Revised Draft Water Resources Management Plan 2024

Section 10 – Programme Appraisal and Scenario Testing

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Introduction and Background

What's changed since the draft WRMP?

Our approach to programme appraisal and scenario testing is unchanged from the draft WRMP. It remains consistent with the approach, developed and undertaken at regional level through the Water Resources in the South East Group (WRSE).

Following consultation and due to updates in input data, along with changes in the Water Resources Planning Guideline and government policy, as set out in the previous sections of the plan, the programme appraisal has been re-visited, re-modelled and re-written.

Consequently, there are changes to the least cost and alternative plans put forward to solve the supply demand deficits in the Thames Water supply area, and to the plan put forward as the candidate Overall Best Value Plan.

In summary, the changes made since the draft have resulted in greater need for solutions in the short and medium-term, but reduced the need in the long-term.

To meet new demand targets set out in the updated Planning Guideline, we are proposing more ambitious company-led household and non-household demand management measures and placing increased reliance on the government to bring forward measures they control in order to reduce demand.

It remains the case that demand management alone cannot solve the deficits and in the Thames Water area we are proposing the Teddington DRA and joint regional development of the SESRO (at 150Mm^3), alongside greater resource sharing between companies in the South East.

The reduction in need in the longer term has lessened the requirement for the Severn-Thames Transfer, but it and the Beckton water recycling option will continue to be pursued as additional strategic schemes, should further schemes be required in the future.

What's in this section?

The processes, plans and pathways described in this section are consistent with the 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 how modelling has identified a candidate Overall Best Value Plan, including 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) in checking and approving the programme appraisal process. 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 have 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 and represents least regrets 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 candidate 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 feasible connections and an enhanced water efficiency programme.

Demand management programmes, including Government-led initiatives, are not able 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 if required, 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 review helped shape 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 rdWRMP24.

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. Whilst company WRMPs already account for replacing a significant amount of

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

water from unsustainable sources, in particular the unique and highly valued chalk streams, the Framework indicates that eventual reductions in abstraction may be 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 the WRMP24 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 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 between WRMP19 and WRMP24 is to bring analysis of alternative futures and adaptability, which were sensitivity tests for WRMP19, forward into the baseline for WRMP24. 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 The computer-led optimisation process for identifying programmes of options to solve the planning problems can now be carried out over a range of futures at once, and in consideration of each other. This 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 the WRPG to identify a preferred (single) pathway for reporting purposes.

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

[3] Environment Agency, Ofwat and Natural Resources Wales, Water Resources Planning Guideline: April 2023.

Section structure

10.17 The rest of this section covers appraisal method, our decision support tools, model outputs and consideration of those outputs, 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 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 Candidate Overall Best Value Plan – explains how the candidate plan was identified from the modelling work 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 of the draft plan for consultation. We published our draft WRMP24 for consultation between 13 December 2022 and 21 March 2023 and the level of engagement was encouraging. We strongly value the input received from stakeholders and customers and have published our consideration of the feedback in our Statement of Response that accompanies this revised plan.

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 It should also be noted that the iterative nature of the WRMP planning process is also relevant here. Full revision every 5 years and annual reviews allow us to refine our understanding of the future and make regular adjustment to track and review plans as appropriate.

Problem characterisation

10.24 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.

10.25 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.

10.26 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.

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

10.28 The summary problem characterisation matrices from the analysis we undertook for WRMP19 and WRMP24 are shown in Table 10-1. The matrix is unchanged from draft WRMP24 to this revised draft.

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

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

Table 10-1: Problem characterisation summary matrix

10.29 Strategic risks and complexity factors have generally increased in most WRZs 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.

10.30 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. This enables analysis of inter-zonal transfer capabilities and shared water resource planning where a management problem is significant and widespread.

10.31 As such, we consider that our supply system can be characterised as high-risk.

10.32 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.

10.33 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).

10.34 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?

10.35 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 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 and societal 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.

10.36 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.

10.37 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

10.38 The future is inherently uncertain, so we have also 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

10.39 There are a wide range of decision support tools available to facilitate programme appraisal, from simple to advanced.

10.40 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.

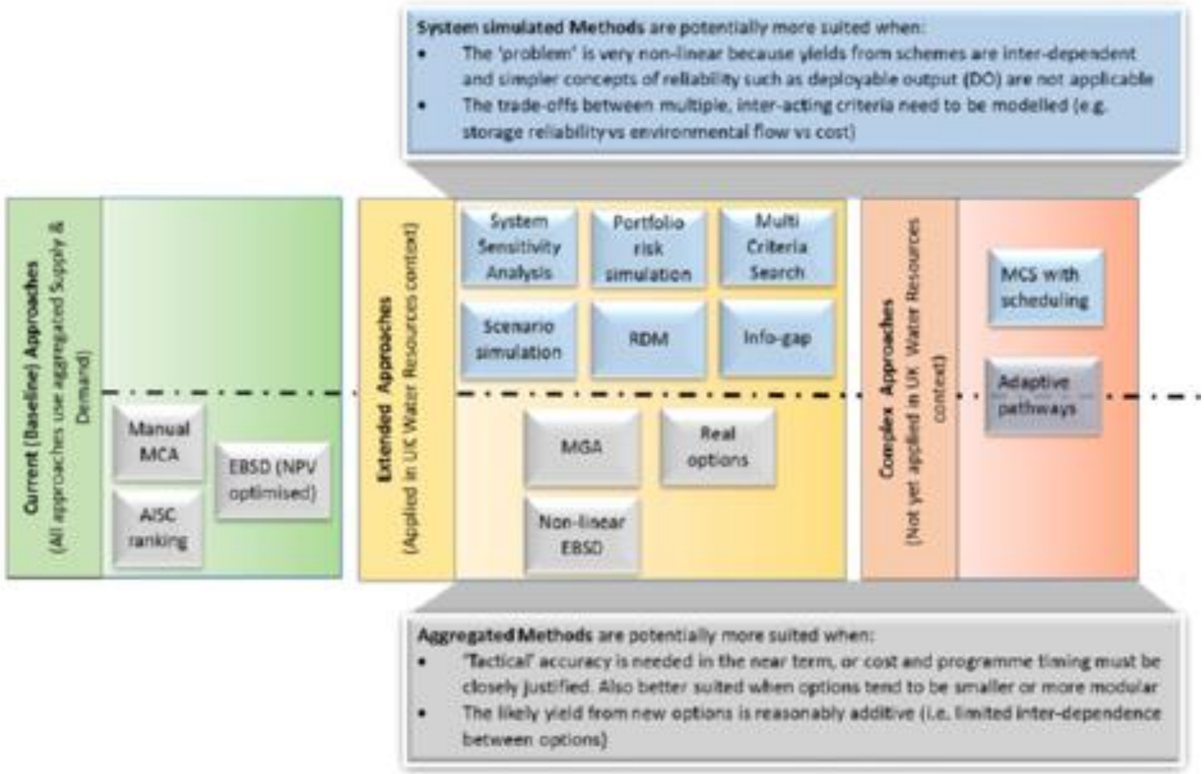


Figure 10-1: Decision-making methods and tools for problems of different complexity

Source: UKWIR WRMP 2019 Methods

10.41 We, as part of the WRSE regional group, have developed a tool, 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).

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

Table 10-2: Our Decision Support Tools and modelling approaches

[5] NPV – Net Present Value

10.42 There has been a continuum of model development (using computer-assisted optimisation techniques which analyse large amounts of data and present the best solutions based on defined criteria) 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, single future, but 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

10.43 The primary purpose of the IVM is to identify and schedule programmes of options to meet the supply demand challenges passed to it. It can 'optimise' solutions by:

- Conjunctively solving for four planning scenarios across all WRZs at the same time
- Ensuring 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)
- Considering a single future situation or multiple futures, defined in a situation tree

10.44 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, the model optimises on least cost considerations only at this point
- 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

10.45 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

10.46 Our Best Value planning process for generating, testing and identifying the best value plan can be summarised into seven key stages, as shown in Figure 10-2.

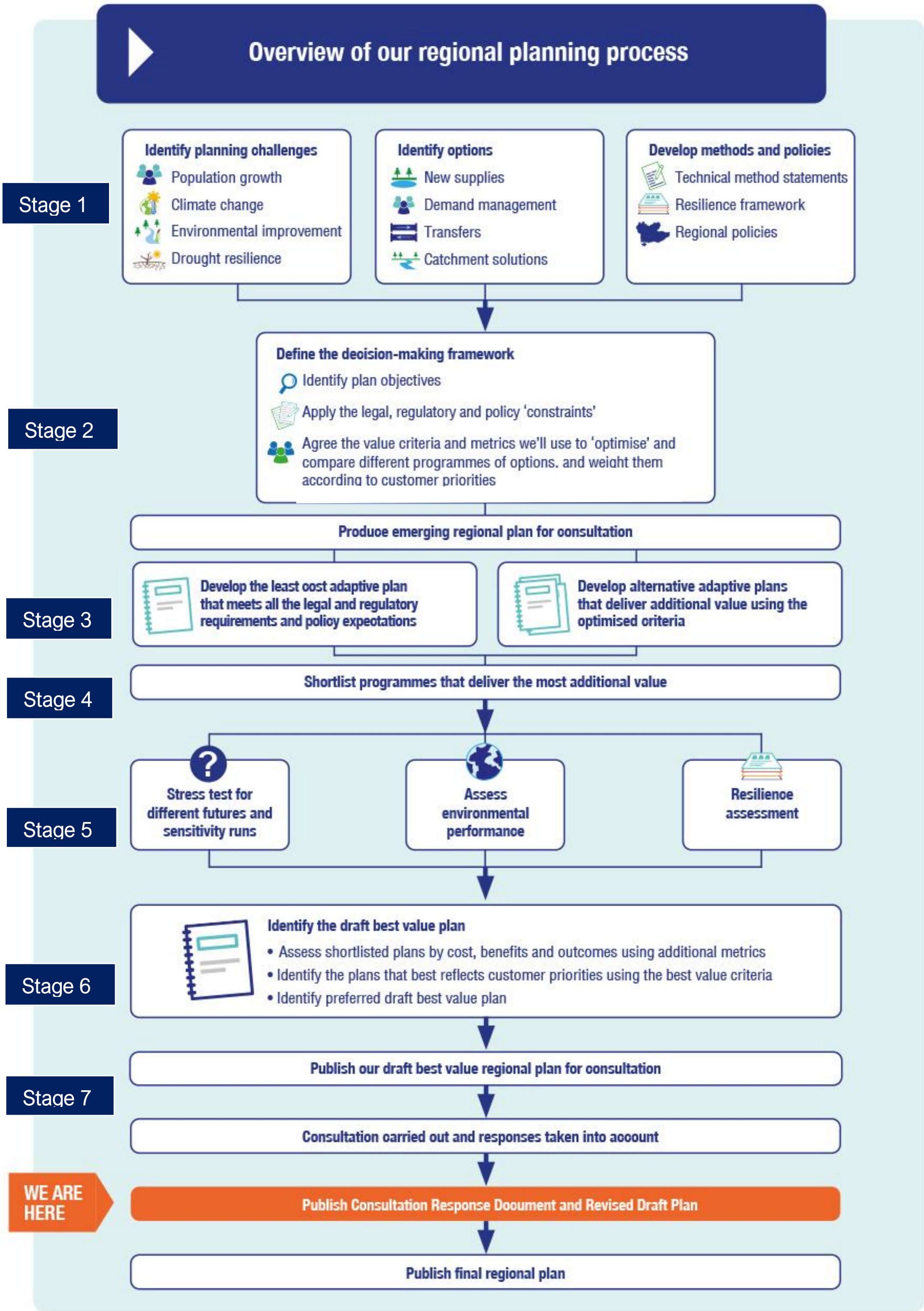


Figure 10-2: Best Value Planning Stages

Source: WRSE

Stage 1: Data validation

10.47 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 IVM. This ensures 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

10.48 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.

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

10.50 We 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

10.51 In this stage we explain the range of modelled potential alternative futures 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

10.52 In Stage 4 we explain how we've used the IVM and 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 alternative plans based on cost and best value performance.

Stage 5: Sensitivity testing

10.53 In Stage 5 the alternative plans are examined in more detail to see how they perform and how robust they are. This included:

- Stress testing (i.e. how would the solution change if 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 hotspots)

10.54 Each alternative plan has different metric outputs. We have to consider how these alternative 'best value plans', trade off benefits and dis-benefits between value criteria, and confirm priorities in selecting a candidate overall Best Value Plan.

Stage 6: Select the Candidate Overall Best Value Plan

10.55 In Stage 6 we select a candidate overall best value programme, based on the modelling output (in this section), and then confirm or change this based on wider considerations and feedback (in Section 11).

Stage 7: Consultation

10.56 We have carried out a public consultation on our proposals and produced a Statement of Response detailing our consideration of and response to the feedback provided.

10.57 Due to changes in base information and updates to policy, we have repeated the programme appraisal process (Stages 1-6) and re-stated the updated findings in this revised plan.

Stage 1: Data validation

10.58 Inputs to programme appraisal have been set out in earlier 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 Data Landing Platform (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.

10.59 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

10.60 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. normal year, dry year, peak week). The datasets can be combined with allowances for uncertainty to define future supply demand challenges (see Stage 3: Baselining and solution development) This information is input to the DLP and checked for errors and consistency across datasets generated by individual companies and by WRSE.

The options

10.61 In Sections 7 and 8 of our WRMP we have set out the identification and screening of potential demand management and resource development options and the datasets that define the costs and benefits of each option. This data is uploaded and held in the DLP and checked.

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

10.63 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 Deployable Output, (DO), limit to avoid in-combination environmental impacts).

10.64 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

10.65 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.

10.66 Under our best value planning approach, we have identified and agreed at regional and company-level four objectives for our plan to achieve, as shown below.

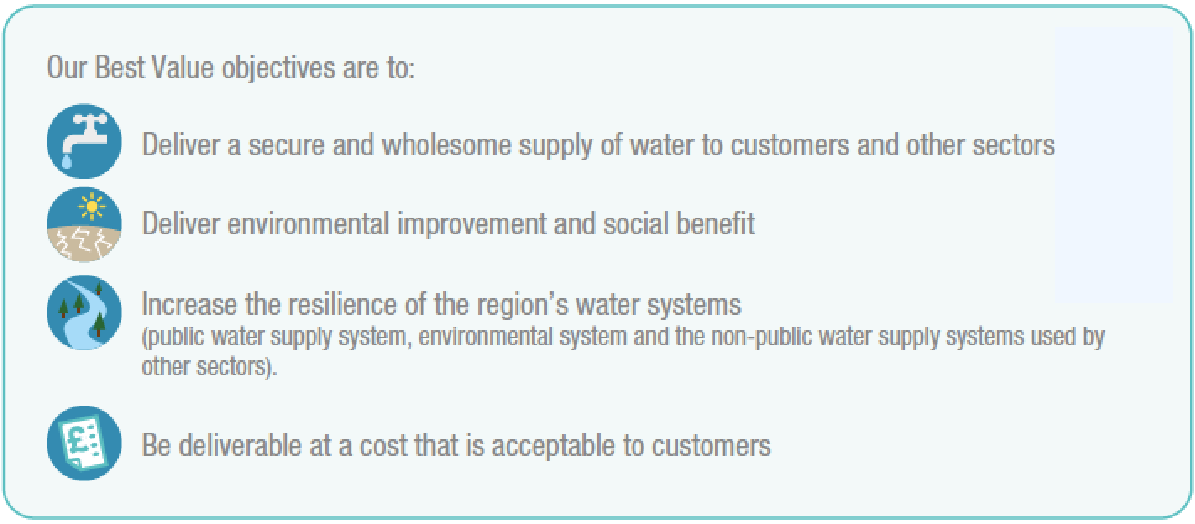


Figure 10-3: Best Value Objectives

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

10.68 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.

10.69 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.

10.70 These are described as constraints and include:

- Meeting the supply-demand balance in all years and scenarios
- Halving leakage (from 2017/18 levels) by 2050 and reducing it further beyond 2050
- Reducing water consumption in households and non-households in line with glidepath targets set out in Defra's Environmental Improvement Plan.
- Achieving levels of abstraction reduction
- Increasing resilience to a one in 500-year drought event by 2039/40

10.71 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.

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)

Figure 10-4: Best Value Objectives and Criteria

Modelled metrics

10.72 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.

10.73 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.

10.74 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.

10.75 The modelled metrics are shown 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.

10.76 The resilience metrics (reliability, adaptability and evolvability) are discussed in the WRSE Resilience Framework. Note that these metrics reflect the combined characteristics of the options that make up each programme. They are not a measure of overall system resilience to drought, which is a specific policy standard (ie. 1:200 by 2033, 1:500 by 2040).

Metric	Unit	WRSE Method Statement	Programme-Level Calculation
Cost	£m	Options appraisal	Options scheduled, capital cost annuitised 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		Cumulative sum of selected option scores per year
SEA Environmental dis-benefit	Score		
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		

Table 10-3: BVP Modelled metrics

10.77 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. We mitigate this risk by being aware of it when these metrics are considered for decision-making.

10.78 Nevertheless, we have retained all the metrics as they highlight a particular element of interest and can be used to differentiate potential solutions. We have taken account of this in our decision-making process when we are assessing potential programmes.

Stage 3: Baseline position & solution development

Establishing a Baseline position

10.79 In Section 6 of the WRMP 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.

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

10.81 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.

10.82 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

10.83 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.

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

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

10.85 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.

10.86 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

10.87 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.

10.88 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).

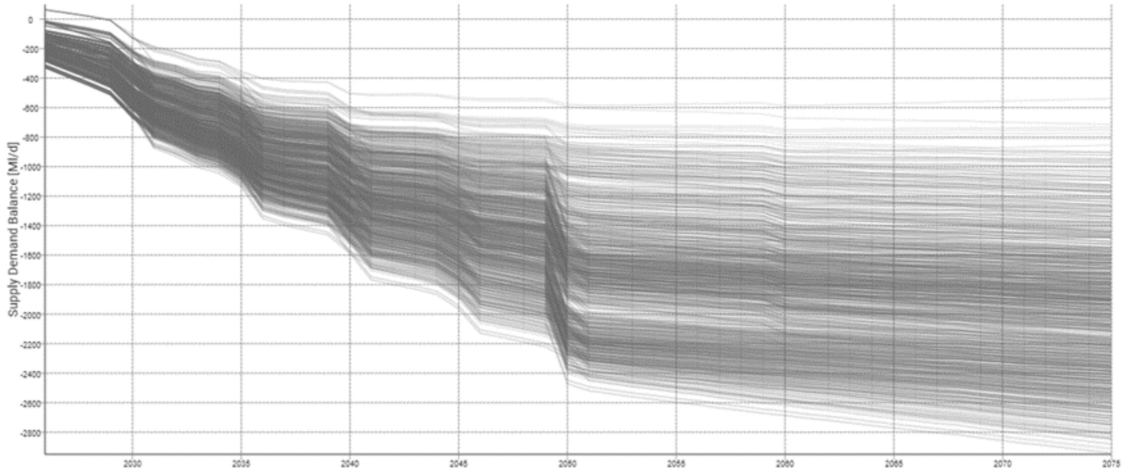


Figure 10-5: Range of future forecast supply demand balances (WRSE, DYAA)

10.89 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.

10.90 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

10.91 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.

10.92 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.

10.93 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.

10.94 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.

10.95 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.

10.96 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)

10.97 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.

10.98 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

10.99 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 WRMP24.

10.100 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.

10.101 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.

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

10.103 A tree has now been chosen with supply-demand branch points at 2035 and 2040 and decision points five years earlier in 2030 and 2035 respectively. These timings allow

[6] WRSE Emerging Regional Plan, January 2022

focus initially on the variability caused by different growth forecasts and then on resilience, environmental destination and climate change.

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

10.105 The root branch (Stage 1) 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.

10.106 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 to allow growth projections other than Local Authority housing plan to be considered for adaptive planning purposes. 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 our rdWRMP 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.

10.107 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.

10.108 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

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

10.110 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 at this stage.

10.111 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.

10.112 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.

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

Table 10-4: What's included in each of the nine pathways

10.113 We have selected 'situation 4' (shaded green) as the preferred pathway. This is primarily because it aligns with the approach set out in the WRPG, which is the regulators' policy guidance as to how a WRMP should be prepared and attracts significant weight:

- It uses Local Authority housing plan-based forecasts
- It includes 'High' environmental destination (according with the approach set out in the National Framework, Regional Plan and WRPG, when read together)

10.114 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.

10.115 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. However, this pathway is not in accordance with the WRPG.

