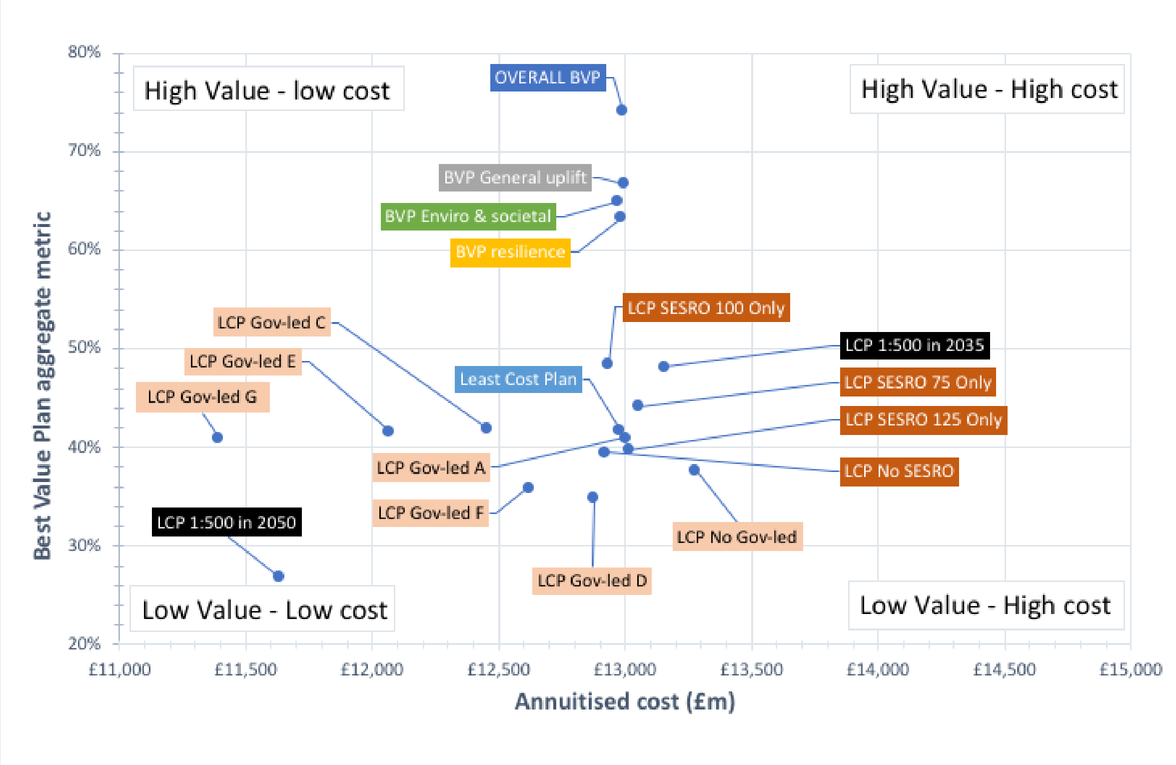


10.293 Finally, to develop the Overall BVP, we re-ran the model seeking a BVP General Uplift with SESRO 100Mm^3 being the only reservoir size available for selection.

10.294 The outcome in terms of cost vs relative aggregate BVP is shown below, with the new Overall BVP run shown in a darker shade of blue near the top of the plot. As anticipated, the relative improvement in BVP metric score compared to the BVP General Uplift run (in grey) is in line with that seen when we compared the LCP run (light blue) with the LCP SESRO 100Mm^3 only run (dark brown, central) at the sensitivity stage.

10.295 The Overall BVP is discussed briefly across all pathways in the section (The Overall BVP plan) below, with further details provided in Section 11.

Figure 10 - 19: Cost vs BVP metric (v3, Overall BVP run)



The Overall BVP plan

10.296 The overall best value plan metrics across all pathways are shown below with the preferred pathway, pathway 4, highlighted in green.