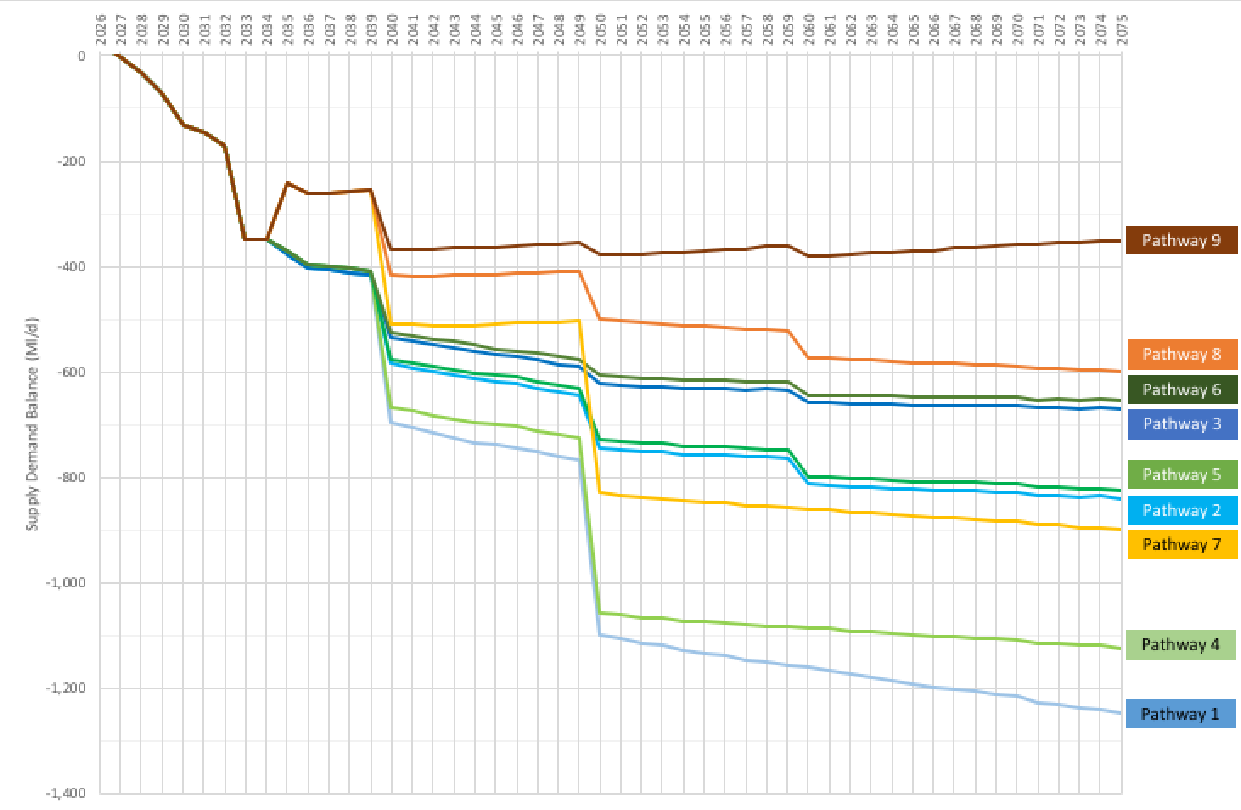


Figure 10-6: Range of future forecast supply demand balances by pathway (Thames Water, Dry Year Annual Average)

Pathway	Baseline Supply Demand Balance (DYAA, Ml/d)					
	2030	2040	2050	2060	2070	2075
1	-131	-695	-1,098	-1,162	-1,216	-1,248
2	-131	-584	-743	-814	-828	-840
3	-131	-535	-622	-658	-663	-671
4	-131	-667	-1,057	-1,086	-1,108	-1,124
5	-131	-576	-728	-798	-813	-825
6	-131	-527	-607	-643	-648	-656
7	-131	-509	-829	-859	-883	-900
8	-131	-417	-500	-572	-588	-601
9	-131	-368	-378	-382	-357	-351

Table 10-5: Company-level baseline supply demand balances

Stage 4: Assess solutions

The Investment Model

10.116 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.

10.117 Further information on the model, including method statements and assurance can be found on the WRSE website. Appendix W also provides additional information.

10.118 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.

10.119 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 – those seeking to increase performance for the Best Value metrics (in the environment and society and resilience categories) in trade-off with cost
- 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

10.120 The programmes produced when focusing on Cost, Environment and Society (E&S) and Resilience are described in the following sub-sections. The sensitivity tests are described in Stage 5. The candidate Overall BVP identified through the modelling is discussed in Stage 6.

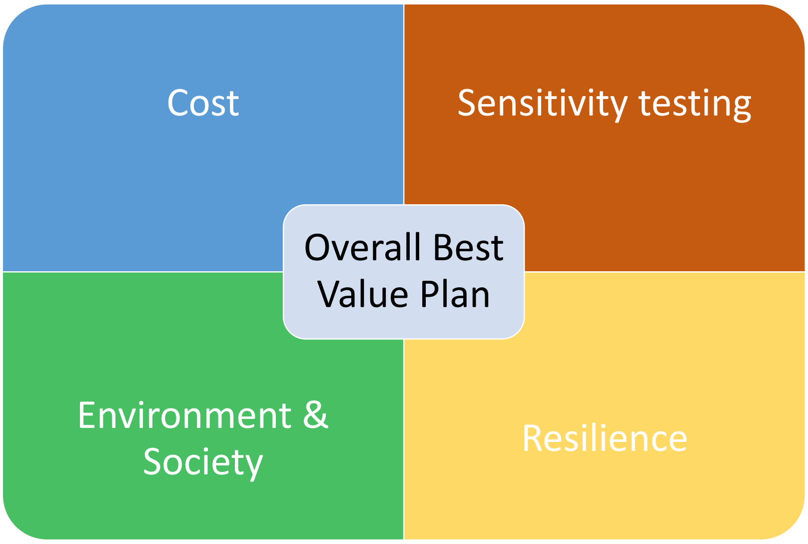


Figure 10-7: The inputs to the overall BVP

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

Output Visualisation

10.122 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.

10.123 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.

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

10.125 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.

10.126 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.

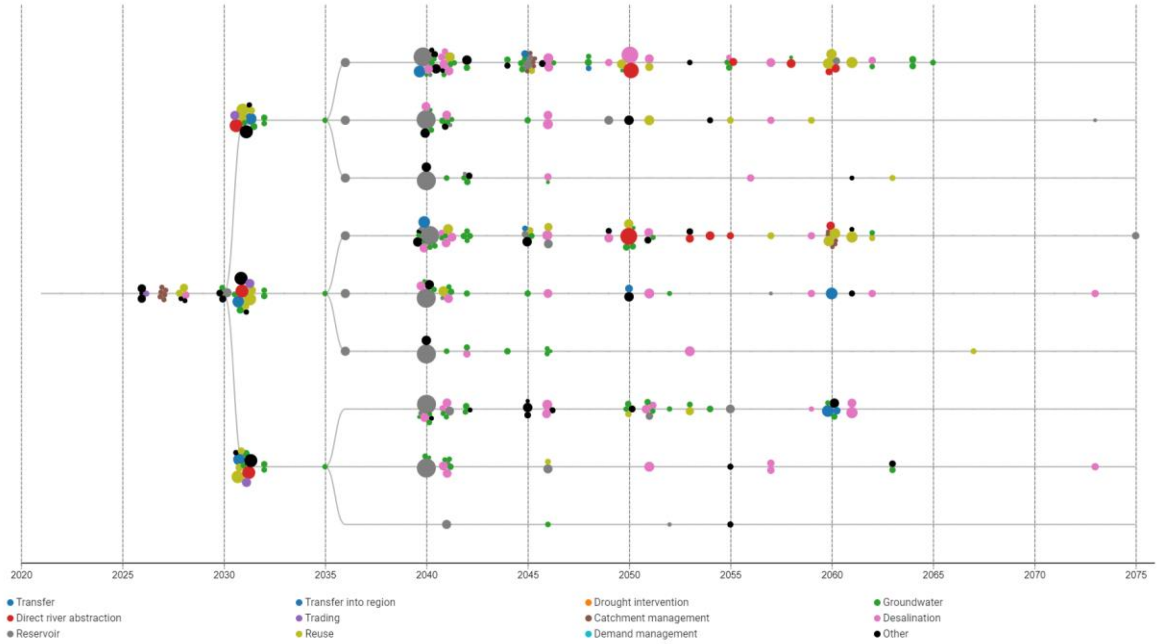


Figure 10-8: Example Option selection plot

10.127 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.

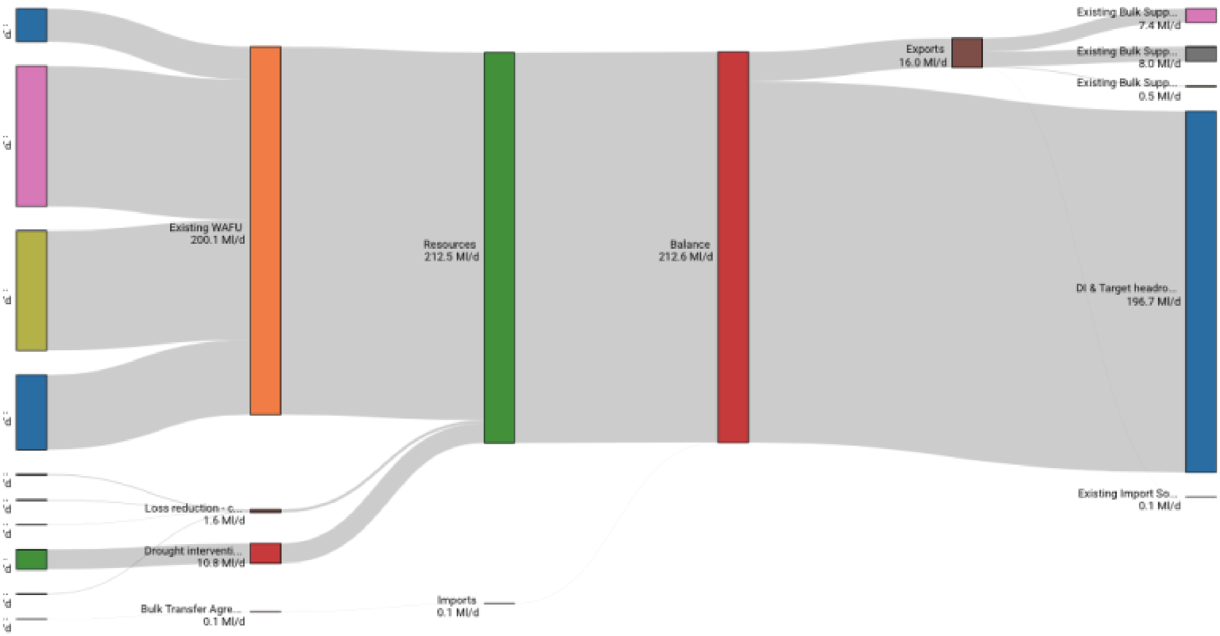


Figure 10-9: Example Sankey plot

10.128 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.

10.129 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.

10.130 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).

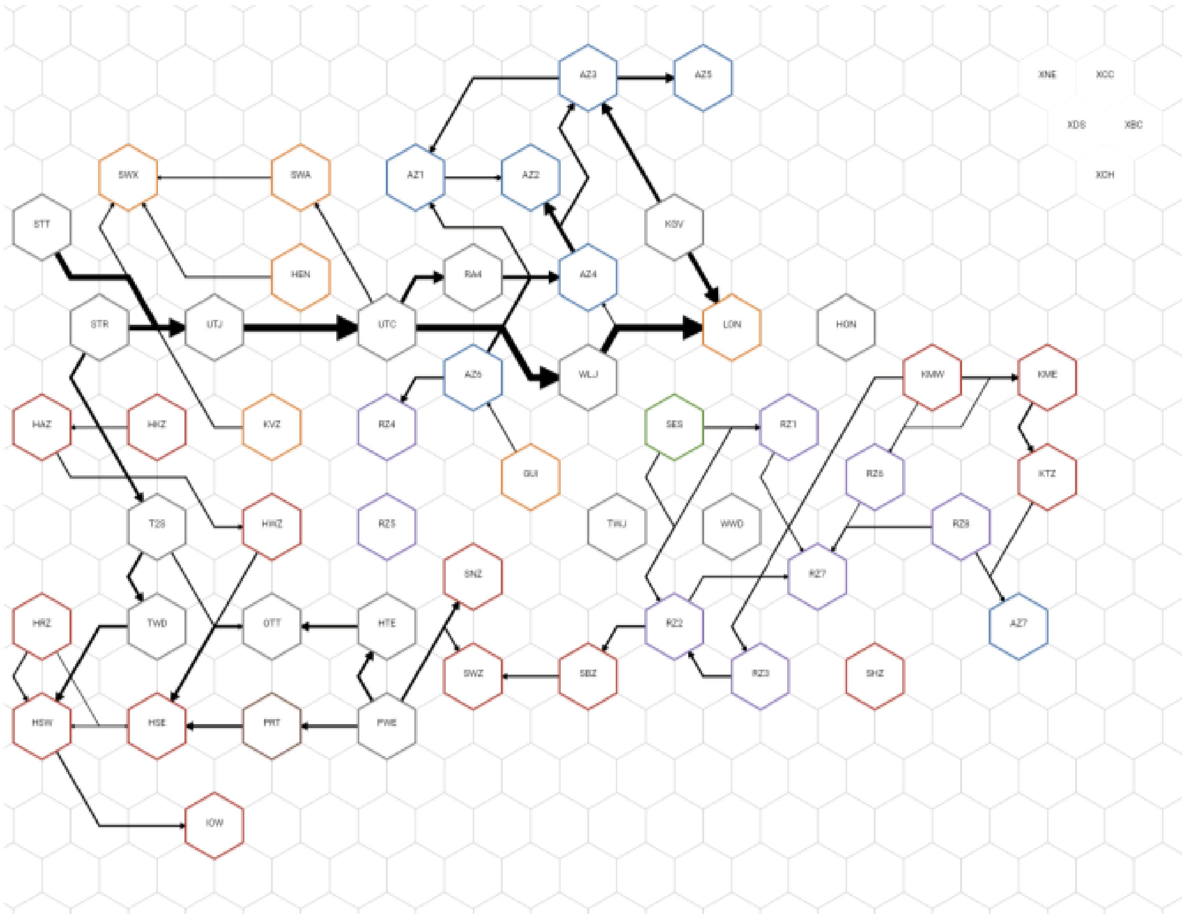


Figure 10-10: Example ‘hex’ transfer plot

10.131 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.

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

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

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

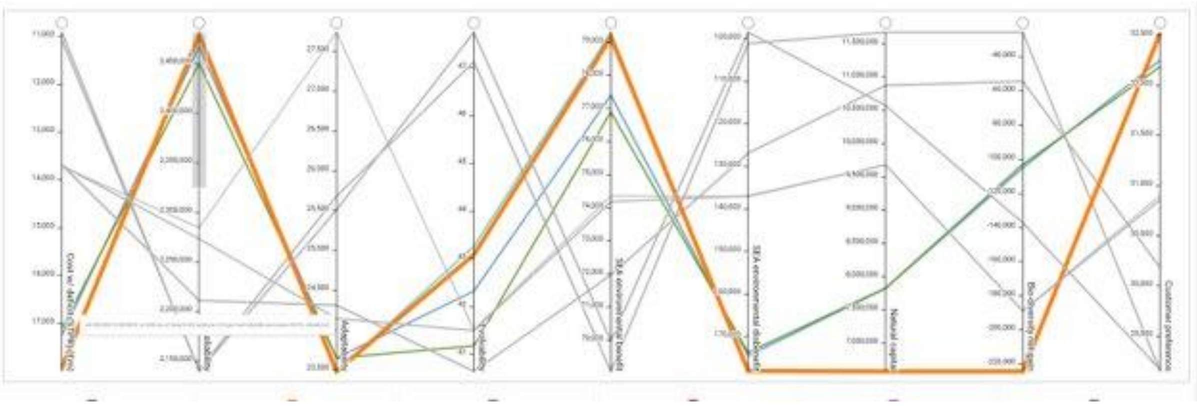


Figure 10-11: Example Parallel plot

10.135 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 10-12: Example Cost vs BVP Metric scatter plot

10.136 Each model run appears as a single dot on this plot. The cost is the average annuitized NPV cost across the nine pathways (or just pathway 4 as an alternative), 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.

10.137 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.

10.138 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

10.139 We begin by using the IVM to generate cost-based 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.

10.140 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.

10.141 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.

10.142 All costs incurred over this span (capital costs are annuitized) 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.

10.143 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.

10.144 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.

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

Discount rate	Average Cost (£bn NPV)
STPR	17.67
LTDR	19.30
IGEQ	25.99

Table 10-6: Least cost plan cost by discount rate

10.146 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.

10.147 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.

10.148 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

10.149 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.

10.150 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

10.151 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.

10.152 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 have 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.

10.153 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.

Cost-based outputs, single future

10.154 Initially, we want to assess the solutions when the model optimises (cost-based run using the STPR discount rate) each of the nine potential pathways separately. That is to say that the outputs only consider a single future and pathways are not adaptive.

10.155 As discussed earlier in the introductory sub-sections on the Best Value approach and our modelling, single future assessment represents a starting point. It subsequently enables us to compare outputs with a run that optimises across all pathways at once, and thus gain an understanding of the impact of adaptive hedging. The ability to model adaptively is an important advancement in modelling since WRMP19.

The metric table below provides a basis for comparison with the metric tables of alternative plan runs as we move through the programme appraisal process. The preferred pathway is shaded green and the core pathway in tan.

Metric	Pathway (individually optimised, non-adaptive)									
	1	2	3	4	5	6	7	8	9	AVE
Cost	20.51	17.01	15.42	19.04	16.90	15.26	17.47	16.10	14.18	16.88
NC	81,687,215	64,404,018	9,594,082	75,274,762	64,073,448	9,780,072	80,863,550	6,324,437	11,438,317	44,826,656
BNG	-212,965	-148,001	-181,862	-202,200	-142,220	-171,048	-147,286	-191,207	-145,551	-171,371
Env +	70,066	64,650	61,009	68,067	64,877	61,315	66,095	62,244	58,797	64,124
Env -	113,840	86,801	76,236	100,395	86,281	72,835	89,356	75,032	60,192	84,552
Cust_p	35,097	33,629	32,970	34,245	33,733	32,820	33,706	32,940	31,762	33,434
Reliab	31	27	28	31	27	28	30	30	31	29
Adapt	15	15	16	15	15	16	16	17	18	16
Evolv	20	19	21	19	19	21	21	23	24	21

Table 10-7: Single Future (cost-based) – regional-level metric outputs

10.156 We can observe the following trends in metric outputs between pathways 1-3 (highest population growth), 4-6 (LA Housing plan growth) and 7-9 (Trend based growth) linked to the level of supply and demand deficit being resolved:

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

10.157 The above trends also apply between 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.

10.158 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 include 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

- Natural capital costs are higher than those in the draft plan, due to a change in method whereby the values are now stated as a cumulative annual total over the planning period, rather than an average.
- Resilience metrics are lower than the draft because fewer resource options are required following the inclusion of new policy targets for demand.

10.159 The single future cost-based run, when optimised regionally, has an average NPV cost of £16.9 billion with a maximum of £20.5 billion and minimum of £14.2 billion.

10.160 These costs are higher than in the draft WRMP, primarily due to increased demand option costs (particularly for leakage control) and also the need for more demand management activity associated with meeting government targets for household and non-household demand.

10.161 With respect to the options selected in each pathway, a table of the selected resource and transfer elements are shown in the table below by the date the option is first utilised. The key Strategic Resource Options are in **bold**.

Option Name	WRZ	DO	Pathway (Individually optimised, non-adaptive)								
			1	2	3	4	5	6	7	8	9
Drought restrictions (Media, TUBs, NEUBs)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Company-led Demand Management (High)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government-led Demand Management (C+)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Teddington DRA	**LON**	**67**	**2033**			**2033**					
Licence transfer AFW (**GUC 50 Ml/d**)	LON	50	2033	2033	2033	2033	2033	2033	2033	2033	2033
GW - Moulsford	SWX	2	2033	2033	2033	2033	2033	2033	2033	2033	2033
GW - Woods Farm	SWX	2	2033	2073	2074	2040		2040			
Oxford Canal	SWX	12	2056			2040					
Oxford Canal	LON	10		2033	2033		2033	2033	2033	2033	2033
Reservoir - SESRO 150 Mm^3	**SWX**	**271**	**2040**			**2040**					
Reservoir - SESRO 75 Mm^3	**SWX**	**149**							**2040**		
Reservoir - SESRO 30 Mm^3	**SWX**	**66**		**2040**			**2040**				
STT300: Unsupported pipeline + Netheridge	**SWX**	**104**			**2052**			**2052**		**2040**	
STT300: Vyrnwy release 1 (25 Ml/d bypass)	**SWX**	**13**								**2070**	
Transfer - Henley to SWOX – 5 Ml/d	SWX	5	2040		2040	2040		2040			
Transfer – T2ST Kennet Valley spur	KEN	40	2042			2042			2050		
Transfer – SES Cheam to LON Merton	LON	15	2040	2033	2033	2050	2033	2033	2033	2033	2033
DRA – Medmenham	SWA	24	2050			2050			2050		
Transfer – SEW to Guildford	GUI	10	2050			2050					
GW – Datchet	SWA	2	2054			2051					
GW – Southfleet & Greenhithe	LON	9	2040	2033	2033	2052	2033	2033	2033	2033	2033
GW - Mortimer Recommission	KV	5	2059			2062					
GW - Addington	LON	3	2040	2033	2033	2068	2033	2033	2033	2033	2033
ASR - Horton Kirby	LON	5	2056	2033	2033	2070	2033	2033	2033	2033	2033

Option Name	WRZ	DO	Pathway (Individually optimised, non-adaptive)								
			1	2	3	4	5	6	7	8	9
GW - London Confined Chalk	LON	2	2059	2035	2035	2070			2033	2033	
GW - Merton Recommissioning	LON	2	2067	2035	2035	2072					
AR - Merton (SLARS3)	LON	6	2069			2074					
CM – Darent and Cray	LON	1	2075			2075	2035	2035	2033	2033	
Desalination – Beckton 150	LON	134	2050								
Water recycling - Deephams	**LON**	**42**	**2061**								
ASR – South East London	LON	3	2068	2033	2033		2033	2033			2033
ASR – Thames Valley Central	LON	3	2068								
Transfer – SES Woodmansterne to LON	LON	10	2070	2033	2033		2033	2033	2033	2033	2033
Water recycling - Mogden South Sewer	**LON**	**23**	**2072**								
AR Kidbrooke (SLARS1)	LON	8	2074								

Table 10-8: Single futures (cost based) – options selected (Thames)

10.162 In the early period of the forecast, to 2033, we can observe that:

- Demand management remains 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, by selecting the 'High' basket of options. Government-led demand management measures are also required in combination with the high company-led basket in order to meet the government's policy targets on water usage.
- 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 from a return period of 1:100 to 1:200 in the early 2030s we also need some resource development:
  - In pathways 1 and 4 (the most challenging pathways) the Teddington DRA scheme is selected, supported by groundwater development and the Oxford Canal scheme. We would also receive support from Affinity Water via a licence transfer at Egham, made possible by their development of the Grand Union Canal transfer and demand management savings.
  - In the other pathways the Teddington DRA scheme is not selected and is replaced by transfers from SES Water that should become available due to demand management savings in their supply area.
- The Teddington DRA scheme involves tertiary treatment of a portion of treated effluent flow from Mogden STW and then re-routing it to discharge 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

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

- In all pathways, demand management work continues. At this point the metering programme will be completed, with leakage reductions continuing towards and beyond the policy target of a 50% reduction from 2017-18 levels by 2050.
- In this period, in all but the most optimistic pathway (9) there is need for resource development to bring water into the west of the catchment and to share it with neighbouring companies
- The model selects the SESRO sized at 150Mm^3 in pathways 1 and 4, 75Mm^3 in pathway 7 and a 30Mm^3 in pathways 2 and 5
- The Severn-Thames Transfer (STT), sized at 300 Ml/d, capacity is selected in pathway 8, supported by Netheridge

10.164 By 2050 we will have met and exceeded our leakage reduction target and have delivered our environmental destination programme. We observe:

- In all pathways the company (High) and government-led (C+) demand management activity is forecast to have brought PCC down to the target of 110 l/p/d at Company and Regional level
- Continued investment in resource development is required in pathway 1, with the construction of a desalination plant at Beckton (150 Ml/d) in order to meet the high growth, environmental destination and climate change scenarios
- In Thames Valley, 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

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

- In Pathway 1, development of water recycling options at Mogden and Deephams alongside groundwater
- In Pathway 4, development of groundwater
- In Pathways 3 and 6, development of the STT 300 options supported by Netheridge. water recycling and desalination options also appear as further smaller internal and external transfers are also required and groundwater options.
- In pathway 8 a further STT support element is required in 2070
- Little further development is required in pathways 2, 5, 7 and 9

10.166 Overall, the outputs for the single future runs demonstrate some interesting patterns in the development of strategic resource options preferred by the cost-based modelling. In the core pathway (8), early resource sharing and groundwater development is followed by the STT. In the reported pathway (4), the increased need leads to the development of the Teddington DRA scheme alongside resource sharing and then the SESRO 150Mm^3, to meet planned growth and to enable high environmental destination.

10.167 However, this is just a first step and we are no longer restricted to the modelling of single futures. We now more on to investigate how the metrics and solutions would change if the model optimised adaptively, i.e. cognisant of the full potential range of futures rather than just one.

The Adaptive Least Cost Plan

10.168 The metric outputs of the adaptive least cost plan run (still using the STPR discount rate) are shown in the table below. The preferred pathway is shaded green and the Ofwat Core pathway shown in tan.

Metric	Pathway (adaptive)									
	1	2	3	4	5	6	7	8	9	AVE
Cost	20.53	17.66	16.99	19.05	17.55	16.80	17.60	16.75	16.06	17.67
Carbon	9,579,047	7,361,001	7,102,085	8,753,995	7,335,167	7,003,364	7,616,577	6,947,700	6,658,764	7,595,300
NC	81,558,380	77,108,628	79,953,049	75,242,447	77,050,016	79,699,195	80,870,399	81,648,863	84,520,786	79,739,085
BNG	-218,825	-154,246	-127,650	-204,324	-154,023	-128,380	-124,133	-96,975	-67,921	-141,831
Env +	69,276	63,943	63,099	67,149	63,619	62,710	63,882	61,608	60,552	63,982
Env -	113,350	81,960	75,599	99,769	79,604	73,499	83,904	70,527	61,680	82,210
Cust_p	33,935	31,847	31,498	33,042	31,693	31,300	31,706	30,797	30,307	31,792
Reliab	29	29	32	28	29	32	28	31	35	31
Adapt	14	16	18	14	16	17	15	18	20	16
Evolv	19	20	22	19	20	22	20	23	26	21

Table 10-9: Adaptive Least Cost Plan – regional-level metric outputs

10.169 The adaptive Least Cost plan, when optimised regionally, has an average NPV cost of £17.7 billion with a maximum of £20.5 billion and minimum of £16.1 billion.

10.170 The average cost across the pathways for the adaptive Least Cost Plan is on average £800m higher than the average cost of the single future solutions. However, this ranges from less than £20m in the challenging situations to over £1.8 billion in the least challenging.

10.171 This is expected as the adaptive model has to hedge that more (or less) challenging futures may occur and select options accordingly. It balances the potential for overinvestment and option under-utilisation against under-investment and the need for further reactive, potentially inefficient option development later in the planning period.

10.172 As such, it is the least challenging solutions that see the biggest uplifts in cost and changes in metrics (notably BNG and Natural Capital) due to the alternative schemes selected, whereas the challenging solutions are already meeting all or most of the need and therefore are largely unchanged from the single future solution.

10.173 With respect to the options selected in each of the adaptive 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 Resource Options are in **bold**.

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Drought restrictions (Media, TUBs, NEUBs)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
TW Integrated Demand Management (High)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government Led Demand Management (C+)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Teddington DRA	**LON**	**67**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**
Licence transfer AFW (**GUC 50 Ml/d**)	LON	50	2033	2033	2033	2033	2033	2033	2033	2033	2033
GW – Moulsford	SWX	2	2033	2033	2033	2033	2033	2033	2033	2033	2033

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Reservoir – SESRO 150 Mm^3	**SWX**	**271**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**			
Reservoir – SESRO 75 Mm^3	**SWX**	**149**							**2040**	**2040**	**2040**
GW - Woods Farm	SWX	2	2040			2040					
Transfer - Henley to SWOX – 2.4 Ml/d	SWX	2	2042			2040	2040	2040			
Oxford Canal (SWOX)	SWX	12	2058			2040					
Transfer - T2ST to Kennet Valley spur	KV	10	2042	2042	2042	2042	2042	2042	2042	2042	2042
Transfer – SES Cheam to LON Merton	LON	15	2040	2040	2040	2050					
DRA - Medmenham	SWA	24	2050			2050			2050		
GW - New River Head (Pump)	LON	3	2050			2050					
Transfer – SEW Hogsback to Guildford	GUI	10	2050			2050					
Transfer – SWOX (Horspath) to SWA	SWA	1	2050			2050					
GW - Datchet	SWA	2	2054			2051					
GW – Southfleet & Greenhithe	LON	9	2040			2052					
GW - Addington	LON	3	2040			2059					
GW - Mortimer	KV	5	2059			2067					
ASR Horton Kirby	LON	5	2055			2070					
GW - London Confined Chalk	LON	2	2059			2070					
GW - Merton Recommissioning	LON	2	2067			2072					
AR - Merton (SLARS3)	LON	6	2069			2074					
CM – Darent and Cray	LON	1	2075			2075					
Desalination - Beckton 150 Ml/d	LON	133	2050								
Transfer - Kennet Valley to Henley	HEN	2	2056								
Recycling - Deephams (to TLT)	**LON**	**47**	**2061**								
ASR - Thames Valley Central	LON	3	2068								
ASR - South East London (Addington)	LON	3	2068								
Transfer – SES (Woodmansterne) to Epsom	LON	10	2070								
Recycling - Mogden South Sewer	**LON**	**23**	**2072**								
AR - Kidbrooke (SLARS1)	LON	8	2074								

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

10.174 Compared to the non-adaptive single future runs, we can see that the options selected in the adaptive least cost run are now more consolidated. The model has reduced the number of strategic resource options, instead choosing ones that work best when having to hedge across all pathways. This consolidation in turn impacts the smaller options, with fewer options now needed to solve the less challenging pathways.

10.175 The adaptive Least Cost Plan to the early 2030s, when we plan to increase drought resilience from 1:100 to 1:200, includes the following across all pathways:

- Demand management continues to be the focus, as it was in WRMP19 and dWRMP24. The model outputs strongly suggest continuing with our key polices of leakage reduction, and encouraging usage reduction through metering and water efficiency. It also assumes the Government implements water labelling on appliances with minimum standards and encourages market transformation

- In line with our levels of service, we still require additional savings to be made during droughts in this period
- Resource development, principally the Teddington DRA scheme, supported by the sharing of resources with Affinity Water, whose supplies are augmented by the Grand Union Canal transfer scheme (50 Ml/d)
- In the period to 2030 the SESRO would also enter the planning process, given the long lead time for the scheme

10.176 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 2040, with the 150Mm^3 SESRO selected in pathways 1-6, where population growth follows the local authority housing plans or higher and the 75Mm^3 SESRO in pathways (7-9) where population growth follows the ONS18 principal forecast or lower scenario
- SESRO is selected in preference to the Severn-Thames Transfer (STT), which is consistent with the findings of WRMP19
- The water from the reservoir is shared between Thames Water, Affinity and Southern Water

10.177 By 2050 we will have met and exceeded 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 businesses, housing developers and manufacturers), to continue to drive market transformation. Particular attention will be needed on tightening building standards and regulations for water-using devices 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
- Internal transfers are also selected in order to distribute the water from SESRO 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

10.178 In the longer-term, further resource development is only required in pathways 1 (desalination, recycling and groundwater) and 4 (groundwater only).

Discussion (Preferred pathway)

10.179 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.

10.180 The selection of the Teddington DRA in 2033 remains our main resource development option, now supported by increased transfers from Affinity Water, made available by its inclusion of the Grand Union Canal option in its WRMP.

10.181 Following consultation on the draft plan, we received feedback from the local community on the Teddington DRA option. We have considered the concerns raised and have investigated alternatives in Stage 5 – sensitivity testing.

10.182 In 2040, in order to meet the requirements for increased drought resilience and to allow for proposed sustainability reductions to existing abstractions the adaptive least cost plan follows the non-adaptive solution by selecting SESRO 150Mm^3.

10.183 Output from SESRO would be shared by ourselves, Affinity Water and Southern Water.

10.184 We have explored within our sensitivity testing (see Stage 5), what would happen in the event that SESRO was no longer available.

10.185 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.

10.186 An in-combination, cumulative effects assessment of pathway 4 of the Least Cost Plan, has been completed as part of environmental assessment. A summary of the findings can be found in the Annex at the end of this section. Further information is provided in the following appendices:

- Appendix B - Strategic Environmental Assessment
- Appendix C – Habitats Regulation Assessment
- Appendix D – Water Framework Directive
- Appendix AA – Natural Capital and Bio-diversity Net Gain
- Appendix BB – INNS (invasive species)

10.187 A range of cumulative positive and negative impacts were identified, but at this stage none that would make this programme invalid.

10.188 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 water recycling) 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.

BVP metric-based plans

10.189 Having produced cost-based plans, we now look to improve value by extending the analysis to look at plans produced based on alternative best value planning (BVP) metrics.

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

10.191 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 (Environmental & Society or Resilience) at lowest cost
- Stepped increase in all BVP metrics at once at lowest cost

10.192 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.

10.193 Our view is that a WRMP that generated unnecessary surpluses would not be deemed an efficient plan, and so we sought to limit the degree to which the model built excess capacity.

10.194 When undertaking the second type of run, stepped increases for groups of metrics were undertaken at the same time (for example the environmental and society metrics or the resilience metrics). 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. In other words, it is possible to have an overall uplift within a grouping, but that some of the metrics could get worse. 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.

10.195 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.

10.196 We found that some environmental and 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 society and resilience metrics at the same time.

An Environmental and society-focused plan

Derivation

10.197 We have configured the model to find plans that increase the combined, aggregated 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)

10.198 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 adaptive Least Cost Plan (LCP) are shown in bold.

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	20.93	17.66	16.93	19.38	17.46	16.64	17.79	16.92	16.21	17.77
Carbon	9,901,874	7,387,877	7,070,709	8,955,498	7,500,154	6,981,319	7,882,114	7,007,665	6,670,444	7,706,406
NC	85,108,022	**81,330,185**	**84,296,487**	**82,655,299**	**81,692,048**	**84,214,246**	81,123,885	81,730,236	84,622,240	82,974,738
BNG	**-166,079**	**-120,333**	**-91,865**	**-172,101**	**-117,321**	**-99,790**	-116,524	-92,322	-67,332	**-115,963**
Env +	66,230	65,108	65,094	68,530	65,274	65,094	66,237	65,094	65,094	65,751
Env -	104,837	81,825	75,682	102,686	79,988	74,025	82,773	70,102	62,511	81,603
Cust_p	**36,750**	**35,377**	**35,066**	**36,736**	**35,210**	**34,964**	**35,248**	**34,597**	**34,112**	**35,340**
Reliab	28	**28**	**30**	**27**	**28**	**30**	29	32	36	30
Adapt	14	15	17	14	15	17	15	18	20	16
Evolv	19	20	22	19	20	22	20	23	26	21

Table 10-11: Environment and Society focused plan – regional-level metric outputs

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Drought restrictions (Media, TUBs, NEUBs)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
TW Integrated Demand Management (High)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government Led Demand Management (C+)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Teddington DRA	**LON**	**67**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**
Licence transfer AFW (**GUC 100 Ml/d**)	LON	50	2033	2033	2033	2033	2033	2033	2033	2033	2033
GW – Moulsford	SWX	2	2033	2033	2033	2033	2033	2033	2033	2033	2033
Reservoir – SESRO 75 Mm3	**SWX**	**149**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**
Oxford Canal (SWOX)	SWX	12	2070			2040					
Transfer - Henley to SWOX – 5 Ml/d	SWX	5				2040	2040	2040			
Transfer - T2ST to Kennet Valley spur	KV	10	2042	2042	2042	2042	2042	2042	2042	2042	2042
GW - Woods Farm	SWX	2	2040			2050					
GW – Southfleet & Greenhithe	LON	9	2040			2050					
DRA - Medmenham	SWA	24	2050			2050			2050		
Transfer – SEW Hogsback to Guildford	GUI	10	2050			2050					
Transfer – SWOX (Horspath) to SWA	SWA	1	2050			2050					
Transfer - Kennet Valley to Henley	HEN	2	2050			2050					
GW - Datchet	SWA	2				2050					

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Desalination - Beckton 100 Ml/d	LON	89				2050					
GW - Mortimer	KV	5	2040			2051					
Transfer – SES Cheam to LON Merton	LON	15	2040	2040	2040	2053					
GW - Addington	LON	3	2073			2063					
AR - Kidbrooke (SLARS1)	LON	8	2074			2069					
ASR Horton Kirby	LON	5	2057			2070					
GW - London Confined Chalk	LON	2				2070					
CM – Darent and Cray	LON	1				2070					
GW - Merton Recommissioning	LON	2				2072					
AR - Merton (SLARS3)	LON	6				2074					
Transfer – SES (Woodmansterne) to Epsom	LON	10	2040	2040	2040						
Transfer - Henley to SWOX – 2.4 Ml/d	SWX	2	2042								
Desalination - Beckton 150 Ml/d	LON	133	2050								
STT300 pipeline + Netheridge	**SWX**	**104**	**2050**								
GW - New River Head (Pump)	LON	3	2059								
Recycling – Deephams (to KGV)	**LON**	**47**	**2064**								
ASR - South East London (Addington)	LON	3	2070								
300: Lake Vyrnwy stage 1 (25Ml/d)	**SWX**	**13**	**2071**								
GW - East Woodhay pumps	KV	2po	2072								
300: Lake Vyrnwy stage 2 (25Ml/d)	**SWX**	**16**	**2075**								

Table 10-12: Environment and Society Plan – TW options selected

10.199 The Environment and society focused plan, when optimised regionally, has an average NPV cost of £17.8 billion with a maximum of £20.9 billion and minimum of £16.2 billion. This is on average £100m higher than the adaptive LCP, £150m higher in Pathway 8 and £331m higher in Pathway 4.

10.200 The principal change in BVP metric performance versus the LCP is a c.20% improvement in bio-diversity net gain, which overshadows smaller negative movements in Natural Capital (-4%), SEA Environmental Benefit (-3%) and Carbon emissions (-1%).

10.201 This improvement is brought about by reducing the size of the SESRO option to 75 Mm^3. The reduced output of SESRO is replaced by the earlier (2033) upsizing of the Grand Union Canal option to 100 Ml/d and the inclusion of a desalination (pathway 4) or the Severn-Thames transfer (300 Ml/d pipeline in pathway 1) in 2050.

10.202 Overall, as expected, we can observe that it is possible to increase BVP performance by trading-off performance with other metrics. We can also observe that the impacts vary across the pathways. Whilst potentially appearing to be a favourable trade-off at lower levels of challenge, the increased cost of replacing the reduced SESRO capacity at higher levels of challenge, including pathway 4 which meets the requirements of the

Water Resources Planning Guideline, is an outcome to be considered further later in this section.

10.203 An in-combination, cumulative effects assessment of pathway 4 of the Least Cost Plan, has been completed as part of environmental assessment. A summary of the findings can be found in the Annex at the end of this section. Further information is provided in the following appendices:

- Appendix B - Strategic Environmental Assessment
- Appendix C – Habitats Regulation Assessment
- Appendix D – Water Framework Directive
- Appendix AA – Natural Capital and Bio-diversity Net Gain
- Appendix BB – INNS (invasive species)

10.204 A range of cumulative positive and negative impacts were identified, but at this stage none that would make this programme invalid.

A Resilience-focused plan

Derivation

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

Outputs (across all pathways)

10.206 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.

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	20.85	17.43	16.73	19.38	17.32	16.54	17.62	16.77	16.08	17.63
Carbon	9,812,498	7,243,935	6,979,808	8,973,344	7,206,963	6,876,152	7,637,067	6,958,514	6,663,627	7,594,656
NC	84,358,115	**81,291,106**	**84,135,851**	77,815,049	**81,338,202**	**83,885,992**	80,965,871	81,728,691	84,600,613	82,235,499
BNG	**-189,408**	**-121,220**	**-94,886**	**-170,954**	**-114,312**	**-92,664**	-121,041	-93,500	-64,446	**-118,048**
Env +	71,169	65,623	64,006	69,397	65,016	63,789	65,723	63,528	62,472	65,636
Env -	115,704	85,635	76,078	104,493	80,318	74,831	85,424	72,421	63,574	84,275
Cust_p	34,393	32,419	31,823	33,788	32,070	31,600	32,067	31,152	30,662	32,219
Reliab	28	28	**30**	28	28	**30**	29	32	35	30
Adapt	14	15	17	14	15	17	16	18	20	16
Evolv	20	20	22	**20**	20	22	20	23	26	22

Table 10-13: Resilience-focused plan – regional-level metric outputs

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Drought restrictions (Media, TUBs, NEUBs)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
TW Integrated Demand Management (High)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government Led Demand Management (C+)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Teddington DRA	**LON**	**67**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**
Licence transfer AFW (**GUC 50 Ml/d**)	LON	50	2033	2033	2033	2033	2033	2033	2033	2033	2033
GW – Moulsford	SWX	2	2033	2033	2033	2033	2033	2033	2033	2033	2033
Reservoir – SESRO 75 Mm3	**SWX**	**149**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**
GW – Southfleet & Greenhithe	LON	9	2033	2033	2033	2033	2033	2033	2033	2033	2033
GW - Woods Farm	SWX	2	2040			2040					
Transfer - Henley to SWOX – 2.4 Ml/d	SWX	2	2042			2040	2040	2040			
Oxford Canal (SWOX)	SWX	12				2040					
Transfer - T2ST to Kennet Valley spur	KV	10	2042	2042	2042	2042	2042	2042	2042	2042	2042
DRA - Medmenham	SWA	24	2050			2050			2050		
Transfer – SEW Hogsback to Guildford	GUI	10	2050			2050					
Transfer – SWOX (Horspath) to SWA	SWA	1	2050			2050					
STT300 pipeline + Netheridge	**SWX**	**104**	**2050**			**2050**					
GW - New River Head (Pump)	LON	3	2051			2050					
Transfer - Kennet Valley to Henley	HEN	2	2053			2050					
GW - Datchet	SWA	2	2060			2050					
GW - Addington	LON	3	2040			2051					
ASR Horton Kirby	LON	5	2050			2054					
GW - Mortimer	KV	5	2045			2055					
Transfer – SES Cheam to LON Merton	LON	15	2040	2040	2040	2058					
CM – Darent and Cray	LON	1	2070	2075		2065	2075				
300: Lake Vyrnwy stage 1 (25Mld - 0-25)	**SWX**	**13**	**2059**			**2070**					
300: Lake Vyrnwy stage 2 (25Mld - 26-50)	**SWX**	**16**	**2070**			**2075**					
Transfer - Kennet Valley to SWOX - 6.7 Ml/d	SWX	6.7	2045								
Oxford Canal (LON)	LON	10	2045								
GW - London Confined Chalk	LON	2	2050								
Desalination - Beckton 150 Ml/d	LON	133	2050								
Recycling - Deephams (to TLT)	**LON**	**47**	**2061**								
ASR - Thames Valley Central	LON	3	2068								

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
300: Lake Vyrnwy stage 3 (30Mld - 51-80)	**SWX**	**19**	**2070**								
GW - Merton Recommissioning	LON	2	2072								
AR - Merton (SLARS3)	LON	6	2074								
300: Lake Vyrnwy stage 4 (30Mld - 81-110)	**SWX**	**19**	**2075**								

Table 10-14: Resilience Plan – TW options selected

10.207 The Resilience-based plan, when optimised regionally, has an average NPV cost of £17.6 billion with a maximum of £20.9 billion and minimum of £16.1 billion. Pathway 4 is £325 million (NPV, STPR) more expensive than the adaptive LCP, while pathway 8 is the same cost as the LCP. The average cost over the nine pathways is also close to the average for the LCP.