Table 10 - 22: Overall BVP – regional-level metric outputs

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	16.45	12.79	11.66	15.59	12.88	11.60	13.54	11.66	10.75	12.99
Carbon	6,181,467	4,041,244	3,455,963	5,744,519	4,087,810	3,456,341	4,386,528	3,293,714	2,965,889	4,179,275
NC	10,163,502	11,611,978	11,979,385	10,790,008	11,946,114	12,223,620	11,408,616	13,632,458	16,165,210	12,213,432
BNG	-260,076	-190,310	-185,348	-260,076	-223,408	-169,801	-202,077	-159,159	-148,418	-199,853
Env +	84,252	78,877	77,171	83,476	77,480	77,065	80,836	76,897	76,642	79,188
Env -	122,674	90,711	82,025	112,972	88,106	80,826	103,672	81,489	72,999	92,830
Cust_p	36,131	34,218	33,668	35,620	34,015	33,668	35,057	33,614	33,203	34,355
Reliab	41	43	47	42	44	47	43	46	53	45
Adapt	20	22	24	21	22	24	22	24	28	23
Evolv	29	30	32	30	30	32	30	32	37	31

10.297 The Overall BVP plan, when optimised regionally, has an average NPV cost of £13 billion with a maximum of £16.5 billion and minimum of £10.8 billion. This is very close to the range of shown by the Least Cost Plan.

10.298 However, we can see BVP metric performance, notably in Natural Capital as a result of reducing the reservoir size. A table of selected options across all pathways is provided below. It contains resource and transfer elements for TW schemes only and shows the date the option is first utilised. SROs are in **bold**.

Table 10 - 23: Overall BVP – Thames Water options selected

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Media Campaigns	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Temporary use bans	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Non-essential use bans	ALL		2031	2031	2031	2031	2031	2031	2031	2031	2031
TW Integrated Demand Management (Deliverable)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government Led Demand Management (Hybrid B)	ALL		2046	2046	2046	2046	2046	2046	2046	2046	2046
Teddington DRA	**LON**	**67**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**	**2031**
Didcot Raw Water Purchase	LON	23	2031	2031	2031	2031	2031	2031	2031	2031	2031
GW - Southfleet/Greenhithe	LON	9	2031	2031	2031	2031	2031	2031	2031	2031	2031
GW - Woods Farm	SWX	2	2031	2031	2031	2031	2031	2031	2031	2031	2031
GW - Addington	LON	3	2032	2032	2032	2032	2032	2032	2032	2032	2032
Reservoir Abingdon 100 Mm³	**SWX**	**185**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	
Henley to SWOX	SWX	5	2045			2040	2040	2040			
GW - Moulsford 1	SWX	2	2045			2040			2050		
GW - Britwell	SWX	1	2046			2042			2060		
GW - Mortimer Recommission	KV	5	2045			2042	2042	2042			
Wessex Water to SWOX (Flaxlands)	SWX	3	2048			2045					
STT400: Unsupported flow + Netheridge	**SWX**	**131**	**2050**								
STT400: Vyrnwy release 1 (25 Ml/d bypass)	**SWX**	**14**	**2055**								
STT400: Vyrnwy release 2 (35 Ml/d bypass)	**SWX**	**20**	**2058**								
STT400: Vyrnwy release 3 (15 Ml/d bypass)	**SWX**	**9**	**2060**								
STT400: Vyrnwy release 4 (30 Ml/d bypass)	**SWX**	**17**	**2060**								
STT400: Minworth STW Phase 1	**SWX**	**35**	**2060**								
STT400: Minworth STW Phase 2	**SWX**	**35**	**2060**								
STT500: Unsupported flow + Netheridge	**SWX**	**157**				**2050**					
STT500: Vyrnwy release 1 (25 Ml/d bypass)	**SWX**	**14**				**2053**					
STT500: Vyrnwy release 2 (35 Ml/d bypass)	**SWX**	**20**				**2054**					
STT500: Vyrnwy release 3 (15 Ml/d bypass)	**SWX**	**9**				**2055**					
STT500: Vyrnwy release 4 (30 Ml/d bypass)	**SWX**	**17**				**2060**					
STT500: Minworth STW Phase 1	**SWX**	**35**				**2060**					
STT500: Minworth STW Phase 2	**SWX**	**35**				**2060**					
ASR Horton Kirby	LON	5	2045			2050			2050		
GW – Dapdune disaggragation	GUI	2	2050			2050					
River Thames to Fobney Transfer	KV	40	2040	2042	2042	2050			2050		
SEW (Hogsback) to Guildford	GUI	10	2050			2050					
SWOX to SWA (Abingdon WTW)	SWA	48				2050					
GW - Datchet	SWA	2	2055			2051					
Deephams Reuse	LON	42	2061			2061			2061		
GW - Merton Recommissioning	LON	6	2062			2062			2052		