10.208 The BVP metric values for resilience are not materially different compared to the Least Cost Plan. There is some minor rebalancing between the pathways, but overall the impact is marginal. Nevertheless, the raw modelling outputs are similar to those from the Best Environment and society run, driven by the reduction in SESRO size. However, in this case the solution does not include the upsizing of GUC or any desalination options, with STT providing the extra volume required to offset the reduced reservoir size in pathways 1 and 4.

10.209 Overall, we were surprised that a resilience focussed run did not choose to upsize the Grand Union Canal option or retain a larger reservoir size. We suspect that the resilience values between plans with different reservoir sizes must be relatively close when averaged across all 9 pathways. We return to this in sensitivity testing in Stage 5, where we examine the impact of different reservoir sizes in least cost runs and best value runs.

Improvement across all the metrics (BVP)

Derivation

10.210 We have configured the model to find plans that increase the combined output of all eight the environment and society and the resilience metrics. We refer to this as a general BVP uplift.

Outputs (across all pathways)

10.211 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.

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	20.87	17.62	16.89	19.49	17.54	16.75	17.86	17.00	16.28	17.81
Carbon	9,956,933	7,355,838	7,002,792	8,998,850	7,319,633	6,927,515	7,719,648	7,013,974	6,676,752	7,663,548
NC	84,043,162	**81,480,829**	**84,182,526**	**80,890,313**	**81,374,431**	**83,918,866**	80,975,953	81,730,202	84,622,206	82,579,832

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
BNG	-164,856	-110,190	-86,765	-164,462	-112,308	-91,042	-119,182	-92,300	-67,310	-112,046
Env +	66,405	65,094	65,094	68,077	65,116	65,094	66,292	65,094	65,094	65,707
Env -	104,845	78,718	71,382	103,159	76,153	71,264	82,317	69,386	61,837	79,896
Cust_p	36,861	35,405	34,878	37,103	35,341	34,976	35,382	34,641	34,201	35,421
Reliab	28	28	30	28	28	30	29	32	35	30
Adapt	15	15	17	14	15	17	16	18	20	16
Evolv	20	21	22	20	20	22	20	23	26	22

Table 10-15: General BVP uplift plan – regional-level metric outputs

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Drought restrictions (Media, TUBs, NEUBs)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
TW Integrated Demand Management (High)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government Led Demand Management (C+)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Teddington DRA	**LON**	**67**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**
Licence transfer AFW (GUC 100 Ml/d)	**LON**	**50**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**
GW – Moulsford	SWX	2	2033	2033	2033	2033	2033	2033	2033	2033	2033
Reservoir – SESRO 75 Mm3	**SWX**	**149**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**
Transfer – SES Cheam to LON Merton	LON	15	2033	2033	2033	2033	2033	2033	2033	2033	2033
GW - Woods Farm	SWX	2	2040			2040					
Transfer - Henley to SWOX – 2.4 Ml/d	SWX	2	2042			2040	2040	2040			
Oxford Canal (SWOX)	SWX	12	2073			2040					
Transfer - T2ST to Kennet Valley spur	KV	10	2042	2042	2042	2042	2042	2042	2042	2042	2042
DRA - Medmenham	SWA	24	2050			2050			2050		
Transfer – SEW Hogsback to Guildford	GUI	10	2050			2050					
Transfer – SWOX (Horspath) to SWA	SWA	1	2050			2050			2054		
Transfer - Kennet Valley to Henley	HEN	2	2050			2050			2050		
GW - Datchet	SWA	2				2050					
Desalination - Beckton 100 Ml/d	LON	89				2050					
GW - Addington	LON	3	2040			2051					
GW – Southfleet & Greenhithe	LON	9	2040			2053					
GW - Mortimer	KV	5	2062			2056					
GW - London Confined Chalk	LON	2	2061			2060					
ASR Horton Kirby	LON	5	2057			2061					
ASR - Thames Valley Central	LON	3	2068			2063					
ASR - South East London (Addington)	LON	3				2066					

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
CM – Darent and Cray	LON	1		2075		2070	2075				
GW - Merton Recommissioning	LON	2	2067			2072					
AR - Merton (SLARS3)	LON	6	2069			2074					
GW - New River Head (Pump)	LON	3	2050								
STT400 pipeline + Netheridge	SWX	131	2050								
400: Minworth STW diversion (115Mld)	SWX	74	2050								
400: Lake Vyrnwy stage 1 (25Mld - 0-25)	SWX	13	2058								
Recycling – Deephams (to KGV)	LON	47	2062								
400: Lake Vyrnwy stage 3 (30Mld - 51-80)	SWX	19	2070								
Transfer - Kennet Valley to SWOX - 6.7 Ml/d	SWX	6.7	2070								
400: Lake Vyrnwy stage 2 (25Mld - 26-50)	SWX	16	2071								
400: Lake Vyrnwy stage 4 (30Mld - 81-110)	SWX	19	2075								

Table 10-16: BVP Uplift Plan – TW options selected

10.212 The General BVP uplift plan, when optimised regionally, has an average NPV cost of £17.8 billion with a maximum of £20.9 billion and minimum of £16.3 billion. Again, this is very similar to the LCP and the Environment and society-focused plan. Pathway 4 is £429 million (NPV, STPR) more expensive than the LCP, while pathway 8 is £250 million more expensive. The average cost over the 9 pathways is £150m more expensive than the LCP.

10.213 This increase in cost is traded-off for improved metric performance across the combined BVP metrics, particularly driven by the improvement in BNG highlighted in the Environmental and Society run output.

10.214 The solution includes selecting:

- A larger temporary licence transfer from Affinity Water in 2033, associated with their construction of a larger Grand Union Canal transfer.
- An earlier transfer of treated water from SES Water (Cheam to Merton) in 2033 (instead of the 2040s (pathways 1-3) or 2050s, for pathway 4),
- A smaller 75Mm^3 reservoir in 2040 in all pathways.
- In pathway 1, the construction of STT (400 Ml/d pipeline) plus supporting elements post-2050, once the smaller SESRO capacity is utilised.
- In pathway 4, a desalination plant (100 Ml/d), post-2050, once the smaller SESRO capacity is utilised.

Overall observations on the BVP runs

10.215 The BVP runs shown that the model is able to find alternative solutions to the Least Cost Plan that offer improved best value performance in a trade-off with cost. We have also seen some commonality in the options selected by the model to achieve that improved performance.

10.216 We can summarise the relative performance of the runs described above using the Cost vs BVP Metric plot, introduced earlier in the section as one of the visualisation tools available to compare run performance.

10.217 Firstly, we plot BVP metric performance against cost across all 9 pathways (top) and then for the reporting pathway, pathway 4 (bottom).

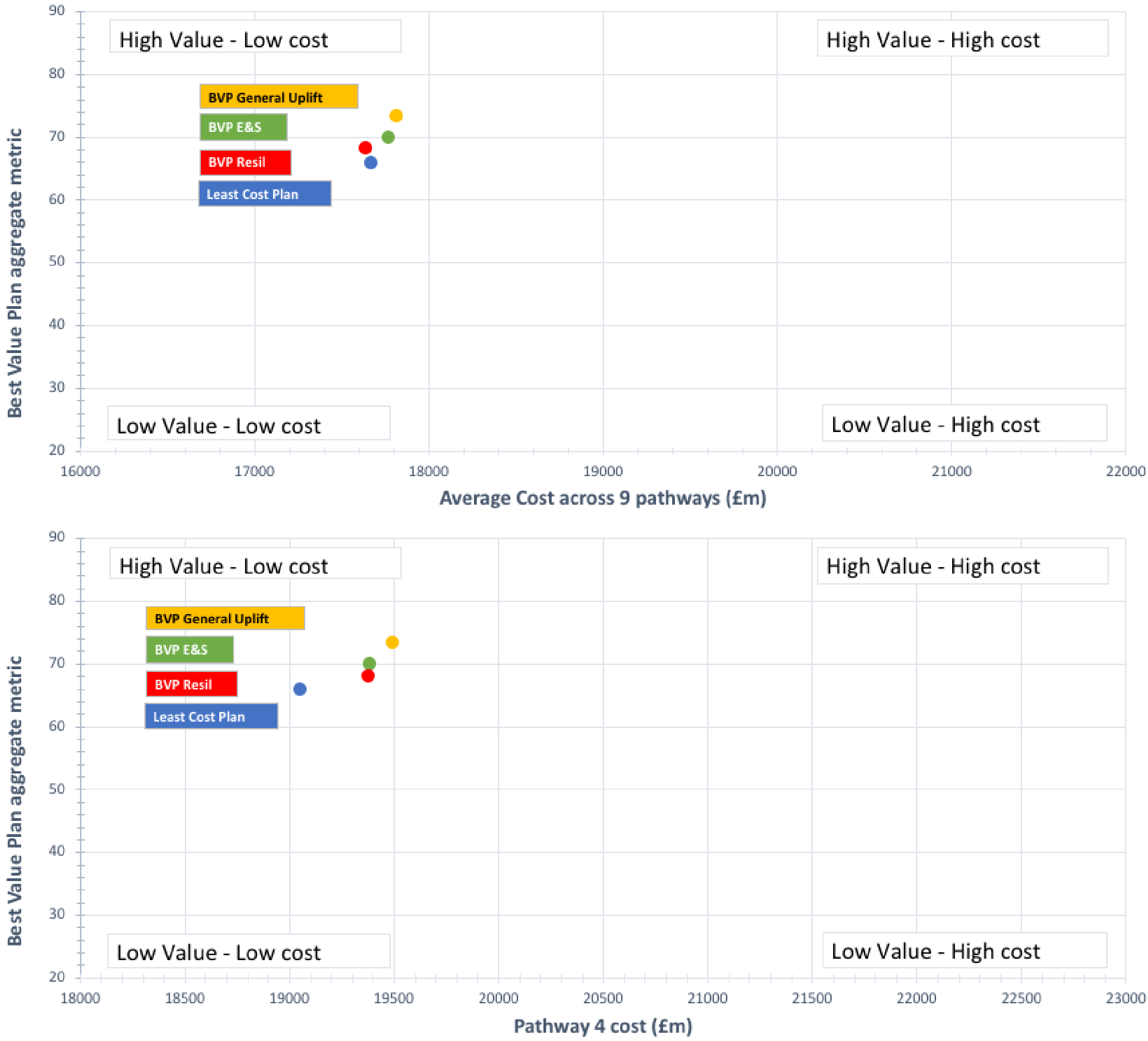


Figure 10-13: Cost vs BVP metric (v1)

10.218 In both plots we can see that, the BVP uplift runs increase best value performance for an increase in cost when compared to the Least Cost Plan. The best BVP performance is achieved when looking for general improvement on average across all of the BVP metrics (yellow dot). The cost of that improved performance is £150m when looking across all 9 pathways and £429m when looking at the cost of the programme for pathway 4 only.

10.219 Compared to the adaptive least cost run, there are similarities in the options selected in the BVP runs:

- No changes to the demand management options. In order to meet the government's Environmental Improvement Plan targets the company-led high basket of options are selected, alongside the government-led C+ profile
- Teddington DRA continues to be selected in 2033, supported by a licence transfer with Affinity Water enabled by their Grand Union Canal transfer scheme.
- SESRO is selected in all pathways.
- When required, desalination is a common selection for 2050 and beyond.
- Groundwater schemes and smaller local transfers are used to support local needs.

10.220 However, there are also differences in option selection that need further exploration in later stages of programme appraisal:

- Increased sharing of resource with our neighbours from 2033. This includes upsizing Grand Union Canal transfer, and also with SES Water, who are forecast to have capacity resulting from demand management savings
- SESRO is selected across all pathways at 75Mm^3, when the Least Cost Plan suggested a 150Mm^3 would be preferable in pathways 1-6
- In the longer-term the reduced contribution from SESRO is made up from desalination and/or the Severn Thames Transfer via pipeline is chosen in 2050 in pathway 1 and occasionally pathway 4
- The capacity of the transfer (300, 400 Ml/d) and how many elements are built after 2050 remains uncertain and is in competition with desalination, which is more regularly selected in pathway 4

10.221 It is important at this stage to remember these are raw model outputs. Variability is to be expected. We need to complete many more runs to better understand the solution space. This will allow us to understand the variability in programme outputs and identify whether there are other alternative plans in close proximity (in terms of cost and BVP metric performance) to these initial least cost and best value runs.

10.222 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 and better candidates to be the overall Best Value Plan.

Stage 5: Sensitivity testing

10.223 To this point we have examined alternative plans by looking at the same dataset under different lenses (Cost and aggregated BVP metrics).

10.224 In Stage 5, we produce alternative plans by changing the input dataset. This can include 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), or combinations of the above.

10.225 In total, over 150 sensitivity tests have been completed by WRSE in the development of the Regional Plan for water resources, The model runs most informative to our programme appraisal decisions are shown in the table below and discussed in the following sub-sections.

Topic	Name	Change
Demand Management Policy	Company demand reductions - Low basket only	Alternative company and government-led demand management delivery profiles used
	Government-led hybrid H	
	Government-led hybrid G	
Supply Options	No SESRO	All SESRO options excluded
	No SESRO or STT	All SESRO and STT options excluded
	150Mm^3 SESRO only	Only one size of SESRO available for selection in the model.
	125Mm^3 SESRO only	
	100Mm^3 SESRO only	
	75Mm^3 SESRO only	
	No Teddington DRA	Teddington DRA excluded
	Upsize GUC to 100	GUC 50 excluded
	Beckton Recycling 50 in 2033	The model must select this option in 2033 as an alternative to DRA
	Beckton Recycling 100 in 2033	
	Beckton Recycling 150 in 2033	
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 2040	
	1:500 by 2050	
	1:200 by 2035	Moving the date for achieving 1:200 resilience from 2033 to 2035.
Base Supply Capability	Gateway Capability	Gateway desalination plant output remains at 50 Ml/d, compared to the planned increase to 75 Ml/d by 2030
	Lower Thames Reductions	Lower Thames baseline DO is reduced, incl. River Thames flood scheme
	Lower Thames Reductions (mitigated by tunnel)	Tunnel option included as mitigation
	WBGWS withdrawn	West Berkshire GW scheme removed from 2040 or 2050

Topic	Name	Change
	ESW transfer	Agreement to reduce export ended from 2030 (instead of 2035)
Combinations	Gov-led H + No SESRO	Alternative Government-led savings profiles in combination with only certain sizes of SESRO available
	Gov-led H + SESRO 125 Mm^3	
	Gov-led H + SESRO 100 Mm^3	
	Gov-led H + SESRO 75 Mm^3	
	Gov-led G + SESRO 150 Mm^3	
	Gov-led G + SESRO 125 Mm^3	
	Gov-led G + SESRO 100 Mm^3	
	Gov-led G + SESRO 75 Mm^3	
	Resilience + SESRO 150Mm^3	Best value plan runs in combination with only certain sizes of SESRO available
	Resilience + SESRO 125Mm^3	
	Resilience + SESRO 100Mm^3	
	Resilience + SESRO 75Mm^3	
	E&S + SESRO 150Mm^3	
	E&S + SESRO 125Mm^3	
	E&S + SESRO 100Mm^3	
	E&S + SESRO 75 Mm^3	
	General BVP + SESRO 150Mm^3	
	General BVP + SESRO 125Mm^3	
	General BVP + SESRO 100Mm^3	
	General BVP + SESRO 75Mm^3	

Table 10-17: List of sensitivity tests

10.226 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 Demand Management Policy

10.227 Demand levels are not controlled by water companies or by the Government, but we each have options available to us to encourage the efficient use of water. The challenge to meet the leakage and usage targets set by Government in the Environment Improvement Plan will need concerted effort from all water users. This challenge should not be underestimated or the savings over-estimated, therefore it is important that we examine a range of alternative forecasts for demand management.

10.228 Here we explore different company-led and government-led demand management profiles and examine 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:

Gov-led activity level	Action	Additional PCC saving
Low	Water Labelling (no minimum standards)	6 l/h/d
Medium	Water Labelling (with minimum standards)	A further 6 l/h/d (12 total)
High	Full government support (optimistic for water labelling with minimum standards, plus enhanced support on new developments)	A further 12 l/h/d (24 total)

Table 10-18: Government-led activity levels

10.229 At draft stage we had included the low level of activity within our baseline demand forecast. In response to representations to the consultation and changes to the Water Resources Planning Guideline we have now removed them from our baseline forecast.

10.230 These activity levels have been combined by WRSE to form ten alternative Government-led savings profiles.

10.231 In order to reach the ambitious targets required for leakage, household and non-household demand, to this point we have seen that the model routinely requires the high basket of company-led demand management options and the 'C+' government-led demand management (24 l/h/d). By 2050, these combined measures are forecast to save 686 Ml/d (391 and 295 Ml/d respectively).

10.232 We have chosen two alternative government-led savings profiles to test. Profile H which assumes only a low level of government-led savings (6 l/h/d) will be achieved and profile G, which is slower to start and achieves 18 l/h/d savings.

10.233 We have also tested the company-led low basket.

10.234 It is important to note that none of these alternatives would enable us to achieve the government's target of 110 l/h/d by 2050.

Scenario	Profile	Saving by 2050 (Ml/d)
Company-led High		391
Company-led Low		250 (-141)
Gov-led C+	Low from 2025; Med from 2030; High from 2035 full cumulative benefits by 2050	295
Gov- led G	Low from 2030; High from 2040, full cumulative benefit by 2055	231 (-64)
Gov-led H	Low from 2025, full cumulative benefits by 2040	76 (-219)

Table 10-19: Demand management sensitivity tests

Metric	Least Cost (Company-led High & Gov-led C+)	Company-led Low	Government-led H	Government-led G
Pathway 4				
Cost	19.05	20.30	21,69	20.71
Carbon	8,753,995	10,461,190	9,807,663	9,769,134
Natural Capital	75,242,447	81,779,467	73,791,385	78,752,047
Bio Net Gain	-204,324	-186,652	-216,079	-223,135
SEA Env +	67,149	55,867	69,343	69,250
SEA Env -	99,769	118,171	109,737	112,198
Cust_preference	33,042	34,661	34,222	34,147
Reliability	28	28	31	31
Adaptability	14	14	15	14
Evolvability	19	19	19	19
Large Options First Utilisation Date	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)
	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)
	SESRO 150 (2040)	SES transfer (2033)	SES transfer (2033)	SES transfer (2033)
	SES transfer (2050)	SESRO 75 (2040)	SESRO 150 (2040)	SESRO 150 (2040)
		STT300 Pipeline (2050-75)	Beckton Desal 150 (2050)	Beckton Desal 100 (2050)
		Beckton Desal 100 (2050)	STT 400 Pipeline (2050-59)	

Table 10-20: Sensitivity run outputs – Demand management

10.235 We can observe that company-led and government-led demand management scenarios are an important influence on cost and BVP metric performance and in terms of the programmes of options selected.

10.236 If the company-led demand programme only delivers the equivalent savings of the low basket instead of the high, the overall cost of the programme for pathway 4 would increase by £1.25 billion as additional resource development would be required to make up the short-fall. This would include the upsizing of the Grand Union Canal and licence transfer from Affinity Water. Transfers would also be required from SES Water. Additionally, some smaller groundwater schemes would be brought forward from later in the least cost programme. In the longer term, a second large scheme would be needed after SESRO in 2050, with the model selecting a Severn Thames Transfer pipeline (300Ml/d capacity) and a further 100 Ml/d desalination plant at Beckton.

10.237 If the government-led demand management measures underdeliver, the impacts are even more severe, with potentially between £1.7 billion (profile G) and £2.6 billion (profile H) of extra investment required in pathway 4. The transfers from Affinity Water and SES Water would again be required, assuming sufficient surpluses are available. SESRO 150 Mm^3 remains unchanged in 2040 in both cases. but with a desalination plant being selected in 2050 in both cases, and a Severn-Thames Transfer if only low government savings are achieved.

10.238 Overall, we conclude that demand management underperformance would require more water resource development. A third and potentially fourth large scheme would have to be brought online to make up for the short-fall. It is essential that we deliver our company-led forecast and that there is a step change in support from government to tighten regulations and standards and drive market transformation. Equally, we should be prepared to bring alternative or additional schemes online as soon as possible if necessary, which will require that these options continue to be progressed.

Changes in Option availability/capability

Upper Thames (SESRO and STT)

10.239 In these sensitivity runs we have either excluded SESRO, excluded both SESRO and STT or only allowed the model to select a certain size of SESRO. The remaining option types are unchanged.

Metric	Least Cost	No SESRO	No SESRO or STT	SESRO 150 Only	SESRO 125 Only	SESRO 100 Only	SESRO 75 Only
Pathway 4							
Cost	19.05	19.68	20.00	19.05	19.2	19.27	19.37
Carbon	8,753,995	9,723,054	9,080,120	8,762,053	8,843,227	8,921,619	8,934,869
Natural Capital	75,242,447	3,433,466	3,595,856	75,268,234	77,437,185	78,170,977	79,672,258
Bio Net Gain	-204,324	-242,921	-117,433	-202,738	-187,850	-182,146	-161,377
SEA Env +	67,149	65,210	65,499	67,206	66,521	67,014	66,373
SEA Env -	99,769	97,836	99,052	99,970	97,286	100,581	99,156
Cust_preference	33,042	33,225	33,183	33,102	32,995	33,159	33,008
Reliability	28	27	27	28	28	28	27
Adaptability	14	13	14	14	14	14	14
Evolvability	19	19	19	19	19	19	19

Metric	Least Cost	No SESRO	No SESRO or STT	SESRO 150 Only	SESRO 125 Only	SESRO 100 Only	SESRO 75 Only
Large Options First Utilisation Date	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)
	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)
	SESRO 150 (2040)	STT 300 pipe (phased (2040-70)	Reservoir - Marsh Gibbon 50 (2040)	SESRO 150 (2040)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)
	SES transfer (2050)		SES transfer (2050)	SES transfer (2050)	SES transfer (2054)	SES transfer (2050)	SES transfers (2053&2070)
			Beckton Desal 100 (2050)			Deephams (2061)	Beckton Desal 100 (2050)
			Deephams (2069)				

Table 10-21: Sensitivity run outputs – option availability (SESRO)

10.240 Excluding all SESRO options from selection forces the model to find an alternative and, as expected, given the need to provide water in the West of the Region, the STT pipeline is chosen by the model. The 300 Ml/d size variant is selected, with flow support stages from Netheridge, Minworth and Vyrnwy from 2040 through to 2070. It also chooses to upsize GUC to 100 and increase the transfer from Affinity, which is common response across the majority of sensitivity tests.

10.241 In metric terms the No SESRO solution is £630m NPV more expensive than least cost, provides substantially lower natural capital (as the STT does provide as much opportunity for natural capital increases) and requires more money to offset carbon emissions and credits to ensure biodiversity net gain.

10.242 With no SESRO or STT options available, the solution is £1bn more expensive than least cost and includes alternative reservoir storage at Marsh Gibbon. With all reservoir sites excluded as well as STT (not shown in the table above), the model is not able to solve the deficit. This highlights the importance of strategic resource development within the Upper Thames.

10.243 Of the alternative reservoir sizes, we note that cost increases as the size is reduced, with the programme containing the 75Mm^3 being £320m more expensive in pathway 4.

10.244 If SESRO is re-sized from 150Mm^3 to 100Mm^3 (a c.100Ml/d reduction in DO), the model builds a larger GUC (2033), includes a transfer from SES Water (2050) and then Deephams recycling plant (2061). If SESRO is resized to 75Mm^3 (a 122 Ml/d reduction in DO), a 100 Ml/d desalination plant at Beckton is required in 2050 and both SES Transfers in 2053 and 2070..

Other options (Teddington DRA, GUC and Beckton Recycling)

10.245 In these sensitivity runs we examined potential alternatives to the commonly selected Teddington DRA scheme in 2033.

Metric	Least Cost	No Teddington DRA	Upsize Grand Union Canal	Beckton Recycling 50 in 2033	Beckton Recycling 100 in 2033	Beckton Recycling 150 in 2033
Pathway 4						
Cost	19.05	19.26	19.21	19.70	19.94	20.02
Carbon	8,753,995	8,765,492	8,854,593	9,027,860	9,031,073	9,152,905
Natural Capital	75,242,447	75,553,168	77,452,821	77,189,985	79,426,287	77,986,481
Bio Net Gain	-204,324	-197,779	-185,990	-196,564	-172,354	-181,876
SEA Env +	67,149	66,834	66,539	67,308	67,336	67,227
SEA Env -	99,769	100,680	97,200	102,921	104,185	99,219
Cust_preference	33,042	33,109	32,962	33,326	33,248	33,029
Reliability	28	28	28	28	27	28
Adaptability	14	14	14	14	14	14
Evolvability	19	19	19	19	19	19
Large Options First Utilisation Date	Teddington (2033)	AFW GUC 100 transfer (2033)	Teddington (2033)	AFW GUC 50 transfer (2033)	AFW GUC 50 transfer (2033)	AFW GUC 50 transfer (2033)
	AFW GUC 50 transfer (2033)	SES transfer (both in 2033)	AFW GUC 100 transfer (2033)	Beckton recycling 50 (2033)	Beckton recycling 100 (2033)	Beckton recycling 150 (2033)
	SESRO 150 (2040)	7x GW (2033)	SESRO 125 (2040)	SES transfer (2033)	SESRO 75 (2040)	SESRO 100 (2040)
	SES transfer (2050)	SESRO 150 (2040)	SES transfer (2052)	SESRO 100 (2040)	Teddington (2050)	Teddington (2050)
		Deephams Recycling (2069)		Teddington (2050)	Crossness Desal 50 (2050)	SES transfer (2070)
					SES transfer (2050s)	

Table 10-22: Sensitivity run outputs – option availability (Other)

10.246 In the draft WRMP24, removing Teddington DRA resulted in its replacement with a water recycling plant at Beckton at an increased cost of £450m. We can see in this assessment that Teddington DRA can be replaced by temporary transfers in from neighbouring water companies and the bringing forward of a large number of groundwater options, at an increased cost of £210m.

10.247 However, this would make us reliant on the donor companies being able to deliver the schemes they need to deliver (demand management and GUC) in order to make available surplus to us. This is not without risk given the ambitious, policy-led demand management requirements. Additionally, bringing forward a large number of groundwater options reduces future flexibility as these schemes are ideal smaller options for dealing with minor deviations from the forecast as they arise.

10.248 We have noted that the upsizing of Affinity Water's Grand Union Canal option is a regular feature of the alternative programmes, so we looked at the impact of this individual change. We can see that upsizing costs an additional £160m to the programme with relatively minor impacts on the wider BVP metrics. The additional water available means that a slightly smaller SESRO at 125Mm^3 is required in 2040.

10.249 To examine the impact of replacing the combined impact of these smaller options and transfers, we have also tested forcing in a water recycling plant at Beckton of various sizes. We can see that this would come with greater cost (£650m-£1bn) and carbon impacts.

10.250 In these cases, Teddington DRA is deferred to 2050 and we also see that increasing the water available in the 2030s impacts the size of SESRO selected in 2040.

10.251 Overall, these sensitivities suggest that replacing the Teddington DRA scheme would not represent good value at a programme level.

Changes in Policy – Drought Resilience Delivery Dates

Metric	Least Cost (1:200 in 2033 1:500 in 2040)	1:200 in 2035	1:500 in 2035	1:500 in 2045	1:500 in 2050
Pathway 4					
Cost	19.05	19.18	19.87	19.45	19.21
Carbon	8,753,995	8,856,267	9,008,715	8,959,742	8,795,128
Natural Capital	75,242,447	75,553,727	78,409,978	78,116,497	75,509,425
Bio Net Gain	-204,324	-197,575	-208,101	-167,102	-205,946
SEA Env +	67,149	66,453	67,330	67,493	66,997
SEA Env -	99,769	94,520	102,534	100,444	99,912
Cust_preference	33,042	32,727	33,453	33,247	33,012
Reliability	28	29	29	27	28
Adaptability	14	14	14	14	14
Evolvability	19	19	19	19	19
Large Options First Utilisation Date	Teddington (2033)	AFW GUC 100 transfer (2033)	Teddington (2031)	Teddington (2031)	Teddington (2031)
	AFW GUC 50 transfer (2033)	SES transfers (both 2036)	AFW GUC transfer 100 (2031)	AFW GUC transfer 50 (2031)	AFC GUC transfer 50 (2031)
	SESRO 150 (2040)	SESRO 150 (2040)	SES transfers (both 2035)	SESRO 75 (2040)	SESRO 150 (2040)
	SES transfer (2050)	Teddington (2050)	SESRO 150 (2040)	STT300 Pipeline (2050)	SES transfers (2057&65)
				SES transfers (2050&65)	

Table 10-23: Sensitivity run outputs – Drought resilience delivery dates

10.252 We are required in the WRPG to improve the resilience of our supply system to drought. This means reaching a 1:200 level of resilience as soon as possible and a 1:500 level of resilience by 2039/40. Our least cost plan achieves this in 2033 and 2040 respectively, but what is the impact if we change these dates?

10.253 By bringing forward the date of 1:500 drought resilience to 2035, we can see the model upsizes and brings schemes forward to meet the additional requirement. This comes at an extra £820bn cost. It does not alter the selection of SESRO 150 in 2040.

10.254 The three tests that defer the implementation of drought resilience dates indicate that this would not reduce the cost of the solutions for pathway 4. Deferring the delivery date of 1:200 drought resilience to 2035 (from 2033) increases the cost in pathway 4 by £130 million NPV compared to the least cost plan. Deferring the delivery date of 1:500 resilience from 2040 to 2045 or 2050 increases cost by between £160m and £400m

10.255 In the case of the 1:200 deferral, the cost increases as the model chooses to upsize the Grand Union Canal transfer and bring forward the transfers with SES Water. These costs are higher than the amount saved by the 2-year deferral of investment for resilience and the deferral of the Teddington DRA scheme to 2050. Reservoir selection is unchanged.

10.256 Unlike in the draft plan when deferring 1:500 resilience led to the deferral of the strategic resource option chosen, in the revised draft plan no deferral of the 2040 option takes place. This indicates that the selection of an option in 2040 is primarily driven by environmental need.

10.257 We do see that in the 5-year deferral the model chooses to reduce the size of SESRO to 75 Mm^3 and to develop a Severn-Thames transfer in 2050, however if the date is put back further to 10-years it reverts to the 150 Mm^3 size selected in the least cost plan with no STT.

10.258 Overall, these results do not support changing drought resilience dates as part of a best value plan.

Changes in Base Supply Capability

10.259 In Section 4 and Appendix CC we have set out a variety of risks to our base supply capability in the London WRZ. In this sub-section we examine the impact of a potential change in base supply capability. The change in the input data set for each run is described below:

- Gateway at 50Ml/d – In this test the Gateway plant will have a capability of 50Ml/d over the planning period. The maximum impact is 25 Ml/d in the London WRZ.
- Lower Thames – Operating during the 2022 drought revealed two risks, one related to abstraction capability at low flows and the other the potential impact of the EA/Surrey County Council River Thames Scheme (planned for 2030), which potentially derogates our ability to abstract. The maximum impact is 236 Ml/d in the London WRZ.
- Lower Thames (incl. Tunnel) – This run shows the impact of a new tunnel to mitigate the losses from the above risks on the Lower Thames.
- WBGWS – The Environment Agency own and operate a groundwater augmentation scheme (the West Berkshire GW Scheme) that operates during a drought. We have been asked to explore the impact of non-operation of this scheme at a range of dates, we include the impact from 2050 here. The maximum impact is 74 Ml/d in the London WRZ.

- ESW transfer – We assess the impact of early return to Essex and Suffolk Water of their full entitlement for the Chingford bulk supply export. The Impact is 20 Ml/d in 2030-35 in the London WRZ.

Metric	Least Cost	Gateway remains at 50 Ml/d	Lower Thames Base DO	Lower Thames (incl. Tunnel)	WBGWS withdrawn from 2040	WBGWS withdrawn from 2050	ESW Transfer
Pathway 4							
Cost	19.05	19.42	21.83	19.56	19.66	19.54	19.27
Carbon	8,753,995	8,986,079	10,251,219	9,019,574	9,107,392	9,070,632	8,891,679
Natural Capital	75,242,447	77,785,726	75,535,721	75,570,441	79,750,859	75,499,771	75,481,231
Bio Net Gain	-204,324	-172,506	-208,092	-196,740	-202,531	-201,160	-199,087
SEA Env +	67,149	68,166	69,426	66,509	68,219	67,697	67,026
SEA Env -	99,769	104,495	108,358	96,452	103,141	100,731	95,095
Cust_preference	33,042	33,619	34,080	33,058	33,583	33,258	32,901
Reliability	28	27	30	26	29	29	28
Adaptability	14	14	14	13	14	14	15
Evolvability	19	19	20	17	19	19	19
Large Options First Utilisation Date	Teddington (2033)	Teddington (2033)	DEFICIT (2026-34)	DEFICIT (2026-34)	Teddington (2033)	Teddington (2033)	Didcot (2030)
	AFW GUC 50 transfer (2033)	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	Teddington (2033)
	SESRO 150 (2040)	SES transfers (2033 &35)	Teddington (2033)	Lower Thames Tunnel (2034)	SESRO 150 (2040)	SESRO 150 (2040)	AFW GUC 100 transfer (2033)
	SES transfer (2050)	SESRO 75 (2040)	Beckton Recycling 150 (2034)	SES transfer (2034)	SES transfers (both 2050)	SES transfers (both 2050)	SES transfer (2033)
		STT300 Pipeline (2050-75)	SES transfers (both 2034)	SESRO 150 (2040)	Deephams Recycling (2063)	Deephams Recycling (2064)	SESRO 150 (2040)
			SESRO 150 (2040)	Teddington 50 (2040)			
			Crossness Desalination 50 (2050)				

Metric	Least Cost	Gateway remains at 50 Ml/d	Lower Thames Base DO	Lower Thames (incl. Tunnel)	WBGWS withdrawn from 2040	WBGWS withdrawn from 2050	ESW Transfer
			Deephams Recycling (2074)				

Table 10-24: Sensitivity run outputs – Base supply capability

10.260 All of these risks have a potential negative impact on our supply capability. The impact is a function of how quickly solutions would need to be found and how big the step change would be.

10.261 Changes later in the planning period such as those from the WBGWS can be managed through upsizing or adding schemes as required, with an associated cost impact. The model in this case increases the GUC transfer and includes Deephams recycling at an additional cost of £490-610m.

10.262 Other changes are more imminent and so there is limited time to find replacement volume. Gateway and Essex and Suffolk Water transfer changes are of a size (20Ml/d) that can be mitigated with increased transfers and groundwater development in the near-term. The changes to the Lower Thames (236Ml/d) are however, beyond what our options set can currently support in the period to 2034.

10.263 Without the mitigating tunnel (which will take until 2034 to complete) we can see the model constructs what it has available as quickly as possible, notably a large water recycling plant as well as Teddington DRA and inter-company transfers at an additional cost of £2.8 bn.

Combination testing

Government-led H and SESRO sizes

10.264 In these sensitivity runs we have repeated the SESRO-related sensitivity tests (exclusion and size) reported earlier, but this time doing so in combination with assuming that the government-led demand management measures will not be greater than 6 l/h/d (gov-led profile H).

10.265 We are testing this combination because we consider the delivery of government-led demand management is out of our control and comes with the highest risk of delivery amongst the demand side measures. Also, because on the supply-size, we are looking to inform the decision regarding SESRO size.

10.266 To re-cap, we have seen in earlier sensitivity tests that without option restriction, when changing to government-led profile H the model selects SESRO 150 in 2040.

Metric	Least Cost	Gov-led H	Gov-led H & No SESRO	Gov-led H & SESRO 125 Only	Gov-led H & SESRO 100 Only	Gov-led H & SESRO 75 Only
Pathway 4						
Cost	19.05	21,69	22.66	21.72	21.83	21.97
Carbon	8,753,995	9,807,663	10,726,086	9,751,290	9,873,924	10,096,651
Natural Capital	75,242,447	73,791,385	1,369,605	74,822,185	74,984,281	76,334,113
Bio Net Gain	-204,324	-216,079	-239,532	-211,008	-209,889	-194,783
SEA Env +	67,149	69,343	68,595	69,748	69,698	69,632
SEA Env -	99,769	109,737	116,335	113,294	114,804	113,879
Cust_preference	33,042	34,222	34,662	34,591	34,690	34,689
Reliability	28	31	30	31	30	30
Adaptability	14	15	14	14	14	14
Evolvability	19	19	20	19	19	19
Large Options First Utilisation Date	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)
	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFC GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)
	SESRO 150 (2040)	SES transfer (2033)	STT300 Pipeline (2040)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)
	SES transfer (2050)	SESRO 150 (2040)	SES transfers (2033&70)	SES transfers (2033&54)	SES transfers (2033&51)	SES transfers (2033&52)
		Beckton Desal 150 (2050)	Marsh Gibbon 30 (2047)	STT300 Pipeline (2050)	STT300 Pipeline (2045)	STT300 Pipeline (2042)
		STT 400 Pipeline (2050-59)	Beckton Recycling 100 (2050)	Beckton Desal 150 (2050)	Beckton Desal 150 (2050)	Beckton Desal 150 (2050)
			Beckton Desal 150 (2050)	Deephams Recycling (2061)	Deephams Recycling (2061)	Deephams Recycling (2060)
			Deephams Recycling (2064)			

Table 10-25: Sensitivity run outputs – Combination (Gov-led H and SESRO)

10.267 The inclusion of demand management underperformance, when optimising based on cost and focussing on the impacts on pathway 4, supports the need for larger reservoir sizes. Reducing the reservoir size incrementally increases the cost of the programme as other, more expensive alternatives are sought.

10.268 Without SESRO, the model still opts to increase storage, with a 30Mm^3 reservoir at Marsh Gibbon, then with a mix of water recycling and desalination options in 2050 and 2064.

10.269 When SESRO remains available and its size is reduced, the model reacts by bringing forward the Severn-Thames transfer and options to support the transfer.

Government-led G and SESRO sizes

10.270 In these sensitivity runs we have repeated the SESRO size-related sensitivities in combination with an alternative government-led demand management savings profile (profile G), which allows greater savings than the profile (H) used above.

Metric	Least Cost	Gov-led G	Gov-led G & SESRO 150 Only	Gov-led G & SESRO 125 Only	Gov-led G & SESRO 100 Only	Gov-led G & SESRO 75 Only
Pathway 4						
Cost	19.05	20.71	20.71	20.82	21.23	21.04
Carbon	8,753,995	9,769,134	9,773,963	9,824,066	10,057,768	10,042,174
Natural Capital	75,242,447	78,752,047	78,736,673	80,688,691	81,605,408	81,526,257
Bio Net Gain	-204,324	-223,135	-225,791	-217,176	-205,052	-185,302
SEA Env +	67,149	69,250	69,125	69,397	69,606	69,277
SEA Env -	99,769	112,198	112,398	113,126	115,933	113,113
Cust_preference	33,042	34,147	34,221	34,269	34,474	34,309
Reliability	28	31	31	31	30	30
Adaptability	14	14	14	15	14	14
Evolvability	19	19	19	19	20	20
Large Options First Utilisation Date	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)
	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)
	SESRO 150 (2040)	SES transfer (2033)	SES transfers (both 2033)	SES transfers (both 2033)	SES transfers (both 2033)	SES transfers (both 2033)
	SES transfer (2050)	SESRO 150 (2040)	SESRO 150 (2040)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)
		Beckton Desal 100 (2050)	Beckton Desal 100 (2050)	Beckton desal 150 (2050)	Beckton recycling 50+100 (2050)	STT 500 Pipeline (2050)

Metric	Least Cost	Gov-led G	Gov-led G & SESRO 150 Only	Gov-led G & SESRO 125 Only	Gov-led G & SESRO 100 Only	Gov-led G & SESRO 75 Only
					Crossness Desal 50 (2050)	Crossness Desal 50 (2050)

Table 10-26: Sensitivity run outputs – Combination (Gov-led and SESRO size)

10.271 Although profile G represents a smaller reduction in expected demand savings than profile H, we continue to see SESRO 150 Mm^3 favoured over alternative smaller sizes. Costs increase between £110m and £330m as SESRO size is reduced, which is a similar range to that identified in the tests without the change in government-led profile.