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Oxford Canal - Cropredy	LON	10	2045						2060		
GW - London Confined Chalk	LON	2	2048						2051		
Medmenham WTW Phase 1	SWA	24	2048						2050		
Medmenham WTW Phase 2	SWA	24	2050								
Beckton Desalination 150	LON	133	2050								
KV to Henley	HEN	7	2050								
KV to SWOX	SWX	7	2050								
AR Streatham (SLARS2)	LON	7	2055						2051		
AR Kidbrooke (SLARS1)	LON	8	2064								
AR Merton (SLARS3)	LON	5	2064						2054		
ASR Thames Valley Central	LON	5	2065						2053		
SES (Reigate) to Guildford	GUI	5							2050		
Crossness Desalination Ph 1	LON	44							2061		

10.300 Demand management is confirmed in all zones and in all pathways. Our highest and immediate priority is to make the most effective use of the water we already have.

10.301 The programme will build on WRMP19 activity and includes further cuts to leakage as we head to towards an overall reduction of 50% by 2050. We will continue to roll-out our smart metering programme, seeking to meter all connections to our mains. We have already brought forward metering activity as we know it is very helpful to help customers use less water and critical to provide the information we need to pinpoint leaks. Alongside both programmes will be an ambitious programme of water efficiency activity.

10.302 Customers strongly favour demand management before resource development. However, demand management alone will not be enough and resource development will be necessary in addition.

10.303 Overall, there are four important periods over the 50 years of the forecast where significant resource developments are likely to be needed:

- For the early 2030s – In all pathways the Teddington DRA scheme (75 Ml/d), a temporary licence transfer with RWE Didcot (23 Ml/d) and three smaller groundwater enhancements in London and SWOX (14 Ml/d) are required
- 2040 – The completion of the SESRO 100Mm^3 reservoir development (185 Ml/d) for London and SWOX WRZs and to facilitate greater sharing of resources across the South East via significant transfers with Affinity and Southern Water. Additional small-scale transfers and groundwater developments are selected (up to 25 Ml/d) to the middle of the decade, depending on the future pathway

  In the two lowest growth, climate change and environmental destination pathways (8 and 9), this will be enough to balance supply and demand to 2075. In pathways that don't allow for high environmental destination and climate change assumptions (2, 3, 5 and 6) further minor resource development and inter-zonal transfers are required. In the higher demand pathways (1, 4 and 7) further strategic resource development is required

- 2050 – The unsupported Severn-Thames Transfer pipeline between Deerhurst and Culham is required in pathways 1 and 4, along with the Netheridge support option. The STT is not required in pathway 7. Due to the reduced size of the SESRO, the two highest capacity transfers, either 400 or 500 Ml/d are selected, however the decision on which size of transfer is needed does not need to be made now and studies will continue

  The large Beckton Desalination plant (150) would also be required by 2050 in the most challenging future, pathway 1

  Small groundwater developments and transfer schemes are also required to re-distribute the water, driven by the completion of the environmental destination programme in all zones

- Beyond 2050 – Further phases of STT and Deephams effluent reuse are selected in pathways 1, 4 through to 2061. Smaller, supporting groundwater and transfer options are also selected

  In pathway 7, where there is no STT, Deephams re-use and a desalination plant at Crossness are chosen in early 2061, preceded by a suite of groundwater and the Oxford Canal transfer

10.304 Full details of the demand management and resources development programmes and further discussion of the alternatives are provided in Section 11.

10.305 Also included in Section 11 is a monitoring plan to allow us to track our progress and allow us early sight of whether we may need to move to a different pathway should the future turn out differently. We have also developed an ongoing study programme for the next five years that will ensure that decisions required in WRMP29 can be made with the best possible information available.

10.306 An intra and inter-plan cumulative effects assessment of pathway 4 of the Overall BVP, completed as part of the Strategic Environmental Assessment is provided in Appendix B. A summary of key environmental impacts is also provided in Section 11.

Thames Water