10.272 As the reservoir size is reduced, initially the size of the desalination option selected in 2050 increases. This is partially replaced by phased water recycling with a 100 Mm^3 SESRO. With a 75Mm^3 SESRO, the model selects the largest Severn-Thames transfer with a smaller desalination plant in 2050.

Best Value Plan runs and SESRO sizes

10.273 We noted earlier in Stage 4 of the BVP process, that the best value plan runs for resilience, environmental and social and general BVP uplift, selected a different combination of options compared to the least cost run, particularly in relation to SESRO size. To explore this further, in these sensitivity runs we have repeated the optimisation of BVP aggregates (ie. environment and society, resilience and general all metric uplift) but only allowing one size of SESRO to be available for selection.

10.274 To re-cap the BVP runs selected a 75Mm^3 reservoir and a 100 Ml/d desalination plant (in pathway 4), whereas the Least Cost runs selected a single SESRO at 150Mm^3.

10.275 The outputs of the sensitivity tests are shown in the sets of tables below, firstly for environment and society (E&S), then resilience, then for general uplift across all BVP metrics.

Metric	Least Cost	E&S + SESRO 150	E&S + SESRO 125	E&S + SESRO 100	E&S + SESRO 75
Pathway 4					
Cost	19.05	19.34	19.36	19.42	19.42
Carbon	8,753,995	9,010,535	9,029,183	8,994,835	8,963,039
Natural Capital	75,242,447	82,733,280	81,460,112	80,973,683	80,977,882
Bio Net Gain	-204,324	-202,283	-187,095	-182,790	-167,101
SEA Env +	67,149	67,145	68,499	68,366	67,451
SEA Env -	99,769	97,667	100,368	102,821	100,922
Cust_preference	33,042	36,399	36,566	36,675	36,593
Reliability	28	28	28	27	27
Adaptability	14	14	14	14	14
Evolvability	19	19	19	19	19
	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)

Metric	Least Cost	E&S + SESRO 150	E&S + SESRO 125	E&S + SESRO 100	E&S + SESRO 75
Large Options First Utilisation Date	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)
	SESRO 150 (2040)	SESRO 150 (2040)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)
	SES transfer (2050)	SES transfer (2033)	SES transfers (2033+63)	SES transfers (both 2050)	SES transfers (2033+70)
				Deephams recycling (2060)	Beckton Desalination 100 (2050)

Table 10-27: Sensitivity run outputs – Combination (Environment and Society and SESRO size)

Metric	Least Cost	Resilience + SESRO 150	Resilience + SESRO 125	Resilience + SESRO 100	Resilience + SESRO 75
Pathway 4					
Cost	19.05	19.32	19.34	19.43	19.49
Carbon	8,753,995	9,013,020	9,038,728	9,070,888	9,035,211
Natural Capital	75,242,447	76,465,996	77,132,999	82,483,867	79,274,686
Bio Net Gain	-204,324	-204,879	-198,101	-187,772	-170,302
SEA Env +	67,149	68,363	68,523	69,623	68,804
SEA Env -	99,769	100,185	103,135	108,020	103,751
Cust_preference	33,042	33,273	33,524	33,789	33,525
Reliability	28	29	29	28	28
Adaptability	14	14	14	14	14
Evolvability	19	20	20	20	20
Large Options First Utilisation Date	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)
	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)
	SESRO 150 (2040)	SESRO 150 (2040)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)
	SES transfer (2050)		SES transfers (2050+70)	SES transfers (both 2050)	SES transfers (2054+70)
				Deephams recycling (2060)	Beckton Desalination 100 (2050)

Table 10-28: Sensitivity run outputs – Combination (Resilience and SESRO size)

Metric	Least Cost	All BVP + SESRO 150	All BVP + SESRO 125	All BVP + SESRO 100	All BVP + SESRO 75
Pathway 4					
Cost	19.05	19.35	19.36	19.45	19.52
Carbon	8,753,995	9,009,360	9,044,388	9,097,088	9,045,005
Natural Capital	75,242,447	81,736,582	81,270,674	80,957,004	81,395,991
Bio Net Gain	-204,324	-202,165	-197,535	-177,610	-172,543
SEA Env +	67,149	67,729	69,341	68,993	69,107
SEA Env -	99,769	99,854	103,064	102,778	103,938
Cust_preference	33,042	36,629	36,864	36,819	36,889
Reliability	28	29	29	28	28
Adaptability	14	14	14	14	14
Evolvability	19	20	20	20	20
Large Options First Utilisation Date	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)	Teddington (2033)
	AFW GUC 50 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)	AFW GUC 100 transfer (2033)
	SESRO 150 (2040)	SESRO 150 (2040)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)
	SES transfer (2050)	SES transfer (2070)	SES transfers (2033+75)	SES transfers (both 2050)	SES transfer (2033)
				Mogden SS recycling (2053)	Beckton Desal 100 (2050)
				Deephams recycling (2061)	

Table 10-29: Sensitivity run outputs – Combination (General BVP uplift and SESRO size)

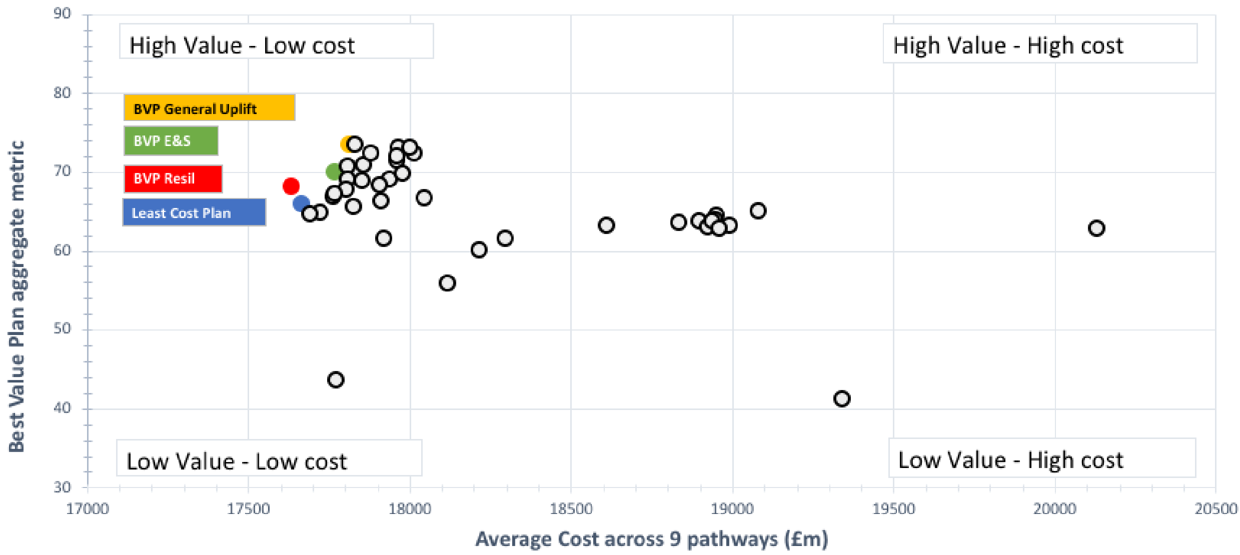
10.276 What we note from these tests is that in each case and across the metrics, the difference caused by varying SESRO size is quite muted.

10.277 Programmes containing the largest reservoir are cheaper and have better natural capital values, but smaller sizes, as noted earlier, perform better on biodiversity net gain (the score is less negative). Resilience marginally improves with reservoir size.

10.278 There is some commonality in outputs with the earlier groups of tests varying reservoir size (versus the Least Cost plan and including alternative lower demand management profiles). As reservoir size is reduced transfers and groundwater are brought forward, with water recycling and desalination plants selected post-2050.

Cost vs Metric Plots

10.279 Adding outcomes of the sensitivity tests to the Cost vs BVP aggregated metric plot (below), demonstrates the spread in cost and relative BVP performance derived from these runs. We provide two versions. As before in v1 of the plots, the upper plot is average cost across all pathways, the lower plot is against the cost of pathway 4 only. We have not labelled the dots at this stage in order to observe the spread and any patterns.



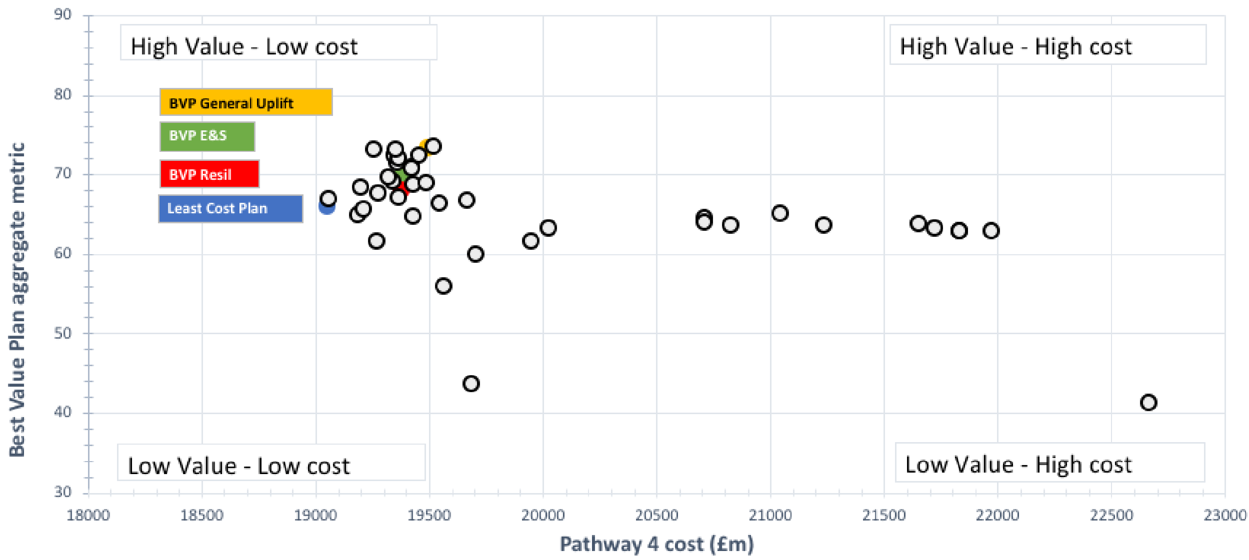


Figure 10-14: Cost vs BVP metric (v2, Sensitivity runs)

10.280 Looking at the pattern of the dots, in both plots we can observe a distinct cluster in the top left of the plot. There are many alternative solutions with relatively similar cost and BVP performance.

10.281 We can observe that many runs have notably lower best value performance and/or materially higher cost.

10.282 In the top plot we can see the four coloured dots for the adaptive Least Cost and BVP runs are at the top left. The sensitivity tests then add cost and have similar or lower BVP metric value. This is to be expected as the optimiser should identify the combinations with the highest value and lowest cost.

10.283 However, when plotting the same best value data against pathway 4 costs (representing a future pathway that is more challenging than the average, but is better aligned with the WRPG), we can observe that the coloured dots, particularly those for the BVP runs, are buried within the cluster of alternative plans. We return to this observation by focussing in on this cluster shortly, below.

10.284 Other observations:

- Pathway 4 costs increase away from the LCP more than for the average of the 9 pathways. In other words, the lower plot is more stretched from the LCP point i.e, the BVP and No SESRO dots are further right of the LCP, and the clusters of dots representing different SESRO sizes are now more elongated.
- This indicates that pathway 4 is more sensitive to the size and combinations of options selected, which is reasonable to expect as this pathway is more challenging.

10.285 We add labels in the next set of plots (v3) below, average cost across nine pathways at top and just pathway 4 at bottom. The cluster of results at the top left are not labelled as they will be examined further in the next sub-section.

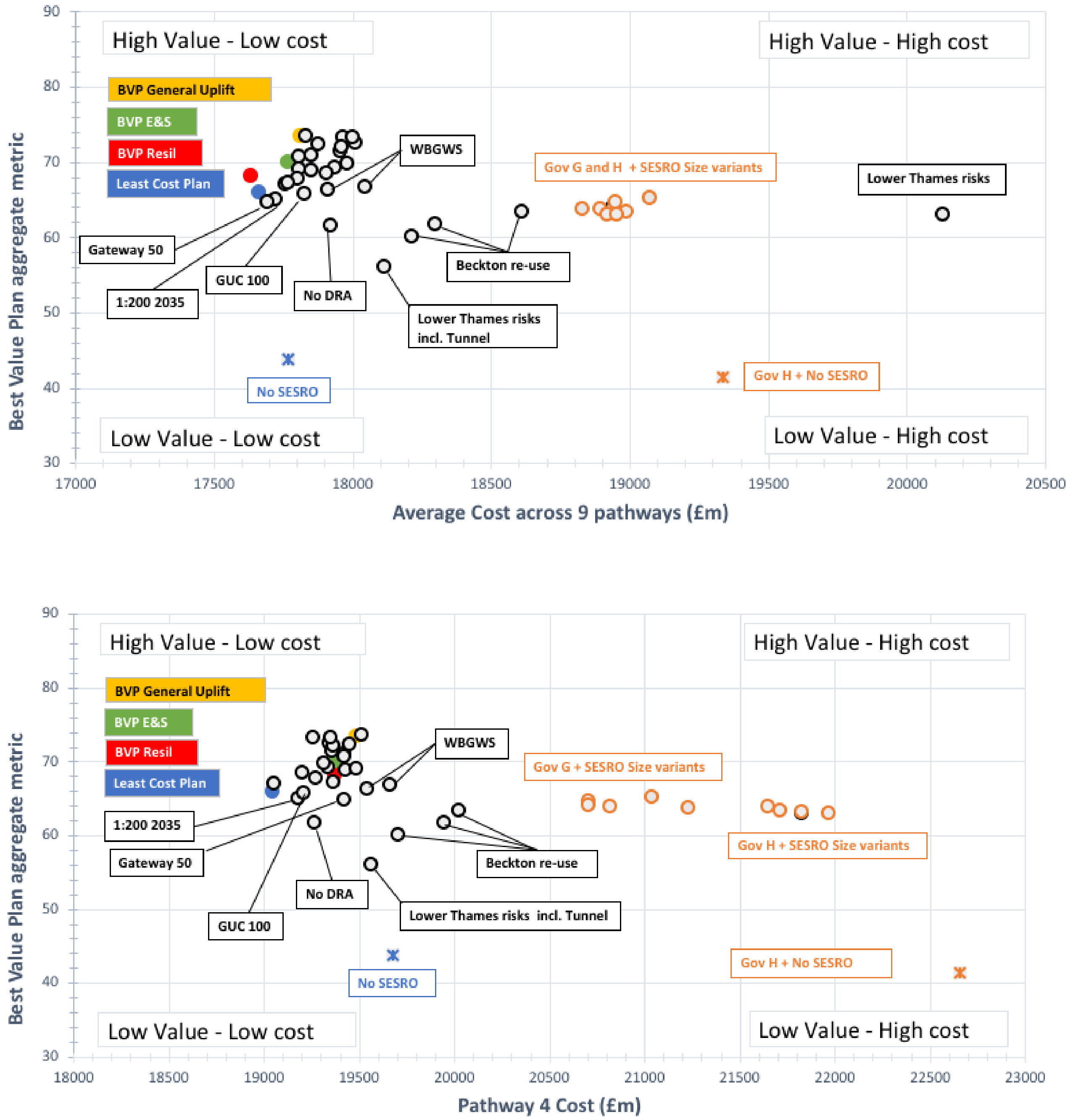


Figure 10-15: Cost vs BVP metric (v3, Sensitivity runs, labelled)

10.286 We observe the following, in support of the points raised from the analysis of the tabulated outputs:

- The No SESRO sensitivities perform poorly for best value in both plots and also on cost when considering pathway 4.
- Low government-led demand savings substantially increases programme cost, but with a relatively minor BVP impact.
- The stretching out of the clusters of SESRO size runs in the pathway 4 plot, most notable when comparing the Gov G and Gov H clusters, is useful. As the size of the reservoir reduces the cost of the programme increases. In other words, the bigger the

future challenge you can reduce overall programme costs by increasing reservoir size. Additionally, the impact of doing so on BVP metric score is limited.

- Sensitivities involving Beckton water recycling in 2033 instead of Teddington DRA results in significant cost increase and reduction in BVP performance.
- Lower Thames risks have the potential to add significant cost to the programme, but that this can be mitigated, albeit with a reduction in best value performance.

Focusing on SESRO size

10.287 The large cluster of outputs in the top left corner of the Cost vs BVP metric plots spans c.£500m in programme cost and a BVP metric range of about 8%.

10.288 We now focus on that portion of the Cost vs BVP metric plots to examine the impact on BVP aggregated metric performance and cost of alternative reservoir sizes.

10.289 For orientation in the plots below, the adaptive Least Cost Plan and BVP runs are coloured as before. The shapes represent the size of SESRO selected in each programme: 75Mm^3 circles; 100Mm^3 diamonds; 125Mm^3 triangles; 150Mm^3 squares. Least cost alternatives are bordered in blue, BVP alternatives are bordered in black. The greyed-out crosses are other sensitivity results, also left in to aid orientation.

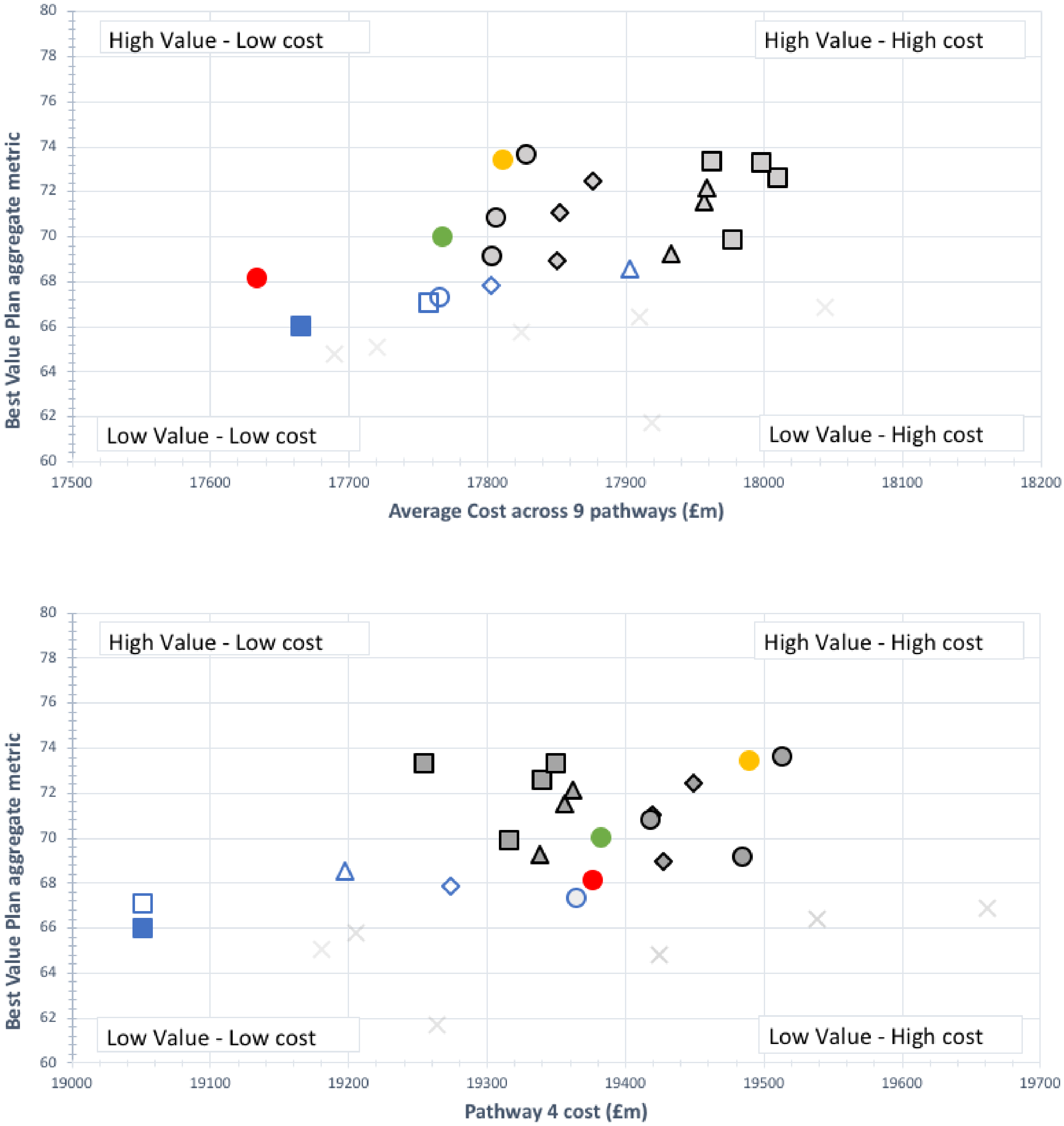


Figure 10-16: Cost vs BVP metric (v4, Sensitivity runs, size matters)

10.290 Observations:

- In the top plot (average for all 9 pathways), the BVP alternatives (grey, black border) form quite a clear pattern by SESRO size left to right, smaller (circles) to larger (squares)
- In the bottom plot (just pathway 4) that pattern switches round, left to right, larger to smaller
- In the least cost alternatives (those with a blue border) the 150Mm^3 performs better in both plots, notably so in pathway 4
- This supports a link between scale of future supply demand challenge and the selected size of reservoir.

- In the lower plot we can see that when considering the level of challenge in pathway 4, it is possible to produce BVP programmes that are cheaper than the free-choice modelled BVP runs (red, green and yellow). The programmes containing the 150Mm^3 reservoir offering a cheaper solution with minimal impact on BVP metric performance.

Summary of sensitivity testing

10.291 The sensitivity testing programme has generated a variety of alternative plans that enables us to consider the impacts of key future risks, option choices and policy drivers.

10.292 We have noted the following for the reporting pathway, pathway 4:

Demand Management

- Given the significant and expanded contribution from demand management options compared with the draft WRMP, we note that our tests show high sensitivity to any reduction to that contribution. Progressive company and government-led demand management programmes are shown to be key influencer on cost and the timing of SRO development.
- Replacement of any demand management savings, whether from a shortfall in company or government-led activity results in large cost increases. Our test of a low company demand management basket resulted in a £1.25 billion increase in programme cost, with alternative lower government-led savings profiles showing £1.7bn and £2.6bn extra cost.
- In response to the underperformance the model chooses to upsize the Grand Union Canal transfer and bring forward other transfers and groundwater options, alongside the Teddington DRA. In the medium-term it favours building a large reservoir and in the longer term, the Severn Thames Transfer, desalination or water recycling.

Solutions for the period to 2033 (achieving 1:200 resilience)

- The sensitivity tests have confirmed the general stability of the solution to 2033, with the Teddington DRA option supported by a licence transfer from Affinity Water linked to their development of the Grand Union Canal scheme.
- If Teddington DRA is excluded, transfers linked to the Grand Union Canal are upsized and additional transfers are brought in from SES Water alongside a number of local groundwater developments. This is at an additional £210m to the programme cost. This assumes that surplus is available to transfer as a result of demand management savings. As such, we tested replacement of Teddington DRA with a larger scheme.
- We tested bringing Beckton water recycling at various sizes in 2033. The cost impact ranged from £650m-£1bn.
- The sensitivity testing as a whole supported the findings of the BVP metric runs in suggesting that the upsizing of the Grand Union Canal to 100Ml/d would be prudent at an additional programme cost of £160m.

Solutions for 2040 (achieving 1:500 resilience and Environmental Destination)

- Sensitivity testing regularly selects SESRO as the joint Strategic Resource Option for 2040, with onward transfers of water to Southern Water, Affinity Water as well as support to London and the Thames Valley.

- In tests where SESRO was excluded the impact on costs was £630m, rising to £1bn if combined with lower demand management savings. The Severn-Thames Transfer pipeline is brought in as the replacement option.
- The additional cost of reducing reservoir size in the Least Cost Plan is in the range of £0-320m depending on the reduction in size. The model reacts to reducing reservoir size by increasing the size of the GUC transfer, brings in other transfers and smaller schemes, ahead of a larger resource in 2050

Solutions for 2050 and beyond (further Environmental Destination)

- The need for further resource development beyond 2050 is linked to SESRO size and also future pathway.
- In pathway 4 we see that progressively reducing the reservoir size brings in transfers and groundwater, then smaller water recycling, then desalination and ultimately STT if the challenge is severe.
- Each of these scheme-types regularly appear in sensitivity testing as replacements or as additional options to meet various levels of need, indicating their importance as back-up options.

Changes in base DO capability

- Reductions in base DO capability in the region of 20 Ml/d can be solved using increased transfer and groundwater development. These option types are brought forward for variances of this magnitude, highlighting their value as gap fillers whenever needed in the profile or as mitigation for underperformance.
- Larger reductions of the level potentially required for the risks in the Lower Thames would cause temporary deficits. The sensitivity tests do show however that mitigation via a Tunnel would be substantially cheaper than building assets from the existing options set.

Changes in drought resilience policy date

- Deferral of drought resilience delivery dates does not reduce the cost of the solutions produced by the model. The cost of the options brought in is higher than the saving from deferral. Changing just the resilience date is now insufficient to defer the strategic resource option required in 2040.

On the question of SESRO size

- On a least cost basis the SESRO 150Mm^3 is preferred. On a best value plan basis, although across all 9 pathways SESRO 75Mm^3 is chosen by the model, through sensitivity testing we have seen that when focussing on pathway 4, as the pathway closest to the requirements of the WRPG, upsizing to SESRO 150Mm^3 is cheaper with a marginal impact on overall BVP metric performance.

10.293 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.

Type	Option	Pathways selected in draft WRMP	Pathways selected in revised WRMP
DRA	Teddington	96%	94%
Imports	SEW to GUI	23%	24%
	SES to GUI	11%	-
	WSX to SWOX	25%	-
	Affinity (Grand Union Canal 50)	-	26%
	Affinity (Grand Union Canal 100)	-	71%
	SES to London (Merton)	-	57%
	SES to London (Epsom)	-	27%
	Oxford Canal (SWOX)	26%	20%
	Oxford Canal (LON)	14%	7%
Reservoir	SESRO 150 Mm^3	48%	36%
	SESRO 125 Mm^3	11%	13%
	SESRO 100 Mm^3	16%	13%
	SESRO 75 Mm^3	10%	26%
	Marsh Gibbon 30 Mm3	-	1%
	Phased development	0%	<1%
STT*	STT 500 pipeline + Netheridge	18%	1%
	STT 400 pipeline + Netheridge	6%	2%
	STT 300 pipeline + Netheridge	12%	9%
	STT 300 Canal	-	1%
Desalination	Beckton 150	14%	10%
	Crossness 100	1%	2%
	Beckton 100	2%	3%
	Crossness 50	1%	2%
Water recycling	Deephams	20%	11%
	Beckton 100	4%	3%
	Beckton 100 Phase 2	2%	1%
	Beckton 50 Phase 2		1%
	Beckton 50	3%	3%
	Beckton 150	1%	3%
	Mogden South Sewer 25	-	2%
Groundwater	Woods Farm SWOX	98%	33%
	Southfleet LON	95%	34%
	Addington LON	94%	44%
	Mortimer KV	52%	23%
	ASR Horton Kirby LON	52%	28%
	New River Head (Pumps)	-	28%
	Moulsford SWOX	46%	96%
	Confined Chalk LON	35%	23%
	Britwell SWOX	32%	-
	Datchet SWA	24%	21%
	Ashton Keynes SWOX	-	16%
	Merton LON	29%	21%
	AR Merton LON	26%	16%
	Dapdune GUI	21%	6%
	AR Streatham LON	27%	-
	ASR Thames Valley LON	23%	14%
	AR Kidbrooke LON	20%	14%
	ASR Addington LON	16%	14%
	Dorney SWA	0%	-
Other	Didcot licence transfer	100%	9%

Type	Option	Pathways selected in draft WRMP	Pathways selected in revised WRMP
	Catchment Man. - Colne	44%	-
	Catchment Man. - Upper Lee	19%	-
	Catchment Man. - Darent Cray	12%	18%

Table 10-30: Resource option frequency of selection (across all pathways)

* STT support elements not included in table

10.294 It should be noted that these selection statistics are across all the LCP, BVP and sensitivity runs completed (draft n=60, revised draft n=120).

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

10.296 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.

10.297 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, a groundwater scheme and a licence trade with Affinity Water linked to the Grand Union Canal
- All four of the strategic option types (reservoir, STT, desalination and water recycling) are commonly chosen in runs, with a tendency towards the larger sizes, with the exception of recycling
- At pathway level SESRO 150Mm^3 is the most highly selected strategic option providing new resource in the Upper Thames.
- 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

Stage 6: The preferred plan

Our Programme Appraisal journey

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

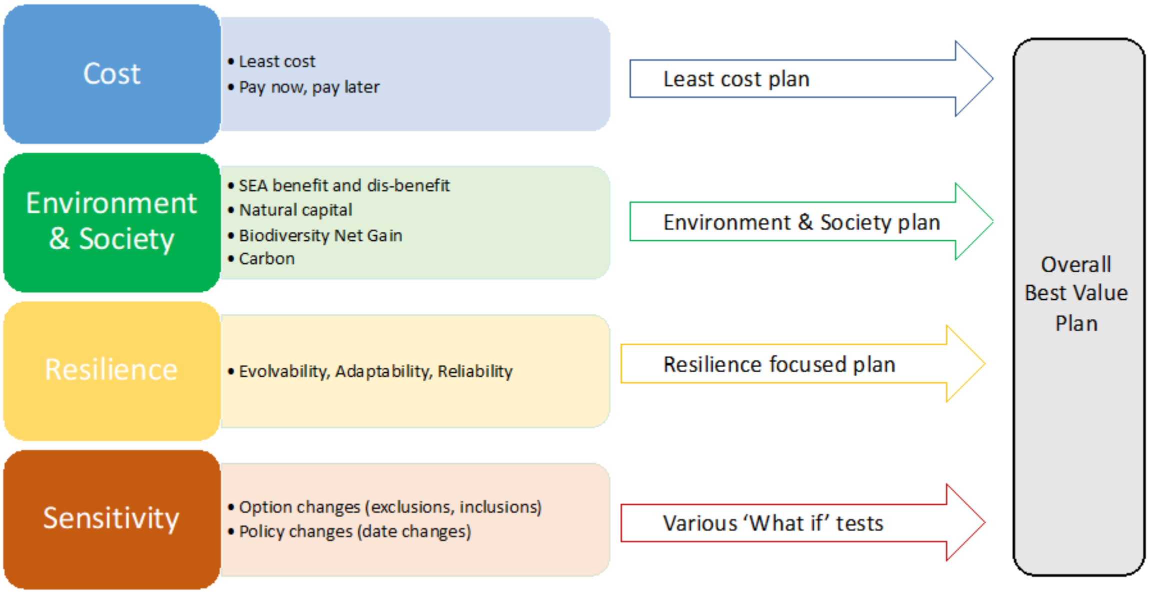


Figure 10-17: The programme appraisal journey

10.299 We have identified an adaptive Least Cost plan and explored alternative Best Value runs that trade-off cost for improvement in BVP metrics. We then used sensitivity testing to produce further alternatives of both the least cost and best value runs, by changing the options set available for selection, changing key policy, base supply capability and combinations of the above.

10.300 These runs represent raw modelled outputs, that can be used to identify a candidate Overall Best Value Plan.

10.301 This information leaves decision makers with clear areas of commonality in solutions, but also identifies areas of difference. How we have identified a candidate Overall Best Value Plan from the modelling outputs is summarised below and expanded upon in Section 11.

Selecting a Candidate Overall BVP

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

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

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

10.305 All the alternative modelled 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 110 litres/person/day target by 2050, through a combination of company and government-led measures.
- 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, where required
- To share water resources and encourage cross-sectoral co-operation

10.306 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 expectation and challenge for this planning cycle, through increased drought resilience and a greater than ever focus on environmental sustainability improvements, this WRMP24 is able to show a good level of continuity with WRMP19.

10.307 Demand management continues to play a significant role the regional solution. In fact, by 2050 the proportion of the need that is now met by demand management has increased from 50% to 80%.

10.308 We continue to see the need for supporting resource development in the 2030s and 2040, in order to meet drought resilience and environmental goals. The need for major resource development at 2050 has lessened due to the increased demand management.

10.309 Unless told not to select them in sensitivity testing, the predominant strategic resource options in the 2030s and 2040 remains Teddington DRA and SESRO, respectively.

10.310 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 due to our adaptive planning approach and the need to be able to meet the wide range of potential future pathways.

10.311 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.

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

10.313 Best Value runs have provided us with plans including alternative resource that offer improved BVP metric performance in a trade off with cost. These together with the sensitivity runs have helped to establish an understanding of the general order of preference for resource schemes.

10.314 This has led us to two important decisions:

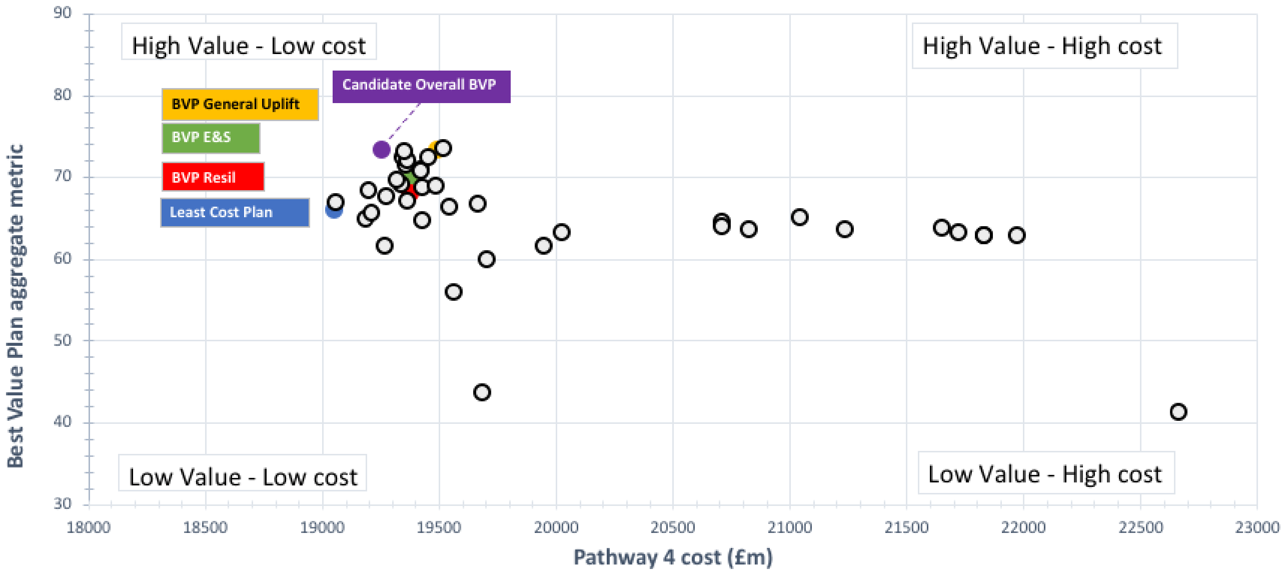
- Selecting a base model run that represents best value
- Making changes to that run as a consequence of sensitivity testing and wider non-modellable factors

10.315 We consider that the overall BVP should go beyond least cost. The General BVP uplift modelling run provides a uniform uplift in BVP metrics whilst minimising cost (i.e. the BVP uplift run).

10.316 However, the sensitivity testing has shown that there is a cluster of alternatives in close proximity to that run. These alternatives are linked to programmes that include different reservoir sizes. The cluster including the LCP and BVP alternatives lies within a cost range of £500m and an 8% change in aggregate BVP metric.

10.317 Focussing in on these solutions, the model, when given free choice of SESRO sizes and modelling across all the 9 pathways, selects a SESRO of 75Mm^3, however when you look at the outcome for the reporting pathway, pathway 4, larger reservoir sizes are preferred and present a cheaper solution. The programme including a 150Mm^3 SESRO is £235m cheaper in pathway 4 with only a 0.1% reduction in BVP performance.

10.318 This is reflected in the updated Cost vs BVP metric plots for pathway 4, with the candidate Overall BVP shown in purple (top-left focussed shown in bottom plot).



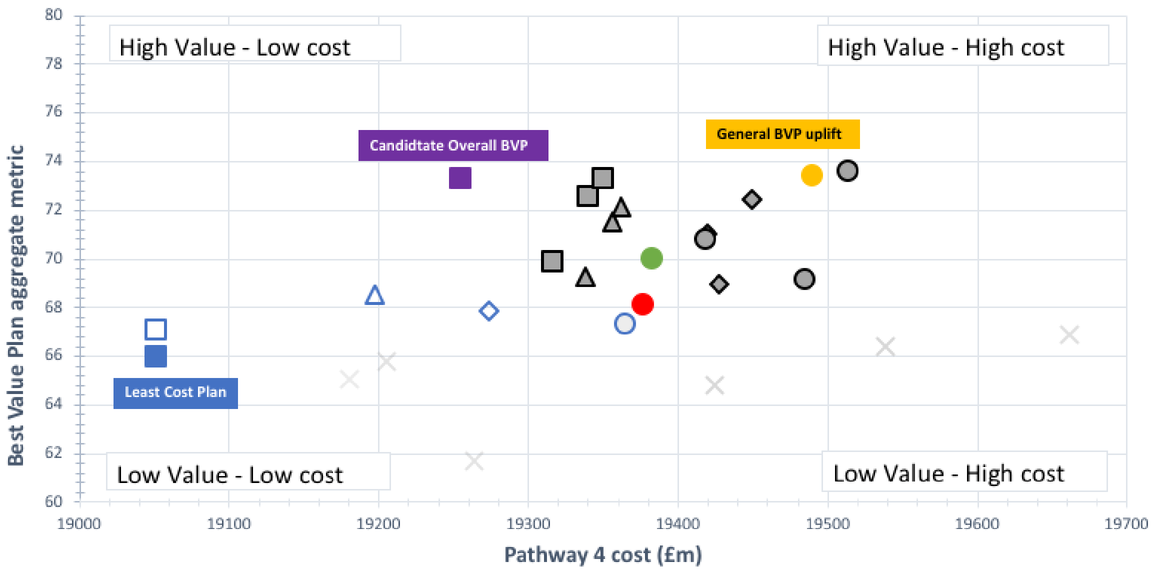


Figure 10-18: Cost vs BVP metric (v5 pathway 4 only, Overall BVP run)

The Candidate Overall BVP plan

10.319 The metric outputs across all pathways for the candidate overall best value plan are shown below with the preferred pathway, pathway 4, highlighted in green and the core pathway (8) in tan.

Metric	Pathway									
	1	2	3	4	5	6	7	8	9	AVE
Cost	20.62	17.92	17.20	19.26	17.77	16.97	18.13	17.26	16.54	17.96
Carbon	9,659,356	7,470,091	7,140,746	8,849,739	7,457,027	7,144,904	7,858,690	7,146,814	6,815,264	7726959
NC	82,030,356	81,052,068	81,238,836	81,015,364	81,188,621	81,479,509	81,609,503	81,352,663	81,731,503	81410936
BNG	-202,722	-144,618	-126,255	-199,827	-150,321	-121,902	-150,989	-127,691	-99,097	-147047
Env +	66,691	65,338	65,338	67,933	65,340	65,338	66,722	65,338	65,338	65931
Env -	104,955	77,782	72,756	97,446	78,090	71,933	83,773	70,130	61,721	79843
Cust_p	36,704	35,098	34,819	36,555	35,130	34,696	35,269	34,496	33,967	35193
Reliab	30	30	32	29	30	33	31	35	39	32
Adapt	14	16	18	14	16	17	16	18	21	17
Evolv	20	20	22	20	20	22	21	24	27	22

Table 10-31 Overall BVP – regional-level metric outputs

10.320 The candidate Overall BVP plan, when optimised regionally, has an average NPV cost of £18 billion with a maximum of £20.6 billion and minimum of £16.5 billion. Compared to the adaptive LCP, the average cost across all pathways is £300m higher, pathway 4 cost is £210m higher than the LCP. The Pathway 8 cost is £510m higher.

10.321 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**.

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
Drought restrictions (Media, TUBs, NEUBs)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
TW Integrated Demand Management (High)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Government Led Demand Management (C+)	ALL		2026	2026	2026	2026	2026	2026	2026	2026	2026
Teddington DRA	**LON**	**67**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**
Licence transfer AFW (**GUC 100 Ml/d**)	LON	Var	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**	**2033**
GW – Moulsford	SWX	2	2033	2033	2033	2033	2033	2033	2033	2033	2033
Reservoir – SESRO 150 Mm³	**SWX**	**271**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**	**2040**
Oxford Canal (SWOX)	SWX	12	2065			2040					
Transfer - Henley to SWOX – 5 Ml/d	SWX	5	2042			2040	2040	2040			

Option Name	WRZ	DO	Pathway								
			1	2	3	4	5	6	7	8	9
GW - Mortimer	KV	5	2042			2042					
Transfer - T2ST to Kennet Valley spur	KV	10	2050			2050			2050		
DRA - Medmenham	SWA	24	2050			2050			2050		
Transfer – SEW Hogsback to Guildford	GUI	10	2050			2050					
Transfer – SWOX (Horspath) to SWA	SWA	1	2050			2050					
GW - New River Head (Pump)	LON	3	2056			2050					
Transfer - Kennet Valley to Henley	HEN	2	2065			2057					
GW – Southfleet & Greenhithe	LON	9	2040			2069					
GW - Addington	LON	3	2040			2073					
GW - Woods Farm	SWX	2	2040			2074					
GW - Datchet	SWA	2	2064			2074					
CM – Darent and Cray	LON	1	2075			2075					
Transfer – SES Cheam to LON Merton	LON	15	2040	2040	2040						
Desalination - Beckton 150 Ml/d	LON	133	2050								
ASR Horton Kirby	LON	5	2065								
Recycling - Deephams (to TLT)	**LON**	**47**	**2069**								
GW - Merton Recommissioning	LON	2	2072								
AR - Merton (SLARS3)	LON	6	2074								
AR - Kidbrooke (SLARS1)	LON	8	2074								
GW - London Confined Chalk	LON	2	2075								
ASR - South East London (Addington)	LON	3	2075								

Table 10-32: Overall BVP – Thames Water options selected

10.322 Demand management is confirmed as an essential part of the candidate overall BVP 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.

10.323 The programme will build on WRMP19 activity and includes further cuts to leakage as we work towards an overall reduction of over 50% by 2050. We will continue to roll-out our smart metering programme, seeking to meter all connections (where feasible) 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.

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

10.325 Overall, there are three important periods over the 50 years of the forecast where significant resource developments are likely to be needed to come online:

- 2033 – In all pathways the Teddington DRA scheme (75 Ml/d), a licence transfer from Affinity Water supported by their construction of the Grand Union Canal option, and small groundwater enhancements is proposed in SWOX
- 2040 – The completion of the SESRO 150Mm^3 reservoir development (271 Ml/d) will continue to facilitate greater sharing of resources across the South East via significant transfers with Affinity Water and Southern Water. Additional small-scale transfers and groundwater developments are selected to the middle of the decade, depending on the future pathway
- 2050 onwards – Due to the size of the SESRO, further resource developments are largely confined to the most challenging pathways, 1, 4 and 7
- In pathways 4 and 7 the development of internal transfers and groundwater options is required to re-distribute the water in our WRZs, driven by the completion of the environmental destination programme
- In pathway 1, the need is still driven by growth and larger options are required, including a desalination plant at Beckton (100Ml/d) and a water recycling plant at Deephams in 2069, alongside further groundwater development

10.326 This candidate plan represents what we consider to be the best performing modelled output. The model is a decision support tool, not a decision-making tool, so we now take the candidate plan forward to Section 11, where we make the decisions on the overall BVP.

10.327 Also included in Section 11 are full details of the demand management and resources development programmes that make up the overall BVP and further discussion of the alternatives.

10.328 A monitoring plan is set out, which enables us to track our progress in delivery 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.

10.329 A summary of key environmental impacts of the Overall BVP is also provided in Section 11, including an in-combination effects assessment for pathways 1, 4 and 8. It is suggested that the assessment for the Overall BVP is read first, before the Annex below, as the Annex makes comparison with the content of that assessment.

Annex – Environmental in-combination assessment summary

10.330 This annex contains a summary of the in-combination effects assessments for the preferred pathway (pathway 4) of the adaptive least cost (LCP) and best environmental and society plans (BESP).

10.331 In-combination assessment examines the potential combined impacts of programmes of options on environmental receptors and also other whether any plans or programmes (e.g. new developments) in the local area may cause combined impacts with our plans.

10.332 It is advised that this annex is read in conjunction with the in-combination assessment for the Overall BVP, provided in Section 11, as comparisons are made to that assessment in the summaries below.

10.333 Full details of the assessments are contained in the Environmental Appendices:

- Appendix B - Strategic Environmental Assessment (SEA)
- Appendix C – Habitats Regulation Assessment (HRA)
- Appendix D – Water Framework Directive (WFD)
- Appendix AA – Natural Capital and Bio-diversity Net Gain (BNG)
- Appendix BB – Invasive species (INNS)

Least Cost Plan

SEA

10.334 The outcomes of the SEA cumulative effects assessment for the LCP are very similar to the BVP preferred pathway due to similar options being selected. Positive cumulative effects for the SEA objectives on biodiversity, water quality and vulnerability to climate risks were identified due to the inclusion in the LCP of a 'High' Environmental Destination, consumption reduction options, change in level of service to enhance water available for use (WAFU) (i.e. media campaigns, TUBs and NEUBs) and leakage reductions. The cumulative effects of these options will result in more water being kept within the natural environment. Positive cumulative effects were also identified for the SEA objective on delivering reliable and resilient water supply to customers through delivery of new water supply options, increased capacity and improving transfers across the region.

10.335 The SEA cumulative effects assessment identified cumulative negative effects for SEA objectives on soil due to cumulative loss of agricultural land, carbon due to construction and operational carbon emissions across the plan, and resource use due to the cumulative effects of materials and resource use and waste production across the plan. We will continue work to identify mitigation for these effects as we develop our options through to detailed design and delivery.

10.336 The SEA cumulative effects assessment identified several options with the potential for interactions with the same sensitive receptors. This was largely due to construction effects such as disturbance from noise, air and light pollution from different options where the construction periods overlapped. These sensitive receptors included LNRs, SSSI, heritage assets and community assets. However, it was concluded that with implementation of best practice construction techniques and a Construction Transport Management Plan, cumulative effects are not anticipated.

WFD

10.337 When compared to the Overall BVP (preferred pathway), the cumulative effects assessment has not identified any additional water bodies at increased risk of WFD deterioration due to the combinations of options selected in the LCP.

10.338 Under the LCP the Thames (Reading to Cookham) water body would feature one fewer option than under the BVP (preferred pathway): DP Sheeplands / Harpsden-Henley. However, as this does not change the outcome of the cumulative effects assessment as set out in the core BVP (preferred pathway) assessment, it has not been considered further.

HRA

10.339 Similarly to the BVP, the HRA identified two options within the LCP with low effects that were therefore taken forward into the in-combination effects assessment. Although the AA concluded no adverse effects on site integrity (AESI) for these options alone, low level effects could combine to cause significant effects affecting site integrity and this was investigated through the in-combination effects assessment. Low level effects on Cannock Extension Canal SAC were identified for the Oxford Canal to Duke’s Cut option and low-level effects on Oxford Meadows SAC from the Duke’s Cut to Farmoor option. The two options affect different Habitats Sites therefore, there are no in-combination effects.

Natural Capital

10.340 A number of natural capital stocks are likely to be temporarily and permanently impacted by the LCP in the absence of mitigation. The LCP is likely to generate the loss of natural capital stocks during construction of some supply options. Habitat is expected to be reinstated and/or compensated for to pre-construction conditions following best practice technique and will likely have no permanent impact to the provision of ecosystem services. The unmitigated predicted permanent impact on the provision of ecosystem services for the LCP Non-SRO options is -£26,576.39 (overall change in value in £/year). Via application of best practice mitigation, the LCP presents an opportunity to improve the existing habitats through post-construction remediation and replacement of low value habitats with higher value habitats. The planned BNG associated with options will also help support provision of ecosystem services. The plan crosses several Natural England Habitat Network Enhancement Zones and is therefore suitable for the planting of new high value habitats. For the SROs, as part of the Gate 2 process additional site-specific information was used that led to different assumptions within the method for the assessment. Therefore, it was not comparable to add these into the Non-SRO cumulative effects assessment. The SRO outcomes are the same as for the BVP preferred pathway, as the same options and capacities were selected. The Teddington DRA scheme is likely to provide overall environmental benefits in relation to climate regulation, natural hazard regulation and agriculture ecosystem services. The estimated 30-year net present value (NPV) benefits are £219,311.

10.341 For SESRO, in the absence of mitigation, dis-benefits are seen for food production, air pollutant removal, and natural hazard regulation services. Details of planned mitigation are available in Appendix B. SESRO has an overall positive impact on climate regulation, water purification, and recreation ecosystem service provision. The estimated change in present net value benefits of ecosystem service provision is £32,005,000.

BNG

10.342 The LCP is expected to result in an unmitigated predicted 19.24% net loss of biodiversity units from Non-SRO options, as a result of most options generating a net loss of biodiversity during construction. It should be noted that the desk-based BNG assessments used to generate these numbers have been carried out using open-source data. Habitat identification will need to be refined at the project level with both habitat survey data and further development of habitat mitigation/enhancement proposals as the options progress through further development through to planning (as relevant) and delivery. The number of units required to achieve a 10% BNG is estimated at 766.41 for the Non-SRO options selected in this programme. The SROs used different BNG assumptions as part of the Gate 2 process as there was more site-specific information available on habitats, habitat condition and strategic significance (which affect assumptions made in the BNG Metric and the BNG units achieved). Therefore, it was not comparable to add these into the Non-SRO cumulative effects. The mitigation required to achieve a minimum of 10% BNG was calculated for each SRO. The SRO outcomes are the same as the BVP Situation 4 as the same options and capacities were selected. The Teddington DRA SRO is estimated to provide a net increase of 2.37 habitat units and a net loss of -0.12 river units. Mitigation measures to enhance off-site sections of river will be required to deliver a minimum of 10% net gain such as enhancing 1.8km of 'other river and stream' located outside the catchment. Enhancement may include the removal of structures within the watercourse to reduce the encroachment, planting, removal of invasive non-native species or restoration measures. Plans to deliver this gain will be further developed as part of the next stages of the RAPID gated process.

10.343 It is noted that all sizes of SESRO will cause the permanent loss of an ancient crack willow (Salix fragilis) tree which is situated within the reservoir footprint for all sizes. This habitat is irreplaceable, and so compensation cannot be provided on a 'like for like' basis that would reduce the impact on those habitats to neutral. Compensation will need to be designed in recognition of the nature and extent of the loss or damage, so that the compensation is considered proportionate, and will be agreed with the relevant conservation bodies. This will not replace the habitat lost but can retain some of the local genetic material stock of ancient plants, soil biota and other attributes.

10.344 As the project will result in the loss of one ancient tree, which is categorised as irreplaceable habitat, the scheme cannot achieve BNG at the 'project level'. However, the project will generate meaningful gains for other biodiversity features, such as neutral grassland, wet woodland and wetland areas.

10.345 SESRO (150Mm3) is estimated to provide a net unit increase of 1,629.34 habitat units equating to a net gain of 33.09%. As much of the baseline habitats will be lost to the reservoir, this significant net gain in biodiversity indicates that the replacement habitats and future landscape surrounding the reservoir will be more beneficial to biodiversity than the current landscape. This is because the habitats to be created, such as the ponds and wetland habitat mosaic, will provide habitat for a range of species from invertebrates and amphibians to riparian mammals and breeding and wintering birds. The species rich grassland habitats will attract birds and invertebrates and the woodland habitats will develop into highly biodiverse areas. SESRO will also result in a net unit loss of 96.45 hedgerow units (21.91% loss). Consequently, off-site compensation for the loss of these hedgerow units will be sought, and at a minimum, an additional 143 hedgerow units will need to be gained to achieve a ≥10% net. This will be undertaken within a location where hedgerows will improve ecological connectivity in landscapes nearby to the scheme impact. The current metric does not take account for any potential advanced planting of hedgerow and tree lines which is likely to occur in order to maintain connectivity across the site during construction. Opportunities for advanced planting will be discussed during further iterations of Abingdon Reservoir masterplan. SESRO is also estimated to provide a net unit increase of 70.26 river units (16.41% net gain). The more naturalised planform and enhanced connectivity of the river channel to wetland floodplain habitats will significantly improve the quality and natural functioning of the river compared to the artificial conditions present currently.

INNS

10.346 The INNS in-combination effects assessment identified several combinations of options where raw water with potential for INNS transfer would be discharging to the same water bodies. In-combination effects were identified for the Abingdon to Farmoor and Duke's Cut to Farmoor options. Mitigation such as a WTW at Abingdon was discussed as part of the Level 2 assessments and would help reduce effects. In-combination effects were also identified for Oxford Canal to Duke's Cut, Duke's Cut to Farmoor, Abingdon to Farmoor and SESRO. These options are connected to transfer water around the network and it is likely that mitigation measures can be incorporated into the options design and through discussion with the Environment Agency to reduce risks. In-combination effects were also identified for the Duke's Cut to Farmoor and Medmenham Intake options, and the Duke's Cut to Farmoor and Teddington DRA options. However, given the distances between these options further investigation is likely to conclude no additional effects and therefore, mitigation is unlikely to be needed. The Environment Agency SAI-RAT tool used for the assessment makes a number of recommendations for biosecurity mitigation measures which can be implemented to reduce effects. These can be found in Appendix BB. It is likely that mitigation measures are available which will reduce INNS transfer risk across the plan. These will be incorporated into option design as each option is progressed and discussed with the Environment Agency.

Best Environment and Society Plan

SEA

10.347 The outcomes of the SEA cumulative effects assessment for the BESP are very similar to the BVP preferred pathway due to similar options being selected. Positive cumulative effects for the SEA objectives on biodiversity, water quality and vulnerability to climate risks were identified due to the inclusion in the BESP of a 'High' Environmental Destination, consumption reduction options, change in level of service to enhance water available for use (WAFU) (i.e. media campaigns, TUBs and NEUBs) and leakage reductions. The cumulative effects of these options will result in more water being kept within the natural environment. Positive cumulative effects were also identified for the SEA objective on delivering reliable and resilient water supply to customers through delivery of new water supply options, increased capacity and improving transfers across the region.

10.348 The SEA cumulative effects assessment identified cumulative negative effects for SEA objectives on soil due to cumulative loss of agricultural land, carbon due to construction and operational carbon emissions across the plan, and resource use due to the cumulative effects of materials and resource use and waste production across the plan. We will continue work to identify mitigation for these effects as we develop our options through to detailed design and delivery.

10.349 The SEA cumulative effects assessment identified several options with the potential for interactions with the same sensitive receptors. This was largely due to construction effects such as disturbance from noise, air and light pollution from different options where the construction periods overlapped. These sensitive receptors included LNRs, SSSI, heritage assets and community assets. However, it was concluded that with implementation of best practice construction techniques and a Construction Transport Management Plan, cumulative effects are not anticipated. The BESP includes Beckton desalination; we have considered the potential for this option to have cumulative effects on water quality and Habitats Sites with other water company desalination options, and given the location and size of other water company options proposed, we do not expect any cumulative effects to be present.

WFD

10.350 When compared to the Overall BVP (preferred pathway), the cumulative effects assessment has not identified any additional water bodies at increased risk of WFD deterioration due to the combinations of options selected in the BESP. Under the BESP the Lower Thames Gravels water body would feature fewer options than under the BVP (preferred pathway). However, as this does not change the outcome of the cumulative effects assessment as set out in the core BVP (preferred pathway) assessment, it has not been considered further.

HRA

10.351 Similar to the BVP, the HRA identified two options within the BESP with low effects that were therefore taken forward into the in-combination effects assessment. Although the AA concluded no adverse effects on site integrity (AESI) for these options alone, low level effects could combine to cause significant effects affecting site integrity and this was investigated through the in-combination effects assessment. Low level effects on Cannock Extension Canal SAC were identified for the Oxford Canal to Duke's Cut option and low-level effects on Oxford Meadows SAC from the Duke's Cut to Farmoor option. The two options affect different Habitats Sites therefore, there are no in-combination effects.

Natural Capital

10.352 A number of natural capital stocks are likely to be temporarily and permanently impacted by the BESP in the absence of mitigation. The BESP is likely to generate the loss of natural capital stocks during construction of some supply options. Habitat is expected to be reinstated and/or compensated for to pre-construction conditions following best practice technique and will likely have no permanent impact to the provision of ecosystem services. The unmitigated predicted permanent impact on the provision of ecosystem services for the BESP Non-SRO options is -£37,775.71 (overall change in value in £/year). Via application of best practice mitigation, the BESP presents an opportunity to improve the existing habitats through post-construction remediation and replacement of low value habitats with higher value habitats. The planned BNG associated with options will also help support provision of ecosystem services. The plan crosses several Natural England Habitat Network Enhancement Zones and is therefore suitable for the planting of new high value habitats. For the SROs, as part of the Gate 2 process additional site-specific information was used that led to different assumptions within the method for the assessment.. Therefore, it was not comparable to add these into the non-SRO cumulative effects assessment. The Teddington DRA scheme is likely to provide overall environmental benefits in relation to climate regulation, natural hazard regulation and agriculture ecosystem services. The estimated 30-year net present value (NPV) benefits are £219,311.

10.353 For SESRO, in the absence of mitigation, disbenefits are seen for food production, air pollutant removal, and natural hazard regulation services. Details of planned mitigation are available in Appendix B. SESRO has an overall positive impact on climate regulation, water purification, and recreation ecosystem service provision. The smaller SESRO scheme (75Mm3) is selected for the BESP and the estimated change in present net value benefits of ecosystem services provision is £35,334,000.

BNG

10.354 The BESP is expected to result in an unmitigated predicted -19.54% net loss of biodiversity units from Non-SRO options, as a result of most options generating a net loss of biodiversity during construction. It should be noted that the desk-based BNG assessments to generate these numbers have been carried out using open-source data. Habitat identification will need to be refined at the project level with both habitat survey data and further development of habitat mitigation/enhancement proposals as the options progress through further development through to planning (as relevant) and delivery. The number of units required to achieve a 10% BNG is estimated at 776.396 for the Non-SRO options selected in this programme. The SROs used different BNG assumptions as part of the Gate 2 process as there was more site-specific information available on habitats, habitat condition and strategic significance (which affect assumption made in the BNG Metric and the BNG units achieved). Therefore, it was not comparable to add these into the non-SRO cumulative effects. The mitigation required to achieve a minimum of 10% BNG was calculated for each SRO. The Teddington DRA SRO is estimated to provide a net increase of 2.37 habitat units and a net loss of -0.12 river units. Mitigation measures to enhance off-site sections of river will be required to deliver a minimum of 10% net gain such as enhancing 1.8km of ‘other river and stream’ located outside the catchment. Enhancement may include the removal of structures within the watercourse to reduce the encroachment, planting, removal of invasive non-native species or restoration measures. Plans to deliver this gain will be further developed as part of the next stages of the RAPID gated process.

10.355 It is noted that all sizes of SESRO will cause the permanent loss of an ancient crack willow (Salix fragilis) tree which is situated within the reservoir footprint for all sizes. This habitat is irreplaceable, and so compensation cannot be provided on a ‘like for like’ basis that would reduce the impact on those habitats to neutral. Compensation will need to be designed in recognition of the nature and extent of the loss or damage, so that the compensation is considered proportionate, and will be agreed with the relevant conservation bodies. This will not replace the habitat lost but can retain some of the local genetic material stock of ancient plants, soil biota and other attributes.

10.356 As the project will result in the loss of one ancient tree, which is categorised as irreplaceable habitat, the scheme cannot achieve BNG at the ‘project level’. However, the project will generate meaningful gains for other biodiversity features, such as neutral grassland, wet woodland and wetland areas.

10.357 SESRO (75Mm3) is estimated to provide a net unit increase of 2,196.37 habitat units equating to a net gain of 51.64%. As much of the baseline habitats will be lost to the reservoir, this significant net gain in biodiversity indicates that the replacement habitats and future landscape surrounding the reservoir will be more beneficial to biodiversity than the current landscape. This is because the habitats to be created, such as the ponds and wetland habitat mosaic, will provide habitat for a range of species from invertebrates and amphibians to riparian mammals and breeding and wintering birds. The species rich grassland habitats will attract birds and invertebrates and the woodland habitats will develop into highly biodiverse areas. SESRO will also result in a net unit loss of 42.99 hedgerow units (10.68% loss). Consequently, off-site compensation for the loss of these hedgerow units will be sought. This will be undertaken within a location where hedgerows will improve ecological connectivity in landscapes nearby to the scheme impact. The current metric does not take account for any potential advanced planting of hedgerow and tree lines which is likely to occur in order to maintain connectivity across the site during construction. Opportunities for advanced planting will be discussed during further iterations of Abingdon Reservoir masterplan. SESRO is also estimated to provide a net unit increase of 128.78 river units (34.84% net gain). The more naturalised planform and enhanced connectivity of the river channel to wetland floodplain habitats will significantly improve the quality and natural functioning of the river compared to the artificial conditions present currently.

INNS

10.358 The INNS in-combination effects assessment identified several combinations of options where raw water with potential for INNS transfer would be discharging to the same water bodies. In-combination effects were identified for the Abingdon to Farmoor and Duke’s Cut to Farmoor options. Mitigation such as a WTW at Abingdon was discussed as part of the Level 2 assessments and would help reduce effects. In-combination effects were also identified for Oxford Canal to Duke’s Cut, Duke’s Cut to Farmoor, Abingdon to Farmoor and SESRO. These options are connected to transfer water around the network and it is likely that mitigation measures can be incorporated into the options design and through discussion with the Environment Agency to reduce risks. In-combination effects were also identified for the Duke’s Cut to Farmoor and Medmenham Intake options, the Duke’s Cut to Farmoor and Teddington DRA options, and the Duke’s Cut to Farmoor and Beckton Desalination options. However, given the distances between these options further investigation is likely to conclude no additional effects and therefore, mitigation is unlikely to be needed. The Environment Agency SAI-RAT tool used for the assessment makes a number of recommendations for biosecurity mitigation measures which can be implemented to reduce effects. These can be found in Appendix BB. It is likely that mitigation measures are available which will reduce INNS transfer risk across the plan. These will be incorporated into option design as each option is progressed and discussed with the Environment Agency.

Thames Water